Quantifying emission reduction contributions by emerging economies

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Disclaimer

In the run-up to the UN-Climate Change summit from 7th to 18th of December 2009 in Copenhagen governments of Brazil, China, India, South Africa and South Korea have announced their own mitigation targets. However, this information could not be integrated into the model runs, which served as the basis for the assessment of the respective national plans on climate change action.

Vorwort

Im unmittelbaren Vorfeld des UN-Klimagipfels vom 07. bis 18.12.2009 in Kopenhagen haben die Regierungen Brasiliens, Chinas, Indiens, Südafrikas und Südkoreas eigene Klimaschutzziele verkündet. Diese Vorgaben konnten in den Modellrechnungen, die die Grundlage für die Bewertung der nationalen Klimaschutzpläne bilden, nicht mehr berücksichtigt werden.

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List of abbreviations

BAU	Business-as-usual (scenario)
CAP	Commitment Achievement Plan
CCS	Carbon capture and storage
CDM	Clean development mechanism
CH_4	Methane
CHP	Combined Heat and Power generation, cogeneration
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalent
CONPET	Brazil's National Programme for the Rational Use of Natural Gas and Oil Products (Programa Nacional da Racionalização do Uso dos Derivados do Petróleo e do Gás Natural)
COP	Conference of the Parties
EEI	Energy Efficiency Index
ENACC	Mexican National Strategy on Climate Change
GDP	Gross Domestic Product
GHG	Greenhouse gas
Gt	Giga tonnes, 10^9 tonnes
GWh	Gigawatt hours
HCFCs	Hydrochlorofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least developed countries
LUCF	Land use change and forestry
LULUCF	Land-use, land-use change and forestry
MME	Brazilian Ministry of Mining and Energy (Ministério de Minas e Energia)
Mt	Megatonnes, 10^6 tonnes
Mtce	Megatonnes of coal equivalent
MW	Megawatt
N_2O	Nitrous oxide
NAMAs	Nationally appropriate mitigation actions
NAPCC	India's National Action Plan on Climate Change
NCCPs	National climate change plans
PECC	PECC - Programa Especial de Cambio Climático 2009-2012 (Mexico's Special Programme on Climate Change 2009-2012)
ppmv	parts per million
PROÁLCOOL	Brazil's National Alcohol Programme (Programa Nacional do Àlcool)
PROCEL	Brazil's National Electrical Conservation Programme (Programa Nacional de Conservação de Energia Eléctrica)
PROINFA	Brazil's Programme for Alternative Sources of Energy (Programa de Incentivo às Fontes Alternatives de Energiea Elétrica)
PV	Photovoltaics
toe	Tonnes of oil equivalents
TWh	Terawatt hours
UNFCCC	United Nations Framework Convention on Climate Change
USD	US Dollar, US$
WEO	World Energy Outlook

Summary

1. Introduction

Further action is needed that goes far beyond what has been agreed so far under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol to ‘prevent dangerous anthropogenic interference with the climate system’, the ultimate objective of the UNFCCC. It is out of question that developed countries (Annex I countries) will have to take a leading role. They will have to commit to substantial emission reductions and financing commitments due to their historical responsibility and their financial capability. However, the stabilisation of the climate system will require global emissions to peak within the next decade and decline well below half of current levels by the middle of the century. It is hence a global issue and, thus, depends on the participation of as many countries as possible.

This report provides a comparative analysis of greenhouse gas (GHG) emissions, including their national climate plans, of the major emitting developing countries Brazil, China, India, Mexico, South Africa and South Korea. It includes an overview of emissions and economic development, existing national climate change strategies, uses a consistent methodology for estimating emission reduction potential, costs of mitigation options, provides an estimate of the reductions to be achieved through the national climate plans and finally provides a comparison of the results to the allocation of emission rights according to different global effort-sharing approaches. In addition, the report discusses possible nationally appropriate mitigation actions (NAMAs) the six countries could take based on the analysis of mitigation options.

This report is an output of the project ‘Proposals for quantifying emission reduction contributions by emerging economies’ by Ecofys and the Wuppertal Institute for the Federal Environment Agency in Dessau. It builds upon earlier joint work “Proposals for contributions of emerging economies to the climate regime under the UNFCCC post 2012” published 2008.

The analysis for this report was completed before the UN climate summit in Copenhagen in December 2009. Hence, it predates the notification of NAMAs under the “Copenhagen Accord”. However, the NAMAs discussed in this report and the NAMAs notified under the Copenhagen Accord operate at different levels. With the exception of Brazil, all the countries discussed in this report notified aggregate national targets under the Copenhagen Accord, either in terms of emission intensity targets or in terms of a reduction of national emissions below “business as usual.” By contrast, this report discusses sector- or technology-specific NAMAs. The NAMAs discussed in this report can therefore be seen as possible ways of achieving the aggregate NAMAs notified under the Copenhagen Accord.

2. Methodology

The report covers four major aspects: estimating reference emissions and mitigation potential, estimating costs, comparing the outcomes with existing effort-sharing approaches, and discussing possible NAMAs as elements of comprehensive low-carbon development strategies.

Estimating reference emissions and mitigation potential

This report includes an update and further development of a bottom-up calculation tool (Höhne et al. 2008), which was designed to describe possible future emission trends and reduction options for six emerging economies until 2020. The idea is to describe the future emission trends and emission reduction options in a consistent manner for Brazil, China, India, Mexico, South Africa and South Korea. We calculated five scenarios for all six countries:

Business-as-usual: The business-as-usual (BAU) scenario follows production, energy consumption and energy efficiency trends that are based on moderate assumptions. Where available, these assumptions and related growth rates were taken from national studies. This was possible for Brazil, China, India and South Africa (Centro Clima et al. 2006; Chen et al. 2006; TERI and CCAP 2006; Winkler (ed.) 2007). Most of these studies include recent national policies up to the year 2005. Later polices are not considered because their level of implementation and the resulting impacts are often still unclear. For countries or sectors for which no detailed studies were available, patterns and growth-rate trends were usually assumed to be similar to those in previous years. These do not include the impact of additional policies. Consequently, this scenario may overestimate the levels of emissions.

No-regret: Pathways under the no-regret scenarios include GHG emission reduction options that can be achieved at negative or no direct costs. These would include, e.g. energy efficiency measures where the economic gains from reduced energy use outweigh the investment costs for more efficient technology. Some would also call this scenario ‘economic potential at costs below 0€/tCO_2eq’. Given the economic net benefit achievable, it should be in the interest of each country to achieve this potential by using its own resources. The international community could, however, support implementation both by making technical contributions and by providing seed funding, e.g. for national revolving funds and by implementing policies and measures designed to overcome non-market barriers.

Co-benefit: Pathways under the co-benefit scenarios consider reduction options that are reasonable in terms of political aims other than GHG reduction. These also include reductions that incur some costs. A typical measure would be the increased use of renewable energy sources to enhance energy security and reduce dependency on importing fossil fuels or switching from diesel to gas in passenger transport (for reasons related to air quality). Recent policies such as those encouraging energy efficiency or setting renewable targets are included in this scenario, assuming that they are fully implemented. But the scenario also includes further measures that could be implemented. It should be in the interest of each country to achieve this potential with its own resources. However, the fact that it may entail some extra cost means that not only technical but also financial contributions from the international community would be helpful to realise this scenario.

Ambitious: This scenario includes reduction options which can be implemented at extra net cost, while maintaining the same level of service. It includes reduction options that are technically feasible and would accelerate capital stock turnover, but would not lead to stranded investments. This potential can be achieved if both the non-market barriers are removed and financial incentives are provided to cover the extra net costs. It could be achieved with additional contributions from the country itself or from the international community.

National climate change plans: This scenario includes our interpretation of the national climate change plans. At the time of analysis, all of the countries except South Korea had presented detailed climate change strategies or scenarios and in some cases other medium-term plans as well. But only Mexico and South Africa provided aggregated emission scenarios. Hence, we had to include all assumptions from these plans to generate such scenarios. However, it was difficult to quantify all plans and to understand clearly from the plans what is additional to BAU. For South Korea we considered only preliminary summaries and an initial outline of possible targets published in August 2009. The final climate plan was published too late to be considered in this study.

Mitigation costs

Our approach to estimating mitigation costs involves making an 'informed expert judgement': We examine marginal abatement cost curves (MAC curves) from various studies and then use expert judgments to derive our results. The advantage compared to just looking at the MAC curves lies in the fact that these are prone to study-related assumptions. The assumptions we made often differed tremendously from those made to construct the MAC curves we looked at. Overall, the approach is in line with the general approach in this paper: to present a transparent, simple, serious analysis of mitigation efforts in developing countries.

We used two sources of MAC curves. The first is the ECN MAC curve database. This curve is the result of a bottom-up analysis, in which MAC curves for developing countries from various sources were combined in one curve (Version April 2009). The second source we used is the SERPEC cost curve. This is a sectoral bottom-up cost curve for the EU27 that was developed by Ecofys. The full SERPEC report is published November 2009.

Sensitivity analysis on parameters and costs

Due to major uncertainties in future developments and extrapolation of data we included a sensitivity analysis. This takes selected parameters to create two extreme cases: one leading to very high emissions (high case) and one leading to comparatively low emissions (low case).

The assumptions related to costs are particularly uncertain. As we used different sources, there is often more than one cost estimate available. In the cost sensitivity we used the upper and the lower cost estimate if this was available. If no range could be derived from the sources available we assumed a change of +30% (high case) and -30% (low case). The results are included in the country chapters.

Effort sharing

We compare the mitigation scenarios developed here with emissions reductions required under global effort-sharing proposals that are consistent with stabilising GHG concentrations at 450 ppmv CO_2eq. We used the Evolution of Commitments tool (EVOC) to quantify the required reductions under five different global effort-sharing approaches:

- Contraction and Convergence (C&C), where per-capita emissions converge at the same time for all countries
- Common but Differentiated Convergence (CDC), where per-capita emissions are reduced to a low level, earlier for developed and later for developing countries
- Greenhouse Development Rights (GDRs), where all countries reduce emissions below their reference emissions according to the principles of responsibility and capability
- Global Triptych, where all countries reduce emissions sectorally according to the same rules

- South-North Dialogue Proposal, where countries participate in different stages, developed countries earlier, developing countries later.

All approaches require developed countries to reduce their emissions by 20 to 60% by 2020 compared to 1990 level. The required reductions for the major developing countries are provided in the following sections.

Possible Elements of Low-Carbon Development Strategies

Based on the analysis of emission reduction potential and related costs as outlined above, the report discusses possible elements of Low-Carbon Development Strategies (LCDS) for the six countries until 2020.

The report first discusses definitions and modalities for NAMAs and LCDS in general. Based on the discussions so far under the FCCC and within literature, the report suggests modalities for the development of NAMAs and LCDS as well as for measuring, reporting and verification. On this basis, the report discusses possible elements of LCDS for the six countries.

Regarding the level of ambition, the discussed elements of LCDS are based on the following two considerations:

- Where possible, the level of ambition is matched to the analysis of global effort sharing proposals as outlined above. This approach is taken where all effort sharing approaches show very similar results.
- In all other cases we considered that the countries should as a minimum aim at mobilising their co-benefit potential, as these measures would yield macro-economic benefits for their economies.

As a caveat it should be noted that most global effort sharing proposals suggest emission reduction targets for industrialized countries that go substantially beyond what most industrialized countries have offered so far. The suggested appropriate range is 25% to 40% below 1990 in 2020, while the current proposals add up to only 17% at the maximum and could be far less depending on the applied rules. It could therefore be argued that proposing developing countries to match their efforts to the allocations under the global effort sharing approaches would require industrialized countries to do the same.

3. National climate strategies

We analysed the national climate strategies for the six countries in the study and drew the following conclusions.

Brazil: The national climate change plan covers all major sectors (energy, forestry and agriculture, industry, waste and transport). It provides a list of measures but the resulting reductions are only quantified for a few measures. The most important measure is the reduction of the deforestation rate, which we would judge as very ambitious. A significant number of measures are not quantifiable with the information provided. These include measures such as the possible establishment of a certification system for biofuels, further development of important programmes such as PROCEL (a programme designed to save energy) and CONPET (a programme designed to rationalise derivatives from oil and gas). In general, it was difficult to judge the overall impact of all such measures because they are often too vague and it is not clear which of the proposed measures are additional actions or are already included in the BAU.

China: China's national climate change strategy includes some quantified emission reduction measures, each with its emission reduction potential. An overall baseline and mitigation scenario is not provided. The Chinese National Action Plan on Climate Change does not mandate any additional mitigation actions, but summarizes the efforts undertaken in different policy areas which have a mitigating effect on greenhouse gases. Consequently, it is sometimes unclear which of the proposed measures are additional actions or already existing. It is very hard to quantify the mitigating effects of measures for which numerical data is not provided, such as spending on research and development and emission reductions in sectors with many decentralized sources (e. g. the building and transport sectors).

India: The national climate plan provides eight 'national missions' in key areas. It provides several measures but only a few of them are quantified in terms of resulting emission reductions. However, detailed targets for the electricity sector are contained in the 11^{th} five-year plan. Most of the measures in the climate plan are rather general, e.g. promoting public transport or switching fuels in industry. The plan does not provide an overall baseline and mitigation scenario. Consequently, it is sometimes unclear which of the proposed measures are additional actions or already existing. The comprehensiveness and detail of the plan corresponds with India's state of development: it focuses on development and lacks quantified options.

Mexico: Mexico has a very detailed national plan up to 2012. It provides measures with their effects on emissions. Even though the resulting emission reductions are not very ambitious in the short term, the plan is in line with an overall strategy to reduce emissions by 50% until 2050, which assumes moderate reductions in early years and more ambitions reductions later on.

South Africa: South Africa has provided a comprehensive study on long-term mitigation pathways and options up to 2050. This, however, does not provide concrete plans which of the measures to implement. Emissions from coal are a major source of GHG emissions and these are currently not directly covered by the measures implemented.

South Korea: South Korea has announced three possible options for emission reduction targets by 2020 (a reduction to 8% above the 2005 emission level, stabilisation at the 2005 emission level or reduction to 4% below the 2005 emission level). South Korea recently provided a climate change strategy. However, it was published too late to be included in this report.

4. Results

The following figures provide the emission scenarios (left), and the allocations that are compatible with stabilising GHG concentrations at 450 ppmv CO_2eq according to the various global effort-sharing approaches (right).

Brazil

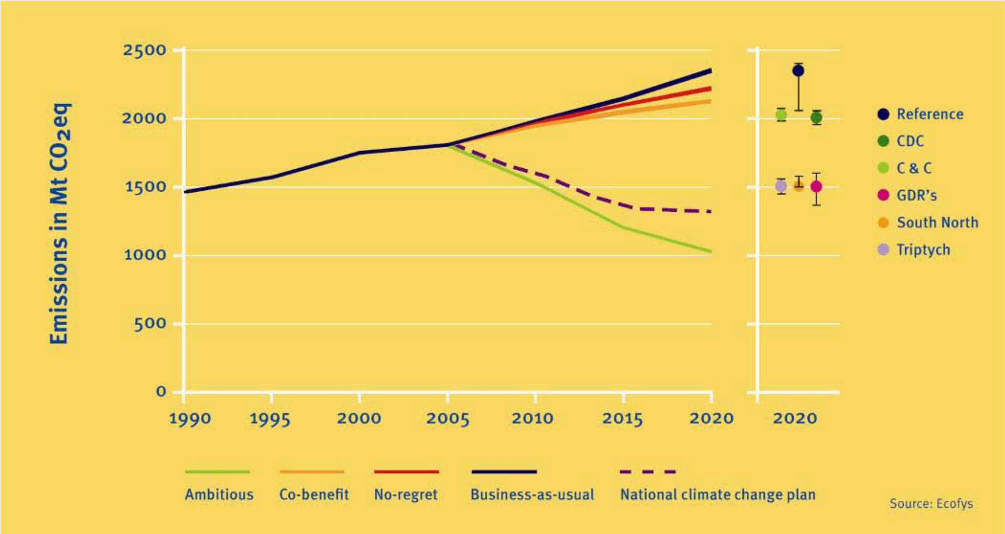

Figure 1 Emission scenarios with allowances according to a range of global effort-sharing approaches in 2020 for Brazil

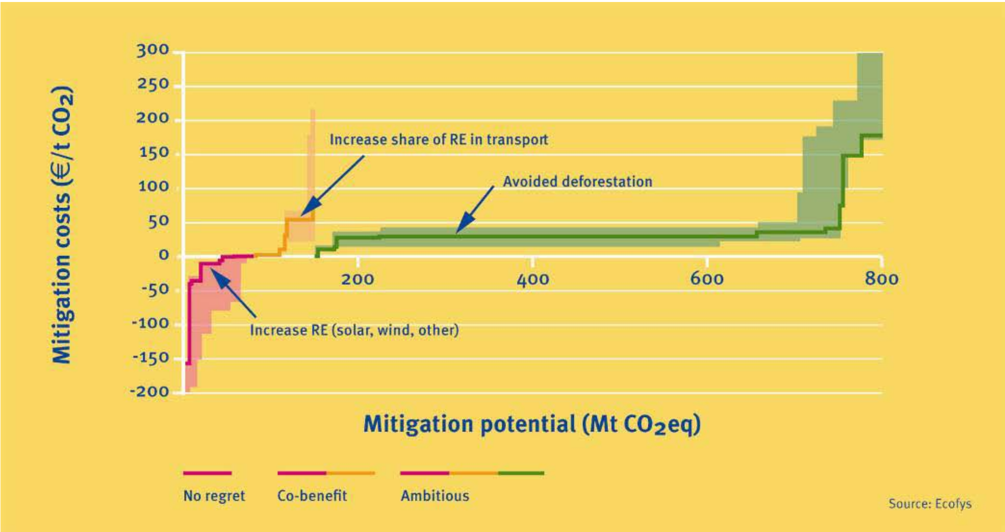

Figure 2 Indicative mitigation costs for emission scenarios 2020 for Brazil

The three sectors with the highest GHG emission reduction potential between 2005 and 2020 under the ambitious potential are the LUCF, transport and the power sector.

Under the no-regret scenario reductions of 5% below BAU (22% above 2005 emissions) are possible. Under the co-benefit scenario reductions of 9% below BAU (17% above 2005 emissions) are feasible. Under the ambitious scenario reductions of 37% below BAU (20% below 2005 emissions) are possible. According to our interpretation of Brazil's national climate change plan reductions of 25% below BAU (4% below 2005 emissions) are possible, but depend strongly on achieving the ambitious deforestation goal.

If Brazil can achieve its ambitious reductions in deforestation as planned, then its national plan is in line with the emission level of the global effort-sharing approaches that are based on GDP. Sharing allowances on the basis of per-capita emissions (which exclude emissions from forestry) would lead to less stringent reduction requirements.

China

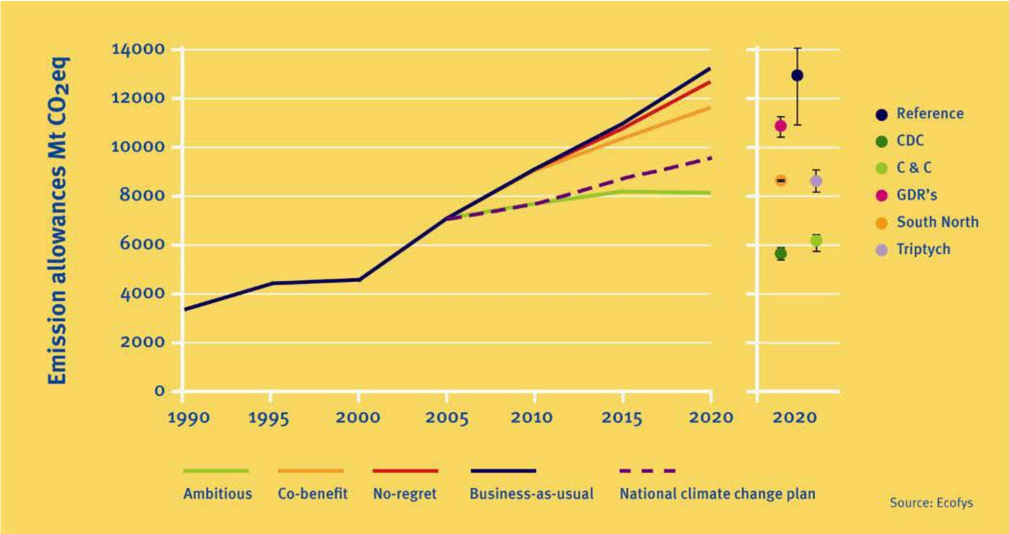

Figure 3 Emission scenarios with allowances according to a range of global effort-sharing approaches for China

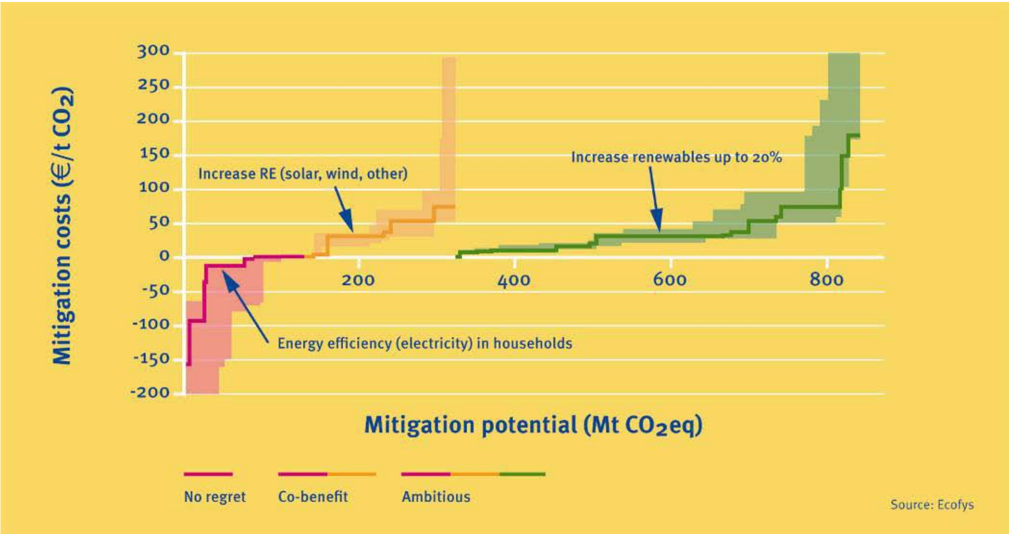

Figure 4 Indicative mitigation costs for emission scenarios in 2020 for China

The three sectors with the highest GHG emission reduction potential between 2005 and 2020 under the ambitious scenario are the power, industry and the other energy industry sector.

Under the no-regret scenario reductions of 4% below BAU (80% above 2005 emissions) are possible. Under the co-benefit scenario reductions of 12% below BAU

(65% above 2005 emissions) are feasible. Under the ambitious scenario reductions of 39% below BAU (15% above 2005 emissions) are possible. According to our interpretation of China's national climate change plan reductions of 28% below BAU (36% above 2005 emissions) are possible.

According to our interpretation, China's national plan is quite ambitious in several respects. It includes measures with substantial costs and is more ambitious than our co-benefit scenario. It is also more ambitious compared to the results of the Greenhouse Development Rights approach that judges China's responsibility and capability as low. It is in line with the Triptych approach, which looks at sectoral reduction opportunities. Only approaches based on per-capita emissions would require more ambitious reductions than those in China's national plan.

India

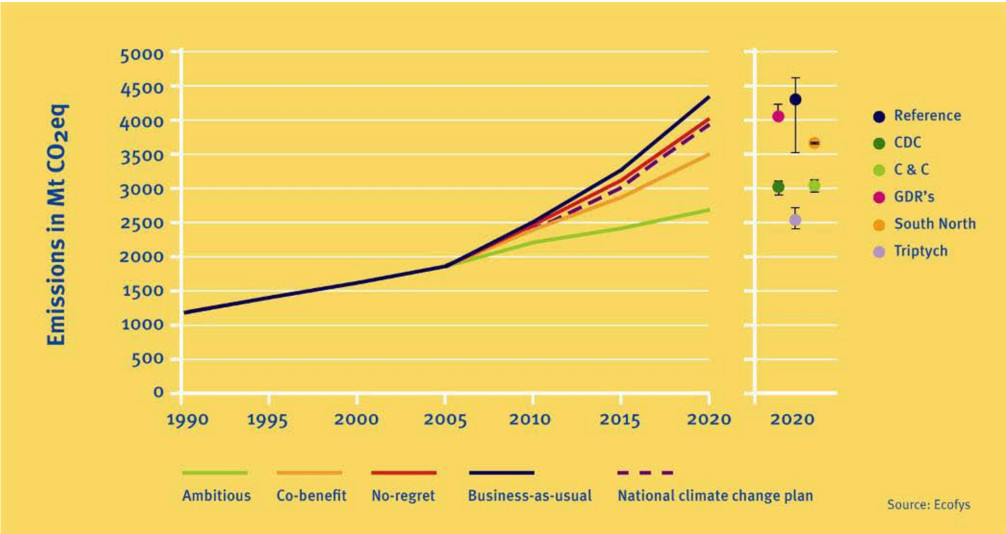

Figure 5 Emission scenarios with allowances according to a range of global effort-sharing approaches in 2020 for India

The three sectors with the most important GHG emission reduction potential between 2005 and 2020 under the ambitious scenario are the power, transport and the industry sector.

Under the no-regret scenario reductions of 7% below BAU (121% above 2005 emissions) are possible. Under the co-benefit scenario reductions of 20% below BAU (92% above 2005 emissions) are feasible. Under the ambitious scenario reductions of 39% below BAU (46% above 2005 emissions) are possible. According to our interpretation of India's national climate change plan reductions of 9% below BAU (117% above 2005 emissions) are possible.

The reductions under India's national plan are in line with the results of the effort-sharing approaches that judge India's responsibility and capability as low. They place the required effort in the range of the no-regret and co-benefit scenarios. Approaches that are based on sectoral considerations or only per-capita emissions would require (much) more ambitious reductions.

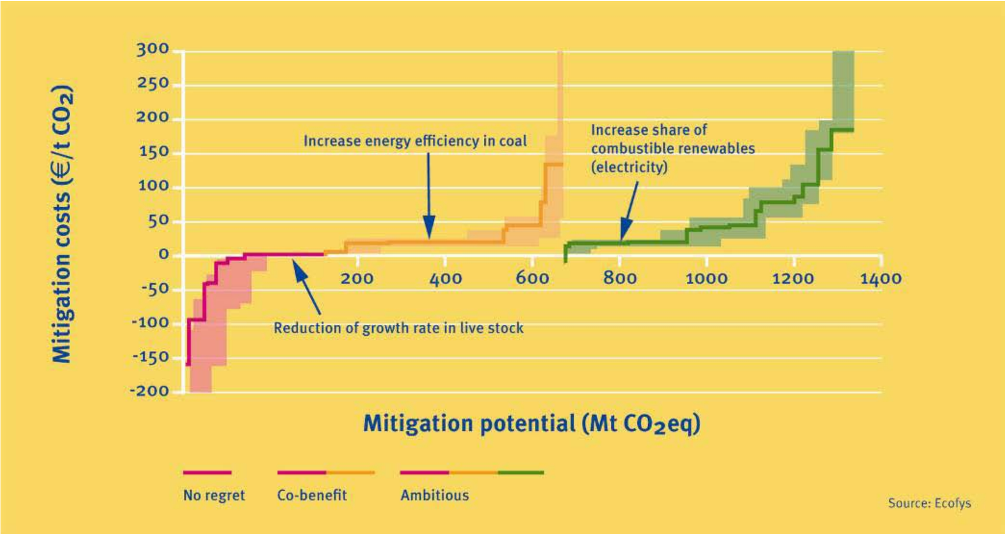

Figure 6 Indicative mitigation costs for emission scenarios in 2020 for India

Mexico

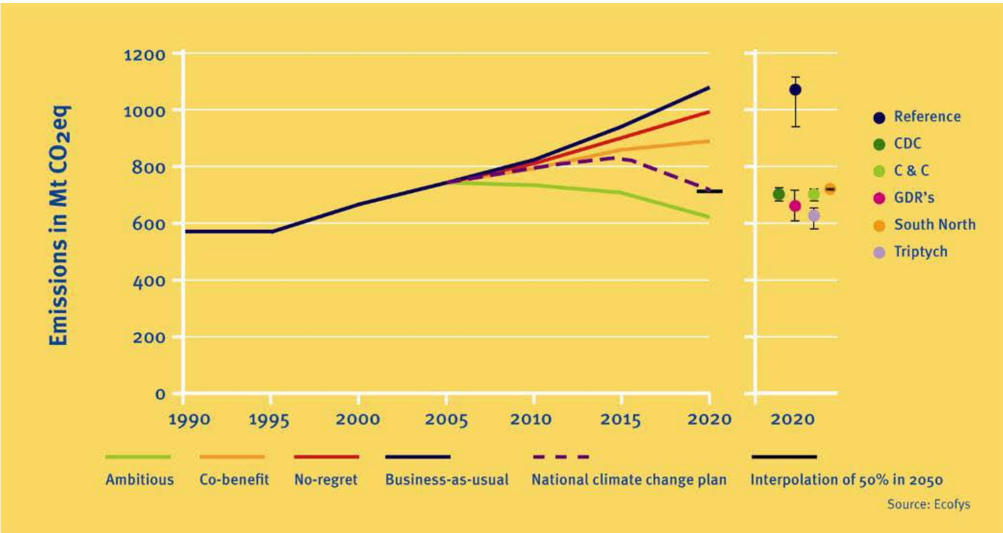

Figure 7 Emission scenarios with allowances according to a range of global effort-sharing approaches in 2020 for Mexico

The three sectors with the highest GHG emission reduction potential between 2005 and 2020 under the ambitious scenario are energy industry (oil and gas sector), transport and the power production sector.

Under the no-regret scenario reductions of 8% below BAU (34% above 2005 emissions) are possible. Under the co-benefit scenario reductions of 18% below BAU (20% above 2005 emissions) are feasible. Under the ambitious scenario reductions of 43% below BAU (16% below 2005 emissions) are possible. According to our interpretation of Mexico's national climate change plan, reductions of 34% below BAU (3% below 2005 emissions) are possible. The plan contains significantly higher reductions than in the co-benefit scenario.

The ambitions in Mexico's national plan are well in line with all of the effort-sharing approaches analysed here. Although the effort-sharing approaches are based on very different principles, their results are very similar. These approaches assign relatively high responsibility and capability to Mexico.

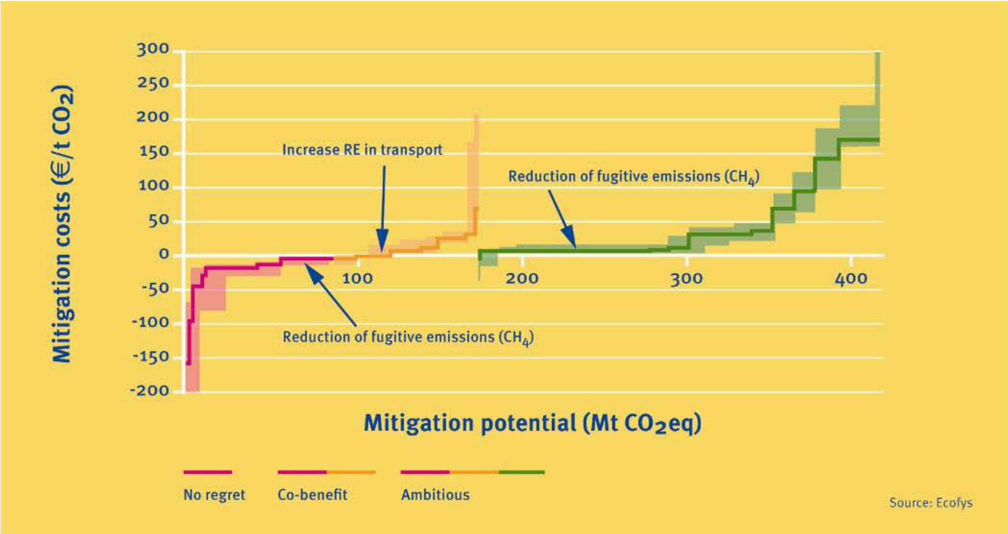

Figure 8 Indicative mitigation costs for emission scenarios in 2020 for Mexico

South Africa

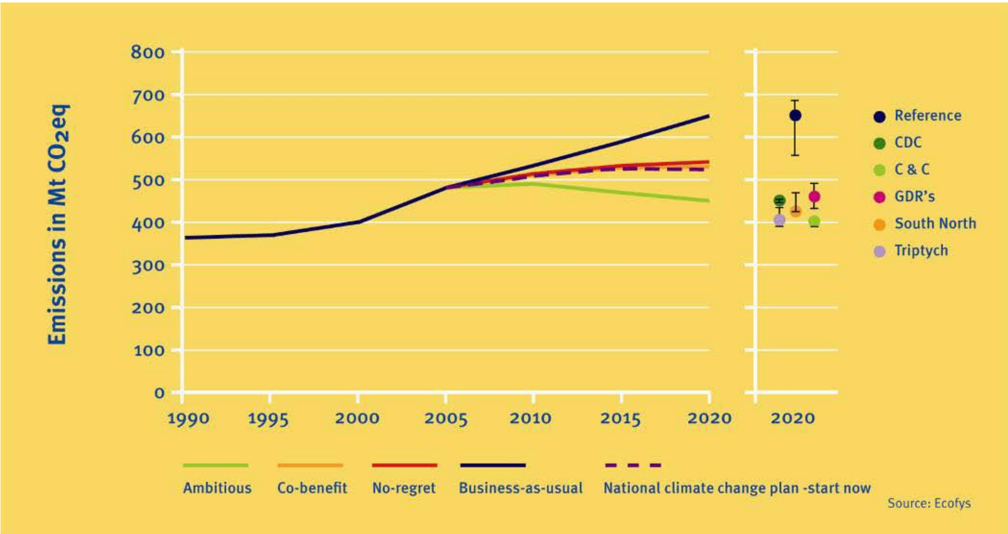

Figure 9 Emission scenarios with allowances according to a range of global effort-sharing approaches in 2020 for South Africa

The three sectors with the highest GHG emission reduction potential between 2005 and 2020 under the ambitious scenario are the power, the industry and the other energy industry (coal, oil and gas) sector.

Under the no-regret scenario reductions of 16% below BAU (12% above 2005 emissions) are possible. The no-regret potential is relatively high compared to other countries. Under the co-benefit scenario reductions of 18% below BAU (10% above 2005 emissions) are feasible. Under the ambitious scenario reductions of 30% below BAU (7% below 2005 emissions) are possible. According to South Africa's national climate change plan, reductions of 19% below BAU (9% above 2005 emissions) are possible.

The ambition level of South Africa's plan is unclear. Our interpretation of South Africa's 'start now' scenario results in emissions that are higher than all of the effort-sharing approaches analysed here. Although based on very different principles, the results of the effort-sharing approaches for South Africa are very similar. These approaches assign relatively high responsibility and capability to South Africa.

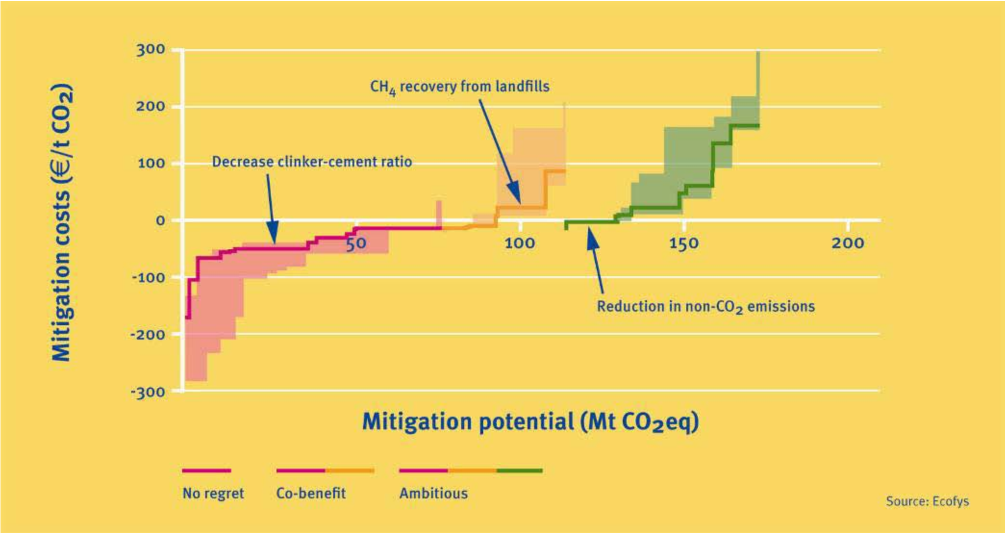

Figure 10 Indicative mitigation costs for emission scenarios in 2020 for South Africa

South Korea

The three sectors with the highest GHG emission reduction potential between 2005 and 2020 under the ambitious scenario are power production, transport and the industry sector.

Under the no-regret scenario reductions of 7% below BAU (37% above 2005 emissions) are possible. Under the co-benefit scenario reductions of 16% below BAU (24% above 2005 emissions) are feasible. Under the ambitious scenario reductions of 41% below BAU (12% below 2005 emissions) are possible. According to South Korea's national climate change plan reductions of 17% below BAU (23% above 2005 emissions) are possible. Korea has presented three options for a national target, which are somewhere between our co-benefit and ambitious scenarios.

The ambition level of the announced possible targets of South Korea exceeds that of the co-benefit potential, but is still less ambitious than the results from all of the effort-sharing approaches analysed here. The approaches assign relatively high responsibility and capability to South Korea. Those approaches that acknowledge that

South Korea is already very efficient result in slightly less ambitious reduction requirements.

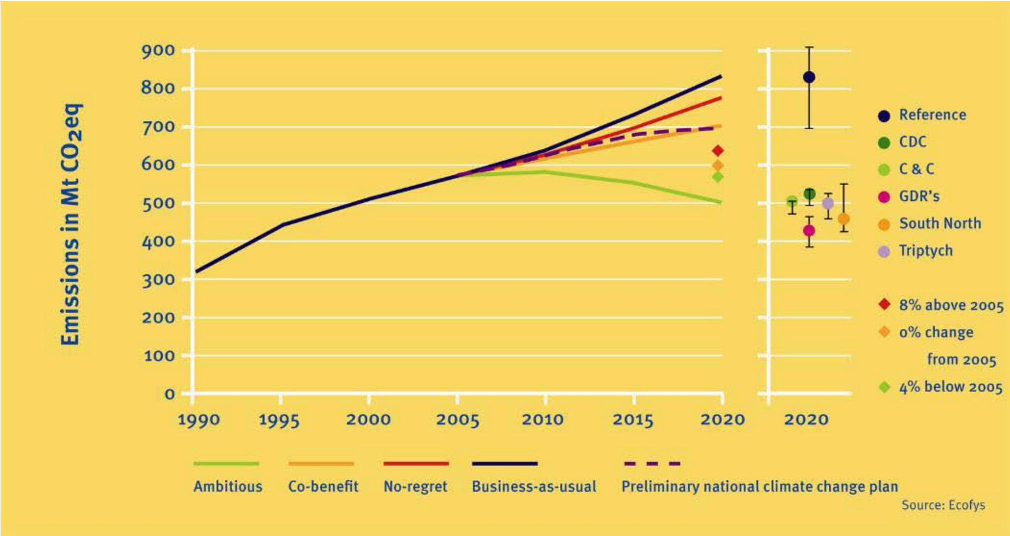

Figure 11 Emission scenarios with allowances according to a range of global effort-sharing approaches in 2020 for South Korea

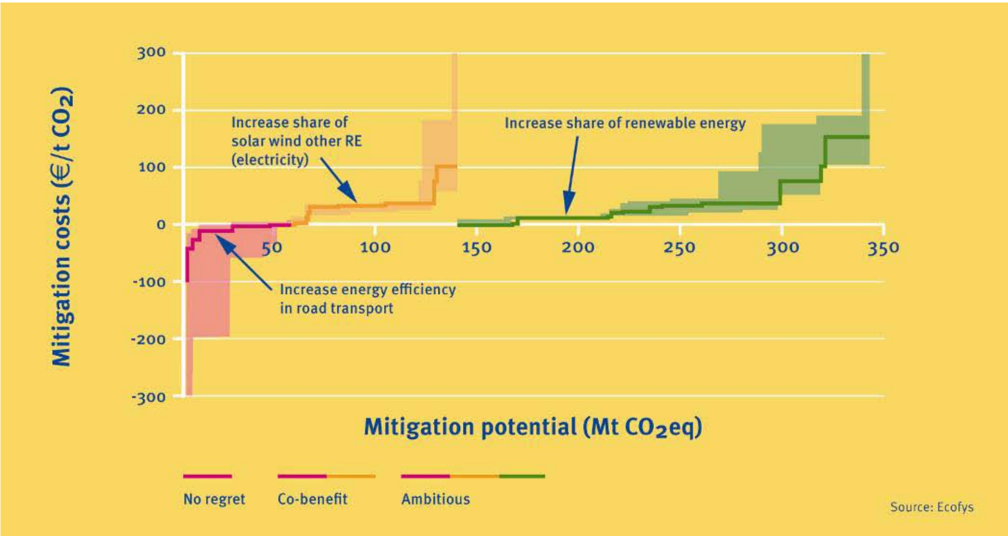

Figure 12 Indicative mitigation costs for emission scenarios in 2020 for South Korea

5. Suggested modalities for the development of Low-Carbon Development Strategies

To give clear directions for all future investments and make strategic use of the resources to be provided by industrialised countries, non-Annex I countries should ideally develop integrated LCDS. These should set out a long-term vision for low-emission development as well as comprehensive "Nationally Appropriate Mitigation Actions" (NAMAs) covering all the key emitting sectors that are needed to implement this vision. Ideally, national plans should be developed in a transparent and participatory process through high level cross-ministerial and multi-stakeholder groups.

The actions taken by developing countries should be inscribed into an international register under the UNFCCC and would need to be "MRVable" – measurable, reportable and verifiable – to qualify for financial and technological support. The guidance and requirements for elaborating NAMAs as well as the assessment process could be inspired by the reporting infrastructure that is already in place under the FCCC.

What is emerging for developing countries in the negotiations is a framework for highly diversified actions, based on countries' differing national circumstances. While some more advanced developing countries may adopt actions like sectoral no-lose targets, for the most part developing country actions will probably not be target-based but consist of specific policies and measures. This makes MRV far more challenging.

Attempting to measure the impacts of a specific action is not at all straightforward. While it will be necessary to get a clear picture of both the implementation of NAMAs as well as the development of emissions in developing countries, it might therefore be recommendable to separate MRV of the two, especially at the beginning while no strong technical capacities are in place neither nationally in developing countries nor internationally for the review process. That is, NAMAs could in the starting phase be MRVed not as regards their emission impact but as regards their implementation. How successful developing countries are in reducing their emissions could then be assessed at the aggregate level through much more robust and frequent emission inventories and an international review process.

Several non-Annex I countries have in the meantime attained levels of development and per capita emissions that are comparable to or even exceeding those of a number of Annex I countries. Such countries could therefore assume legally binding emission targets. Among the six countries in this report, this applies in particular to South Korea.

However, as the first commitment period has shown, commitments to legally binding emission targets do not automatically mean that countries will in fact reduce their emissions. We therefore suggest that all countries with binding targets – Annex I countries and newly industrialised countries – should therefore develop commitment achievement plans (CAPs). These should essentially contain a coherent vision and action programme for how each country wants to achieve a rapid transition to a low-carbon society. Like LCDS, these should be developed in a participatory process. In addition, the CAPs should be submitted to an international review process. The modalities for the development and review of the CAPs should build on the modalities already in place for the development and review of national communications, GHG inventories etc. The Conference of the Parties should review the results of the technical analysis and may decide to request countries to revise their CAPs to ensure that they are consistent with meeting their obligations.

6. Conclusions

This report shows for the first time a comparable overview of the national climate plans of Brazil, China, India, Mexico, South Africa and South Korea. As most of these countries have not provided aggregated scenarios for their plans, the scenarios in this report are our interpretation of the national climate plans.

The aggregated reductions of the climate plans are quite substantial and would lead to substantive emission reductions if implemented as planned. Our estimates show that national climate plans could lead to a joint reduction of 25% below BAU by 2020 (see

Figure 13). According to the ambitious scenario a reduction of 40% below BAU would be possible. The aggregated results are dominated by those projected for China.

We also compared for the first time the mitigation potential scenarios to what various effort-sharing approaches would suggest.

China's climate plan is very ambitious according to our interpretation. It is well beyond the co-benefit potential, many measures of the plan are already implemented and it is roughly in line with results of effort-sharing approaches.

Under all effort sharing approaches, Mexico, South Africa and South Korea have to achieve a significant deviation from the reference by 2020 and well beyond the co-benefit potential. Only Mexico has proposed action in its climate plan that is in line with these results.

Brazil's climate plan can be judged as ambitious, but depends on the successful halting of deforestation. First results of a new policy have already achieved a reduction in deforestation rate.

India's plan is the least concrete, reflecting the relative development state of India compared to the other countries. Nevertheless, according to our interpretation India's plan does not even attain the level of the co-benefit potential and should therefore be further strengthened.

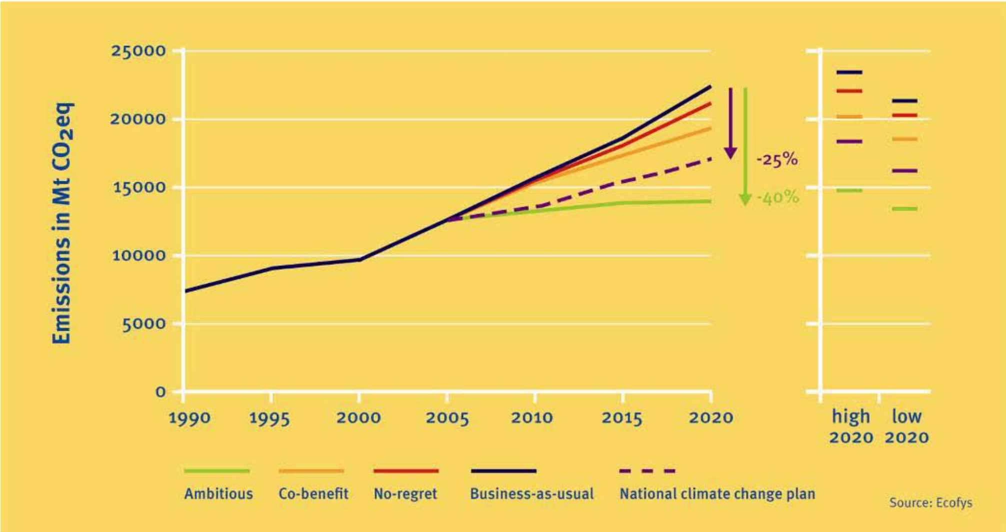

Figure 13 Reduction potential for the combined emissions of Brazil, China, India, Mexico, South Africa and South Korea under a range of scenarios *including LUCF* (left) and sensitivity analysis (right). Note that aggregate reductions are estimates and therefore need to be interpreted with care.

A closer analysis of the details of the national plans reveals that the level of ambition varies significantly between sectors. On the one hand, the countries that are not very ambitious overall usually have one or two sectors where ambitious plans have been developed. In particular the plans for the power sector are in each country among the most detailed and the most ambitious. On the other hand, the plans of the more ambitious countries all have some "blind spots", that is, emission reduction potential that does not appear to be addressed in the national plans. Significant further improvements of the level of ambition may therefore be possible without too much effort.

This report provides in addition a method to identify such further action as Nationally Appropriate Mitigation Action (NAMAs): We compared the mitigation potential per sector with the reductions achieved through the national plans.

For the purpose of this report, we define a NAMA as any kind of measure that reduces emissions. We distinguish the following three basic types of NAMAs:

- Emission-target based NAMAs, which may take the form of binding or voluntary ("no-lose") sectoral or national emission targets.
- Technology-specific NAMAs, such as targets for the share of renewable energy sources in power production, efficiency targets or standards.
- Policy-based NAMAs, such as feed-in tariffs, financial incentives or pricing instruments.

The discussion in this report is restricted to emission-target based and technology-specific NAMAs. Discussing reasonable policy-based NAMAs would require having detailed information about the current policy landscape in each individual country, which was not feasible within the framework of this project.

Due to data availability the most detailed assessment was pursued for overall emissions and for the power and industry sectors. For the other sectors much less data was available and therefore a less elaborate approach was taken which focuses on individual actions.

Priority areas for further action should be those sectors where national plans are less ambitious than at least the no-regret or the co-benefit potential. While our results are sensitive to the (often scarce) data availability, the method as such could be further explored in the future. If sufficient data was available, it would be possible to do a detailed analysis of the mitigation potential also in those sectors where only very limited data was available in this project. These are in particular the domestic, transport and waste sectors. In addition, it would be possible to do a detailed projection of the impacts of existing and planned policies and measures sector by sector. If these projections fell significantly short of mobilising the available mitigation potential, further steps could analyse possible ways of increasing a country's efforts. Such an analysis would need detailed and reliable data on emissions and emission drivers as well as detailed information on existing and planned policies and measures.

Zusammenfassung

1. Einführung

Zur Verhinderung einer 'gefährlichen anthropogenen Störung des Klimasystems', dem Ziel der Klimarahmenkonvention der Vereinten Nationen (UNFCCC), sind weitere Maßnahmen gefordert, die weit über die hinausgehen, die bisher unter der UNFCCC und dem Kyoto-Protokoll vereinbart wurden. Auf Grund ihrer finanziellen Möglichkeiten und der historischen Verantwortung steht außer Frage, dass die Industriestaaten (Annex I Staaten) eine Führungsrolle übernehmen und sich zu substantiellen Emissionsreduktionen so wie zu finanziellen Zugeständnissen verpflichten müssen. Die Stabilisierung des Klimasystems kann aber nur erreicht werden, wenn im nächsten Jahrzehnt der Emissionshöhepunkt erreicht wird und bis zur Mitte des Jahrhunderts Emissionen um mehr als die Hälfte im Vergleich zum heutigen Niveau eingespart werden. Die globale Dimension dieser Aufgabe erfordert somit die Beteiligung möglichst vieler Länder.

In diesem Bericht werden die Schwellenländer und wichtigen Emittenten Brasilien, China, Indien, Mexiko, Südafrika und Südkorea analysiert und ihre Treibhausgasemissionen einschließlich der nationalen Klimapläne verglichen. Der Bericht beinhaltet einen Überblick über Emissionen und wirtschaftliche Entwicklung, bestehende nationale Klimastrategien, Abschätzungen von Emissionsreduktionspotenzialen nach einer konsistenten Methode, Emissionsvermeidungskosten, die Schätzung von erreichbaren Reduktionen durch nationale Klimapläne und ein Vergleich der Emissionsrechteverteilung unter verschiedenen globalen Verteilungsansätzen. Darüber hinaus diskutiert der Bericht mögliche „nationally appropriate mitigation actions“ (NAMAs), die die sechs Länder auf Grundlage der Analyse der Minderungsoptionen ergreifen könnten.

Dieser Bericht ist ein Ergebnis des Projektes „Proposals for quantifiable emission reduction contributions of emerging economies“ das Ecofys und das Wuppertal Institut für das Umweltbundesamt in Dessau durchführen. Dieses Projekt basiert auf einem Vorgängerprojekt, welches 2008 unter dem Namen „Proposals for contributions of emerging economies to the climate regime under the UNFCCC post 2012” veröffentlicht wurde.

Die Analysen für diesen Bericht wurden vor dem Kopenhagener Klimagipfel im Dezember 2009 abgeschlossen. Sie gingen daher der Ankündigung von NAMAs im “Copenhagen Accord” voraus. Die NAMAs, die in diesem Bericht diskutiert werden, und die NAMAs im Copenhagen Accord sind jedoch auf verschiedenen Ebenen angesiedelt. Mit Ausnahme Brasiliens haben alle der hier betrachteten Länder im Copenhagen Accord aggregierte nationale Emissionsziele notifiziert, entweder als Intensitätsziele oder als Abweichung der nationalen Emissionen von einer “Business-as-usual”-Entwicklung. Im Gegensatz dazu diskutiert dieser Bericht sektor- und technologiespezifische NAMAs. Die NAMAs in diesem Bericht können daher als mögliche Wege gesehen werden, auf denen die aggregierten NAMAs des Copenhagen Accord erreicht werden können.

2. Methodik

Der Bericht beinhaltet vier Hauptaspekte: Abschätzung einer Referenzentwicklung der Emissionen und Reduktionspotenziale, Abschätzung der Kosten, Vergleich der Ergebnisse mit verschiedenen Emissionsrechteverteilungsansätzen und die Diskussion möglicher NAMAs als Elemente umfassender Low-Carbon Development Strategies.

Abschätzung von Referenzemissionen und Reduktionspotenzialen

Der Bericht beinhaltet eine Aktualisierung und eine Weiterentwicklung des bottom-up Berechnungs-Tools (Höhne et al. 2008) zur Darstellung möglicher zukünftiger Emissionstrends und Reduktionsoptionen bis 2020 für sechs Schwellenländer. Das Ziel des Tools ist die Beschreibung zukünftiger Emissionstrends und Emissionsreduktionsoptionen mit einer einheitlichen Methode für Brasilien, China, Indien, Mexiko, Südafrika und Südkorea. Hierfür haben wir den Einfluss von fünf Szenarien auf diese sechs Länder berechnet:

Business-as-usual: Die Wachstumsraten für Produktion, Energieverbrauch und Energieeffizienztrends im Referenzszenario (business-as-usual, BAU) basieren auf moderaten Annahmen. Wenn möglich wurden diese Annahmen oder damit verbundene Wachstumsraten nationalen Studien entnommen. Dies war für Brasilien, China, Indien und Südafrika (Centro Clima et al. 2006; Chen et al. 2006; TERI and CCAP 2006; Winkler (ed.) 2007) möglich. Die meisten dieser Studien beinhalten aktuelle nationale Politikmaßnahmen bis zum Jahr 2005. Spätere Maßnahmen sind nicht berücksichtigt, da ihre Umsetzung und die Auswirkungen noch unklar sind. Für Länder oder Sektoren, für die keine detaillierten Studien verfügbar waren, haben wir Wachstumsraten fortgeschrieben. Diese Daten beinhalten keine zusätzlichen Politikmaßnahmen und folglich kann bei diesem Szenario die Emissionsmenge überschätzt werden.

No-regret: Pfade unter dem no-regret Szenario beinhalten Treibhausgasemissionsreduktionsoptionen, die zu negativen oder keinen direkten Kosten durchgeführt werden können. Solche Maßnahmen sind zum Beispiel Energieeffizienzmaßnahmen, bei denen die wirtschaftlichen Gewinne durch eingesparte Energie die Investitionskosten für eine effizientere Technologie übersteigen. Man könnte dieses Szenario auch als „Wirtschaftliches Potenzial zu Kosten unter 0€/tCO_2eq“ bezeichnen. Unter der Annahme eines wirtschaftlichen Gewinns sollte die Realisierung dieses Potenzials mit eigenen Mitteln im Interesse jedes Landes liegen. Dennoch kann die internationale Gemeinschaft die Umsetzung sowohl mit technischen Beiträgen als auch mit Anschubfinanzierungen, zum Beispiel für nationale revolvierende Fonds und durch Umsetzung von Politiken und Maßnahmen zur Überwindung von Nicht-Marktbarrieren unterstützen.

Co-benefit: Emissionspfade unter dem co-benefit Szenario berücksichtigen Reduktionen, die auch unter anderen Gesichtspunkten als dem Klimaschutz sinnvoll sind. Dies beinhaltet auch Maßnahmen die zusätzliche Kosten mit sich bringen. Eine typische co-benefit Maßnahme ist die stärkere Nutzung von erneuerbaren Energiequellen um die Energiesicherheit zu gewährleisten und Abhängigkeiten vom Import fossiler Energieträger zu reduzieren. Eine andere Maßnahme ist der Wechsel von Diesel zu Gas im Personentransport aus Gründen der Luftqualität. Neuere Politikmaßnahmen der betrachteten Länder, zum Beispiel Energieeffizienz oder Erneuerbare-Energien-Ziele, sind ebenfalls in diesem Szenario beinhaltet. Dabei nehmen wir an, dass solche Ziele vollständig umgesetzt werden. Es sollte im Interesse jedes Landes sein, dieses Potenzial mit eigenen Mitteln zu realisieren. Aufgrund der dennoch anfallenden zusätzlichen Kosten wären nicht nur technische sondern auch finanzielle Beiträge der internationalen Gemeinschaft für eine Umsetzung dieses Szenarios hilfreich.

Ambitious: Das ambitious Szenario beinhaltet Reduktionsoptionen, die zu zusätzlichen Kosten umgesetzt werden können aber nicht zur Einschränkung des Verbrauchs führen. Dieses Szenario beinhaltet Reduktionsoptionen, die technisch möglich sind und den Umbau des Kapitalbestandes beschleunigen, aber nicht zur vorzeitigen Abschaltung von Anlagen vor Ende der Lebensdauer führen. Das Potenzial kann realisiert werden, wenn Nicht-Marktbarrieren beseitigt und finanzielle Anreize bereitgestellt werden um die zusätzlichen Kosten zu tragen. Dies kann mit zusätzlichen Beiträgen vom Land selbst oder von der internationalen Gemeinschaft umgesetzt werden.

National climate change plans: Dieses Szenario enthält unsere Interpretation der nationalen Klimapläne. Bei der Aktualisierung des Excel-Tools waren für alle Länder, bis auf Südkorea detaillierte Klimastrategien, Szenarien oder andere mittelfristige Pläne verfügbar. Allerdings wurden nur von Mexiko und Südafrika aggregierte Emissionsszenarien bereitgestellt. Daher haben wir alle Annahmen dieser Pläne unseren Szenarien zu Grunde gelegt. In vielen Fällen war es jedoch schwierig alle Maßnahmen zu quantifizieren und aus den Plänen klar zu erkennen, welche Maßnahmen als zusätzlich zum BAU zu verstehen sind. Für Südkorea wurden nur eine im August 2009 veröffentlichte vorläufige Zusammenfassungen und ein Entwurf von möglichen Zielen berücksichtigt. Südkoreas Klimastrategie wurde erst im September 2009 veröffentlicht und kam damit zu spät, um in diesem Bericht Berücksichtigung zu finden.

Emissionsreduktionskosten

Unser Ansatz zur Abschätzung von Reduktionskosten ist der einer „informierten Expertenschätzung”: Wir haben Grenzkostenkurven (MAC-Kurven) aus unterschiedlichen Quellen analysiert und anhand von Expertenschätzungen unsere Ergebnisse entwickelt. Der zusätzliche Nutzen im Vergleich zur Verwendung von nur einer Kostenkurve liegt darin, dass Kostenkurven stark von den zugrunde liegenden Annahmen abhängen. Unsere Annahmen wiederum sind andere als die hinter den von uns herangezogenen Kostenkurven. Insgesamt folgt dieses Vorgehen dem generellen Ansatz dieses Berichts: Eine transparente, einfach und tiefgehende Analyse von Emissionsreduktionsmöglichkeiten in Schwellenländern darzustellen.

Wir haben Kostenkurven aus zwei verschiedenen Quellen verwendet. Die erste Quelle ist eine Kosten-Datenbank von ECN. Die Kurve ist das Ergebnis einer bottom-up Methode, bei der Kostenkurven für Entwicklungsländer aus verschiedenen Quellen in einer Kurve kombiniert wurden (Version April 2009). Die zweite Quelle ist eine sektorale bottom-up Kostenkurve für die EU27 im Rahmen des SERPEC Projekts, die von Ecofys entwickelt wurde. Der Bericht wurde im November 2009 veröffentlicht.

Sensitivitätsanalyse von Parametern und Kosten

Aufgrund hoher Unsicherheiten zukünftiger Entwicklungen und Extrapolationen der Daten haben wir eine Sensitivitätsanalyse durchgeführt. Diese berücksichtigt ausgewählte Parameter um zwei extreme Fälle darzustellen: Einen, der zu relativ hohen Emissionen (high case) und einen, der zu vergleichsweise niedrigen Emissionen (low case) führt.

Die Kostenannahmen sind besonders unsicher. Da wir verschiedene Quellen verwendet haben, war oft mehr als eine Kostenabschätzung verfügbar. Für die Kosten-Sensitivitätsanalyse haben wir soweit wie möglich die höchsten und niedrigsten Werte verwendet. Wenn keine Kostenspanne verfügbar war, haben wir eine Abweichung von +30% (high case) und -30% (low case) angenommen. Die Ergebnisse sind in den Länderkapiteln beschrieben.

Verteilung von Emissionsrechten

Wir vergleichen die hier entwickelten Reduktionsszenarien mit nötigen Emissionsreduktionen unter globalen Emissionsrechteverteilungsansätzen. Diese Ansätze verteilen Emissionsrechte unter der Annahme, dass die globalen Emissionen auf dem Konzentrationsniveau von 450 ppmv CO_2eq stabilisiert werden. Wir haben das Evolution of Commitments Tool (EVOC) zur Quantifizierung der Emissionsreduktionen unter fünf verschiedenen globalen Verteilungsansätzen verwendet:

- Contraction and Convergence (C&C), bei dem Pro-Kopf-Emissionen für alle Länder zum gleichen Zielwert konvergieren
- Common but Differentiated Convergence (CDC), bei dem Pro-Kopf-Emissionen zu einem niedrigen Wert reduziert werden; dies geschieht in Industriestaaten früher, in Entwicklungsländern später.
- Greenhouse Development Rights (GDRs), bei dem alle Länder ihre Emissionen auf Grundlage von Verantwortung und ihrer Fähigkeit zu reduzieren vermindern
- Global Triptych, bei dem alle Länder ihre Emissionen in den einzelnen Sektoren anhand der gleichen Regeln reduzieren
- South North Proposal, bei dem Länder in verschieden Stufen teilnehmen, Industriestaaten früher, Entwicklungsländer später.

Alle Ansätze führen zu einer Emissionsreduktion von 20% bis 60% von 1990 bis 2020 für die Industrieländer. Die nötigen Reduktionen für Schwellenländer sind im Folgenden beschrieben.

Mögliche Elemente von Low-Carbon Development Strategies

Auf Grundlage der Analyse der Emissionsreduktionspotenziale und der damit verbundenen Kosten diskutiert der Bericht mögliche Elemente von Low-Carbon Development Strategies (LCDS) für die sechs Länder bis 2020.

Der Bericht diskutiert zunächst Definitionen und Modalitäten für NAMAs und LCDS im Allgemeinen. Auf Grundlage der bisherigen Diskussion unter der FCCC und in der Literatur schlägt der Berichte Modalitäten für die Entwicklung von NAMAs und LCDS und für deren Messung, Berichterstattung und Verifizierung vor. Auf dieser Grundlage diskutiert der Bericht mögliche Elemente für LCDS für die sechs Länder.

In Bezug auf das Ambitionsniveau basieren die diskutierten Elemente auf den folgenden zwei Erwägungen:

- Wo möglich wird das Ambitionsniveau an die Analyse der globalen Emissionsrechteverteilungsansätze angepasst. Dieser Ansatz wird in den Fällen verfolgt, in denen die Emissionsrechteverteilungsansätze sehr ähnliche Ergebnisse zeigen.
- In anderen Fällen zeigen die Emissionsrechteverteilungsansätze sehr unterschiedliche Ergebnisse. In diesen Fällen arbeiten wir auf der Grundlage, dass die Länder zumindest ihr co-benefit-Potenzial mobilisieren sollten, da diese Maßnahmen einen makroökonomischen Nutzen für ihre Volkswirtschaften abwerfen würden.

Als Vorbehalt ist hierzu anzumerken, dass die meisten Emissionsrechteverteilungsansätze für die meisten Industrieländer deutlich schärfere Ziele vorsehen, als diese bisher angeboten haben. Von der als ausreichend bezeichneten Reduktion um 25 % bis 40 % in 2020 gegenüber 1990 werden von den Industriestaaten nur maximal 17% erreicht, je nach angewandten Regeln sogar deutlich weniger. Ein Vorgehen, nach dem die Schwellenländer ihre Anstrengungen nach den Emissionsrechteverteilungsansätzen ausrichten sollen, würde daher für die Industrieländer dasselbe erfordern.

3. Nationale Klimastrategien

Wir haben die nationalen Klimastrategien für die sechs Länder analysiert und ziehen daraus die folgenden Schlussfolgerungen:

Brasilien: Der nationale Klimaplan deckt alle relevanten Sektoren ab (Energie, Forst- und Landwirtschaft, Industrie, Abfall und Transport) und beinhaltet eine Liste von Reduktionsmaßnahmen. Die daraus resultierenden Emissionsreduktionen sind allerdings nur für einige Maßnahmen quantifiziert. Die wichtigste Maßnahme ist die Verringerung der Entwaldung, deren Umfang wir als sehr ambitioniert einschätzen. Eine große Zahl an Maßnahmen ist mit den im Plan verfügbaren Informationen nicht quantifizierbar. Solche Maßnahmen sind zum Beispiel die Einführung eines Zertifizierungssystems für Biotreibstoff oder eine Weiterentwicklung wichtiger Programme wie PROCEL (Energieeinsparprogramm) oder CONPET (Programm zur Einsparung von Öl- und Gasderivaten). Insgesamt war es schwierig den gesamten Einfluss all dieser Maßnahmen abzuschätzen, da diese oft zu unklar waren. Auch ist oft nicht klar, ob die angegebenen Maßnahmen zusätzlich oder bereits in dem Referenzszenario enthalten sind.

China: Chinas nationale Klimaschutzstrategie beinhaltet einige quantifizierte Emissionsreduktionsmaßnahmen und die damit verbundenen Emissionsreduktionspotenziale. Ein allgemeines Referenzszenario und Reduktionsszenarien sind nicht enthalten. Der Chinesische „National Action Plan on Climate Change“ enthält keine zusätzlichen Reduktionsmaßnahmen, sondern gibt einen Überblick über die bereits durchgeführten Emissionsreduktionsmaßnahmen. Manchmal ist dennoch nicht eindeutig, welche der beschriebenen Maßnahmen zusätzlich und welche bereits im Referenzszenario enthalten sind. Eine Quantifizierung der Emissionsreduktionen ist für viele Maßnahmen schwierig. Darunter fallen beispielsweise Ausgaben für Forschung und Entwicklung und Emissionsreduktionen in Sektoren mit vielen dezentralen Quellen (z.B. durch Standards im Gebäude- und Transportsektor).

Indien: Der nationale Klimaplan enthält acht ‘nationale Missionen’ in Schlüsselbereichen. Der Plan beschreibt viele Maßnahmen aber nur wenigen können quantifizierbare Emissionsreduktionen zugeordnet werden. Detaillierte Ziele für den Elektrizitätsbereich sind allerdings im elften Fünfjahresplan enthalten. Die meisten Maßnahmen im Klimaplan sind eher allgemeiner Natur, beispielsweise die Förderung des Öffentlichen Nahverkehrs oder ein Wechsel zu anderen Brennstoffen im Industriesektor. Der Plan enthält kein allgemeines Referenzszenario oder Reduktionsszenarien. Daher ist oft unklar welche der angegebenen Maßnahmen zusätzlich und welche bereits im Referenzszenario enthalten sind. Die Vollständigkeit und Detailgenauigkeit des Plans spiegelt Indiens Entwicklungsstand wieder: Der Plan setzt den Schwerpunkt auf Entwicklung und beinhaltet überwiegend qualitative Maßnahmen.

Mexiko: Mexiko hat einen sehr detaillierten nationalen Plan bis 2012 vorgelegt, der Maßnahmen und deren Effekte auf die Emissionen beschreibt. Obwohl die Emissionsreduktionen auf kurze Sicht nicht sehr ambitioniert sind, ist der Plan auf eine Gesamtstrategie ausgerichtet, die vorsieht bis 2050 die Emissionen um 50% zu reduzieren. Nach einer ersten Phase, in der nur geringe Reduktionen angenommen werden, folgen ambitioniertere Reduktionsziele.

Südafrika: Südafrika hat eine umfassende Studie zu langfristigen Reduktionspfaden und -optionen bis 2050 vorgelegt. Jedoch sind keine konkreten Pläne enthalten, die angeben, welche Maßnahmen umgesetzt werden. Außerdem sind Emissionen aus der Kohlenutzung zwar eine wichtige Treibhausgasquelle, werden aber bisher nicht direkt von den Maßnahmen abgedeckt.

Südkorea: Südkorea hat drei mögliche Optionen für Emissionsreduktionsziele bis 2020 angekündigt (Reduktion auf 8% über dem Emissionslevel von 2005, Stabilisierung auf dem Emissionslevel von 2005 oder Reduktion auf 4% unter 2005er Emissionen). Südkorea hat zwar kürzlich eine Klimastrategie vorgestellt. Jedoch wurde diese für eine Berücksichtigung in diesen Bericht zu spät veröffentlicht.

4. Ergebnisse

Die folgenden Abbildungen stellen die Emissionsszenarien (links) dar sowie die verschiedenen Emissionsrechteverteilungen (rechts), die mit der Stabilisierung der Treibhausgaskonzentration auf ein Niveau von 450 ppmv CO_2eq kompatibel ist.

Brasilien

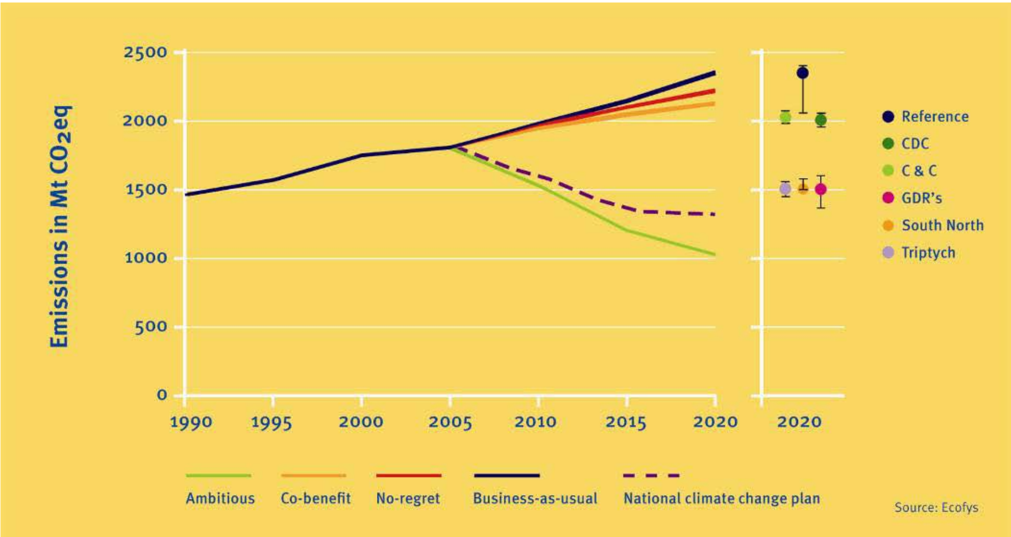

Abbildung 1 Emissionsszenarien mit Verteilung von Emissionsrechten anhand verschiedener globaler Emissionsrechteverteilungsansätze in 2020 für Brasilien

Die drei Sektoren mit den höchsten Treibhausgasemissionsreduktionspotenzialen zwischen 2005 und 2020 unter dem ambitionierten Szenario sind LUCF, Transport und der Energiesektor.

Unter dem no-regret Szenario sind Reduktionen von 5% unter BAU (22% über den Emissionen von 2005) möglich. Unter dem co-benefit Szenario sind Reduktionen von 9% unter BAU (17% über den Emissionen 2005) zu erreichen. Das ambitionierte Szenario erlaubt Einsparungen von 37% unter BAU (20% unter dem Emissionsniveau von 2005). Gemäß unserer Interpretation von Brasiliens nationalem Klimaplan sind

Reduktionen von 25% unter BAU (4% unter den Emissionswerten von 2005) möglich. Dies ist jedoch stark von dem Erreichen der ambitionierten Entwaldungsziele abhängig.

Wenn Brasilien seine ambitionierten Pläne zur Reduzierung der Entwaldung erreicht, dann passen die nationalen Pläne zu den Anforderungen der globalen Emissionsrechte-verteilungsansätzen, die auf dem BIP basieren. Eine Verteilung der Emissionsrechte auf Basis der Pro-Kopf-Emissionen (wobei die Waldemissionen nicht berücksichtigt werden) würde jedoch zu weniger ambitionierten Reduktionszielen führen.

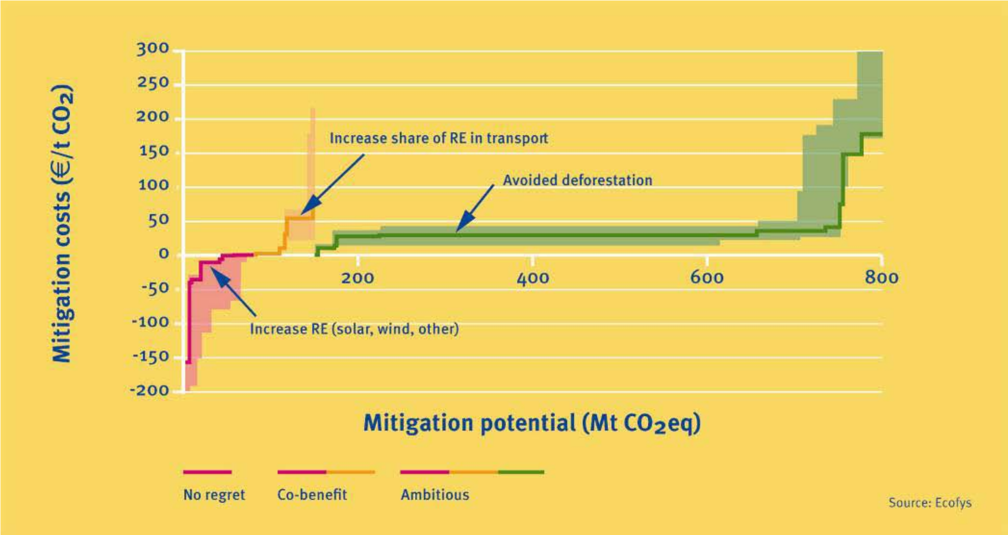

Abbildung 2 Abschätzung der Reduktionskosten der Emissionsszenarien in 2020 für Brasilien

China

Zwischen 2005 und 2020 sind der Energiesektor, der Industriesektor und andere Energieindustrien unter dem ambitionierten Szenario die drei Sektoren mit den höchsten Treibhausgasemissionsreduktionspotenzial.

Unter dem no-regret Szenario sind Reduktionen von 4% unter BAU (80% über den Emissionen von 2005) möglich. Nach dem co-benefit Szenario sind Einsparungen von 12% unter BAU (65% über den Emissionen von 2005) zu erreichen. Das ambitionierte Szenario erlaubt Reduktionen von 39% unter BAU (15% über den Emissionen von 2005). Nach unserer Interpretation von Chinas nationalem Klimaplan sind Einsparungen von 28% unter BAU (36% über den Emissionen von 2005) möglich.

Nach unserer Einschätzung ist Chinas nationaler Plan hinsichtlich mehrer Gesichtspunkte sehr ambitioniert: Es sind Maßnahmen enthalten, die mit beträchtlichen Kosten verbunden sind, und unser co-benefit Szenario wird sogar übertroffen. Der nationale Plan ist sogar ambitionierter als die Ergebnisse des Greenhouse Development Rights Ansatzes, der Chinas Verantwortung und Fähigkeit als gering einstuft. Darüber hinaus kommt der Plan zu ähnlichen Ergebnissen wie der Triptych Ansatz, der sektorale Reduktionspotenziale betrachtet. Einzig Ansätze, die auf Pro-Kopf-Emissionen basieren, würden ein ehrgeizigeres Reduktionsziel fordern als in den chinesischen Plänen festgeschrieben ist.

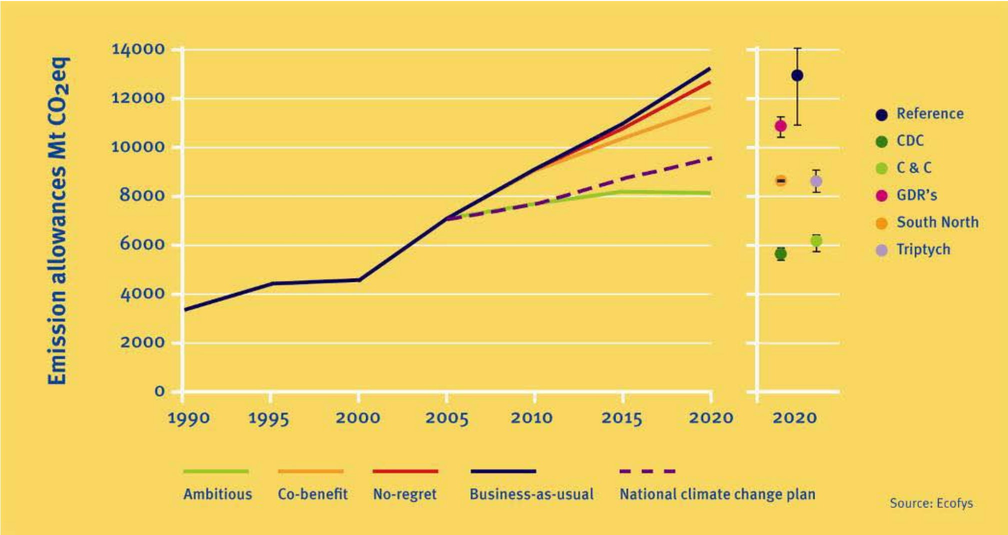

Abbildung 3 Emissionsszenarien mit Verteilung von Emissionsrechten anhand verschiedener globaler Emissionsrechteverteilungsansätze in 2020 für China

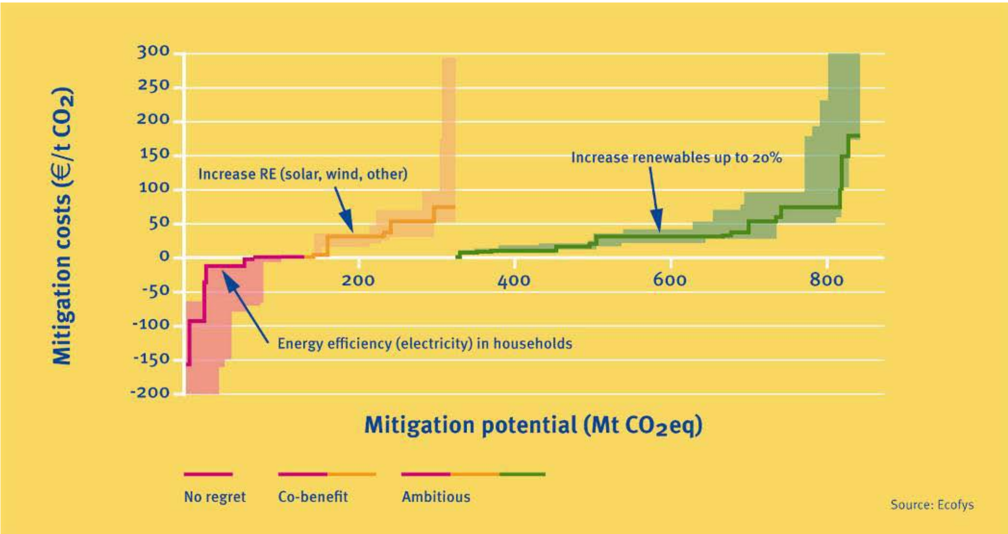

Abbildung 4 Abschätzung der Reduktionskosten der Emissionsszenarien in 2020 für China

Indien

Zwischen 2005 und 2020 sind der Energie-, der Transport- und der Industriesektor unter dem ambitionierten Szenario die drei Sektoren mit den höchsten Treibhausgasemissionsreduktionspotenzial.

Nach dem no-regret Szenario sind Reduktionen von 7% unter BAU (121% über den Emissionen von 2005) möglich. Unter dem co-benefit Szenario sind Einsparungen von 20% unter BAU (92% über den Emissionen von 2005) zu bewerkstelligen. Das ambitionierte Szenario erlaubt eine Abnahme von Emissionen um 39% unter BAU (46% über den Emissionen 2005). Nach unserer Interpretation von Indiens nationalem Klimaplan sind Reduktionen von 9% unter BAU (117% über den Emissionen von 2005) möglich.

Die Einsparungen unter Indiens Plan passen zu den Ergebnissen der Emissionsrechteverteilungsansätze, die Indiens Verantwortung und Fähigkeit als gering einstufen. Dabei liegen die notwendigen Reduktionsbeiträge zwischen dem no-regret und dem co-benefit Szenario. Ansätze, die auf sektoralen Betrachtungen basieren oder nur den Pro-Kopf-Emissionen folgen, würden ambitioniertere Reduktionen fordern.

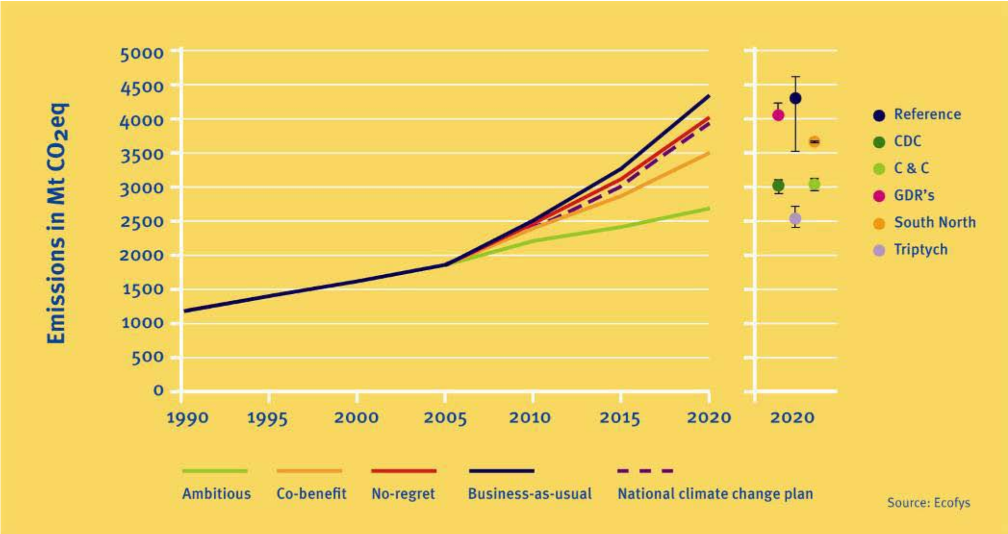

Abbildung 5 Emissionsszenarien mit Verteilung von Emissionsrechten anhand verschiedener globaler Emissionsrechteverteilungsansätze in 2020 für Indien

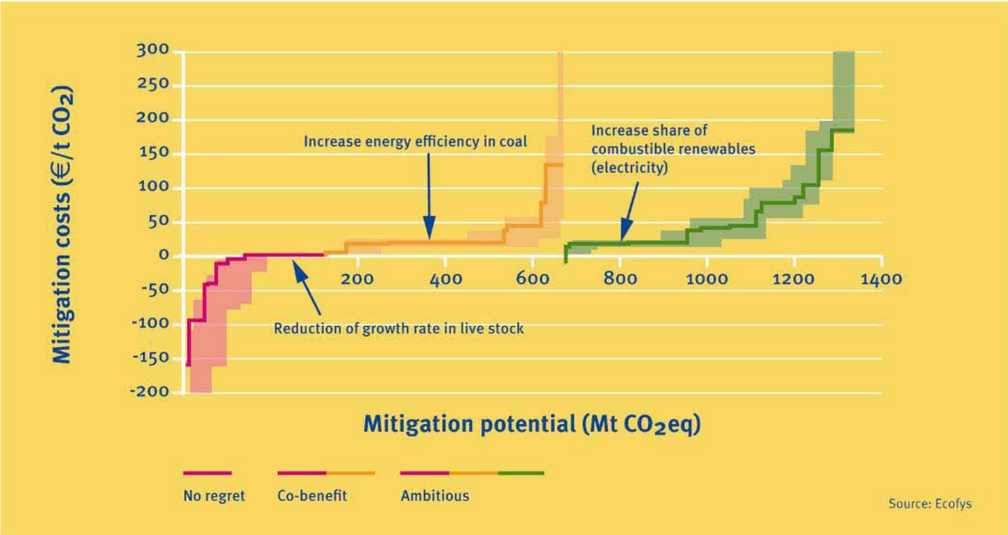

Abbildung 6 Abschätzung der Reduktionskosten der Emissionsszenarien in 2020 für Indien

Mexiko

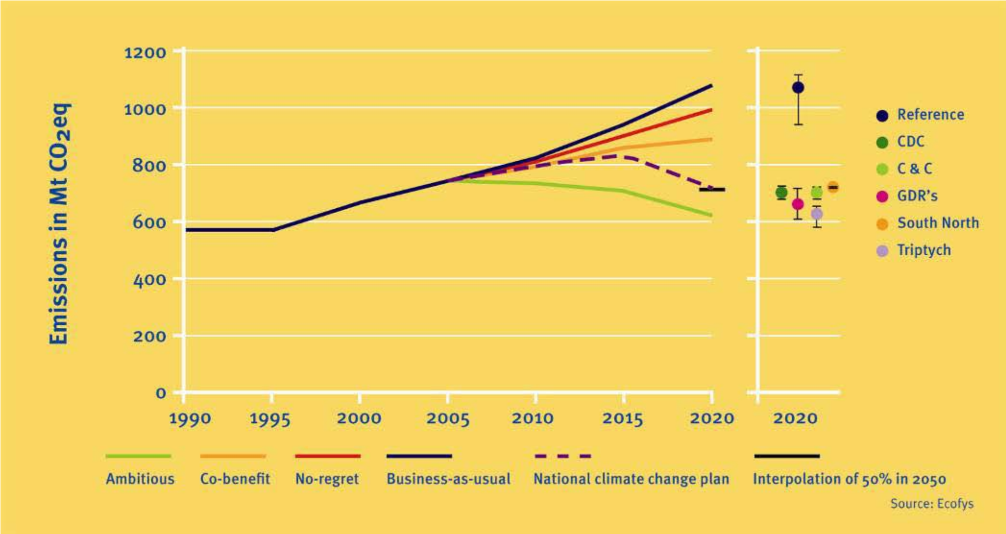

Abbildung 7 Emissionsszenarien mit Verteilung von Emissionsrechten anhand verschiedener globaler Emissionsrechteverteilungsansätze in 2020 für Mexiko

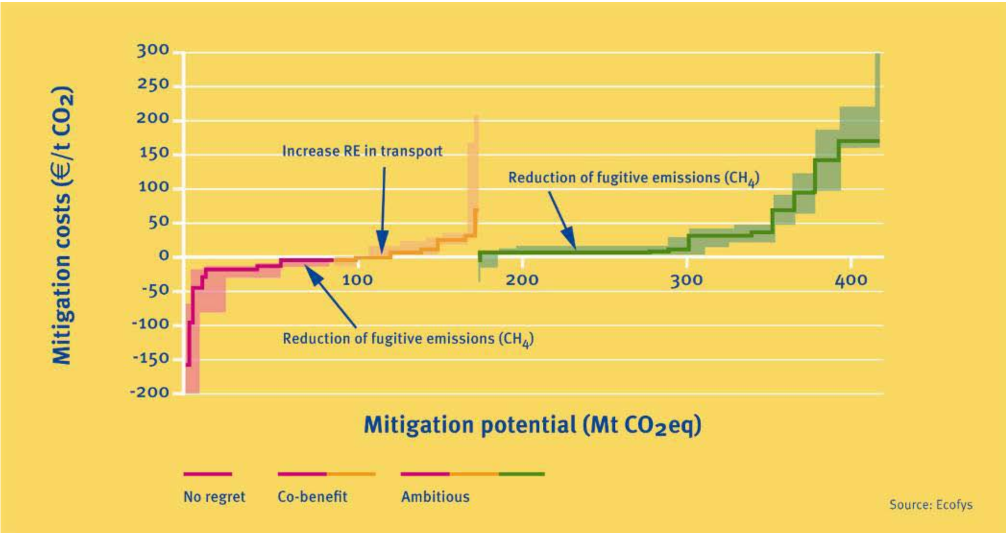

Abbildung 8 Abschätzung der Reduktionskosten der Emissionsszenarien in 2020 für Mexiko

Zwischen 2005 und 2020 sind Energieindustrie (Öl und Gas), Transport und Stromproduktion unter dem ambitionierten Szenario die drei Sektoren mit den höchsten Treibhausgasemissionsreduktionspotenzial.

Gemäß dem no-regret Szenario sind Reduktionen von 8% unter von BAU (34% über den Emissionen von 2005) möglich. Nach dem co-benefit Szenario sind Einsparungen von 18% unter von BAU (20% über den Emissionen von 2005) zu erreichen. Unter dem ambitionierten Szenario können Reduktionen von 43% unter BAU (16% unter den Emissionswerten von 2005) erreicht werden. Nach unserer Interpretation von Mexikos nationalem Klimaplan sind Einsparungen von 34% unter BAU (3% unter den Emissionswerten von 2005) möglich. Der Plan enthält bedeutend höhere Reduktionen als das co-benefit Szenario.

Mexikos Ziele passen zu den Ergebnissen der hier betrachteten Emissionsrechteverteilungsansätze. Obwohl die Ansätze auf sehr unterschiedlichen Prinzipien beruhen, sind die Ergebnisse sehr ähnlich. Diese Ansätze sprechen Mexiko eine relativ hohe Verantwortung und Fähigkeit zur Emissionsreduktion zu.

Südafrika

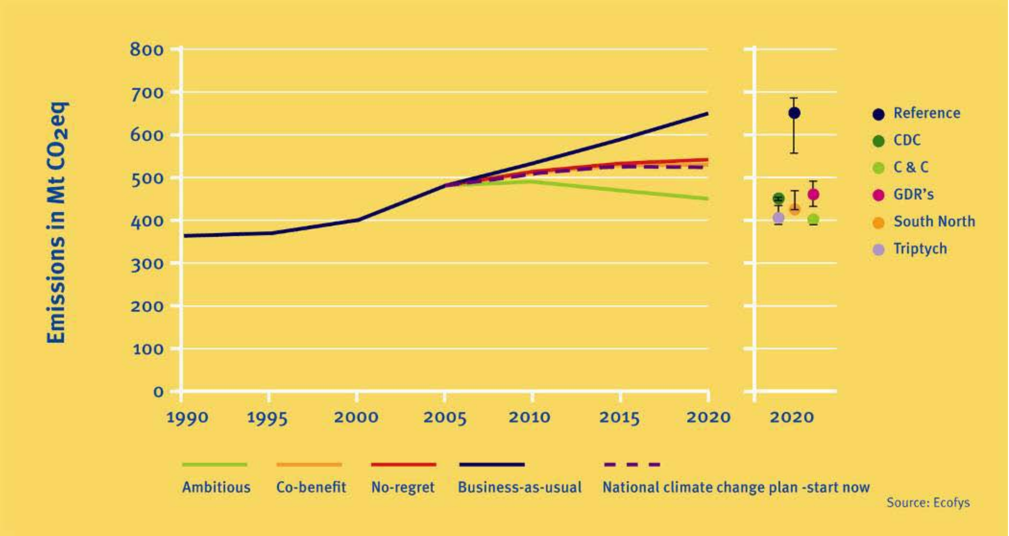

Abbildung 9 Emissionsszenarien mit Verteilung von Emissionsrechten anhand verschiedener globaler Emissionsrechteverteilungsansätze in 2020 für Südafrika

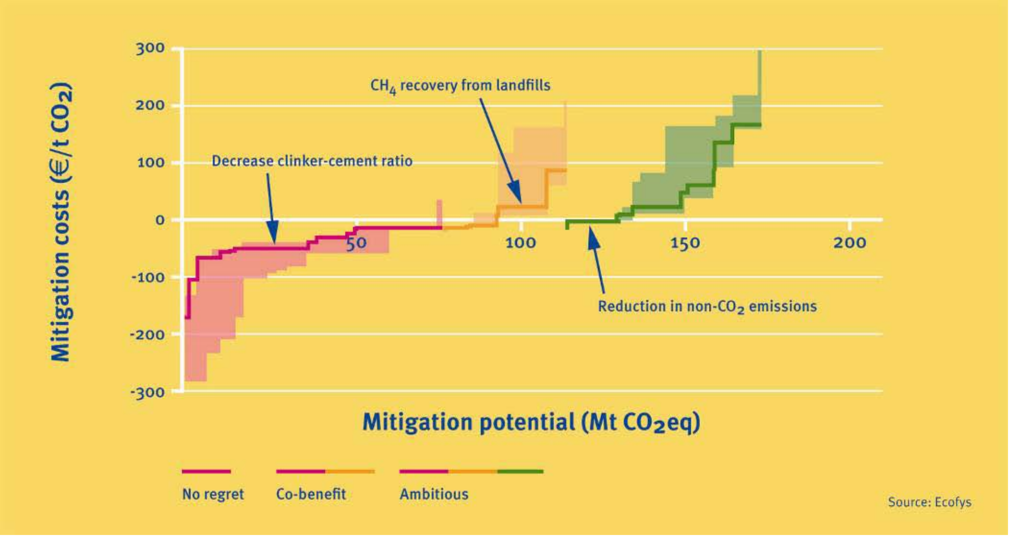

Abbildung 10 Abschätzung der Reduktionskosten der Emissionsszenarien in 2020 für Südafrika

Zwischen 2005 und 2020 sind Stromproduktion, Industrie und Energieindustrie (Kohle, Öl und Gas) unter dem ambitionierten Szenario die drei Sektoren mit den höchsten Treibhausgasemissionsreduktionspotenzial.

Unter dem no-regret Szenario ist eine Reduktion von 16% unter BAU (12% über den Emissionen von 2005) erreichbar. Das no-regret Potenzial ist relativ hoch im Vergleich zu anderen Ländern. Nach dem co-benefit Szenario sind Einsparungen von 18% unter BAU (10% über den Emissionen von 2005) möglich. Unter dem ambitionierten Szenario sind Reduktionen von 30% unter BAU (7% unterhalb der Emissionen von 2005) erreichbar. Gemäß dem südafrikanischen Klimaplan sind Einsparungen von 19% unter BAU (9% über den Emissionen von 2005) möglich.

Wie ambitioniert der südafrikanische Plan ausfällt, ist unklar. Unsere Interpretation des von Südafrika vorgelegten ‘start now’ Szenarios ergibt Emissionen, die höher sind als die Ergebnisse der hier analysierten Emissionsrechteverteilungsansätze. Obwohl diese auf sehr unterschiedlichen Prinzipien beruhen, sind die Ergebnisse der Emissionsrechteverteilungsansätze für Südafrika sehr ähnlich. Dabei wird Südafrika eine relativ hohe Verantwortung und Fähigkeit zur Reduktion zu gesprochen.

Südkorea

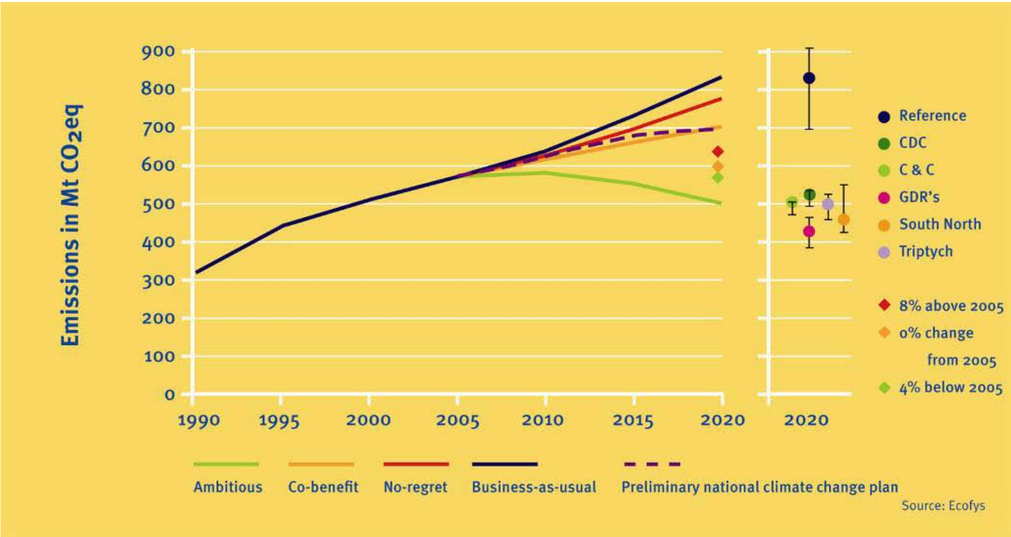

Abbildung 11 Emissionsszenarien mit Verteilung von Emissionsrechten anhand verschiedener globaler Emissionsrechteverteilungsansätze in 2020 für Südkorea

Zwischen 2005 und 2020 sind Stromproduktion, Transport und der Industriesektor unter dem ambitionierten Szenario die drei Sektoren mit den höchsten Treibhausgasemissionsreduktionspotenzial.

Nach dem no-regret Szenario sind Reduktionen von 7% unter BAU (37% über den Emissionen von 2005) möglich. Unter dem co-benefit Szenario sind Einsparungen von 16% unter BAU (24% über den Emissionen von 2005) erreichbar. Gemäß dem ambitionierten Szenario sind Reduktionen von 41% unter BAU (12% unterhalb der Emissionen von 2005) möglich. Nach dem südkoreanischen nationalen Klimaplan können Einsparungen von 17% unter BAU (23% über den Emissionen von 2005) erreicht werden. Korea hat drei Möglichkeiten für nationale Reduktionsziele vorgestellt, die zwischen unserem co-benefit und dem ambitionierten Szenario liegen.

Südkoreas eigene Ziele sind ambitionierter als das co-benefit Szenario. Sie sind jedoch weniger ehrgeizig als die Ergebnisse von allen Emissionsrechteverteilungsansätzen, die hier analysiert wurden. Die Ansätze sprechen Südkorea eine relativ hohe Verantwortung und Fähigkeit zur Emissionsminderung zu. Ansätze die anerkennen, dass Südkorea schon vergleichsweise effizient ist, führen zu weniger ambitionierten Reduktionszielen.

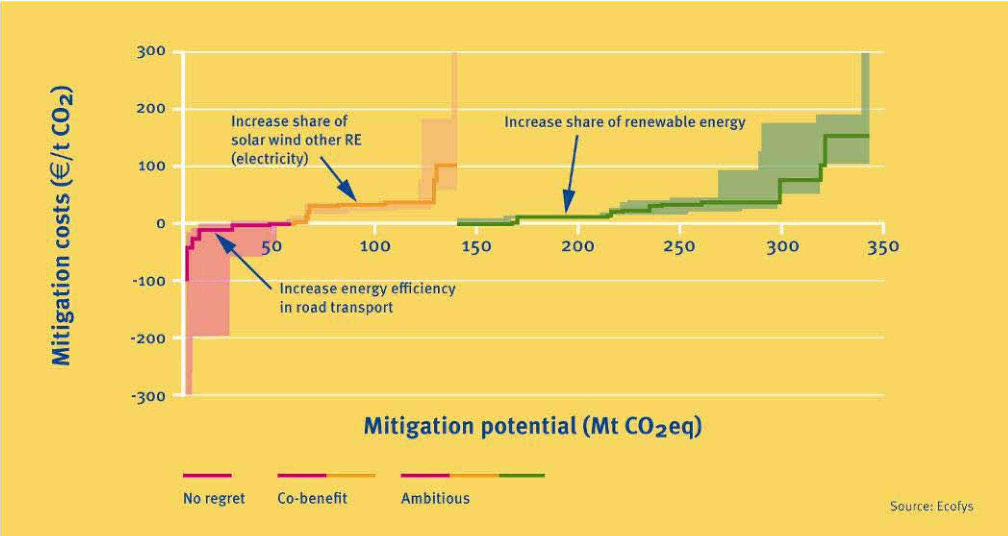

Abbildung 12 Abschätzung der Reduktionskosten der Emissionsszenarien in 2020 für Südkorea

5. Vorschläge für Modalitäten für die Entwicklung von Low-Carbon Development Strategies

Um allen zukünftigen Investitionen eine klare Richtung zu geben und die Ressourcen, die von den Industrieländern bereit gestellt werden sollen, strategisch einzusetzen, sollten die nicht-Annex I-Länder idealerweise umfassende LCDS entwickeln. Diese sollten eine langfristige Vision für eine Entwicklung mit niedrigen Emissionen entwickeln sowie umfassende „Nationally Appropriate Mitigation Actions, NAMAs“ für alle Schlüsselsektoren, die zur Umsetzung dieser Vision erforderlich sind. Idealerweise sollten nationale Pläne in einem transparenten und partizipativen Verfahren unter Einbeziehung aller Ministerien und Interessensgruppen entwickelt werden.

Die Maßnahmen sollten in einem internationalen Register unter der UNFCCC notifiziert werden und „MRVable“ sein – messbar, berichtbar und verifizierbar – um sich für finanzielle und technologische Unterstützung zu qualifizieren. Die Leitlinien und Anforderungen für NAMAs sowie der Überprüfungsprozess könnten auf den Verfahren aufbauen, die bereits unter der FCCC etabliert sind.

Was sich in den Verhandlungen heraus kristallisiert, ist ein Rahmen für hochdifferenzierte Maßnahmen, basierend auf den unterschiedlichen nationalen Gegebenheiten der Länder. Während einige fortgeschrittene Länder möglicherweise Maßnahmen wie sektorale „no-lose“-Ziele ergreifen, dürften die Maßnahmen größtenteils aus spezifischen Politiken und Maßnahmen bestehen. Dies stellt eine erhebliche Herausforderung für MRV dar.

Die Auswirkungen einer spezifischen Maßnahme zu bewerten ist alles andere als trivial. Es ist zwar nötig, ein klares Bild sowohl von der Umsetzung der NAMAs als auch von der Emissionsentwicklung in den Entwicklungsländern zu erhalten. Es könnte aber empfehlenswert sein, MRV dieser beiden Punkte zu trennen, insbesondere zu Anfang, wenn weder national noch international starke technische Kapazitäten vorliegen. Es bietet sich daher an, NAMAs vor allem in der Startphase nicht primär bezüglich ihrer Emissionsauswirkungen, sondern vor allem bezüglich ihrer Umsetzung zu überprüfen. Wie erfolgreich Entwicklungsländer dabei sind, ihre Emissionen zu reduzieren, könnte demgegenüber auf der aggregierten Ebene durch robustere und häufigere Emissionsinventare überprüft werden.

Mehrere nicht-Annex I-Länder haben inzwischen ein Entwicklungsniveau und Pro-Kopf-Emissionen erreicht, die mit denen von Annex I-Ländern vergleichbar sind. Diese Länder sollten sich daher auf verbindliche Emissionsziele verpflichten. Von den sechs Ländern in diesem Bericht betrifft dies insbesondere Südkorea.

Wie jedoch die erste Verpflichtungsperiode gezeigt hat, bedeuten Verpflichtungen auf verbindliche Ziele noch nicht automatisch, dass die Länder tatsächlich ihre Emissionen reduzieren werden. Wir schlagen deshalb vor, dass alle Länder mit verbindlichen Zielen – Annex I-Länder und neuindustrialiserte Länder –daher commitment achievement plans (CAPs) entwickeln. Diese sollten insbesondere eine kohärente Vision und einen Aktionsplan enthalten, wie das jeweilige Land einen raschen Übergang zu einer Gesellschaft mit niedrigen Emissionen erreichen will. Wie LCDS sollten diese in einem partizipativen Prozess entwickelt werden. Zusätzlich sollten sie einer internationalen Begutachtung vorgelegt werden. Die Modalitäten für die Entwicklung und Begutachtung der Pläne sollten auf den vorhandenen Modalitäten für die Entwicklung und Begutachtung der Nationalberichte, Inventare etc. aufbauen. Die Vertragsstaaten sollten die Ergebnisse der Begutachtung diskutieren und bei Bedarf die jeweiligen Länder darum bitten, ihre Pläne so zu revidieren, dass sie mit ihren Verpflichtungen konsistent sind.

6. Schlussfolgerungen

Dieser Bericht gibt erstmals einen vergleichbaren Überblick über die nationalen Klimaplänen von Brasilien, China, Indien, Mexiko, Südafrika und Südkorea. Da die meisten Länder keine aggregierten Szenarien für ihre Pläne vorgestellt haben, stellen die Szenarien dieses Berichts unsere Interpretation der nationalen Klimapläne dar.

Die aggregierten Reduktionen der Klimapläne sind recht beträchtlich und würden zu substantiellen Emissionsreduktionen führen, insofern sie wie geplant durchgeführt werden. Die nationalen Klimapläne können zu einer gemeinsamen Reduktion von 25% unter BAU im Jahr 2020 führen (siehe Abbildung 13). Gemäß dem ambitionierten Szenario sind Einsparungen von 40% unter BAU möglich. Die aggregierten Resultate werden durch Chinas Entwicklung dominiert.

Wir haben auch erstmals Szenarien zu Reduktionspotenzialen mit den Ergebnissen von Emissionsrechteverteilungsansätzen verglichen.

Chinas Klimaplan ist nach unserer Interpretation sehr ambitioniert, geht über das co-benefit Potenzial hinaus. Viele der Maßnahmen des Plans sind bereits umgesetzt. Außerdem passen die Reduktionen zu den Ergebnissen der Emissionsrechteverteilungsansätze.

Unter allen Emissionsrechteverteilungsansätzen müssen Mexiko, Südafrika und Südkorea ihre Emissionen signifikant unter ihre BAU Emissionen im Jahr 2020 und unter ihr co-benefit Potenzial reduzieren. Nur Mexiko hat in seinem Klimaplan Reduktionsmaßnahmen vorgeschlagen, die zu diesen Forderungen passen.

Brasiliens Klimaplan kann als ambitioniert eingestuft werden, hängt aber wesentlich von der erfolgreichen Reduktion der Entwaldung ab. Hier wurden in der Vergangenheit erste Erfolge erzielt.

Indiens Plan ist der am wenigsten konkrete, was den Entwicklungsstand Indiens im Vergleich zu anderen Ländern widerspiegelt. Jedoch erreicht Indiens Plan nach unserer Interpretation noch nicht einmal das Niveau des co-benefit-Potenzials und sollte daher verstärkt werden.

Eine genauere Analyse der Details der nationalen Pläne zeigt, dass das Ambitionsniveau von Sektor zu Sektor stark unterschiedlich ist. Einerseits haben auch die Länder, die insgesamt nicht sehr ambitioniert sind, normalerweise einen oder zwei Sektoren, für die ambitionierte Pläne vorliegen. Insbesondere die Pläne für den Energiesektor gehören in allen Ländern zu den detailliertesten und ambitioniertesten. Andererseits haben auch die Pläne der ambitionierten Länder “blinde Flecken”, also Reduktionspotenziale, die in den Plänen anscheinend nicht adressiert werden. Es könnte daher möglich sein, das Ambitionsniveau ohne zu große Anstrengung noch weiter deutlich zu verbessern.

Dieser Bericht enthält auch eine Methode, neue Maßnahmen als „Nationally Approproate Mitigation Actions“ zu identifizieren: Der Vergleich der Reduktionspotenziale in den einzelnen Sektoren mit den Minderungen durch die nationalen Pläne.

Für diese Studie definieren wir NAMAs als jede Art von Maßnahme, die Emissionen reduziert. Wir unterscheiden drei grundsätzliche Arten von NAMAs:

- Emissionsziel-basierte NAMAs, dies können verbindliche oder freiwillige, nationale oder sektorale Emissionsziele sein.
- Technologie-spezifische NAMAs, wie bspw. Ziele für den Anteil von Erneuerbaren in der Energieproduktion, Effizienzziele oder -standards.
- Politik-basierte NAMAs, wie bspw. Einspeisevergütungen für Erneuerbare, finanzielle Anreize oder Preisinstrumente.

Die Diskussion in dieser Studie beschränkt sich auf Emissionsziele und technologie-spezifische NAMAs. Um politikbasierte NAMAs zu diskutieren, wäre es erforderlich, über detaillierte Informationen über die aktuelle politische Landschaft in jedem Land zu verfügen. Dies war jedoch im Rahmen dieses Projekts nicht möglich.

Aus Gründen der Datenverfügbarkeit ist die Diskussion für die Gesamtemissionen sowie für den Energie- und Industriesektor am detailliertesten. Für die anderen Sektoren waren nur wenige Daten verfügbar, daher ist die Diskussion weniger detailliert und fokussiert auf einzelne Maßnahmen.

Die Sektoren, in denen nationale Pläne nicht das „No-regret“ oder „Co-benefit“ Potenzial ausnutzen, sollten mit höchster Priorität behandelt werden. Obwohl unsere Analyse stark von der oft unzureichenden Datenverfügbarkeit abhängt, könnte diese Methode der Auswahl von NAMAs in der Zukunft weiter untersucht werden. Wenn ausreichende Daten verfügbar sind, wäre es möglich auch für die Sektoren detailliert die Minderungspotenziale zu untersuchen, in denen in diesem Projekt nur begrenzt Daten verfügbar waren. Dies betrifft insbesondere den Haushalts-, Verkehrs- und Abfallsektor. Zudem wäre es bei ausreichender Datengrundlage möglich, Sektor für Sektor detaillierte Projektionen über die Auswirkungen bestehender oder geplanter Politiken und Maßnahmen durchzuführen. Sollten diese Projektionen signifikant unterhalb des verfügbaren Minderungspotenzials liegen, könnten in weiteren Schritten detaillierter die Möglichkeiten untersucht werden, die Anstrengungen zu erhöhen. Eine solche Analyse würde sowohl detaillierte und verlässliche Daten über Emissionen und Emissionstreiber als auch detaillierte Informationen über bestehende und geplante Politiken und Maßnahmen erfordern.

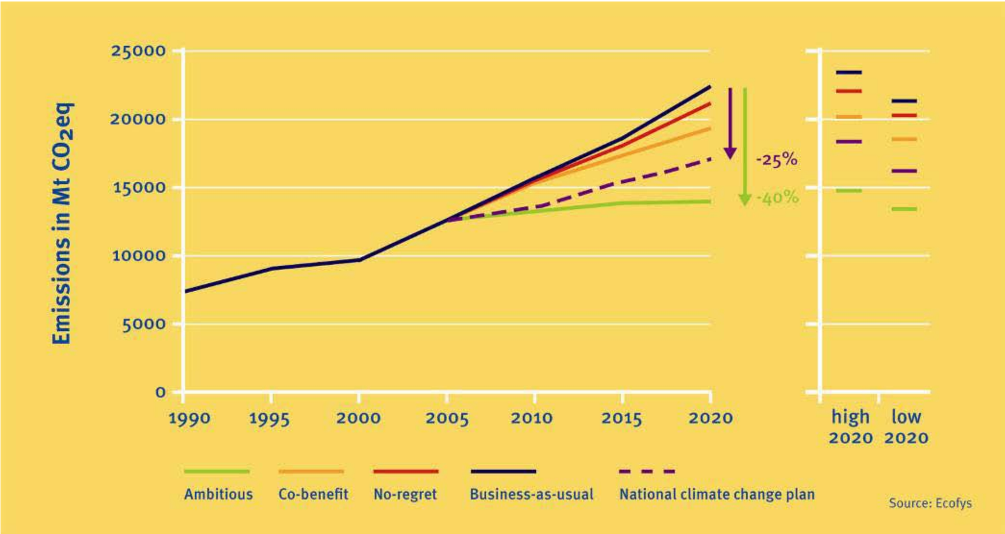

Abbildung 13 Reduktionspotenzial für die gemeinsamen Emissionen von Brasilien, China, Indien, Mexiko, Südafrika und Südkorea unter verschiedenen Szenarien einschließlich LUCF (links) und Sensitivitätsanalyse (rechts). Es ist zu beachten, dass die aggregierten Reduktionen Schätzungen darstellen und daher mit Vorsicht ausgelegt werden müssen.

1 Introduction

Further action is needed that goes far beyond what has been agreed so far under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol to 'prevent dangerous anthropogenic interference with the climate system', the ultimate objective of the UNFCCC. It is out of question that developed countries (Annex I countries) will have to take a leading role. They will have to commit to substantial emission reductions and financing commitments due to their historical responsibility and their financial capability. However, the stabilisation of the climate system will require global emissions to peak within the next decade and decline well below half of current levels by the middle of the century. It is hence a global issue and, thus, depends on the participation of as many countries as possible.

Many countries, including the European Community, and many environmental NGOs have agreed that global average temperature increase should be limited to 2°C above pre-industrial levels to avoid such dangerous interference. The risk that a stable greenhouse gas concentration of e.g. 450 ppmv CO_2eq would result in global average temperature above 2°C in the long term is around 50%. At 400 ppmv CO_2eq, the risk is 30% (Meinshausen 2005). Consequently, global emissions have to peak in the next 15 years and decline well below the 1990 level in 2050 and further thereafter.

Under the principle of 'common but differentiated responsibilities,' one of the guiding principles stipulated in Article 3.1 of the United Nations Framework Convention on Climate Change (UNFCCC), only Annex I countries have emission limitation or reduction commitments. Not least since the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC-AR4), however, the pressure is mounting on all countries to contribute actively to the mitigation of climate change. This conflict between non-Annex I and Annex I parties has become more intense since the initiation of the post 2012 negotiations in 2005 in Montreal. While Annex I parties argued that strengthened action by the major developing countries is a precondition for taking on any new commitments under Article 3.9 of the Kyoto Protocol (KP), non-Annex I parties insisted that Annex I parties take the lead by determining their further commitments in the Ad-hoc working group under the Kyoto Protocol and to transfer technology and financial resources necessary for controlling their GHGs (Sterk et al. 2007). Therefore, innovative ideas are needed for the next phase of the negotiations in order to break the deadlock and enhance the participation of the emerging economies in the climate regime.

Developing countries have a lower historical responsibility for climate change but are already or will become important emitters. A less carbon intensive development will have positive effects on these countries' sustainable development and on the global climate system. On the one hand, climate change action will contribute directly to achieving sustainable development objectives, such as energy security, sustainable economic development, technology innovation, job creation, local environmental protection and enhancement of capacity to adapt to climate change impacts. On the other hand, especially developing countries will benefit from a more stable global climate because they are the most vulnerable to climate change effects.

The Bali Action Plan hence calls for "nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner." In this project 'Proposals for quantifying emission reduction contributions by emerging economies' for the Federal Environment Agency in Dessau

Ecofys and the Wuppertal Institute analyse in detail the situation of the major emitting developing countries Brazil, China, India, Mexico, South Africa and South Korea. It is an update of Höhne et al. 2008. It includes an overview of emissions and economic development, existing national climate change strategies, estimates of emission reduction potential in a consistent manner, costs of mitigation options, a comparison of the allocation of emission rights according to different global effort-sharing approaches, and a discussion of possible nationally appropriate mitigation actions (NAMAs) in the six countries.

We first describe the methodology of the project (Chapter 2), then our findings on emission pathways, mitigation potential, costs and emission rights per country (Chapters 3 to 8). Third, we on this basis discuss possible NAMAs in the six countries (Chapters 9 and 10). Finally, we give an overview of the results for all countries (Chapter 11). The Appendix provides additional information on data (Appendix A) and effort-sharing approaches as implemented for this report (Appendix B).

The analysis for this report was completed before the UN climate summit in Copenhagen in December 2009. Hence, it predates the notification of NAMAs under the "Copenhagen Accord". However, the NAMAs discussed in this report and the NAMAs notified under the Copenhagen Accord operate at different levels. With the exception of Brazil, all the countries discussed in this report notified aggregate national targets under the Copenhagen Accord, either in terms of emission intensity targets or in terms of a reduction of national emissions below "business as usual." By contrast, this report discusses sector- or technology-specific NAMAs. The NAMAs discussed in this report can therefore be seen as possible ways of achieving the aggregate NAMAs notified under the Copenhagen Accord.

2 Methodology

This project 'Proposals for quantifying emission reduction contributions by emerging economies' includes an update and further development of a bottom-up calculation tool to describe possible future emission trends and reduction options for Brazil, China, India, Mexico, South Africa and South Korea by 2020. The aim of the tool is to describe the future emission trends and emission reduction options in a consistent manner for all six countries. So far studies on individual countries are available but these are not comparable between countries. The developed tool allows this comparison. This section describes the methodology used.

2.1 Scenario descriptions

We calculated four scenarios in a consistent manner for all countries:

Business-as-usual

The business-as-usual (BAU) scenario follows production, energy consumption and energy efficiency trends that are based on moderate assumptions. Where available, these assumptions or related growth rates were taken from national studies. This was possible for Brazil, China, India and South Africa (Centro Clima et al. 2006; Chen et al. 2006; TERI and CCAP 2006; Winkler (ed.) 2007). Most of these studies include recent national policies up to the year 2005. Later polices are not considered because often their level of implementation and the resulting impacts are still unclear. For those countries or sectors where no detailed studies were available, patterns and growth rate trends were usually assumed to be similar to previous years. These do not include special additional policies. Consequently, this scenario can be considered to lead to relatively high levels of emissions.

No-regret

Pathways under the no-regret scenarios include greenhouse gas (GHG) emission reduction options that can be achieved at negative or no direct costs. These would include, e.g. energy efficiency measures where the economic gains from reduced energy use outweigh the investment costs for more efficient technology. Some would call this scenario also 'economic potential at costs below 0€/tCO_2eq'. Given the economic net benefit achievable, it should be in the interest of each country to achieve this potential with its own resources. The international community could, however, support implementation both by technical contributions and by seed funding for, e.g. national revolving funds and for implementing policies and measures to overcome non-market barriers.

Co-benefit

Pathways under the co-benefit scenarios consider reduction options that are reasonable due to political aims other than GHG reduction. This includes also reductions at some costs. A typical measure would be the increased use of renewable energy sources to increase energy security and to decrease dependency on import of fossil fuels or switching from diesel to gas in passenger transport for air quality reasons. Recent policies agreed in the countries such as energy efficiency or renewable targets are included in this scenario assuming that they are fully implemented. But the scenario also includes further measures that could be implemented. It should be in the interest of each country to achieve this potential with its own resources. However, the fact that it may entail some extra costs means that not only technical but also financial contributions from the international community would be helpful to achieve this scenario.

Ambitious

The ambitious scenario includes reduction options which can be implemented but at extra net costs, while maintaining the same service level. This scenario includes reduction options that are technically feasible and would accelerate the capital stock turnover, but they would not lead to stranded investments. This potential can be achieved if both the non-market barriers are removed and financial incentives are provided to cover the extra net costs. It could be achieved with additional contributions from the country itself or from the international community.

National climate change plans

All countries except for South Korea had detailed climate change plans or scenarios and in some cases also other medium-term plans available when we updated the excel tool (see Table 1). South Korea recently provided a climate change strategy. However, it was published too late to be included in this report.

Table 1 National climate plans

Country	National climate plan
Brazil	Government Brazil 2008b
China	Government China 2008; Government China and National Development and Reform Commission 2007; NDRC 2008
India	Government India 2008, Five-year Plan 2007-2012: Government India and Planning Commission 2008
Mexico	Government Mexico 2007, SEMARNAT 2009
South Africa	DEAT 2007; ERC 2007; Taviv et al. 2007
South Korea	National Plan to be published soon; other relevant documents: Government South Korea 2003; Jeong 2008

The level of detail of the measures and impacts on emissions reductions is very divers throughout the plans. As far as possible we included the aims and targets into this scenario. Where only rough assumptions on measures and related changes in emissions where available we made assumptions on the impacts of different policies or measures. However, for most of the plans it was difficult to assess which policies are actually in place and running and to which extent.

2.2 Mitigation costs

Estimating the costs of mitigating CO_2 is a complex matter influenced by the uncertainties of a future world. On the one hand, various institutions have published cost curves for countries mostly located in the developed world in the last years (see for instance McKinsey Global cost curve, SERPEC, etc.). On the other hand, these curves are often intransparent or even contradict each other, largely caused by differences in assumptions underlying their work. Yet, from all this work general tendencies can be observed, and an increased international effort is taking place to harmonise the existing work.

Especially climate change negotiations are pushing hard for the quantification of the efforts to mitigate climate change. Even though this desire is understandable, a word of caution should be added here as the assumptions made in any quantification effort are crucial to the outcome. Assuming for instance strong technological growth for renewable energy technologies over smaller growth rates will decrease the cost of climate mitigation extensively. Against all this background, we attempt to add value to the discussion in providing first order estimates of costs that could arise in developing countries.

In the light of all this our approach here is that of an 'informed expert judgement': We take a look at various marginal abatement cost curves (MAC curves) and then involve expert judgements to derive our results. The value added over taking only the MAC curves lies in the fact that the MAC curves are prone to their assumptions. The assumptions we made in developing our scenarios often differ tremendously from those made to construct the MAC curves at hand. Especially the extent of the mitigation effort in the MAC curves is limited. Furthermore, the data available is limited and often no data was available at country level. Overall, the approach is in line with the general approach in this paper: to present a transparent, simple but not trivial analysis of mitigation efforts in developing countries.

We used two sources of MAC curves. The first source is the ECN MAC curve database. This curve is the result of a bottom-up effort, in which MAC curves for developing countries from various sources were combined in one curve (Version April 2009). The second source used here is the SERPEC cost curve. This curve is a sectoral bottom-up cost curve for the EU27 member states that was developed by Ecofys.[1]

Based on the MAC curve available we took a three step approach:

1. In a first step we derive country-specific mitigation costs for the measures given in our scenarios. Data availability was limited, and some countries have only very few cost estimates available. In this step only the ECN MAC curve could be used.
2. In a second step we derived generic mitigation costs for the measures given in our scenarios. Data availability was much better as a country resolution was not required. Here we used the ECN MAC curve as well as the SERPEC curve. The applicability of SERPEC data is limited though as it was created for developed countries and not developing countries.
3. In a last step we compared the data sources and chose the most reasonable estimates on the basis of an expert judgement. The general preference was to take country specific costs where available. In some cases the costs were not judged reasonable and hence replaced with more reasonable costs. When no costs were available expert judgement was used.

[1] Wesselink, Deng, 2009: "Sectoral Emission Reduction Potentials and Economic Costs for Climate Change (SERPEC-CC)- Summary report", available at www.ecofys.com

In this manner we derived the specific mitigation costs in €/t CO_2[2] per measure taken in the given scenarios. The specific costs were then multiplied by the assumed mitigation achieved by the given measure. These were then summed to arrive at an absolute cost estimate on a sectoral country-by-country basis. Results of this analysis are presented in the corresponding country chapters below. Detailed cost estimates are given in Appendix A 2.

There are some major shortcomings with respect to the data sources being used here. The bottom-up collection of ECN from country studies does not provide the underlying assumptions. The costs very much depend on the perspective of the study authors, assumption on financial parameters and country specific assumptions. The SERPEC data use generic measures that were selected for the EU member states.

For Land use change and forestry (LUCF) we used a slightly different approach. Regional emission mitigation costs for LUCF are taken from the IPCC AR4 (IPCC 2007, Chapter 9, Table 9.3). We chose the relevant regional costs per country. Average costs per tonne of CO_2 avoided are assumed as given in Table 2. Please note that costs for LUCF are highly uncertain. Other sources can provide very different values.

Table 2 Costs for afforestation and avoided deforestation in the LUCF sector

Afforestation				
	Fraction in cost class: 1-15 €/tCO2	Fraction in cost class: 15-38 €/tCO2	Fraction in cost class: 38-75 US$/tCO2	Average costs in €/tCO2 per country
Average costs (€$/tCO2) per fraction	10 €/tCO2	35 €/tCO2	75 €/tCO2	
Brazil	39%	33%	28%	36 €/tCO2
China	39%	31%	30%	37 €/tCO2
India	39%	31%	30%	37 €/tCO2
Mexico	39%	33%	28%	36 €/tCO2
South Africa	70%	16%	14%	23 €/tCO2
South Korea	26%	26%	48%	48 €/tCO2
Avoided deforestation				
	Fraction in cost class: 1-15 €/tCO2	Fraction in cost class: 15-38 €/tCO2	Fraction in cost class: 38-75 €$/tCO2	Average costs in €/tCO2
Average costs (€$/tCO2) per fraction	10 €/tCO2	35 €/tCO2	75 €/tCO2	
Brazil	47%	37%	16%	30 €/tCO2
China	52%	23%	25%	32 €/tCO2
India	52%	23%	25%	32 €/tCO2
Mexico	47%	37%	16%	30 €/tCO2
South Africa	70%	19%	11%	22 €/tCO2
South Korea	35%	29%	36%	41 €/tCO2

Note: For conversion we assumed 1 US$ to be 1€

2.3 Calculation of scenarios

The aim of the modelling under this project is to show the emission development and the reduction potential of the major developing countries in a consistent and comparable manner.

The general methodology is a bottom-up approach: For each sector, production and performance parameters are collected (e.g. tonnes of cement produced and energy

[2] We used a general conversion ration from US$ to Euro of 1:1.

efficiency of cement production). From these figures, energy demand as well as energy and process related emissions are calculated (see Figure 14).

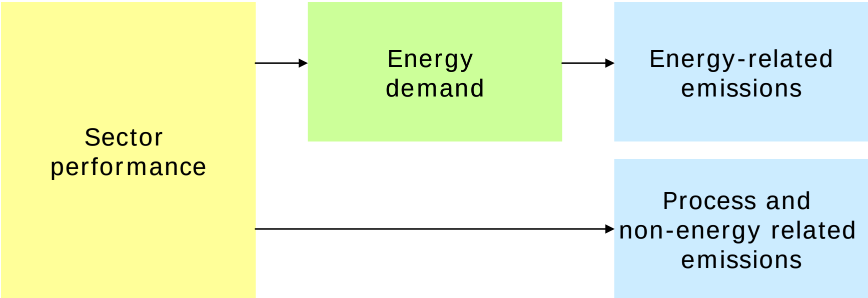

Figure 14 Simplified methodology for developing future emission pathways

The model distinguishes among five main sectors. For each sector several parameters are used as inputs. Table 3 provides a rough overview of the most important input parameters that we considered per sector. The following sections explain the methodology per sector in more detail.

The approach works well for the energy and industry sectors, due to relatively good data availability, to a certain extent also for agriculture and waste. For households and services, only limited performance data are available. Except for South Korea, the data availability for transport is weak as well. For land-use change and forestry we based our assumptions on national communications submitted to the UNFCCC and the national climate change plans.

Table 3 Different sectors and the related sector performance input parameters

Sector	**Subsectors (*sector performance input parameters*)**				
General	For all sectors:	*GDP*	*Population*	*Emission factors*	
Power production sector	Electricity, CHP, heat generation	Other energy industry	Distribution losses	Production, net imports, international marine bunkers, stock changes	
	Demand in other sectors + Distribution losses	*Demand in other sectors*	*Historic development related to actual power production*	*Demand in other sectors*	
Industry sector	Iron + steel	Cement	Pulp + paper	Rest of industry	
	Steel production *Iron production*	*Cement production* *Clinker production*	*Pulp production* *Paper production*	*GDP* *historic growth rate*	
Domestic sectors	Households	Commercial + services			
	Population growth *Number of households* *Households/ population connected to the electricity grid*	*Population growth* *Labour force*			
Agriculture + waste	Agriculture	Waste	Rest (fishing + non-specified other sectors)	Non-energy use	Land-use change and forestry
	Population growth *Use of fertiliser* *Increase in crop* *Manure management* *Methane enteric fermentation* *N2O Manure* *N2O soil fertiliser, soil livestock and soil crop related*	*Population growth* *Recovered methane* *% landfilled* *Waste generation per capita* *Methane conversion fraction*	*Population growth* *historic growth*	*increase due to average historic growth rate*	*afforestation and deforestation rates*
Transport sector	Aviation	Road transport	Rail	Domestic navigation	
	development related to GDP growth	*development related to GDP growth*	*development related to GDP growth or constant*	*development related to GDP growth or constant*	

Table 4 below includes the most important historical and scenario parameters for all countries and sectors. The parameters chosen for future developments are based on national studies where available, e.g. Winkler et al. 2005, Winkler (ed.) 2007, Centro Clima et al. 2006, Chen et al. 2006, TERI and CCAP 2006 and others. Due to poor data availability, the classification of the scenarios is not as clear for the transport sector as for the other sectors.

The table includes red figures. These are not consistent with what we would expect the data for these countries to look like (e.g. very low Energy Efficiency Index). Data shortcomings can be found especially in the transport sector. But also in the industry sector (e.g. South Africa: too low energy consumption values for pulp and paper production; South Korea: too low energy consumption values for iron and steel production) some gaps still exist that we had to fill with imperfect data.

Table 4 Selected historical and scenario parameters for all countries and sectors

Scenario parameters	Korea Historical	Korea BAU 2020	Korea No regret 2020	Korea Co-benefit 2020	Korea Ambitious mitigation 2020	Korea National climate change plans 2020	South Africa Historical	South Africa BAU 2020	South Africa No regret 2020	South Africa Co-benefit 2020	South Africa Ambitious mitigation 2020	South Africa National climate change plans 2020	Mexico Historical	Mexico BAU 2020	Mexico No regret 2020	Mexico Co-benefit 2020	Mexico Ambitious mitigation 2020	Mexico National climate change plans 2020
Power production + other energy industries																		
Electricity and CHP output																		
Annual growth in (non-CHP) electricity generation (2005 to 2020)	9%	5%	3%	3%	3%	3%	3%	3%	0%	0%	0%	0%	4%	3%	3%	3%	3%	3%
Share coal without CCS	38%	38%	38%	28%	16%	20%	94%	94%	73%	73%	72%	73%	14%	13%	2%	0%	0%	0%
Share coal with CCS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Share petroleum products	5%	5%	5%	5%	5%	5%	0%	0%	0%	0%	0%	0%	28%	22%	17%	10%	0%	0%
Share gas	14%	16%	16%	16%	16%	16%	0%	0%	0%	0%	0%	0%	39%	46%	61%	61%	61%	60%
Share nuclear	42%	40%	40%	40%	40%	40%	5%	5%	10%	10%	10%	10%	4%	4%	4%	4%	4%	4%
Share hydro	1%	1%	1%	1%	3%	3%	1%	1%	2%	2%	2%	2%	11%	12%	12%	12%	12%	12%
Share solar, wind, others	0%	0%	0%	5%	10%	8%	0%	0%	10%	10%	10%	10%	0%	0%	0%	5%	10%	10%
Share combustable renewables and waste	0%	0%	0%	5%	10%	8%	0%	0%	2%	2%	2%	2%	1%	1%	1%	5%	10%	10%
Annual growth in CHP production (2005 to 2020)	31%	2%	2%	2%	2%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share of CHP in total electricity generation	10%	13%	14%	14%	14%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Efficiency electricity gegeration																		
Coal without CCS	38%	42%	42%	42%	44%	44%	37%	43%	43%	43%	43%	43%	35%	40%	40%	40%	45%	45%
Coal with CCS																		
Petroleum products	69%	75%	75%	75%	75%	75%	0%	0%	0%	0%	0%	0%	34%	38%	38%	38%	38%	38%
Natural gas	59%	68%	68%	68%	70%	70%	34%	40%	40%	40%	40%	40%	39%	44%	44%	44%	50%	50%
Distribution losses																		
Electricity losses to production ratio	4%	4%	4%	4%	4%	4%	7%	8%	8%	8%	8%	8%	17%	17%	17%	17%	17%	17%
Other energy industries (mainly coal transf. and refineries)																		
Efficiency (output/input)	87%	88%	88%	88%	90%	90%	54%	52%	52%	52%	52%	52%	80%	76%	76%	76%	76%	76%
Industry																		
Iron and steel																		
Annual production growth (steel, 2005 to 2020)	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	1%	1%	1%	1%	1%
Ratio iron over steel production	58%	57%	51%	51%	41%	57%	80%	83%	66%	66%	66%	66%	63%	62%	62%	62%	62%	62%
Share coal	72%	62%	62%	62%	62%	62%	89%	88%	78%	78%	78%	88%	26%	29%	19%	19%	19%	19%
Share petroleum products	11%	10%	10%	10%	10%	10%	0%	0%	0%	0%	0%	0%	7%	6%	6%	6%	6%	6%
Share gas	17%	18%	18%	18%	18%	18%	11%	12%	12%	12%	12%	12%	67%	65%	65%	65%	65%	65%
Share combustable renewables and waste	0%	10%	10%	10%	10%	10%	0%	0%	10%	10%	10%	0%	0%	0%	10%	10%	10%	10%
Share electricity	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Annual change in energy consumption per primary steel (2005 to 2020)	4%	-0.2%	-0.2%	-0.2%	-0.3%	-0.3%	1%	-2.3%	-2.5%	-2.5%	-2.5%	-2.5%	-0.5%	-1.0%	-1.0%	-1.0%	-1.2%	-1.0%
Energy efficiency index	0.8	0.5	0.5	0.5	0.4	0.5	2.1	1.1	1.0	1.0	1.0	1.0	1.3	1.1	1.1	1.1	1.0	1.1
Cement																		
Annual production growth (cement, 2005 to 2020)	4%	0%	0%	0%	0%	0%	4%	5%	5%	5%	5%	5%	3%	4%	4%	4%	4%	4%
Clinker cement ratio	89%	89%	79%	79%	79%	89%	90%	90%	80%	80%	80%	80%	86%	86%	76%	76%	76%	86%
Share coal	86%	86%	76%	66%	56%	56%	90%	90%	80%	70%	60%	60%	7%	7%	0%	0%	0%	0%
Share petroleum products	2%	2%	2%	2%	2%	2%	0%	0%	0%	0%	0%	0%	74%	74%	73%	63%	53%	53%
Share gas	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	4%	4%	4%	4%	4%
Share combustable renewables and waste	0%	0%	10%	20%	30%	30%	0%	0%	10%	20%	30%	30%	3%	3%	10%	20%	30%	30%
Annual change in energy consumption per clinker (2005 to 2020)	-0.4%	-0.4%	-0.4%	-0.4%	-0.5%	-0.5%	0.0%	0.0%	-2.0%	-2.0%	-2.0%	-2.0%	-1.1%	-0.1%	-0.1%	-0.1%	-0.5%	-0.1%
Energy efficiency index	1.0	0.9	0.9	0.9	0.9	0.9	1.3	1.3	1.0	1.0	1.0	1.0	1.1	1.2	1.2	1.2	1.1	1.2
Pulp and Paper																		
Annual production growth (pulp and paper, 2005 to 2020)	6%	1%	1%	1%	1%	1%	2%	-7%	-7%	-7%	-7%	-7%	2%	3%	3%	3%	3%	3%
Share coal	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share petroleum products	40%	37%	37%	37%	29%	34%	0%	0%	0%	0%	0%	0%	32%	26%	21%	21%	6%	6%
Share gas	3%	4%	4%	4%	4%	4%	25%	24%	19%	19%	4%	24%	40%	44%	44%	44%	44%	44%
Share combustable renewables and waste	13%	12%	12%	12%	20%	15%	0%	0%	5%	5%	20%	0%	0%	0%	5%	5%	20%	20%
Share electricity	37%	39%	39%	39%	39%	39%	75%	76%	76%	76%	76%	76%	28%	30%	30%	30%	30%	30%
Energy efficiency index	1.3	1.1	1.1	1.1	0.9	1.0	0.2	0.2	0.2	0.2	0.2	0.2	1.2	1.0	1.0	1.0	0.9	1.0
Other																		
Annual growth in energy use (2005 to 2020)	6%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	1%	1%	1%	1%	1%
Share coal	13%	13%	13%	13%	8%	13%	30%	29%	29%	29%	19%	29%	1%	1%	1%	1%	1%	1%
Share petroleum products	23%	22%	22%	22%	12%	22%	5%	6%	6%	6%	6%	6%	24%	23%	23%	23%	8%	8%
Share gas	11%	11%	11%	11%	11%	11%	8%	8%	8%	8%	8%	8%	31%	32%	32%	32%	32%	32%
Share combustable renewables and waste	4%	5%	5%	5%	20%	10%	11%	11%	11%	11%	20%	11%	6%	5%	5%	5%	20%	20%
N2O emissions (Mt CO2eq)	8	10	8	8	2	10	2	2	2	2	1	2	1	1	1	1	0	1
HFC emissions (Mt CO2eq)	20	43	43	43	5	43	7	17	17	17	2	17	8	14	14	14	2	5

Scenario parameters	Korea						South Africa						Mexico					
	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020
Power production + other energy industries																		
Electricity and CHP output																		
Annual growth in (non-CHP) electricity generation (2005 to 2020)	9%	5%	3%	3%	3%	3%	3%	3%	0%	0%	0%	0%	4%	3%	3%	3%	3%	3%
Share coal without CCS	38%	38%	38%	28%	16%	20%	94%	94%	73%	73%	72%	73%	14%	13%	2%	0%	0%	0%
Share coal with CCS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Share petroleum products	5%	5%	5%	5%	5%	5%	0%	0%	0%	0%	0%	0%	28%	22%	17%	10%	0%	0%
Share gas	14%	16%	16%	16%	16%	16%	0%	0%	0%	0%	0%	0%	39%	46%	61%	61%	61%	60%
Share nuclear	42%	40%	40%	40%	40%	40%	5%	5%	10%	10%	10%	10%	4%	4%	4%	4%	4%	4%
Share hydro	1%	1%	1%	1%	3%	3%	1%	1%	2%	2%	2%	2%	11%	12%	12%	12%	12%	12%
Share solar, wind, others	0%	0%	0%	5%	10%	8%	0%	0%	10%	10%	10%	10%	0%	0%	0%	5%	10%	10%
Share combustable renewables and waste	0%	0%	0%	5%	10%	8%	0%	0%	2%	2%	2%	2%	1%	1%	1%	5%	10%	10%
Annual growth in CHP production (2005 to 2020)	31%	2%	2%	2%	2%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share of CHP in total electricity generation	10%	13%	14%	14%	14%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Efficiency electricity gegeration																		
Coal without CCS	38%	42%	42%	42%	44%	44%	37%	43%	43%	43%	43%	43%	35%	40%	40%	40%	45%	45%
Coal with CCS																		
Petroleum products	69%	75%	75%	75%	75%	75%	0%	0%	0%	0%	0%	0%	34%	38%	38%	38%	38%	38%
Natural gas	59%	68%	68%	68%	70%	70%	34%	40%	40%	40%	40%	40%	39%	44%	44%	44%	50%	50%
Distribution losses																		
Electricity losses to production ratio	4%	4%	4%	4%	4%	4%	7%	8%	8%	8%	8%	8%	17%	17%	17%	17%	17%	17%
Other energy industries (mainly coal transf. and refineries)																		
Efficiency (output/input)	87%	88%	88%	88%	90%	90%	54%	52%	52%	52%	52%	52%	80%	76%	76%	76%	76%	76%
Industry																		
Iron and steel																		
Annual production growth (steel, 2005 to 2020)	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	1%	1%	1%	1%	1%
Ratio iron over steel production	58%	57%	51%	51%	41%	57%	80%	83%	66%	66%	66%	66%	63%	62%	62%	62%	62%	62%
Share coal	72%	62%	62%	62%	62%	62%	89%	88%	78%	78%	78%	88%	26%	29%	19%	19%	19%	19%
Share petroleum products	11%	10%	10%	10%	10%	10%	0%	0%	0%	0%	0%	0%	7%	6%	6%	6%	6%	6%
Share gas	17%	18%	18%	18%	18%	18%	11%	12%	12%	12%	12%	12%	67%	65%	65%	65%	65%	65%
Share combustable renewables and waste	0%	10%	10%	10%	10%	10%	0%	0%	10%	10%	10%	0%	0%	0%	10%	10%	10%	10%
Share electricity	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Annual change in energy consumption per primary steel (2005 to 2020)	4%	-0.2%	-0.2%	-0.2%	-0.3%	-0.3%	1%	-2.3%	-2.5%	-2.5%	-2.5%	-2.5%	-0.5%	-1.0%	-1.0%	-1.0%	-1.2%	-1.0%
Energy efficiency index	0.8	0.5	0.5	0.5	0.4	0.5	2.1	1.1	1.0	1.0	1.0	1.0	1.3	1.1	1.1	1.1	1.0	1.1
Cement																		
Annual production growth (cement, 2005 to 2020)	4%	0%	0%	0%	0%	0%	4%	5%	5%	5%	5%	5%	3%	4%	4%	4%	4%	4%
Clinker cement ratio	89%	89%	79%	79%	79%	89%	90%	90%	80%	80%	80%	80%	86%	86%	76%	76%	76%	86%
Share coal	86%	86%	76%	66%	56%	56%	90%	90%	80%	70%	60%	60%	7%	7%	0%	0%	0%	0%
Share petroleum products	2%	2%	2%	2%	2%	2%	0%	0%	0%	0%	0%	0%	74%	74%	73%	63%	53%	53%
Share gas	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	4%	4%	4%	4%	4%
Share combustable renewables and waste	0%	0%	10%	20%	30%	30%	0%	0%	10%	20%	30%	30%	3%	3%	10%	20%	30%	30%
Annual change in energy consumption per clinker (2005 to 2020)	-0.4%	-0.4%	-0.4%	-0.4%	-0.5%	-0.5%	0.0%	0.0%	-2.0%	-2.0%	-2.0%	-2.0%	-1.1%	-0.1%	-0.1%	-0.1%	-0.5%	-0.1%
Energy efficiency index	1.0	0.9	0.9	0.9	0.9	0.9	1.3	1.3	1.0	1.0	1.0	1.0	1.1	1.2	1.2	1.2	1.1	1.2
Pulp and Paper																		
Annual production growth (pulp and paper, 2005 to 2020)	6%	1%	1%	1%	1%	1%	2%	-7%	-7%	-7%	-7%	-7%	2%	3%	3%	3%	3%	3%
Share coal	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share petroleum products	40%	37%	37%	37%	29%	34%	0%	0%	0%	0%	0%	0%	32%	26%	21%	21%	6%	6%
Share gas	3%	4%	4%	4%	4%	4%	25%	24%	19%	19%	4%	24%	40%	44%	44%	44%	44%	44%
Share combustable renewables and waste	13%	12%	12%	12%	20%	15%	0%	0%	5%	5%	20%	0%	0%	0%	5%	5%	20%	20%
Share electricity	37%	39%	39%	39%	39%	39%	75%	76%	76%	76%	76%	76%	28%	30%	30%	30%	30%	30%
Energy efficiency index	1.3	1.1	1.1	1.1	0.9	1.0	0.2	0.2	0.2	0.2	0.2	0.2	1.2	1.0	1.0	1.0	0.9	1.0
Other																		
Annual growth in energy use (2005 to 2020)	6%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	1%	1%	1%	1%	1%
Share coal	13%	13%	13%	13%	8%	13%	30%	29%	29%	29%	19%	29%	1%	1%	1%	1%	1%	1%
Share petroleum products	23%	22%	22%	22%	12%	22%	5%	6%	6%	6%	6%	6%	24%	23%	23%	23%	8%	8%
Share gas	11%	11%	11%	11%	11%	11%	8%	8%	8%	8%	8%	8%	31%	32%	32%	32%	32%	32%
Share combustable renewables and waste	4%	5%	5%	5%	20%	10%	11%	11%	11%	11%	20%	11%	6%	5%	5%	5%	20%	20%
N2O emissions (Mt CO2eq)	8	10	8	8	2	10	2	2	2	2	1	2	1	1	1	1	0	1
HFC emissions (Mt CO2eq)	20	43	43	43	5	43	7	17	17	17	2	17	8	14	14	14	2	5

	Scenario parameters	India						China						Brazil					
		Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020
Power production	**Power production**																		
	Elektricity and CHP output																		
	Annual growth in (non-CHP) electricity generation (2005 to 2020)	6%	7%	5%	5%	5%	5%	9%	7%	9%	9%	8%	7%	4%	4%	3%	3%	3%	3%
	Share coal without CCS	69%	69%	69%	60%	47%	61%	79%	80%	80%	71%	49%	50%	2%	2%	2%	2%	1%	2%
	Share coal with CCS	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
	Share petroleum products	4%	4%	4%	4%	4%	4%	2%	2%	2%	2%	2%	2%	3%	2%	2%	2%	1%	2%
	Share gas	9%	9%	9%	9%	9%	9%	0%	0%	0%	0%	0%	0%	5%	23%	4%	5%	2%	6%
	Share nuclear	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	3%	3%	2%	2%	2%	2%	2%	2%
	Share hydro	15%	15%	15%	15%	17%	17%	16%	15%	15%	15%	25%	25%	84%	67%	75%	74%	79%	77%
	Share solar, wind, others	1%	1%	1%	5%	10%	7%	0%	0%	0%	5%	10%	10%	0%	0%	5%	5%	5%	0%
	Share combustable renewables and waste	0%	0%	0%	5%	10%	0%	0%	0%	0%	5%	10%	10%	4%	4%	10%	10%	10%	10%
	Annual growth in CHP production (2005 to 2020)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	8%	8%	8%	8%	8%
	Share of electricity in total CHP generation	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Efficiency																		
	Coal without CCS	27%	29%	29%	36%	41%	29%	37%	40%	40%	40%	44%	44%	32%	37%	37%	37%	37%	37%
	Coal with CCS					35%						35%							
	Petroleum products	29%	31%	31%	31%	52%	31%	42%	46%	46%	46%	49%	49%	36%	41%	41%	41%	41%	41%
	Natural gas	42%	45%	45%	45%	45%	45%	61%	66%	66%	66%	70%	70%	46%	53%	53%	53%	53%	53%
	Distribution losses																		
	Electricity losses to production ratio	24%	18%	18%	18%	10%	18%	8%	8%	8%	8%	8%	8%	17%	17%	13%	13%	8%	3%
		82%	82%	82%	82%	82%	82%	59%	57%	57%	57%	57%	57%	76%	75%	75%	75%	75%	75%
Industry	**Industry**																		
	Iron and steel																		
	Annual production growth (steel, 2005 to 2020)	6%	9%	9%	9%	9%	9%	11%	8%	8%	8%	8%	8%	4%	3%	3%	3%	3%	3%
	Percentage of primary steel	105%	86%	86%	86%	86%	86%	92%	90%	77%	77%	77%	90%	106%	93%	93%	93%	93%	93%
	Share coal	87%	87%	77%	77%	77%	87%	93%	94%	84%	84%	84%	89%	38%	37%	37%	37%	31%	31%
	Share petroleum products	3%	3%	3%	3%	3%	3%	3%	2%	2%	2%	2%	2%	5%	5%	5%	5%	5%	5%
	Share gas	11%	11%	11%	11%	11%	11%	1%	1%	1%	1%	1%	1%	8%	9%	9%	9%	9%	9%
	Share combustable renewables and waste	0%	0%	0%	0%	0%	0%	0%	0%	10%	10%	10%	5%	49%	49%	49%	49%	55%	55%
	Share electricity	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Annual energy efficiency improvement primary steel (2005 to 2020)	-1.0%	-0.1%	-0.5%	-0.5%	-1.0%	-0.5%	-3.1%	-1.1%	-1.1%	-1.1%	-2.7%	-2.7%	-1.3%	0.3%	0.0%	0.0%	-0.5%	-0.5%
	Energy efficiency index	1.9	1.7	1.5	1.5	1.4	1.6	1.2	0.8	0.7	0.7	0.6	0.6	1.1	1.1	1.0	1.0	0.9	0.9
	Cement																		
	Annual production growth (cement, 2005 to 2020)	7%	9%	9%	9%	9%	9%	12%	2%	2%	2%	2%	2%	3%	4%	4%	4%	4%	4%
	Clinker cement ration	86%	80%	70%	70%	70%	80%	72%	72%	65%	65%	65%	65%	73%	73%	65%	65%	65%	73%
	Share coal	89%	90%	80%	70%	60%	90%	92%	92%	82%	72%	62%	85%	5%	5%	5%	5%	0%	5%
	Share petroleum products	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	70%	70%	70%	70%	70%	68%
	Share gas	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Share combustable renewables and waste	0%	0%	10%	20%	30%	0%	0%	0%	10%	20%	30%	7%	25%	25%	25%	25%	30%	27%
	Annual energy efficiency improvement (2005 to 2020)	-2.6%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.5%	0.0%	-0.2%	-0.2%	-2.0%	-3.5%	0.1%	-0.2%	-0.2%	-0.2%	-1.0%	-0.2%
	Energy efficiency index	1.0	0.8	0.8	0.8	0.8	0.8	1.7	1.7	1.6	1.6	1.3	1.0	1.4	1.4	1.4	1.4	1.2	1.4
	Pulp and Paper																		
	Annual production growth (pulp and paper, 2005 to 2020)	6%	8%	8%	8%	8%	8%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	Share coal	85%	85%	70%	70%	45%	85%	54%	52%	37%	37%	12%	42%	1%	1%	1%	1%	1%	1%
	Share petroleum products	0%	0%	0%	0%	0%	0%	5%	5%	5%	5%	5%	5%	10%	6%	6%	6%	6%	5%
	Share gas	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	7%	7%	7%	7%	7%
	Share combustable renewables and waste	0%	0%	15%	15%	40%	0%	0%	0%	15%	15%	40%	10%	66%	69%	69%	69%	69%	71%
	Share electricity	15%	15%	15%	15%	15%	15%	25%	27%	27%	27%	27%	27%	17%	17%	17%	17%	17%	17%
	Energy efficiency index	1.6	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.8	1.4	1.4	1.4	0.9	1.4
	Other																		
	Annual growth in energy use (2005 to 2020)	2%	9%	9%	9%	8%	8%	0%	4%	4%	4%	3%	3%	5%	3%	3%	3%	3%	3%
	Share coal	17%	18%	18%	18%	18%	18%	31%	31%	31%	26%	6%	21%	2%	2%	2%	2%	2%	2%
	Share petroleum products	22%	23%	23%	23%	23%	23%	15%	15%	15%	15%	15%	15%	21%	21%	21%	21%	21%	19%
	Share gas	7%	7%	7%	7%	7%	7%	5%	5%	5%	5%	10%	10%	11%	11%	11%	11%	11%	11%
	Share combustable renewables and waste	32%	31%	31%	31%	31%	31%	0%	0%	0%	5%	20%	5%	39%	41%	41%	41%	41%	43%
	N2O emissions (Mt CO2eq)	3	4	4	4	1	4	32	37	32	32	3	32	6	7	6	6	1	7
	HFC emissions (Mt CO2eq)	12	14	14	14	4	14	100	149	149	149	10	149	8	20	20	20	2	2

Scenario parameters	Korea						South Africa						Mexico					
	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020
Domestic																		
Households																		
People per household	3.2	2.9	2.9	2.9	2.9	2.9	3.7	3.4	3.4	3.4	3.4	3.4	4.2	3.9	3.9	3.9	3.9	3.9
Share of households connected to electricity grid	86%	93%	93%	93%	93%	93%	70%	89%	89%	89%	89%	0%	96%	99%	99%	99%	99%	99%
Share of people with electricity access																		
Share coal	8%	9%	9%	9%	9%	9%	26%	26%	26%	26%	26%	26%	0%	0%	0%	0%	0%	0%
Share petroleum products	25%	27%	27%	27%	22%	22%	7%	7%	7%	7%	7%	7%	52%	53%	53%	53%	53%	53%
Share gas	67%	64%	64%	64%	64%	64%	0%	0%	0%	0%	0%	0%	6%	6%	6%	6%	6%	6%
Share solar, wind, others	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share combustable renewables and waste	0%	0%	0%	0%	0%	0%	67%	67%	67%	67%	67%	67%	42%	41%	41%	41%	41%	41%
FE excl. electricity per household (toe/household)	0.85	0.91	0.91	0.95	0.95	0.91	0.95	0.89	0.89	0.89	0.89	0.89	0.59	0.64	0.64	0.64	0.64	0.64
Electricity use/household connected to the grid (toe/cap)	0.34	0.57	0.48	0.44	0.44	0.48	0.37	0.43	0.37	0.36	0.36	0.36	0.15	0.18	0.15	0.15	0.15	0.15
Electricity use/cap (toe/household)	0.09	0.18	0.15	0.14	0.14	0.15	0.07	0.11	0.10	0.09	0.09	0.09	0.04	0.05	0.04	0.04	0.04	0.04
Commercial and services																		
Active labour force (people employed) (% of working age population)	62%	62%	62%	62%	62%	62%	43%	43%	43%	43%	43%	43%	59%	61%	61%	61%	61%	61%
Share coal	0%	0%	0%	0%	0%	0%	76%	77%	77%	77%	77%	77%	0%	0%	0%	0%	0%	0%
Share petroleum products	64%	52%	52%	52%	42%	42%	23%	23%	23%	23%	23%	23%	85%	84%	84%	84%	84%	84%
Share gas	33%	43%	43%	43%	43%	43%	0%	0%	0%	0%	0%	0%	11%	11%	11%	11%	11%	11%
Share solar, wind, others	0%	0%	0%	0%	5%	5%	0%	0%	0%	0%	0%	0%	4%	5%	5%	5%	5%	5%
Share combustable renewables and waste	3%	4%	4%	4%	4%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FE excl. electricity per employee (ktoe/employee)	516	516	516	516	516	516	168	189	189	189	189	189	45	56	56	56	56	56
Electricity use per employee (ktoe/employee)	411	1135	953	953	953	953	163	242	204	204	204	204	43	170	143	143	143	143
Transport																		
Energy for aviation, annual growth rate	2.5%	5.0%	5.0%	4.8%	3.5%	5.0%	6.2%	3.8%	3.3%	3.3%	1.7%	3.3%	2.9%	4.0%	3.5%	3.5%	1.9%	1.9%
Energy for road transport, annual growth rate	4.8%	2.3%	0.3%	-2.1%	-3.9%	2.3%	2.1%	2.8%	2.3%	1.4%	-0.2%	2.3%	2.2%	3.0%	2.5%	1.6%	0.0%	0.0%
Energy for rail transport, annual growth rate	1.1%	1.0%	1.0%	4.8%	4.8%	1.0%	1.5%	0.0%	0.0%	2.7%	2.7%	0.0%	-1.0%	0.0%	0.0%	5.2%	5.2%	5.2%
Energy for navigation, annual growth rate	1.5%	4.9%	4.9%	4.9%	4.9%	4.9%												0.0%
Energy for total transport, annual grown rate	4.0%	3.1%	2.5%	1.8%	0.6%	3.1%	2.6%	2.8%	2.3%	1.7%	0.2%	2.3%	2.2%	3.0%	2.5%	1.8%	0.3%	0.3%
Agriculture and waste																		
Agriculture																		
Annual production growth (Livestock)		2.7%	1.5%	1.5%	0.6%	2.7%		3.3%	3.3%	2.5%	2.5%	3.3%		1.9%	1.3%	1.3%	0.5%	1.3%
Annual production growth (Use of fertiliser)		-0.9%	-0.9%	-0.9%	-0.9%	-0.9%		5.1%	5.1%	5.1%	5.1%	5.1%		1.2%	1.2%	1.2%	1.2%	1.2%
Annual production growth (crop production)		1.6%	1.6%	1.6%	1.6%	1.6%		2.5%	2.5%	2.5%	2.5%	2.5%		1.6%	1.6%	1.6%	1.6%	1.6%
Annual production growth (rice)		0.1%	0.1%	0.1%	-1.4%	0.1%		0.0%	0.0%	0.0%	0.0%	0.0%		0.9%	0.9%	0.9%	0.3%	0.9%
Annual change in emission factor (CH4 manure management)		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%
Annual change in emission factor (CH4 enteric fermentation)		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%
Annual change in emission factor (CH4 rice)		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%
Waste																		
Percentage of waste landfilled	43%	80%	80%	80%	80%	80%	57%	82%	82%	82%	82%	82%	54%	76%	76%	76%	76%	76%
Waste generation per capita	0.37	0.67	0.67	0.67	0.67	0.67	0.26	0.37	0.37	0.37	0.37	0.37	0.34	0.47	0.47	0.47	0.47	0.47
Methane conversion factor	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Fraction of potential CH4 emissions recovered	0%	1%	1%	10%	50%	1%	0%	1%	1%	10%	50%	35%	0%	1%	1%	10%	50%	20%
LUCF																		
Afforestation [MtCO2eq]	2.66%	-31	-31	-31	-31	-31	-1.49%	-9	-9	-9	-12	-12		4	4	4	-9	-9
Deforestation [MtCO2eq]	4.45%	0	0	0	0	0		0	0	0	0	0		67	67	67	67	67
Other LUCF [MtCO2eq]	-3.46%	3	3	3	3	3	-5.44%	-8	-8	-8	-8	-8		17	17	17	17	17
Emissions, annual growth	2.5%	-1.4%	-1.4%	-1.4%	-1.4%	-1.4%	0.6%	-0.9%	-0.9%	-0.9%	0.3%	0.3%	-1.4%	-0.1%	-0.1%	-0.1%	0.7%	0.7%

Scenario parameters	India Historical	India BAU 2020	India No regret 2020	India Co-benefit 2020	India Ambitious mitigation 2020	India National climate change plans 2020	China Historical	China BAU 2020	China No regret 2020	China Co-benefit 2020	China Ambitious mitigation 2020	China National climate change plans 2020	Brazil Historical	Brazil BAU 2020	Brazil No regret 2020	Brazil Co-benefit 2020	Brazil Ambitious mitigation 2020	Brazil National climate change plans 2020
Domestic																		
Households																		
People per household	5.2	4.8	4.8	4.8	4.8	4.8	3.5	3.2	3.2	3.2	3.2	3.2	3.5	3.2	3.2	3.2	3.2	3.2
Share of households connected to electricity grid						89%						0%	96%	99%	99%	99%	99%	99%
Share of people with electricity access	56%	61%	61%	61%	61%		99%	99%	99%	99%	99%							
Share coal	2%	2%	2%	2%	2%	2%	16%	15%	15%	15%	15%	15%	0%	0%	0%	0%	0%	0%
Share petroleum products	14%	14%	14%	14%	14%	14%	6%	7%	7%	7%	7%	7%	39%	39%	39%	39%	39%	39%
Share gas	0%	0%	0%	0%	0%	0%	3%	4%	4%	4%	4%	4%	1%	1%	1%	1%	1%	1%
Share solar, wind, others	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share combustable renewables and waste	84%	83%	83%	83%	83%	83%	75%	75%	75%	75%	75%	75%	60%	60%	60%	60%	60%	60%
FE excl. electricity per household (toe/household)	0.73	0.78	0.78	0.78	0.78	0.78	0.82	0.99	0.99	0.99	0.99	0.99	0.31	0.34	0.34	0.34	0.34	0.34
Electricity use/household connected to the grid (toe/cap)						0.07						0.00	0.18	0.21	0.17	0.17	0.17	0.20
Electricity use/cap (toe/household)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.09	0.08	0.07	0.05	0.05	0.04	0.06	0.05	0.05	0.05	0.06
Commercial and services																		
Active labour force (people employed) (% of working age population)	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	63%	79%	79%	79%	79%	79%
Share coal	33%	34%	34%	34%	34%	34%	16%	16%	16%	16%	16%	16%	0%	0%	0%	0%	0%	0%
Share petroleum products	0%	0%	0%	0%	0%	0%	71%	71%	71%	71%	71%	71%	72%	69%	69%	69%	69%	69%
Share gas	0%	0%	0%	0%	0%	0%	10%	9%	9%	9%	9%	9%	18%	20%	20%	20%	20%	20%
Share solar, wind, others	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share combustable renewables and waste	67%	66%	66%	66%	66%	66%	0%	0%	0%	0%	0%	0%	10%	10%	10%	10%	10%	10%
FE excl. electricity per employee (ktoe/employee)	21	22	22	22	22	22	50	121	121	121	121	121	22	24	24	24	24	24
Electricity use per employee (ktoe/employee)	7	21	17	17	17	20	14	46	38	38	38	38	91	98	88	88	88	98
Transport																		
Energy for aviation, annual growth rate	3.1%	9.7%	9.2%	9.2%	7.4%	9.7%	16.5%	8.4%	7.9%	7.9%	6.2%	8.4%	2.6%	5.1%	4.6%	4.6%	3.0%	5.1%
Energy for road transport, annual growth rate	2.3%	8.6%	8.1%	7.1%	5.5%	8.6%	8.0%	6.8%	6.3%	5.4%	3.8%	6.8%	3.2%	4.0%	3.5%	2.6%	1.1%	4.0%
Energy for rail transport, annual growth rate	-4.1%	0.7%	0.7%	3.4%	3.4%	0.7%	2.5%	3.4%	3.4%	3.9%	3.9%	3.4%	-1.0%	0.0%	0.0%	7.2%	7.2%	0.0%
Energy for navigation, annual growth rate	-1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	9.8%	5.8%	5.8%	5.8%	5.8%	5.8%	-0.9%	0.0%	0.0%	0.0%	0.0%	0.0%
Energy for total transport, annual growh rate	1.6%	8.3%	7.8%	7.1%	5.5%	8.3%	7.0%	6.3%	5.9%	5.4%	4.2%	6.3%	3.0%	4.0%	3.5%	2.8%	1.3%	4.0%
Agriculture and waste																		
Agriculture																		
Annual production growth (Livestock)		2.8%	1.0%	1.0%	0.7%	2.8%		2.0%	1.6%	1.6%	1.4%	1.6%		1.3%	1.3%	1.3%	1.3%	1.3%
Annual production growth (Use of fertiliser)		1.0%	1.0%	1.0%	1.0%	1.0%		1.1%	1.1%	1.1%	1.1%	1.1%		5.8%	5.5%	5.5%	5.0%	5.8%
Annual production growth (crop production)		1.5%	1.5%	1.5%	1.5%	1.5%		1.1%	1.1%	1.1%	1.1%	1.1%		0.0%	0.0%	0.0%	0.0%	0.0%
Annual production growth (rice)		1.0%	1.0%	1.0%	-0.2%	1.0%		0.4%	0.4%	0.4%	-0.7%	0.4%		0.0%	0.0%	0.0%	0.0%	0.0%
Annual change in emission factor (CH4 manure management)		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	-1.0%		0.0%	0.0%	0.0%	0.0%	0.0%
Annual change in emission factor (CH4 enteric fermentation)		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	-0.2%	-0.2%	-1.0%	0.0%
Annual change in emission factor (CH4 rice)		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	-0.5%		0.0%	0.0%	0.0%	0.0%	0.0%
Waste																		
Percentage of waste landfilled	70%	100%	100%	100%	100%	100%	97%	100%	100%	100%	100%	100%	22%	35%	35%	35%	35%	35%
Waste generation per capita	0.17	0.49	0.49	0.49	0.49	0.49	0.27	0.66	0.66	0.66	0.66	0.66	0.50	0.80	0.70	0.70	0.70	0.80
Methane conversion factor	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Fraction of potential CH4 emissions recovered	0%	1%	1%	10%	50%	1%	0%	1%	1%	10%	50%	1%	0%	0%	2%	10%	50%	10%
LUCF																		
Afforestation [MtCO2eq]	0.00%	-11	-11	-11	-69	-69	0.00%	-345	-345	-345	-456	-456	0.27%	-38	-38	-38	-87	-87
Deforestation [MtCO2eq]	0.00%	18	18	18	18	18	0.00%	24	24	24	24	24	0.52%	994	994	994	194	194
	0.00%	10	10	10	10	10		0	0	0	0	0	-3.19%	-129	-129	-129	-129	-129
Emissions, annual growth	0.0%	1.1%	1.1%	1.1%	-7.2%	-7.2%	0.0%	-1.7%	-1.7%	-1.7%	-0.6%	-0.6%	0.2%	0.1%	0.1%	0.1%	-170.6%	-170.6%

Scenario parameters	India						China						Brazil					
	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020
Power production																		
Elektricity and CHP output																		
Annual growth in (non-CHP) electricity generation (2005 to 2020)	6%	7%	5%	5%	5%	5%	9%	7%	9%	9%	8%	7%	4%	4%	3%	3%	3%	3%
Share coal without CCS	69%	69%	69%	60%	47%	61%	79%	80%	80%	71%	49%	50%	2%	2%	2%	2%	1%	2%
Share coal with CCS	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Share petroleum products	4%	4%	4%	4%	4%	4%	2%	2%	2%	2%	2%	2%	3%	2%	2%	2%	1%	2%
Share gas	9%	9%	9%	9%	9%	9%	0%	0%	0%	0%	0%	0%	5%	23%	4%	5%	2%	6%
Share nuclear	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	3%	3%	2%	2%	2%	2%	2%	2%
Share hydro	15%	15%	15%	15%	17%	17%	16%	15%	15%	15%	25%	25%	84%	67%	75%	74%	79%	77%
Share solar, wind, others	1%	1%	1%	5%	10%	7%	0%	0%	0%	5%	10%	10%	0%	0%	5%	5%	5%	0%
Share combustable renewables and waste	0%	0%	0%	5%	10%	0%	0%	0%	0%	5%	10%	10%	4%	4%	10%	10%	10%	10%
Annual growth in CHP production (2005 to 2020)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	8%	8%	8%	8%	8%
Share of electricity in total CHP generation	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Efficiency																		
Coal without CCS	27%	29%	29%	36%	41%	29%	37%	40%	40%	40%	44%	44%	32%	37%	37%	37%	37%	37%
Coal with CCS					35%						35%							
Petroleum products	29%	31%	31%	31%	52%	31%	42%	46%	46%	46%	49%	49%	36%	41%	41%	41%	41%	41%
Natural gas	42%	45%	45%	45%	45%	45%	61%	66%	66%	66%	70%	70%	46%	53%	53%	53%	53%	53%
Distribution losses																		
Electricity losses to production ratio	24%	18%	18%	18%	10%	18%	8%	8%	8%	8%	8%	8%	17%	17%	13%	13%	8%	3%
	82%	82%	82%	82%	82%	82%	59%	57%	57%	57%	57%	57%	76%	75%	75%	75%	75%	75%
Industry																		
Iron and steel																		
Annual production growth (steel, 2005 to 2020)	6%	9%	9%	9%	9%	9%	11%	8%	8%	8%	8%	8%	4%	3%	3%	3%	3%	3%
Percentage of primary steel	105%	86%	86%	86%	86%	86%	92%	90%	77%	77%	77%	90%	106%	93%	93%	93%	93%	93%
Share coal	87%	87%	77%	77%	77%	87%	93%	94%	84%	84%	84%	89%	38%	37%	37%	37%	31%	31%
Share petroleum products	3%	3%	3%	3%	3%	3%	3%	2%	2%	2%	2%	2%	5%	5%	5%	5%	5%	5%
Share gas	11%	11%	11%	11%	11%	11%	1%	1%	1%	1%	1%	1%	8%	9%	9%	9%	9%	9%
Share combustable renewables and waste	0%	0%	0%	0%	0%	0%	0%	0%	10%	10%	10%	5%	49%	49%	49%	49%	55%	55%
Share electricity	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Annual energy efficiency improvement primary steel (2005 to 2020)	-1.0%	-0.1%	-0.5%	-0.5%	-1.0%	-0.5%	-3.1%	-1.1%	-1.1%	-1.1%	-2.7%	-2.7%	-1.3%	0.3%	0.0%	0.0%	-0.5%	-0.5%
Energy efficiency index	1.9	1.7	1.5	1.5	1.4	1.6	1.2	0.8	0.7	0.7	0.6	0.6	1.1	1.1	1.0	1.0	0.9	0.9
Cement																		
Annual production growth (cement, 2005 to 2020)	7%	9%	9%	9%	9%	9%	12%	2%	2%	2%	2%	2%	3%	4%	4%	4%	4%	4%
Clinker cement ration	86%	80%	70%	70%	70%	80%	72%	72%	65%	65%	65%	65%	73%	73%	65%	65%	65%	73%
Share coal	89%	90%	80%	70%	60%	90%	92%	92%	82%	72%	62%	85%	5%	5%	5%	5%	0%	5%
Share petroleum products	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	70%	70%	70%	70%	70%	68%
Share gas	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share combustable renewables and waste	0%	0%	10%	20%	30%	0%	0%	0%	10%	20%	30%	7%	25%	25%	25%	25%	30%	27%
Annual energy efficiency improvement (2005 to 2020)	-2.6%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.5%	0.0%	-0.2%	-0.2%	-2.0%	-3.5%	0.1%	-0.2%	-0.2%	-0.2%	-1.0%	-0.2%
Energy efficiency index	1.0	0.8	0.8	0.8	0.8	0.8	1.7	1.7	1.6	1.6	1.3	1.0	1.4	1.4	1.4	1.4	1.2	1.4
Pulp and Paper																		
Annual production growth (pulp and paper, 2005 to 2020)	6%	8%	8%	8%	8%	8%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Share coal	85%	85%	70%	70%	45%	85%	54%	52%	37%	37%	12%	42%	1%	1%	1%	1%	1%	1%
Share petroleum products	0%	0%	0%	0%	0%	0%	5%	5%	5%	5%	5%	5%	10%	6%	6%	6%	6%	5%
Share gas	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	7%	7%	7%	7%	7%
Share combustable renewables and waste	0%	0%	15%	15%	40%	0%	0%	0%	15%	15%	40%	10%	66%	69%	69%	69%	69%	71%
Share electricity	15%	15%	15%	15%	15%	15%	25%	27%	27%	27%	27%	27%	17%	17%	17%	17%	17%	17%
Energy efficiency index	1.6	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.8	1.4	1.4	1.4	0.9	1.4
Other																		
Annual growth in energy use (2005 to 2020)	2%	9%	9%	9%	8%	8%	0%	4%	4%	4%	3%	3%	5%	3%	3%	3%	3%	3%
Share coal	17%	18%	18%	18%	18%	18%	31%	31%	31%	26%	6%	21%	2%	2%	2%	2%	2%	2%
Share petroleum products	22%	23%	23%	23%	23%	23%	15%	15%	15%	15%	15%	15%	21%	21%	21%	21%	21%	19%
Share gas	7%	7%	7%	7%	7%	7%	5%	5%	5%	5%	10%	10%	11%	11%	11%	11%	11%	11%
Share combustable renewables and waste	32%	31%	31%	31%	31%	31%	0%	0%	0%	5%	20%	5%	39%	41%	41%	41%	41%	43%
N2O emissions (Mt CO2eq)	3	4	4	4	1	4	32	37	32	32	3	32	6	7	6	6	1	7
HFC emissions (Mt CO2eq)	12	14	14	14	4	14	100	149	149	149	10	149	8	20	20	20	2	2

Scenario parameters	Korea						South Africa						Mexico					
	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020	Historical	BAU 2020	No regret 2020	Co-benefit 2020	Ambitious mitigation 2020	National climate change plans 2020
Domestic																		
Households																		
People per household	3.2	2.9	2.9	2.9	2.9	2.9	3.7	3.4	3.4	3.4	3.4	3.4	4.2	3.9	3.9	3.9	3.9	3.9
Share of households connected to electricity grid	86%	93%	93%	93%	93%	93%	70%	89%	89%	89%	89%	0%	96%	99%	99%	99%	99%	99%
Share of people with electricity access																		
Share coal	8%	9%	9%	9%	9%	9%	26%	26%	26%	26%	26%	26%	0%	0%	0%	0%	0%	0%
Share petroleum products	25%	27%	27%	27%	22%	22%	7%	7%	7%	7%	7%	7%	52%	53%	53%	53%	53%	53%
Share gas	67%	64%	64%	64%	64%	64%	0%	0%	0%	0%	0%	0%	6%	6%	6%	6%	6%	6%
Share solar, wind, others	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share combustable renewables and waste	0%	0%	0%	0%	0%	0%	67%	67%	67%	67%	67%	67%	42%	41%	41%	41%	41%	41%
FE excl. electricity per household (toe/household)	0.85	0.91	0.91	0.95	0.95	0.91	0.95	0.89	0.89	0.89	0.89	0.89	0.59	0.64	0.64	0.64	0.64	0.64
Electricity use/household connected to the grid (toe/cap)	0.34	0.57	0.48	0.44	0.44	0.48	0.37	0.43	0.37	0.36	0.36	0.36	0.15	0.18	0.15	0.15	0.15	0.15
Electricity use/cap (toe/household)	0.09	0.18	0.15	0.14	0.14	0.15	0.07	0.11	0.10	0.09	0.09	0.09	0.04	0.05	0.04	0.04	0.04	0.04
Commercial and services																		
Active labour force (people employed) (% of working age population)	62%	62%	62%	62%	62%	62%	43%	43%	43%	43%	43%	43%	59%	61%	61%	61%	61%	61%
Share coal	0%	0%	0%	0%	0%	0%	76%	77%	77%	77%	77%	77%	0%	0%	0%	0%	0%	0%
Share petroleum products	64%	52%	52%	52%	42%	42%	23%	23%	23%	23%	23%	23%	85%	84%	84%	84%	84%	84%
Share gas	33%	43%	43%	43%	43%	43%	0%	0%	0%	0%	0%	0%	11%	11%	11%	11%	11%	11%
Share solar, wind, others	0%	0%	0%	0%	5%	5%	0%	0%	0%	0%	0%	0%	4%	5%	5%	5%	5%	5%
Share combustable renewables and waste	3%	4%	4%	4%	4%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FE excl. electricity per employee (ktoe/employee)	516	516	516	516	516	516	168	189	189	189	189	189	45	56	56	56	56	56
Electricity use per employee (ktoe/employee)	411	1135	953	953	953	953	163	242	204	204	204	204	43	170	143	143	143	143
Transport																		
Energy for aviation, annual growth rate	2.5%	5.0%	5.0%	4.8%	3.5%	5.0%	6.2%	3.8%	3.3%	3.3%	1.7%	3.3%	2.9%	4.0%	3.5%	3.5%	1.9%	1.9%
Energy for road transport, annual growth rate	4.8%	2.3%	0.3%	-2.1%	-3.9%	2.3%	2.1%	2.8%	2.3%	1.4%	-0.2%	2.3%	2.2%	3.0%	2.5%	1.6%	0.0%	0.0%
Energy for rail transport, annual growth rate	1.1%	1.0%	1.0%	4.8%	4.8%	1.0%	1.5%	0.0%	0.0%	2.7%	2.7%	0.0%	-1.0%	0.0%	0.0%	5.2%	5.2%	5.2%
Energy for navigation, annual growth rate	1.5%	4.9%	4.9%	4.9%	4.9%	4.9%												0.0%
Energy for total transport, annual grown rate	4.0%	3.1%	2.5%	1.8%	0.6%	3.1%	2.6%	2.8%	2.3%	1.7%	0.2%	2.3%	2.2%	3.0%	2.5%	1.8%	0.3%	0.3%
Agriculture and waste																		
Agriculture																		
Annual production growth (Livestock)		2.7%	1.5%	1.5%	0.6%	2.7%		3.3%	3.3%	2.5%	2.5%	3.3%		1.9%	1.3%	1.3%	0.5%	1.3%
Annual production growth (Use of fertiliser)		-0.9%	-0.9%	-0.9%	-0.9%	-0.9%		5.1%	5.1%	5.1%	5.1%	5.1%		1.2%	1.2%	1.2%	1.2%	1.2%
Annual production growth (crop production)		1.6%	1.6%	1.6%	1.6%	1.6%		2.5%	2.5%	2.5%	2.5%	2.5%		1.6%	1.6%	1.6%	1.6%	1.6%
Annual production growth (rice)		0.1%	0.1%	0.1%	-1.4%	0.1%		0.0%	0.0%	0.0%	0.0%	0.0%		0.9%	0.9%	0.9%	0.3%	0.9%
Annual change in emission factor (CH4 manure management)		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%
Annual change in emission factor (CH4 enteric fermentation)		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%
Annual change in emission factor (CH4 rice)		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%
Waste																		
Percentage of waste landfilled	43%	80%	80%	80%	80%	80%	57%	82%	82%	82%	82%	82%	54%	76%	76%	76%	76%	76%
Waste generation per capita	0.37	0.67	0.67	0.67	0.67	0.67	0.26	0.37	0.37	0.37	0.37	0.37	0.34	0.47	0.47	0.47	0.47	0.47
Methane conversion factor	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Fraction of potential CH4 emissions recovered	0%	1%	1%	10%	50%	1%	0%	1%	1%	10%	50%	35%	0%	1%	1%	10%	50%	20%
LUCF																		
Afforestation [MtCO2eq]	2.66%	-31	-31	-31	-31	-31	-1.49%	-9	-9	-9	-12	-12		4	4	4	-9	-9
Deforestation [MtCO2eq]	4.45%	0	0	0	0	0		0	0	0	0	0		67	67	67	67	67
Other LUCF [MtCO2eq]	-3.46%	3	3	3	3	3	-5.44%	-8	-8	-8	-8	-8		17	17	17	17	17
Emissions, annual growth	2.5%	-1.4%	-1.4%	-1.4%	-1.4%	-1.4%	0.6%	-0.9%	-0.9%	-0.9%	0.3%	0.3%	-1.4%	-0.1%	-0.1%	-0.1%	0.7%	0.7%

2.3.1 The power production sector

The power production sector includes total primary energy supply, including all final energy supply, as well as distribution and conversion losses. Historic values are mainly based on IEA 2008b.

Future demand for power production is a result of

- electricity and fuel demand as given as input from the demand sectors, industry, domestic, agriculture and waste as well as transport;
- the share of own use in other energy industry, including all energy transformation except power production, i.e. mainly coal transformation and petroleum refineries;
- distribution losses;
- conversion efficiency of electricity;
- imports and stock changes.

Where no country-specific data were available, we extrapolated historical trends.

Future emissions from this sector are determined by the overall primary energy supply as given above as well as by the fuel mix. The emission factors for all sectors are taken from IPCC 2006.

For all countries we assume a constant share of fuels in electricity production under the BAU until 2020, except for Mexico, where a significant shift toward gas is assumed, and Brazil, where the additional hydropower capacity is minimal, which will lead to an increasing share of fossil fuels. For the co-benefit scenario we usually assume 10% renewables in addition to hydropower, for the ambitious scenario 20%, except for Brazil, where the biomass potential is assumed to be 10% under the no regret and co-benefit and 30% under the ambitious scenario.

In all countries the efficiency of thermal power plants increases slightly under business-as-usual and reaches the current best value under the ambitious scenario.

Distribution losses, significant in Mexico, India and Brazil (according to the IEA dataset used) are constant under BAU, reduced slightly under no regret and co-benefit and reduced significantly under the ambitious scenario.

2.3.2 The industrial sector

In the industrial sector all manufacturing industry is included. Subsectors are iron and steel, cement, pulp and paper, and the rest of industry. Historic physical production values for iron, steel, cement, clinker, pulp and paper are taken from different country-specific sources. The rest of industry is not based on physical production. Energy demand values are mainly based on IEA 2008b. Emissions are mainly derived from energy consumption. Process emissions and non-CO_2 emissions are based on production values and USEPA 2006a.

Future development of energy demand in this sector is based on physical production trends for iron and steel, cement, pulp and paper, taken from country studies or trend interpolations mainly, combined with trends for specific energy consumption. For the rest of industry, energy demand is based on trend interpolations from historic years. Future emissions are then for all subsectors based on the fuel mix of all energy sources except electricity. Process and non-CO_2 emissions are based on production and on USEPA 2006a scenarios. Emissions for electricity generation are allocated to the power production sector.

For iron and steel we assumed that 10% of the energy input can be taken from renewables and waste already under the no-regret scenario in 2020, except for Brazil where it is currently already at 40%.

One option to reduce emissions in cement production is to decrease the percentage of the energy-intensive product clinker in the cement. We assume that this ratio declines to 65% in 2020 already as no-regret option due to decreasing energy costs. Renewable and waste fuels are assumed to be 30% in 2020 as no-regret option, as these fuels are usually available at lower costs than fossil fuels.

For pulp and paper we assumed 5% of the fuels from renewable sources as no-regret potential in 2020. These can be taken from the waste products from pulp and paper making. For the ambitious scenario we assumed 20% renewables, except for Brazil, where the current share of 66% is kept constant.

In the remaining industries we assumed a share of renewable fuels in 2020 of 5% under no-regret and co-benefit and 20% as ambitious, except where the current level is already higher (e.g. Brazil 33%).

For all sectors energy efficiency increases faster for countries with less efficient processes (often e.g. India) and more slowly for already efficient countries (often e.g. South Korea).

2.3.3 The domestic sector

The domestic sector includes private households as well as the commercial and public services sectors. Historic energy demand values are mainly based on IEA 2008b. Important input parameters are population and number of households as well as active labour force. Data on floor space and detailed use of electricity according to appliances would have been more accurate indicators but were not available for most countries.

Future energy demand for households was modelled based on the trends of the number of households with connection to the electricity grid, final energy demand per household and electricity use per household connected to the grid or per person with grid access. These were taken from country studies (see spreadsheets) or own estimates. Future energy demand for commercial and public services was modelled based on the number of people employed as well as on final energy and electricity use per employee. Future emissions for both subsectors are then based on the fuel mix of all energy sources except electricity. Emissions for electricity generation are allocated to the power production sector.

The reduction potential in this sector was difficult to estimate due to the lack of detailed data. Efficiency of appliances or heating demand per square meter are not available. These indicators could have been used to estimate the mitigation potential. We therefore made default assumptions on electricity consumption: in the domestic sector electricity use per capita in households is reduced by 16% in 2020 under the no-regret, co benefit and ambitious scenario and by an additional -7% under the co-benefit and the ambitious scenario due to solar hot water as long as electricity growth rates don’t become negative before 2020

In the commercial and services sector we assumed a reduction of the electricity consumption by 16% in 2020 as long electricity growth rates don't become negative before 2020

2.3.4 The agriculture and waste sector

The agriculture and waste sector includes, besides these two subsectors, also LUCF, unspecified others, e.g. fishing, and non-energy use of fossil fuels. Historic energy demand is based on IEA 2008b. Energy-related emissions are derived from fuel use, non-CO_2 emissions are mainly based on USEPA 2006a.

Agriculture

Future fuel demand for agriculture, the non-specified rest and non-energy use is based on population growth, demand in the last available year or population growth and trend interpolations for previous years, respectively. Energy-related emissions from agriculture and non-specified others are based on this fuel use. Non-energy related historical emissions and future scenarios in the agriculture sector (usually the larger part) are based on USEPA 2006a. Influencing factors include the change in livestock, use of fertilisers, manure management and others.

Waste

Future emissions resulting from waste management depend mainly on population growth, recovered methane, composition and share of landfilled waste as well as waste generation per capita. We assumed that under the co-benefit scenario 10% of the CH_4 from landfills is recovered as this has other side benefits to local pollution. The ambitious scenario assumes 50% recovery.

2.3.5 LUCF

We considered two scenarios for the LUCF sector: Business as usual and national climate change strategy.

The BAU calculations are based on the national submissions for the LULUCF sector to the UNFCCC. For the future emissions in BAU we assume that fewer efforts for afforestation are undertaken. We have reflected this in the calculation by reducing the values of woody biomass to 80% per year until 2020 based of the last historic year. This is applied to all countries but the Republic of Korea for which the BAU scenario is described below.

For the national climate change plan scenario we considered information in the national climate change plan on actions to stop deforestation and planned afforestation and applied to the BAU scenario to the category 'woody biomass'. For the other categories reported under UNFCCC in LUCF no information was available that we could use in a meaningful manner. In cases where no emission reduction potential of the actions was specified in the national plan we calculated it. For emission reductions from afforestation we used average growth rates for the afforestation area specified to calculate emission reductions through forest sinks. If a country's afforestation plans are to be reached before 2020 we assumed a reduction of the available stock of 5% per year afterwards.

From the Brazilian climate change plan (Government Brazil 2008b) we included assumptions on deforestation and afforestation. A total of 4.8 billion tons of carbon dioxide emission reductions through avoided deforestation in the Amazon are the objective (2006-2017). No further details are specified for other forest regions. We calculated the specified emission reductions per year and subtracted them from the BAU. For afforestation an increase of forest plantation area by a total of 5.5 million ha by 2020 was assumed.

In the national Climate Change Plan scenario for China we included the assumption that additional 50 Mt emission reductions are planned through afforestation by 2010 (Government China 2008).

In the national Climate Change Plan scenario for India we included the assumption on afforestation from the national plan that India aims to increase the area of forest plantations by a total of 10 million ha by 2012 (Government India and Planning Commission 2008).

In the national Climate Change Plan scenario for Mexico we included the assumption on afforestation from the national plan to increase the area of forest plantations by a total of 3 million ha by 2017 (Government Mexico 2007).

For South Africa national assumptions on afforestation state to increase the area of forest plantations by 10,000 ha per year between 2007 and 2017 (Taviv et al. 2007).

For South Korea the BAU scenario is calculated differently than for the other countries. The national plan foresees a decrease in the net removals from the LUCF sector. The net removals from land use change and forestry sector between 2000 and 2020 are estimated to fall by 1.4% annually. As we assume that these reductions would take place even without the national plan being implemented in the BAU because they result from not actions we have applied the calculations based on the national climate plan to the BAU scenario starting 2005. As no additional actions in the LUCF sector are specified in the national climate plan the scenarios are assumed to be the same (Government South Korea 2003).

2.3.6 The transport sector

The transport sector includes national and international aviation, road transport of persons and freight, rail transport and domestic navigation. Historic energy consumption is based on IEA 2008b.

Future sector performance is mainly based on fuel demand trends related to GDP growth, efficiency gains and shifts among means of transportation. We choose this comparatively simple methodology based on expert judgements because more precise parameters such as modal split, kilometres per person or tonne and number of cars were not available for most countries. Only for South Korea the data availability was better.

Emissions in the transport sector are derived from fuel use. As the share of non-CO_2 emissions is very small it is included in the industry sector.

2.4 Sensitivity analysis

2.4.1 Parameter sensitivity

Due to high uncertainties in future developments and extrapolation of data we included a sensitivity analysis. This includes selected parameters for each sector (see Table 5). The parameters are selected for two extreme cases: one leading to very high emissions (high case) and one leading to comparatively low emissions (low case). The results are given in the country chapters.

Table 5 Parameters changed for maximum and minimum sensitivity

Sector	Parameter	High emissions case	Low emissions case
Power	Share of emission free sources	-3 percentage points	+3 percentage points
Industry	Annual growth rate of energy demand in pulp and paper production	+2 percentage points	-2 percentage points
Industry	Annual growth rate of energy demand in cement production	+2 percentage points	-2 percentage points
Industry	Annual growth rate of energy demand in iron and steel production	+2 percentage points	-2 percentage points
Domestic	Annual growth rate of energy demand in households	+20%	-20%
Domestic	Annual growth rate of energy demand in commercial and services	+30%	-30%
Agriculture	Annual growth rate of livestock	+30%	-30%
Waste	% of waste landfilled	+5 percentage points	+5 percentage points
Waste	Waste generation per capita	+10%	-10%
LUCF	Carbon factor (t C/ha/year)	-50%	+50%
Transport	Energy consumption	+30%	-30%

2.4.2 Cost sensitivity

The assumptions on costs are highly uncertain. As we used different sources often more than one cost estimate is available. The cost sensitivity was calculated separately from the sensitivity described above. For the cost sensitivity we used the upper and the lower cost estimate if this was available. If no range could be derived from the sources available we assumed a change of +30% (high case) and -30% (low case). The results are included in the country chapters.

2.5 Global approaches to effort sharing

To compare the scenarios developed here with global effort sharing proposals we use the Evolution of Commitments (EVOC) tool. This is described in more detail in Appendix B.

First, we developed the scenarios described in this report.

Second, we chose parameters for EVOC to share the effort to reach 450 ppmv in the long term among countries. We assumed that global emissions in 2020 may not be higher than 10% above 1990 emissions to meet this target.

We analysed five different approaches: Contraction and Convergence (C&C), Common but Differentiated Convergence (CDC), Greenhouse Development Rights (GDRs), Global Triptych and the South-North Dialogue Proposal. The calculations do not include LUCF explicitly. Descriptions of these proposals and the parameters we used can also be found in Appendix B.

Third, we scaled the effort sharing results to the scenarios of this report. The reference scenarios in the EVOC tool for all countries are different to the reference scenario calculated for this report due to several reasons. To make the scenarios and the effort sharing calculations comparable we scaled them. Depending on the general approach behind each effort sharing proposal we scaled the values as percentage change from 1990 (C&C, CDC) or percentage deviation from BAU (GDRs, South North, Triptych).

2.6 Possible Elements of Low-Carbon Development Strategies

Finally, the report aims to outline possible elements of Low-Carbon Development Strategies (LCDS) for the six countries until 2020. The elements are based on the analysis of emission reduction potential and related costs as outlined above.

The report first discusses definitions and modalities for nationally appropriate mitigation actions (NAMAs) and LCDS in general. Based on the discussions so far under the FCCC and within literature, the report suggests modalities for the development of NAMAs and LCDS as well as for measuring, reporting and verification. On this basis, the report discusses possible elements of LCDS for the above mentioned six countries.

Regarding the level of ambition, the discussed elements of LCDS are based on the following two considerations:

- Where possible, the level of ambition is matched to the analysis of global effort sharing proposals as outlined above. For several countries the effort sharing proposals come to very similar results: Mexico, South Africa and South Korea. In these cases, the effort that would be required according to the effort sharing proposals was taken as guideline.
- In other cases the effort sharing proposals show very different results. Some countries would have very steep requirements according to some effort sharing approaches and very lenient ones according to others. This applies to Brazil, China and India. In these cases, we considered that the countries should as a minimum aim at mobilising their co-benefit potential, as these measures would yield macro-economic benefits for their economies.

If the text uses high amounts of comparative data, tables are provided for quick reference at the end of the respective section. The data is assessed using the following rough scale.

Level of Effort	Score
National Climate Change Plan (NCCP) scenario is substantially less ambitious than, as applicable, the allocation from the effort sharing approaches or the co-benefit potential scenario	-2
NCCP scenario is less ambitious than, as applicable, the allocation from the effort sharing approaches or the co-benefit potential scenario	-1
NCCP scenario is about equal to, as applicable, the allocation from the effort sharing approaches or the co-benefit potential scenario	+1
NCCP scenario is substantially more ambitious than, as applicable, the allocation from the effort sharing approaches or the co-benefit potential scenario	+2

As a caveat, it should be noted that experience from industrialised countries shows that it may be too simplistic to expect developing countries to mobilise no-regret or co-benefit potential mainly from their own resources, as often put forward as a position in the negotiations. Industrialised countries also dispose of gigatonnes of no-regret potential and yet have so far not been very successful in actually achieving these emission reductions. Typically, a whole range of formidable financial, institutional, and technical information and capacity barriers prevent implementation. Just as industrialised countries will have to significantly scale up policies and measures including public financial support to tap their own no-regret potential, developing countries may require significant capacity building and financial support to mobilise their no-regret potential. An analysis of prevailing barriers and measures that are necessary to overcome them should form a key part of LCDS. Such considerations are beyond the scope of this study, though.

As a further caveat it has to be noted that the information used to construct the NCCP scenario in this report was often patchy. At the time of writing, most of the NCCPs were not very clear on details. The assessments and suggestions for improvement contained in this report are therefore only indicative.

As a final caveat it should be noted that most global effort sharing proposals suggest emission reduction targets for industrialised countries that go substantially beyond what most industrialised countries have so far offered. Emission reductions between 30% and 60% below 1990 emissions in 2020 are required for Annex I as a whole under the effort sharing approaches applied in this report. It could therefore be argued that proposing developing countries to match their efforts to the allocations under the global effort sharing approaches would require industrialised countries to do the same. At the moment, the pledges by industrialised countries add up to less than 20% below 1990 levels.

3 Brazil

3.1 Brazil's national climate change strategy

The 'National Plan on Climate Change' (Government Brazil 2008b) was published in December 2008. It includes aspired reduction measures that target the following sectors:

- Energy
- Forestry and Agriculture
- Industry
- Waste
- Transport.

Figure 15 shows the distribution of the CO_2 emissions in Brazil in 1994. According to this split the majority of the Brazilian GHG emissions are located in the forestry sector (75 %).

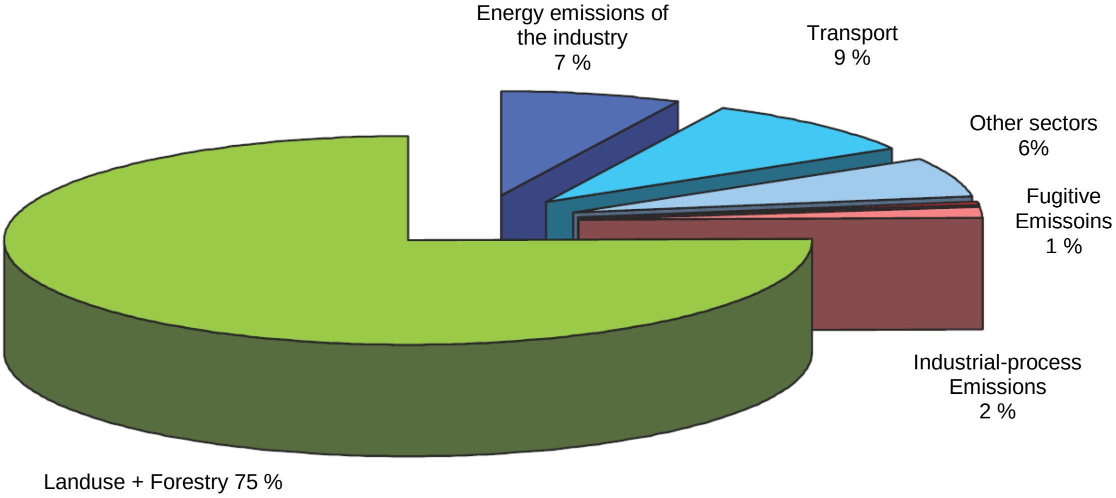

Figure 15 Brazil's CO_2 emissions in 1994

The sections following briefly describe the climate protection measures in the individual sectors

3.1.1 Energy

In comparison to other countries, Brazil has a high share of renewable energy sources. In 2007 this share was 45.8%, of which 30.9% result from biomass use and 14.9% from hydropower. Only looking at electricity, the share of hydropower makes up for 77.3% compared to a 3.5%-share from biomass.

The actions of the climate plan are based in principle on three pillars:

1) Increase of the share of renewables, clean energy and biofuels
2) Reduction in energy consumption (energy efficiency)

3) Reduction of emissions from liquid fuel and gas combustion

1a) Increase of the share of renewables (implemented measures):

(i) It is already agreed that hydropower will be further developed. As part of 'Plano Decenal de Expansão de Energia - PDE 2007/2016' it was agreed that 34.360 MW 2007-2016 will be developed. The investment will be 90 Billion Real[3] within the timeframe of 2010 und 2016.

(ii) In March 2004 the Ministry of Mining and Energy (Ministério de Minas e Energia (MME)) and the Brazilian energy company Centrais Elétricas Brasileiras S.A. (Eletrobrás) have agreed a concept for the development of renewables called PROINFA. As part of this programme 144 new power plants based on renewable energy will be built until 2009. The installed capacity will be 3.299,40 MW. These will be split as follows:

Wind power: 1,422.92 MW

Small hydro[4] (PCH, Pequena Central Hidrelétrica): 1,191.24 MW

Biomass: 685.24 MW

The total investment volume of this programme is 11 billion Real (3.7 billion €) and the saving potential is 2.8 $MtCO_2$ per year.

(iii) Since 2005 the Brazilian government is active in the area of auctioning.

(iv) An expansion of the national power supply in areas of poor or no grid connection is planned by the MME. Through this action inefficient fuel-based power plants (diesel) will be replaced. This is planned for the next ten years and has a saving potential of emissions of 11 $MtCO_2$ equivalents.

(v) Another programme is 'Light for all' (2003-2010), which focuses on providing electricity to the rural population. A part of this project shall be financed through CDM. The total investment is 12.7 Billion Real.

(vi) Development of nuclear power plants to increase capacity from 2,007 MW to 3,087 MW until 2013.

1b) Increase of the share of renewables (planned measure):

(i) Increase of photovoltaic (PV). No special measures are planned so far. First of all, everyone should benefit from the 'Light for all' programme (see above). Second, silicon production should be established within Brazil. Third, the possibilities to feed electricity generated from PV into the grid shall be improved.

(ii) Use of domestic waste for energy production. The combustion of waste is not accepted in the Brazilian culture. Therefore, the use of landfill gas is suggested. Depending on the type of use a potential of 1,230 MW to 8,440 MW from domestic waste until 2030 is estimated.

1c) Use of biofuels (implemented measures):

The use of biofuels is of high interest in Brazil. It is estimated that the demand for bioethanol will increase from currently 25.6 billion litres to 53.2 billion litres

[3] 1 Brazilian Real being 0.34 Euro (1 December 2008)
[4] < 30MW

until 2017. The export of ethanol is expected to increase from currently 4.2 billion litres to 9 billion litres within the same period.

(i) A support programme called Proalcool has been put in place. As part of this programme it is planned that between 2008 and 2012 80 new bioethanol plants will be built. The investment volume is 33 billion US$, of which 23 billion will be used in the industry sector and 10 billion for the agriculture sector.
(ii) On 1 July 2008 a programme to support the production of biodiesel has been approved. Based on this normal diesel has to be blended with a minimum of 2% - 3% biodiesel. Today 43 biodiesel plants exist in Brazil. Including the already approved plants there will be 96 plants in total. These plants have a total production capacity of more then 4 billion litres per year.
(iii) Biomass: 50% of the Brazilian biomass production is from naturally grown wood (tropical rainforest). To reduce the rate of deforestation, it is planed to intensify the cultivation of biomass plants.

1d) Use of biofuels (planned measures):

The establishment of a certification system for biofuels covering the complete production process is discussed in Brazil. In addition, wood waste shall be used in more efficient ways to achieve a higher energy return.

2a) Reduction in energy consumption - energy efficiency (implemented measures):

In Brazil, the energy saving potential through implementation of energy efficiency measures is estimated to be 32 TWh. To improve the situation the following programmes are currently implemented:

(i) Programme to label energy consuming products (1984): This programme has been voluntary so far but has now become mandatory for 33 product categories.
(ii) Programme to save energy, Procel (1985): The programme has saved up to date about 25 TWh and has an investment volume of 1 billion Real.
(iii) Programme to rationalise derivatives from oil and gas (CONPET) (1991): The programme supports the more efficient use of fossil fuels in the transport, building, service, and industry sectors. Through the implementation of CONPET about 300 Billion litres of diesel are saved per year, which is about 20 $MtCO_2e$.
(iv) Programme for energy efficiency of the distributing companies PEE (2000): Every year, distributing companies have to invest 0.5% of their turnover into energy efficiency projects. Up to date, 2 billion Real have been invested and 1700 MW of installed capacity have been installed due to this programme.
(v) Energy Efficiency law (2001): The Energy Efficiency law sets rules for the consumption levels of appliances. This includes: refrigeration devices, electric engines, water heaters, light bulbs, etc. Together with the label 'PROCEL' (see above) every year 4 TWh have been saved so far.

2b) Reduction in energy consumption - energy efficiency (planned measures):

(i) Further development of PROCEL and CONPET (see above): The successful programmes PROCEL and CONPET which were in place only until 2006 shall be re-implemented with a more efficient and improved concept.

(ii) Programme to support the development of energy efficient cooling devices: As part of this programme within the next 10 years estimated 10 million inefficient cooling devices shall be replaced. This has a saving potential of 14 TWh or 7 $MtCO_2$. In addition 5 Mt FCKW cooling liquids shall be replaced.

(iii) Labelling of very heavy machinery: At first the labelling shall be on a voluntary basis but shall become mandatory at a later stage. The goal is to develop awareness and provide incentives to even further increase the already high level of biofuels (43% in transport sector)

(iv) Programme to support the use of solar thermal power: So far 90% of the warm water supply is provided through electricity. It is estimated that the warm water production is responsible for 5 % of the total Brazilian electricity production. The implementation of solar thermal power is assumed to save 2,500 GWh every year. To achieve this, 14 million square meters would have to be covered with solar thermal devices. These shall be installed until 2015. (In 2006, 3 million m^2 were installed.)

(v) Energy efficiency labelling for commercial and public buildings: 42% of the Brazilian energy consumption is used in the building sector (23% housing, 11% commercial, 8% public buildings). In commercial and public buildings most energy is used for air conditioning (48%) and lightning (24%). The labelling shall include air conditioning, lightning, insulation and energy efficiency. Classes between A and E shall be defined.

(vi) Strategic Energy Efficiency Programme (Programa Estratégico de Eficiência Energética – PEEEf): This programme sets the goal to reduce the Brazilian energy consumption trough strategic energy efficiency measures by 10% until 2030. This would save about 130 TWh per year.

(vii) Development of CHP: Currently CHP makes up only about 0.5%. Unused potential shall be used in the future.

3) Reduction of emissions from liquid fuel and gas combustion

3.1.2 Forestry and agriculture

Implemented Measures: maintaining biomass

A high level programme of the Brazilian Government is to reduce the deforestation in the Brazilian Amazon region by 72% until 2017 (reduction of 40% in the first four years, 30% in the second four years, and 30% in the third four years, reaching five thousand km^2 in 2017). Main areas of action are the following:

- Avoidance of illegal slash and burn activities
- reduction of open fires e.g. through BBQs in the forests
- Reduction of illegal logging
- Improvements in precautionary measures to avoid forest fires
- Reduce the process of privatisation of public land through establishment of conservation areas.
- Implement sustainable management of conservation and forest areas
- Increase the personnel to monitor the forest and reduce illegal logging and slash and burn activities.

3.1.3 Industry

1. Implemented measures

a. Climate-friendly iron and steel production

Worldwide, Brazil is one of the few countries using charcoal for iron and steel production. Currently, the share of charcoal is about 5-10%, depending on the sector. The use of charcoal instead of fossil coking coal leads to reduced emissions of about 3 tCO_2 per tonne of iron.

Therefore, the use of charcoal for iron and steel production should be increased. However, this faces several barriers. Major problems are the appropriate delivery of charcoal and the cultivation of land needed for charcoal production because it takes at least ten years from planting to final charcoal.

b. The Brazilian Programme for the establishment of a voluntary greenhouse gas inventory according to the GHG-Protocol

The Brazilian Ministry of the Environment, together with the Foundation Getulio Vargas, the Brazilian Trade Association for Sustainable Development, the World Resource Institute, and the World Business Council for Sustainable Development, initiated a programme for establishing greenhouse gas inventories for the Brazilian industry. The following sectors are taking part in this programme: iron and steel production, cosmetics industry, automotive industry, energy production, food industry and the paper industry. Since 12 May 2008 workshops have been taking place where also the financial and service sector as well as government organisations took part.

The programme has the following purposes:

- Diffusion of the calculation and reporting methods of the GHG-Protocol standards
- Identification and development of methodologies for implementing a voluntary programme for emission reporting according to the GHG-Protocol standard for private and public sectors
- Setup of an easy-to-access data base for companies; the data base should include important data for collection and inventory of greenhouse gas emissions
- Setup of a public data base for publishing the company inventories
- Providing the possibility of exchange between private and public institutions on the establishment of greenhouse gas inventories

c. Phase-out of substances regulated under the Montreal Protocol

Since 2002 Brazil has been successfully establishing a programme for the phase-out of CFCs and now prepares a programme for the phase-out of HCFCs. According to this CFCs programme it has been prohibited to produce or import CFCs since January 2007. Small quantities for medical products are exempt from this regulation until 2010. Due to the phase-out of CFCs about 360 $MtCO_2e$ will be emitted less.

While preparing the phase-out of HCFCs a consumption of 751,422 t HCFCs was assumed for the period between 2008 and 2010. This would be about 1,078 Mt CO_2e for this period.

However, it has to be noted that substitution products for CFCs and HCFCs normally have a high greenhouse gas potential as well. This means that the simple phase out of CFCs and HCFCs does not necessarily lead to direct emissions reductions.

2. Planned measures

Proposal to establish a programme for supporting the use of renewable energy in industry

To support the use of renewable energy sources operators of combustion plants with a capacity of more than 100 MW shall be granted investment assistance.

3.1.4 Waste

Use of landfill gas

Landfilling of municipal solid waste leads to about 12% of the Brazilian methane emissions. Therefore, currently, the use of landfill gas is one of the biggest sectors for implementing CDM projects.

3.1.5 Transport

National Plan for Transport and Logistics (PNLT)

The PNLT shall improve the Brazilian goods traffic system regarding energy efficiency and compatibility with the climate. Therefore, relevant data shall be collected, and the modal shift from road to rail and water ways shall be promoted. The share of rail-based goods traffic (currently 25%) shall increase to 32% during the next 15 to 20 years. The share of water-based goods traffic (currently 13%) shall increase to 29% during the same period.

The needed investment for infrastructure projects until 2023 is assumed to amount to about 172 billion Real. From this, 43% shall be used for road construction projects and 29% shall be used for rail construction.

The PNLT also includes recommendations for public transport. Currently, emissions from the Brazilian aviation sector increase by 12% annually. Detailed analyses are needed and future measures are to be decided.

3.2 Implementation of Brazil’s national climate strategy

The national climate change strategy (Government Brazil 2008a) covers all relevant sectors (energy, forestry and agriculture, industry, waste and transport). It provides a list of measures but the resulting reductions are only quantified for a few measures.

A significant number of measures are not quantifiable with the information provided. These include measures such as the possible establishment of a certification system for biofuels or a further development of important programmes such as PROCEL (Programme to save Energy) and CONPET (Programme to rationalise derivatives from oil and gas). At this point it is not possible for the authors to judge the overall impact of all such measures because they are often too vague and it is not clear which of the proposed measures are additional actions or are already included in existing programmes.

We included several measures from the Brazilian climate strategy into this report (Table 6). Some are based on detailed estimates from the plan itself. For some measures we made rough assumptions ourselves. However, several non-quantifiable measures are included in the national strategy that could not be considered.

Table 6 Measures from Brazil's national climate strategy as included in this report

Sector	Plans and measures	Implementation in this report
All	Reduce carbon content of Brazilian GDP	Included, but as output value, not as input value into the model
All	Reduction in electricity consumption of around 10% (106 TWh = 9114 ktoe) in 2030, resulting in 30 Mt CO_2 reduction.	Reduction of specific energy consumption in several sectors; own estimate: at least 6% or 5470 ktoe by 2020
Electricity	Keep high share of 89% (2007) of renewable energy sources	Renewable share in electricity 88% in 2020
Electricity	Increase electricity supply from cogeneration, mainly from sugarcane bagasse, to 11.4% (136 TWh) of total supply by 2030	Increase of CHP not possible because not enough heat demand included in the model. Biofuels in electricity can only be increased a bit because of very high share of hydro power
Electricity	Reduction of non-technical losses in the electricity distribution at a rate of 1,000 GWh per year between 2008 and 2018, which currently are around 22,000 GWh per year. This will represent a reduction in energy wastage of 400 GWh per year. On average, around 25% (100 GWh per year) of this energy will no longer be produced by thermo power plants.	Reduction of distribution losses in electricity production from 17% to 3% between 2005 and 2020
Electricity	Hydroelectricity: 34,460 MW from new hydropower plants to be added to the system in accordance with the schedule of works of the Ten Year Energy Plan (2007-2016) Expansion of electricity supply will include 95,000 MW from hydropower plants between 2005 and 2030	Maintain high share of hydro power in spite of increasing electricity demand
Energy fuels	Ethanol: encourage industry to achieve an average annual consumption increase of 11%; should prevent the emission of 508	Increase of combustible renewables in industry

Sector	Plans and measures	Implementation in this report
	$MtCO_2$ between 2008 and 2018	
Energy in Industry	Use sustainable charcoal instead of coal for steel production	Increase of combustible renewables in industry
Transport	Obligation to add 5% of this biodiesel to normal diesel by 2010	Increase share of combustible renewables by 5% and keep about 4-5% above BAU until 2020
Energy in households	Solar heating: reducing electricity consumption by 2200 GWh (190 ktoe) per year by 2015 due to increased solar heating	Reducing electricity due to solar heating by 200 ktoe by 2020
Waste	Increase waste recycling by 20% by 2015	Assumption that this also leads to methane recovery → increase of recovered methane to 10%
LUCF	Eliminate the net loss of forest coverage by 2015: double the area of forest plantations from 5.5 million ha to 11 million ha in 2020 Avoid emissions of around 4.8 billion tCO_2 between 2006 and 2017	Afforestation: 5.5 million ha between 2008 and 2020; distributed equally per year Avoided deforestation: 4800 Mt CO_2 avoided between 2006 and 2017, equally distributed per year

3.3 Results on reference emissions, mitigation potential and costs

Figure 16 shows Brazil's greenhouse gas emissions under the business-as-usual (BAU) scenario and four different emission reduction scenarios as calculated in this report. The scenario parameters are based on national studies as far as possible. Major sources for future data in Brazil are Centro Clima et al. 2006, USEPA 2006b, the national climate change plan (Government Brazil 2008b) and trend extrapolation of official national and IEA statistics (IEA 2008b).

As illustrated in Figure 16 (left), the reduction potential for Brazil is 5% (no-regret), 9% (co-benefit) and 37% (ambitious potential) and 25% (national climate change plan) below BAU. The three sectors with the highest GHG emission-reduction potential between 2005 and 2020 (ambitious potential) are the (1) LUCF, (2) transport and (3) the power sector. The ambitious mitigation potential in the LUCF sector is estimated at 486 $MtCO_2eq$ in 2020. In the transport sector, there exists an ambitious potential of 169 $MtCO_2eq$. The ambitious potential in the power sector is estimated at 68 $MtCO_2eq$ in 2020. The total ambitious mitigation potential in Brazil is estimated at 863 $MtCO_2eq$ in the year 2020. A detailed overview of the potential per sector and scenario can be found in Appendix A 1, detailed mitigation measures and costs in Appendix A 2.

On the right side Figure 16 shows the high and low case results of the sensitivity analysis. The high case leads to 95 to 150 $MtCO_2eq$ more compared to the default settings, which are about +5 to +8%. The low case leads to about -90 to -150 $MtCO_2eq$, which are about -5 to -9%.

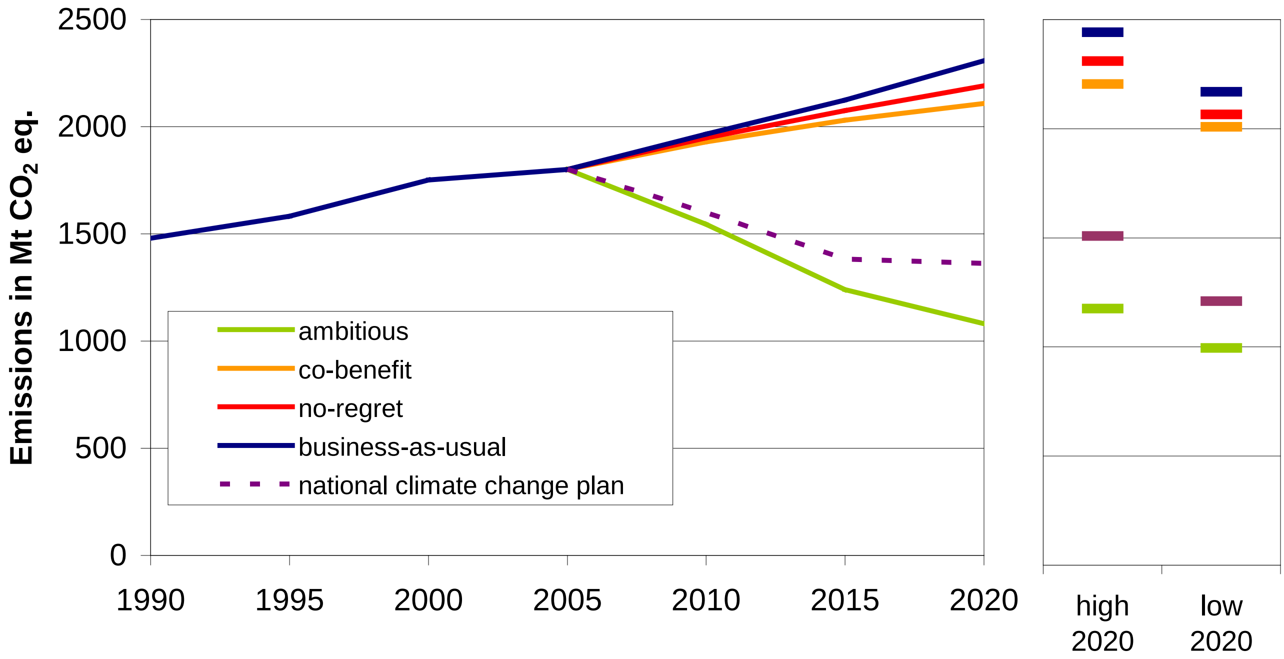

Figure 16 Brazil's national emissions and reduction potential under the BAU and all reduction scenarios between 1990 and 2020 (left) and the sensitivity analysis (right)

3.3.1 Costs

Figure 17 provides Brazil's emission reduction potential in 2020 per sector always compared to the reference scenario in relation to the indicative costs in €/year in 2020. The no-regret and co-benefit scenarios incur relatively little costs, while the ambitious scenario requires substantial resources. Emission reductions in the LUCF sector are most significant, but the costs of halting deforestation are very uncertain.

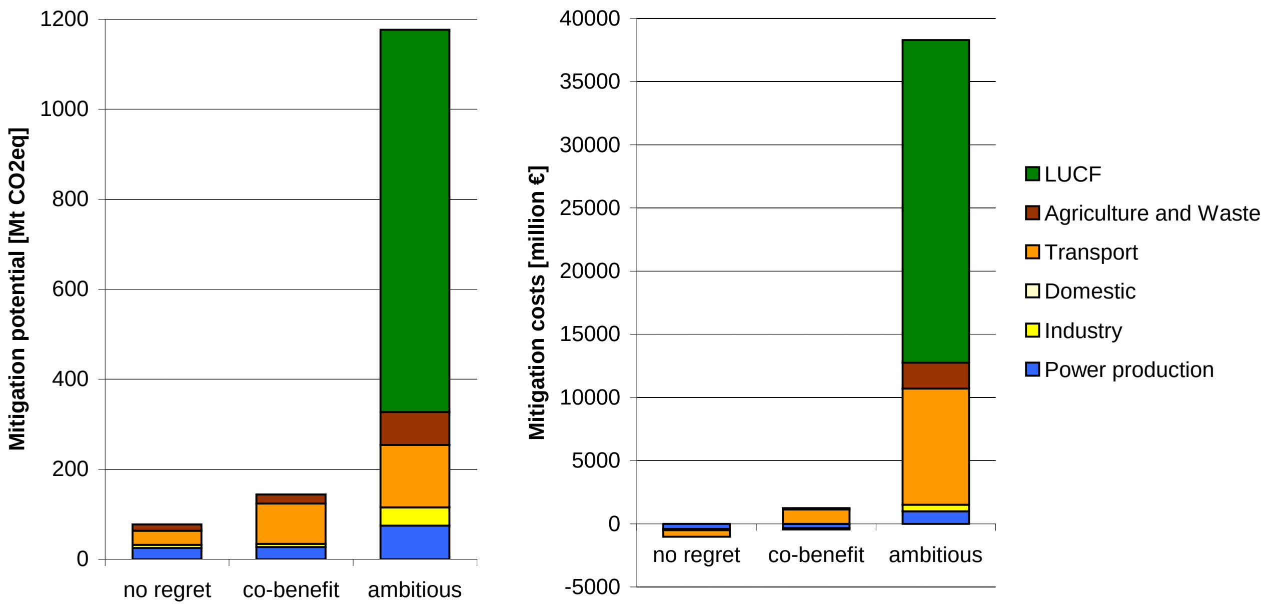

Figure 17 Brazil's emission reduction potential in 2020 per sector always compared to the reference scenario and related indicative costs in €/year in 2020

Figure 18 gives an estimate of Brazil's marginal abatement costs in 2020 under the three reduction scenarios. The no-regret scenario includes costs between -160 and 0 Euro per tonne of CO_2 reduced (yellow curve). The co-benefit scenario includes costs between -160 and 75 Euro per tonne of CO_2 reduced (yellow + orange curve). The ambitious scenario includes costs between -160 and 180 Euro per tonne of CO_2 reduced (yellow + orange + green curve).

The dotted lines give the range of costs that result from the sensitivity analysis. For Brazil a major part of this sensitivity range is below the costs given here for the no-regret potential. For the ambitious scenario the uncertainty is very high for a considerable part of the mitigation potential; a large part of the sensitivity range lies above the costs estimated here.

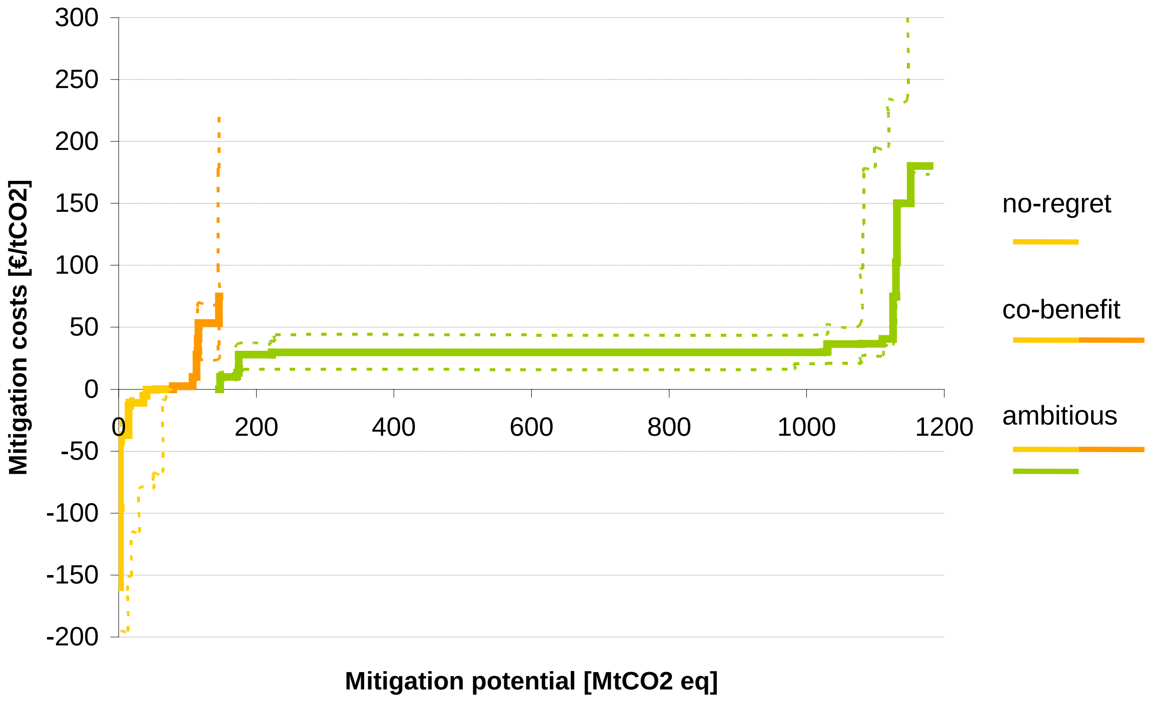

Figure 18 Brazil's mitigation potential and indicative costs in 2020 as marginal abatement cost curve (dotted lines show the cost uncertainty range)

3.3.2 Results per sector

Figure 19 shows Brazil's total reduction potential at sector level under the ambitious potential scenario compared to the business-as-usual scenario and the remaining emissions according to sectors. Figure 20 to Figure 25 show Brazil's national emissions and reduction potential under the BAU and all reduction scenarios per sector.

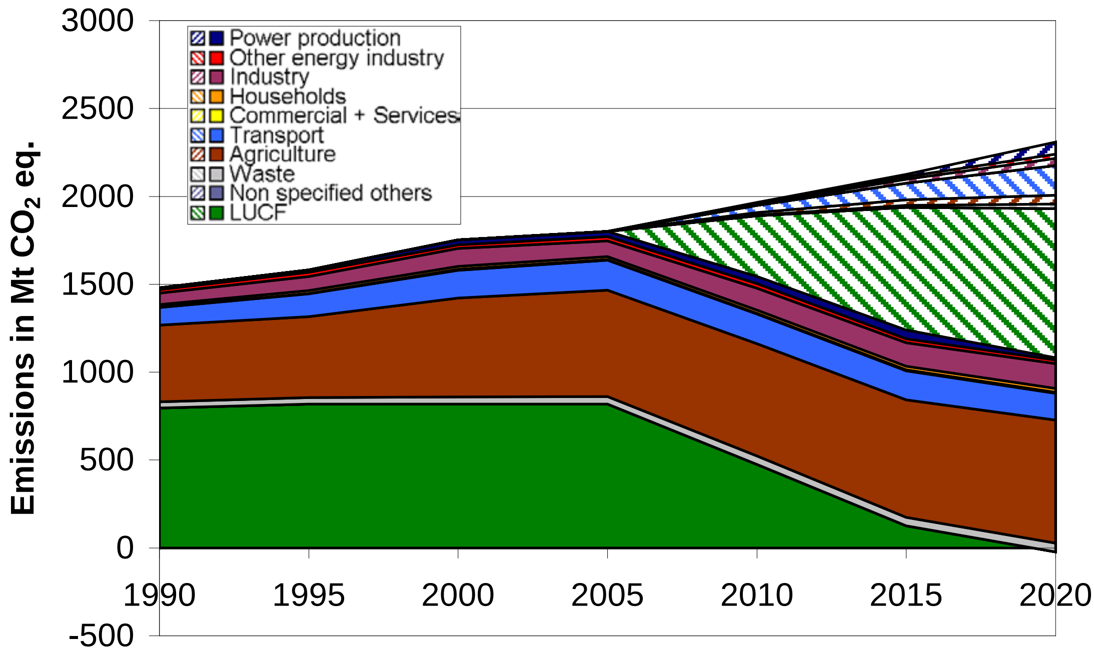

Figure 19 Brazil's national emissions and reduction potential per sector under the BAU and the ambitious scenario between 1990 and 2020. Striped areas show the sectoral emission reduction potential under the ambitious potential scenario compared to BAU.

Since power generation (Figure 20) is largely based on hydropower, the emission reduction potential of current installations is limited. However, new capacity may be built based on fossil fuels. A crucial issue is the availability of financial resources to meet the large investment requirements associated with hydropower and sugar cane bagasse-fired generation capacity. Potential for further hydropower is however decreasing. Distribution losses can be significantly reduced and efficiency improvements in the fossil fuel power plants are available. Under all scenarios a substantial potential exists. Under the ambitious scenario the emission trend could even decrease in the future.

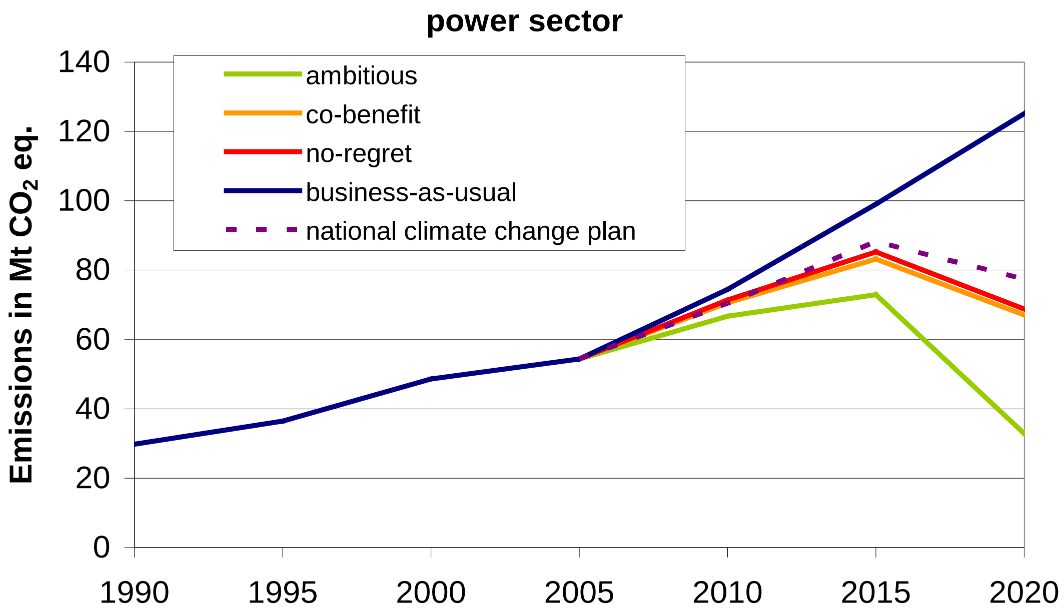

Figure 20 Brazil's emissions and reduction potential under the BAU and all reduction scenarios in the power sector between 1990 and 2020

The industry sector (Figure 21) already uses a high share of renewable energy sources such as charcoal (if the wood is taken from the rain forest it is not considered renewable) and sugar cane bagasse. There is potential for energy efficiency improvements in many industrial branches, one fifth of which can be achieved at no costs. Especially under the ambitious potential and the national climate change plan a considerable reduction potential was identified.

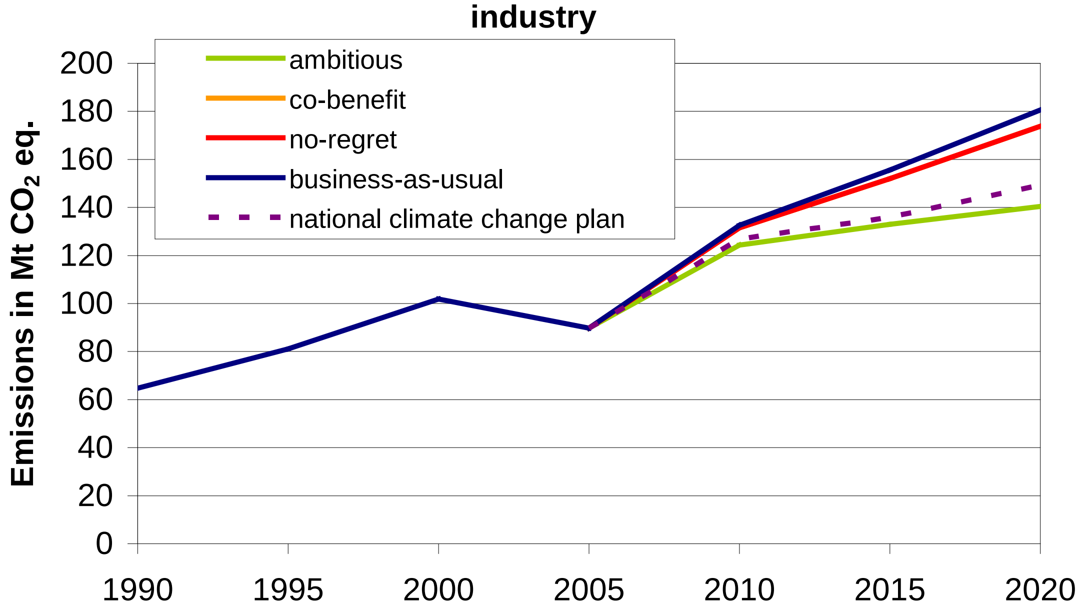

Figure 21 Brazil's emissions and reduction potential under the BAU and all reduction scenarios in the industry sector between 1990 and 2020

In the domestic and services sector (Figure 22) the increase of energy efficiency is considered under all reduction scenarios. Additionally, solar heating plans were considered in the national climate plan. However, the emission reductions are not visible in this sector but in the energy sector, where the electricity is produced. The reduction potential will probably be higher for this sector than what we considered. Due to limited data availability the potential could not be fully taken into account.

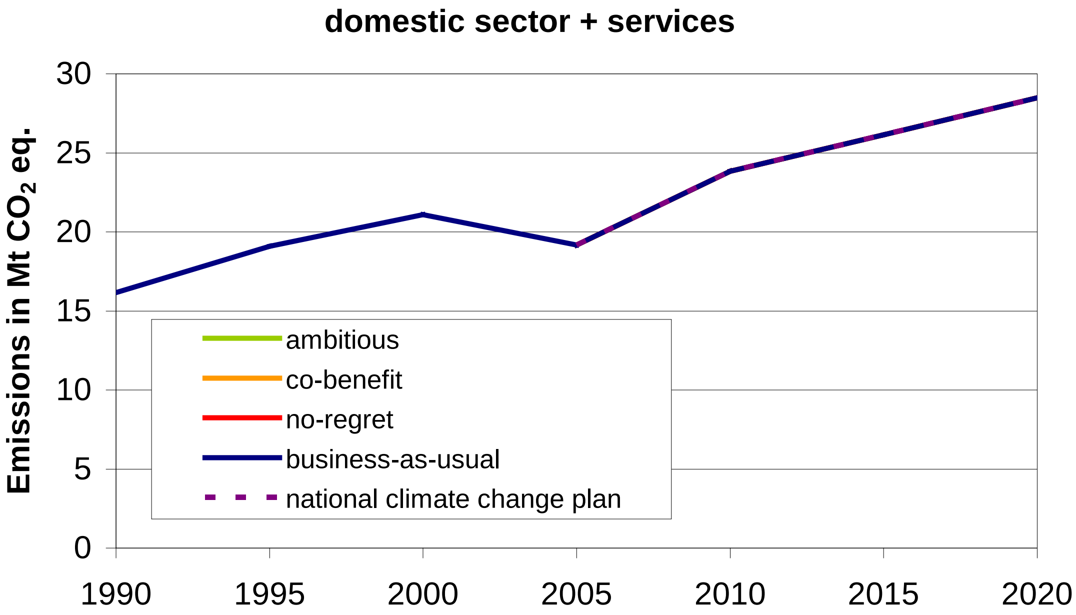

Figure 22 Brazil's emissions and reduction potential under the BAU and all reduction scenarios in the domestic and services sector between 1990 and 2020

The transport sector (Figure 23) offers big opportunities for mitigation. There is potential for significantly increasing the production and use of biofuels such as ethanol from sugar cane and biodiesel from vegetal oils. Energy efficiency improvements in vehicles (cars, trucks, buses) may play an important role. The building of energy efficient transport infrastructure both for passengers and freight (railways, waterways, and mass public transportation) would be crucial to avoid the lock-in effect on GHG emissions from perpetuating the current overwhelming reliance on road and individual transport. The reduction potential is considerable, especially under the co-benefit and the ambitious scenario.

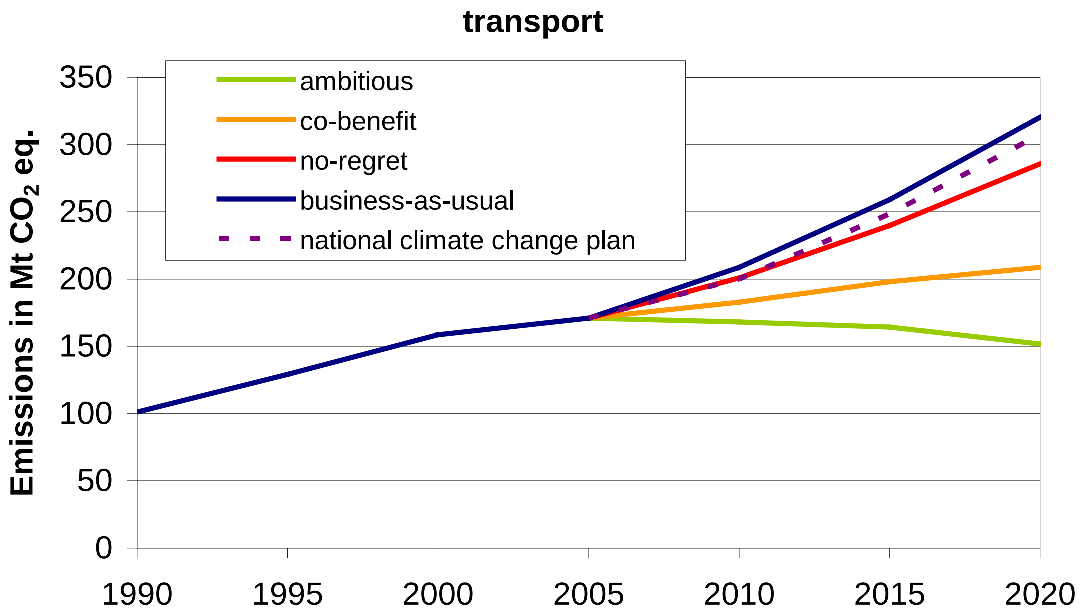

Figure 23 Brazil's emissions and reduction potential under the BAU and all reduction scenarios in the transport sector between 1990 and 2020

Some limited reduction potential is available in the agricultural and waste sector (Figure 24), e.g. through optimised use of fertilisers.

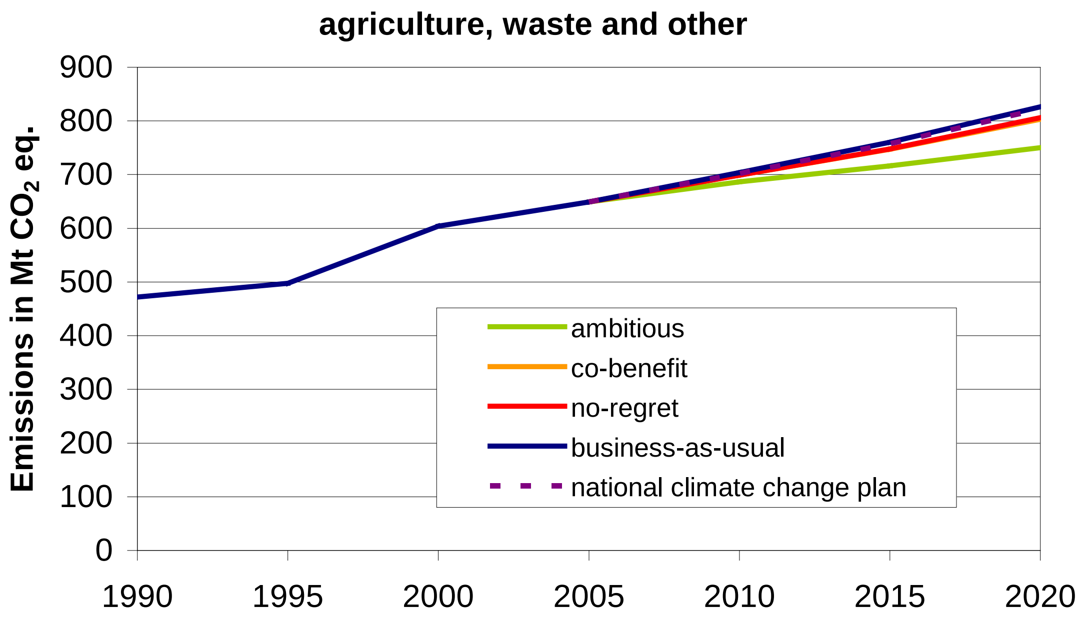

Figure 24 Brazil's emissions and reduction potential under the BAU and all reduction scenarios in the agriculture, waste and other sector between 1990 and 2020

The national plan on the LUCF sector (Figure 25) offers a significant reduction potential, mainly based on avoided deforestation. It is the largest mitigation achieved from the national plan. Implementation of this ambitious goal requires a significant change from the past trend with enforcement of the policies.

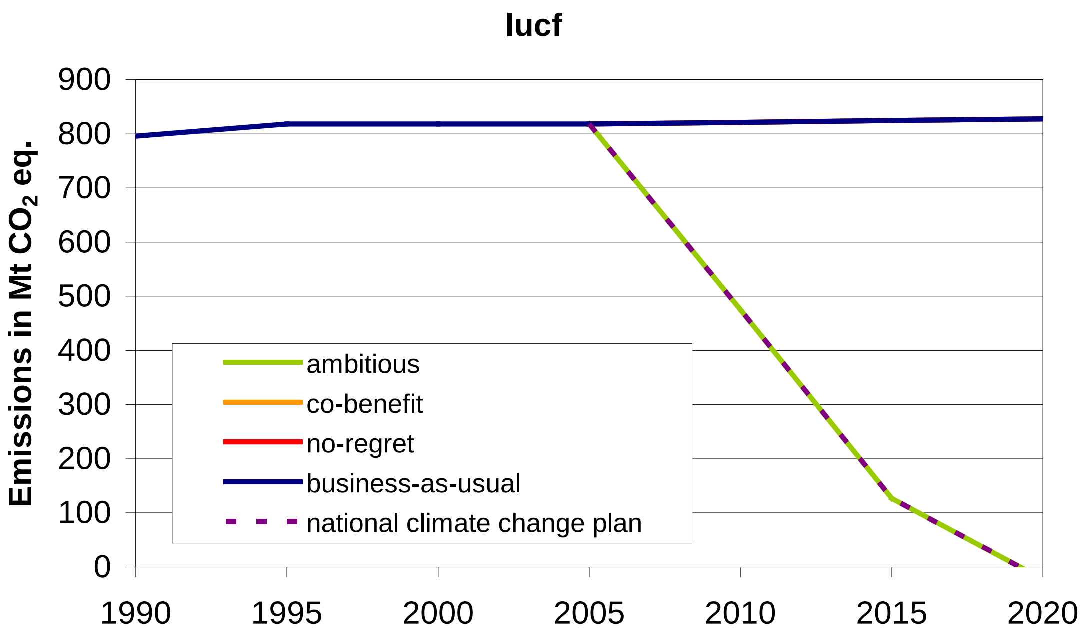

Figure 25 Brazil's emissions and reduction potential under the BAU and all reduction scenarios in the LUCF sector between 1990 and 2020

Most important findings for Brazil:

- Brazil's emissions are projected to increase constantly by about 1.4% per year between 2000 and 2020 due to development and a related increase of transport and energy demand per capita under the business-as-usual scenario. However, this trend could be changed considerably depending upon the policies and measures implemented to curb deforestation in the Amazon region, as the bulk of Brazilian GHG emissions comes from LUCF. This issue is mainly one of governance, as it relates to the capacity of enforcing already existing laws and regulations, and it is not easily translated into mitigation costs.
- In 2005, most emissions resulted from LUCF and agriculture (79%), followed by the transport (9%) and the industry sectors (5%). Under the business-as-usual scenario, this trend is assumed to be similar, but strongly influenced by the outcome of governance issues on LUCF emissions, as mentioned above.
- The three sectors with the highest GHG emission-reduction potential between 2005 and 2020 under the ambitious potential are the LUCF, transport and the power sector.
- Under the no-regret potential scenario reductions of 5% below BAU (22% above 2005 emissions) are possible. Under the co-benefit potential scenario reductions of 9% below BAU (17% above 2005 emissions) are feasible. Under the ambitious potential scenario reductions of 37% below BAU (20% below 2005 emissions) are possible. According to our interpretation of Brazil's national climate change plan reductions of 25% below BAU (4% below 2005 emissions) are possible, but depend strongly on achieving the ambitious deforestation goal.

3.4 Comparison to other sources

3.4.1 Comparison to BAU scenarios from national reports and national climate strategy

Brazil developed a very comprehensive and detailed national plan on climate change (Government Brazil 2008b). However, this does not include national estimates on BAU development or impacts of the described emission reduction measures on national emissions.

3.4.2 Comparison to 2008 report

The most relevant sector in Brazil is the LUCF sector. Emission estimates in this sector face many uncertainties. In the 2008 report we did not consider emission reductions in this sector. The historical level from the 2008 report was taken from Houghton et al. 2006, while the present report starts from the value stated in the national communication, which is less than half. Therefore, a huge difference in absolute emissions can be seen for Brazil compared to Höhne et al. 2008.

Furthermore, emissions from industry grow slightly slower in this report, due to changed historic data.

3.4.3 Comparison to global effort-sharing approaches

Figure 26 compares the outcomes of the scenarios described above (left) to outcomes for Brazil from different global effort-sharing approaches (right) that are compatible with stabilising GHG concentrations at 450 ppmv CO_2eq. Effort sharing results were calculated without LUCF and then scaled to the reduction scenarios. This is particularly important for Brazil as LUCF significantly contributes to its total emissions.

CDC and C&C lead to a relatively high amount allowances, due to the current low per capita emission level of Brazil. The results are in the range of the co-benefit and no-regret scenarios. The Triptych, South North and GDRs approaches lead to a low level of allowances at about 1500 Mt CO_2eq, since they are largely based on the high GDP per capita of Brazil. This is between the national plan and the ambitious scenario.

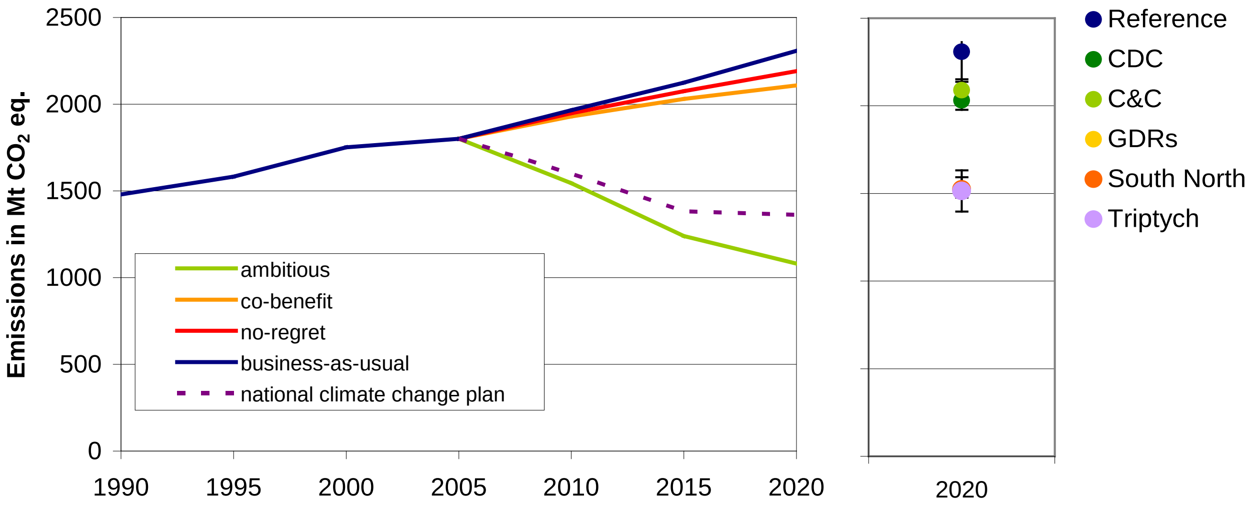

Figure 26 Brazil's emission allowances according to the developed scenarios (left) compared to different global effort-sharing approaches in 2020 (right)

4 China

4.1 China's national climate change strategy

Within the 'National Climate Change Programme' (NDRC 2008) the goals of the Chinese Government are very clearly laid out and specific goals for the different areas/sectors are provided.

The Chinese position towards Kyoto is very clear: 'As a country of responsibility, China will seriously fulfil its commitments under the Convention and the Kyoto Protocol.'

The summary below is based on the original text and focuses on areas where quantitative goals were provided.

To address climate change China plans to look about the following points:

- To give full effect to the Scientific Approach of Development;
- To promote the construction of a socialist harmonious society;
- To advance the fundamental national policy of resources conservation and environmental protection;
- To control GHG emission and enhance sustainable development capacity;
- To secure economic development;
- To conserve energy, to optimise energy structure, and to strengthen ecological preservation and construction;
- To rely on the advancement of science and technology;
- To enhance the capacity to address climate change.

China plans to continue to actively tackle climate change issues in accordance with its national sustainable development strategy in the future.

4.1.1 Objectives

The strategic goal of China to respond to climate change is to make significant achievements in controlling greenhouse gas emissions, to enhance the capability of continuous adaptation to climate change, to promote climate change related science, technology and R&D to a new level, to significantly raise public awareness on climate change, and to further strengthen the institutions and mechanisms on climate change. According to this strategic goal, China will make great efforts to achieve the following specific objectives by 2010.

To control greenhouse gas emissions

- Accelerating the transformation of economic growth patterns; China will achieve the target of about 20% reduction of energy consumption per unit of GDP by 2010, and consequently reduce CO_2 emissions.
- Optimising energy consumption structure. The target is to raise the proportion of renewable energy (including large-scale hydropower) in primary energy supply up to 10% by 2010, the extraction of coal bed methane up to 10 billion cubic meters.
- Reinforcing industrial policy governing metallurgy, building materials, and chemical industry; developing a circular economy; raising resource utilisation efficiency, and strengthening emission control of nitrous oxide. By 2010, the

emissions of nitrous oxide from industrial processes will remain stable as that in 2005.

- Promoting the adoption of low-emission and high-yield rice varieties, promoting biogas utilisation to control the growth rate of methane emissions.
- Increasing the forest coverage rate to 20% and realising the increase of carbon sinks by 50 million tons over the level of 2005 by 2010.

To enhance capacity of adaptation to climate change

- Through strengthening farmland infrastructure, adjusting cropping systems, selecting and breeding stress-resistant varieties and developing bio-technologies and other adaptive countermeasures, the targets by 2010 are to increase the improved grassland by 24 million hectares, restore the grassland suffering from degradation, desertification, and salinity by 52 million hectares, and strive to increase the efficient utilisation coefficient of agricultural irrigation water to 0.5.
- Through strengthening the natural forest conservation and nature reserve management. By 2010, 90% of typical forest ecosystems and national key wildlife are effectively protected and nature reserve area accounts for 16% of the total territory; and 22 million hectares of desertified lands are under control.
- By 2010, the vulnerability of water resources to climate change would be reduced by effective measures. At that time, the anti-flood engineering systems in large rivers and the high standard for drought relief in farmland will be completed.
- By 2010, the construction and expansion of mangroves will be completed, the capability to resist marine disasters will be raised remarkably, and the social influence and economic losses caused by sea level rise will be reduced in maximum through scientific monitoring of sea level change and regulation of the ecosystem of marine and coastal zone areas and through taking the measures of rationally exploiting the coastline and coastal wetland and construction of coastal shelterbelt system.

To enhance R&D

- China will work hard to keep up with international advanced research on climate change in some fields by 2010, so as to provide an effective and scientific basis for the development of the national strategy and policy on climate change, and scientific guidance for participation in international cooperation on climate change.
- In order to build up a strong scientific support to address climate change, China will work hard to build up its independent innovation capacity, to promote international cooperation and technology transfer, to achieve breakthroughs in R&D on energy development, energy conservation and clean energy technology, and to significantly enhance the adaptation capacity of agriculture and forestry by 2010.

To raise public awareness and improve management

- By means of modern information dissemination technologies, to strengthen communication, education and training to raise public awareness and participation in climate change.
- To further improve the inter-ministerial decision-making and coordination mechanism on climate change, China will establish a suitable and highly efficient institutional and management framework to address climate change in the future.

4.1.2 Key areas for GHG mitigation

Energy production and transformation

(1) Formulate and implement relevant laws and regulations
(2) Strengthen institutional innovation and mechanism construction
(3) Intensify relevant policies and measures in energy industry

- Properly develop hydropower on the precondition of protecting the ecosystem. Hydropower development should be regarded as an important countermeasure to promote a cleaner and less carbon intensive energy mix in China. Through the countermeasures mentioned above, it is expected that the GHG emissions can be reduced by about 500 $MtCO_2$ by 2010.
- Actively promote the development of nuclear power. Through the countermeasures mentioned above, it is expected that the GHG emissions can be reduced by about 50 $MtCO_2$ by 2010.
- Expedite technology advancement in thermal power generation. Through the countermeasures mentioned above, it is expected that the GHG emissions can be reduced by about 110 $MtCO_2$ by 2010.
- Vigorously develop coal-bed methane (CBM) and coal-mine methane (CMM) industry. Through the abovementioned countermeasures, it is expected that the GHG emissions can be reduced by about 200 $MtCO_2eq$ by 2010.
- Promote the development of bio-energy. Through the abovementioned countermeasures, it is expected that the GHG emissions can be reduced by about 30 $MtCO_2eq$ by 2010.
- Actively support the development and utilisation of wind, solar, geothermal and tidal energy. Through the abovementioned countermeasures, it is expected that the GHG emissions can be reduced by about 60 $MtCO_2$ by 2010.

(4) Strengthen the development and dissemination of energy conservation technologies in key sectors

- Iron and steel industry:
- Nonferrous metal industry:
- Oil and petrochemical industry:
- Building material industry:
- Transportation:
- Agricultural machinery
- Building
- Commercial and residential energy conservation

(5) Further carry out the 10 key energy conservation priority programmes in the Medium-and-Long-Term Energy Conservation Plan

Actively promote the implementation of the 10 key energy conservation programmes, namely the Upgrading of Low-efficiency Coal-fired Industrial Boiler (Kiln), District Heat and Power Cogeneration, Recovery of Residual Heat and Pressure, Oil Saving and Substitution, Energy Conservation of Motor System, Optimisation of Energy System, Energy Conservation in Buildings, Green Lighting, Energy Conservation in Government Agencies, Building the Energy Conservation Monitoring, and Technological Support System. Ensure the progresses and effects of these key programmes to achieve stable capacity for energy conservation as early as possible. Through the implementation of these ten programmes, it is estimated that 240 Mtce can be conserved during the 11th five-year plan period (2005-2010), equivalent to 550 $MtCO_2$ reductions.

Other areas of action:

- Industrial processes
- Agriculture
- Forestry
- Municipal wastes

4.2 Implementation of China's national climate strategy

The national climate change strategy of China (Government China 2008; Government China and National Development and Reform Commission 2007; NDRC 2008) includes some quantified emission reduction measures with their respective emission reduction potential. An overall baseline and mitigation scenario is not provided. The Chinese 'National Action Plan on Climate Change' does not mandate any additional mitigation actions, but summarizes the efforts undertaken in different policy areas which have a greenhouse gas mitigating effect. Consequently, it is sometimes unclear which of the proposed measures are additional actions or already in existing programmes. It is very hard to quantify the mitigating effects of many of the measures for which numerical data is not provided, this includes spending on research and development, emission reduction in sectors with many decentralized sources (e. g, through standards in the building and transport sectors), etc.

We included several measures from China's climate strategy into this report (Table 7). Some are based on detailed estimates from the plan itself. For some measures we made rough assumptions ourselves. However, several non-quantifiable measures are included in the national strategy that could not be considered.

Table 7 Measures from China's national climate strategy as included in this report

Sector	Plans and measures	Implementation in this report
All	Reduce energy intensity 20% (energy consumption per unit GDP); 700 Mt CO_2 reductions between 2005 and 2010 compared to baseline; 1,500 MT CO_2 reduction in 2010 compared to no intensity change.	Included as output value, not as input value into the model
All	General energy efficiency. Promote implementation of the 10 key energy conservation programmes. These are estimated to save 240 Mtce during the 11th five-year plan period (2005-2010), equivalent to 550 Mt CO_2 reductions.	Considered but not included explicitly as input.
Power production	Raise the proportion of renewable energy (including large-scale hydropower) in primary energy supply up to 10% by 2010, 16% of all energy is to come from wind, biomass, solar, and hydroelectric energy Renewable Energy Law Wind, solar, geothermal, and tidal energy expected to	Included as increase of renewable share in several sectors; share of 16% in 2020

Sector	Plans and measures	Implementation in this report
	have a total reduction of 60 Mt CO_2 by 2010. Bio-energy is expected to create a 30 Mt CO_2e reduction by 2010. Hydroelectricity development is expected to reduce emissions by 500 Mt CO_2 by 2010.	
Power production	Promote nuclear power: Operating power capacity to hit 40 GW by 2020 from 8.6 GW in 2008; 50 Mt CO_2 reduction by 2010	Share of nuclear increased by 1 percentage point to reduce about 50 Mt CO_2
Power production	Improve efficiency; Close 50 GW of small, inefficient and dated power plant capacity by 2010 and develop 600 MW or above supercritical (SC) or ultrasupercritical (USC). 70-80%of new installations will be SC/USC units; Improve coal to electricity efficiency from 366 to 345 Gt coal equivalents per kWh from 2006 to 2020. 110 Mt CO_2 reductions by 2010.	Increase efficiency in electricity production by 7 percentage points compared to BAU
Power production	Develop coal bed methane industry; China targets 10 billion cubic meters of gas production by 2010 and 40 CBM by 2020. The 11th five year plan (2006-2010) also calls for the construction of 10 CBM pipelines	Assumption: 5% less methane emitted compared to BAU; between 2010 and 2020
Industry	Reinforcing industrial policy governing metallurgy, building materials, and chemical industry; developing a circular economy; raising resource utilization efficiency, and strengthening emission control of nitrous oxide. By 2010, N_2O emissions from industrial processes will remain at 2005 levels	Reduction of specific energy consumption, reduction of clinker-cement-ratio and increase share of natural gas.
Residential and services	Establish energy efficiency appliance standards; reduce residential electricity use by 20% by 2010 In 2010, 33.5 billion kilowatt-hours and GHG emissions are expected to be reduced by 11.3 Mt of CO_2, as a result of standards and labels for refrigerators, air conditioners, clothes washers, and colour televisions.	Reduce electricity use per capita by about 5 percentage points by 2020.
Agriculture	Promoting the adoption of low-emission and high-yield rice varieties, the rice cultivation technique of semi-drought, and scientific irrigation technology; strengthening the R&D on outstanding ruminant animal breeds and large-scale breeding and management techniques; reinforcing the management on animal wastes, wastewater and solid wastes, and promoting biogas utilization to control the growth rate of methane emissions.	Increase manure management, decrease rice emission factor, increase of combustible renewables

Sector	Plans and measures	Implementation in this report
LUCF	Increasing the forest coverage rate to 20% and realizing the increase of carbon sink by 50 million tons over the level of 2005 by 2010. Measures in this regard include: continuously carrying out the policies and measures on afforestation, returning farmland to forest and grassland, and natural forest protection, and basic construction for farmland and other key engineering construction.	Increased afforestation leads to sink of 50 $MtCO_2$ in 2010 and 25 $MtCO_2$ in 2020;

4.3 Results on reference emissions, mitigation potential and costs

Figure 27 shows China's greenhouse gas emissions under the business-as-usual (BAU) scenario and four different emission reduction scenarios as calculated in this report. The scenario parameters are based on national studies as far as possible. Major sources for future data in China are Chen et al. 2006, USEPA 2006b, the national climate change plan (Government China 2008; Government China 2004) and trend extrapolation of official national and IEA statistics (IEA 2008b).

As illustrated in Figure 27, the reduction potential for China is 4% (no-regret), 12% (co-benefit) and 39% (ambitious potential) and 28% (national climate change plan) below BAU. The three sectors with the highest GHG emission-reduction potential between 2005 and 2020 (ambitious potential) are the (1) power, (2) industry and (3) the other energy industry sector. The ambitious mitigation potential in the power production sector is estimated at 2565 $MtCO_2eq$ in 2020. In the industry sector, there exists an ambitious potential of 1342 $MtCO_2eq$. The ambitious potential in the other energy industry sector is estimated at 477 $MtCO_2eq$ in 2020. The total ambitious mitigation potential in China is estimated at 5063 $MtCO_2eq$ in the year 2020. A detailed overview of the potential per sector and scenario can be found in Appendix A 1, detailed mitigation measures and costs in Appendix A 2.

On the right side Figure 27 shows the high and low case results of the sensitivity analysis. The high case leads to 340 to 510 $MtCO_2eq$ more compared to the default settings, which are about +4 to +5%. The low case leads to about -340 to -540 $MtCO_2eq$, which are about -4 to -6%.

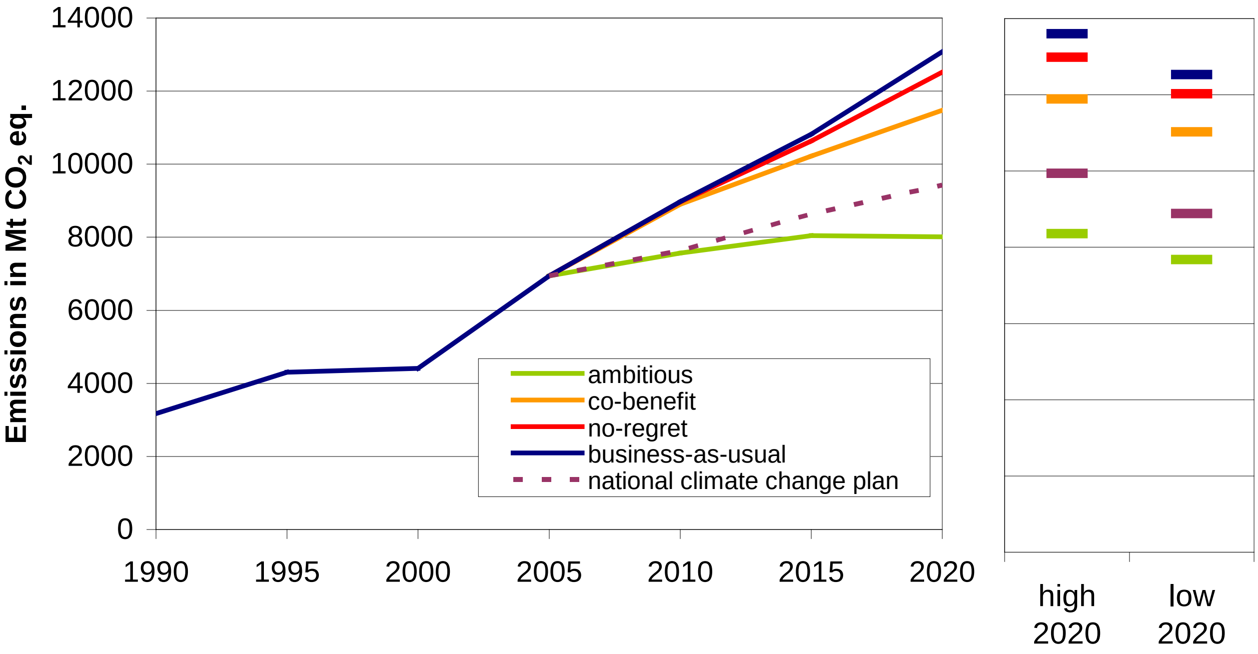

Figure 27 China's national emissions and reduction potential under the BAU and all reduction scenarios between 1990 and 2020 (left) and the sensitivity analysis (right)

4.3.1 Costs

Figure 28 provides China's emission reduction potential in 2020 per sector always compared to the reference scenario in relation to the indicative costs in €/year in 2020. Significant no-regret potential exists in the industry sector and electricity savings in the domestic sectors. Major additional co-benefit potential is in the power sector. High-cost measures can reduce emissions further in all sectors.

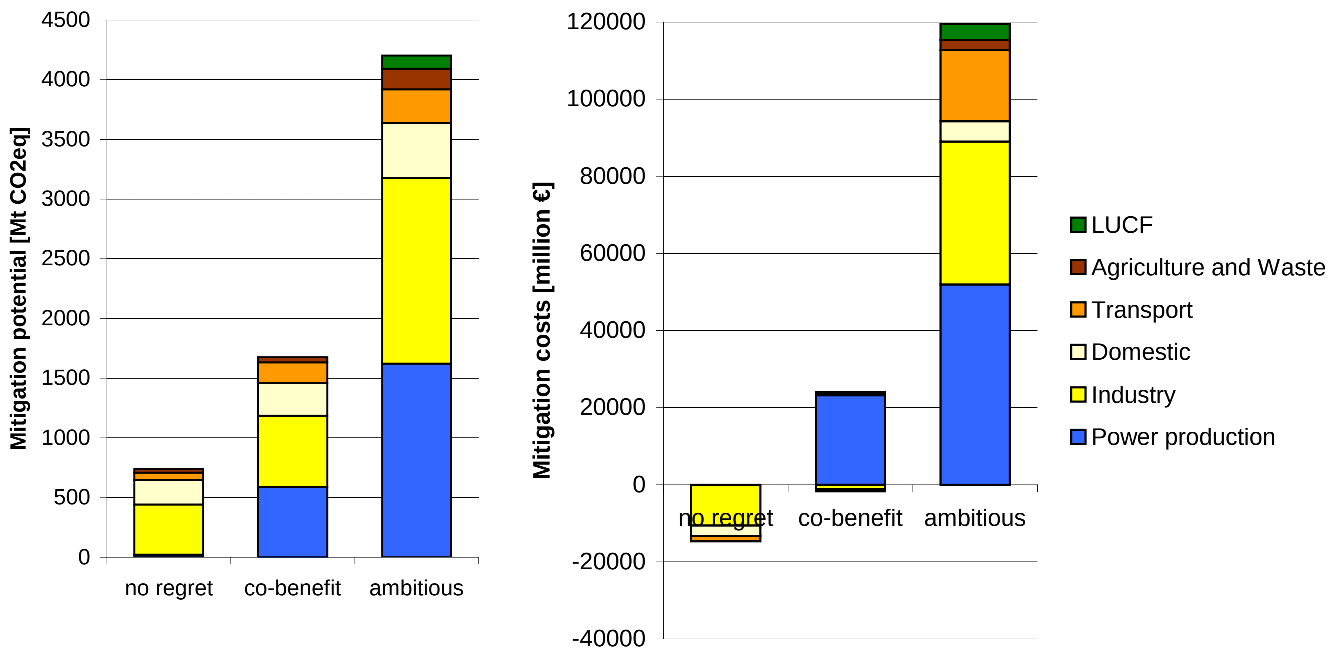

Figure 28 China's emission reduction potential in 2020 per sector always compared to the reference scenario and related indicative costs in €/year in 2020

Figure 29 gives an estimate of China's marginal abatement costs in 2020 under the three reduction scenarios. The no-regret scenario includes costs between -160 and 0 Euro per tonne of CO_2 reduced (yellow curve). The co-benefit scenario includes costs between -160 and 75 Euro per tonne of CO2 reduced (yellow + orange curve). The ambitious scenario includes costs between -160 and 180 Euro per tonne of CO_2 reduced (yellow + orange + green curve).

The dotted lines give the range of costs that result from the sensitivity analysis. For China a major part of this sensitivity range is below the costs given here for the no-regret potential. For the ambitious scenario the uncertainty is very high for a considerable part of the mitigation potential; a large part of the sensitivity range lies above the costs estimated here.

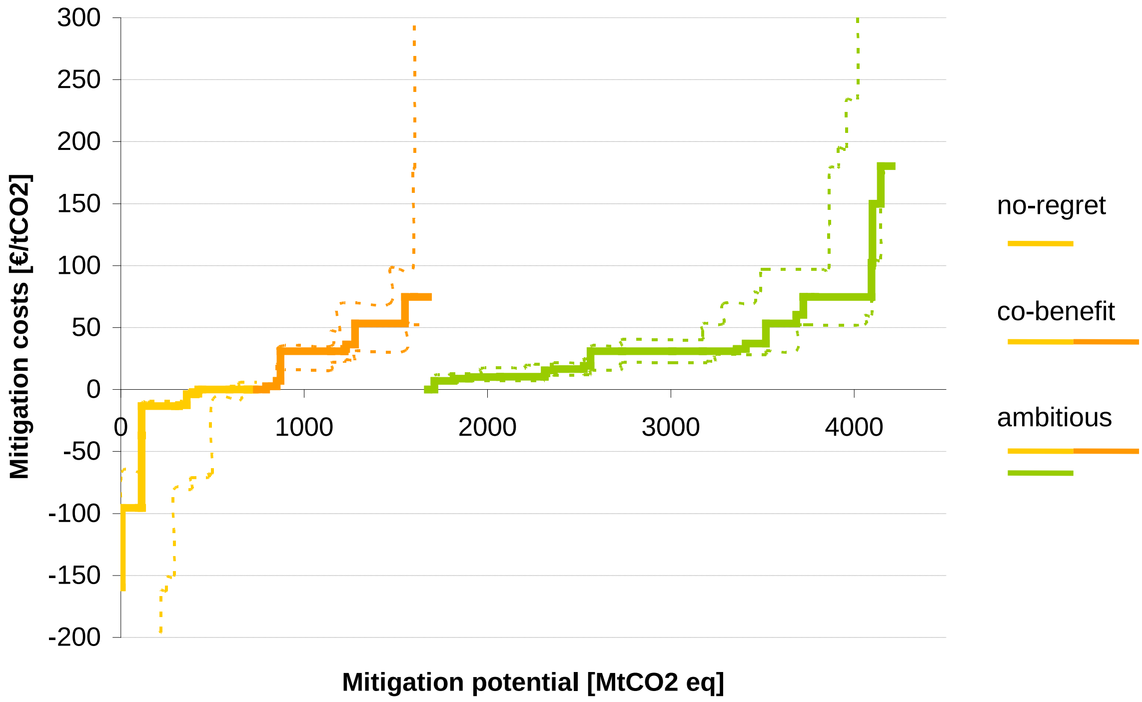

Figure 29 China's mitigation potential and indicative costs in 2020 as marginal abatement cost curve (dotted lines show the cost uncertainty range)

4.3.2 Results per sector

Figure 30 shows China's total reduction potential at sector level under the ambitious potential scenario compared to the business-as-usual scenario and the remaining emissions according to sectors. Figure 31 to Figure 36 show China's national emissions and reduction potential under the BAU and all reduction scenarios per sector.

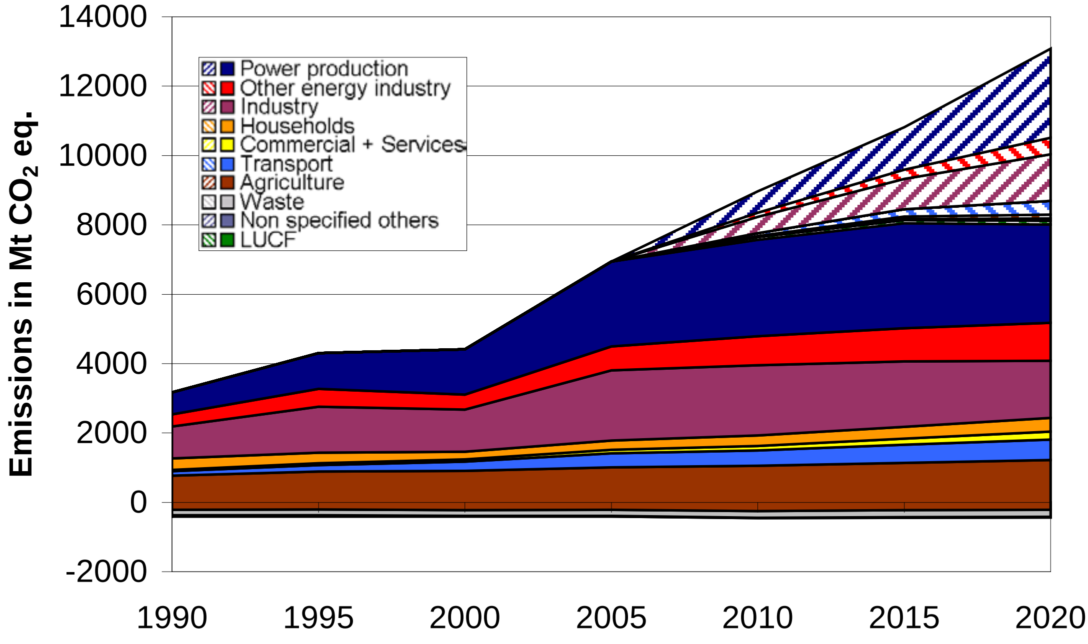

Figure 30 China's national emissions and reduction potential per sector under the BAU and the ambitious scenario between 1990 and 2020. Striped areas show the sectoral emission reduction potential under the ambitious potential scenario compared to BAU.

In the power sector (Figure 31), a major reduction opportunity would be to move away from coal to renewable energy sources (under optimistic assumptions). Energy end-use efficiency especially in industry can contribute reductions. We also assumed 1% of electricity generation with CCS technology by 2020 as ambitious potential. The reduction potential is substantial, especially under the national climate plan and the ambitious scenario. Under the no-regret scenario emissions are even above the BAU. This is due to a shift to electric energy in the demand sectors in order to decrease energy demand and emissions across all sectors. The measures included in the national plan are close to the ambitious scenario. The no-regret and co-benefit scenarios are higher than the reference since measures in other sectors move energy use from less GHG-efficient fuels towards electricity.

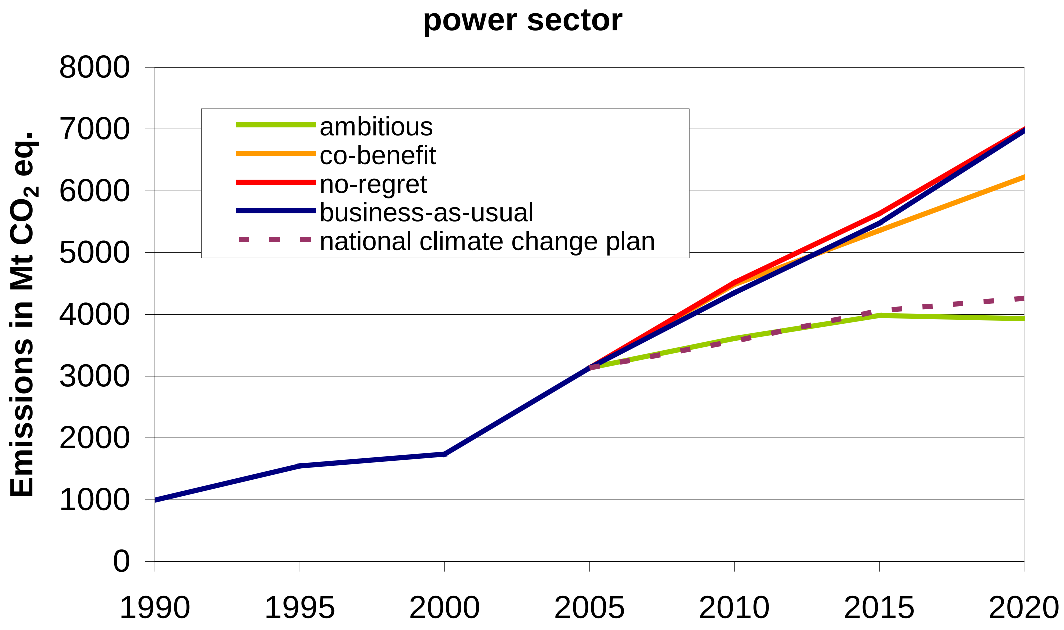

Figure 31 China's emissions and reduction potential under the BAU and all reduction scenarios in the power sector between 1990 and 2020

In industry (Figure 32), the move to renewable energy sources, efficiency improvements and process changes are major reduction options. Emission reductions are considerable under all scenarios. The very strong efficiency goals in the national plan are here part of the ambitious scenario.

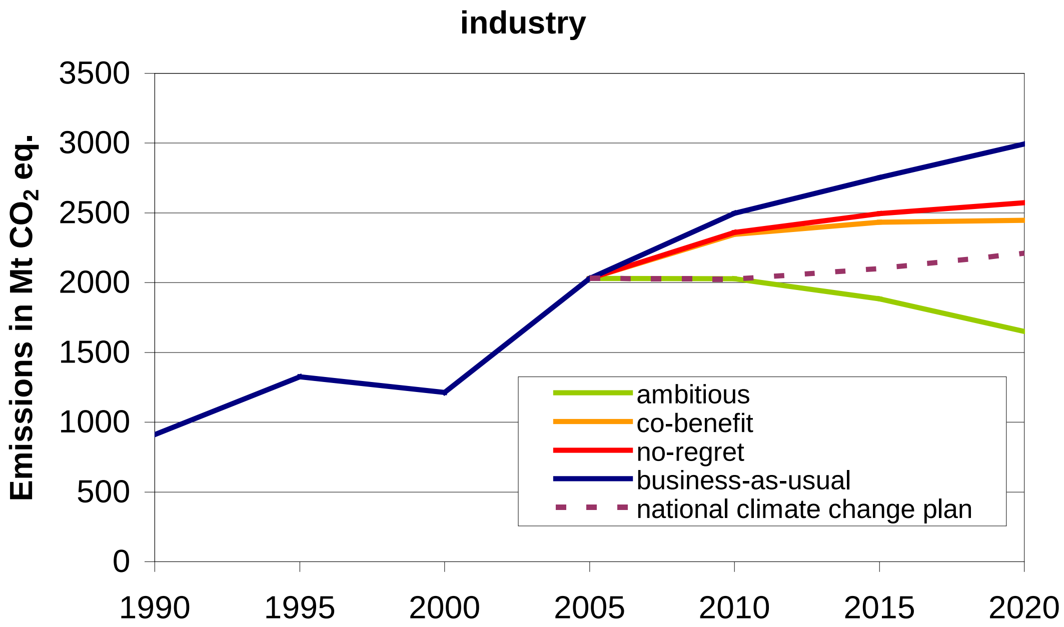

Figure 32 China's emissions and reduction potential under the BAU and all reduction scenarios in the industry sector between 1990 and 2020

For the domestic and services sector (Figure 33) the reduction potential might be high. Here, due to data availability, we included only the reduced electricity demand through more efficient appliances. However, the emission reductions are hardly visible in this sector but in the energy sector, where the electricity is produced. Further analysis on more disaggregated data might be useful.

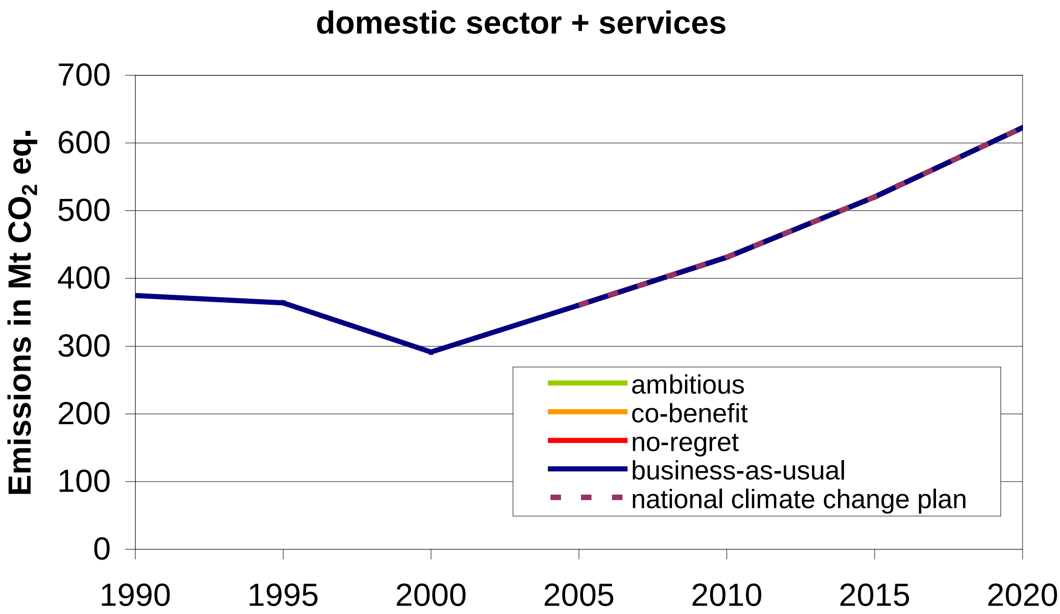

Figure 33 China's emissions and reduction potential under the BAU and all reduction scenarios in the domestic and services sector between 1990 and 2020

In the transport sector (Figure 34) reduction options are considerable compared to the share of transport in overall emissions but limited regarding national emissions as a whole. Options are e.g. to increase the share of natural gas and electricity, efficiency gains, especially in aviation and road transport, a shift to increase the relative share of rail and shipping and telecommunication as a substitute for travelling.

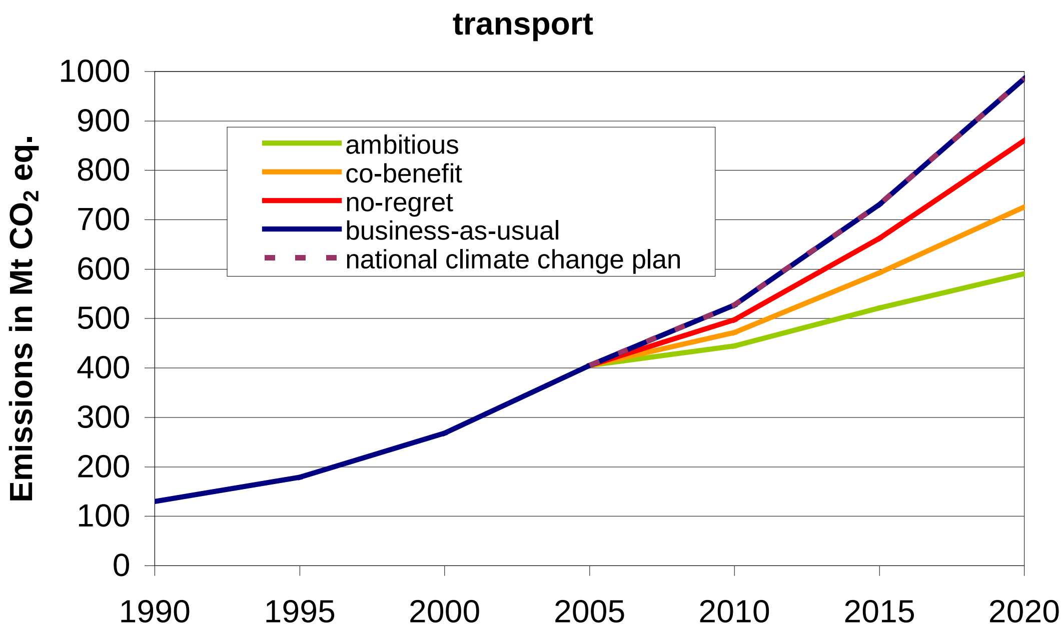

Figure 34 China's emissions and reduction potential under the BAU and all reduction scenarios in the transport sector between 1990 and 2020

Reduction options in agriculture and waste (Figure 35) are limited. The main focus is on CH_4 reduction due to better waste treatment.

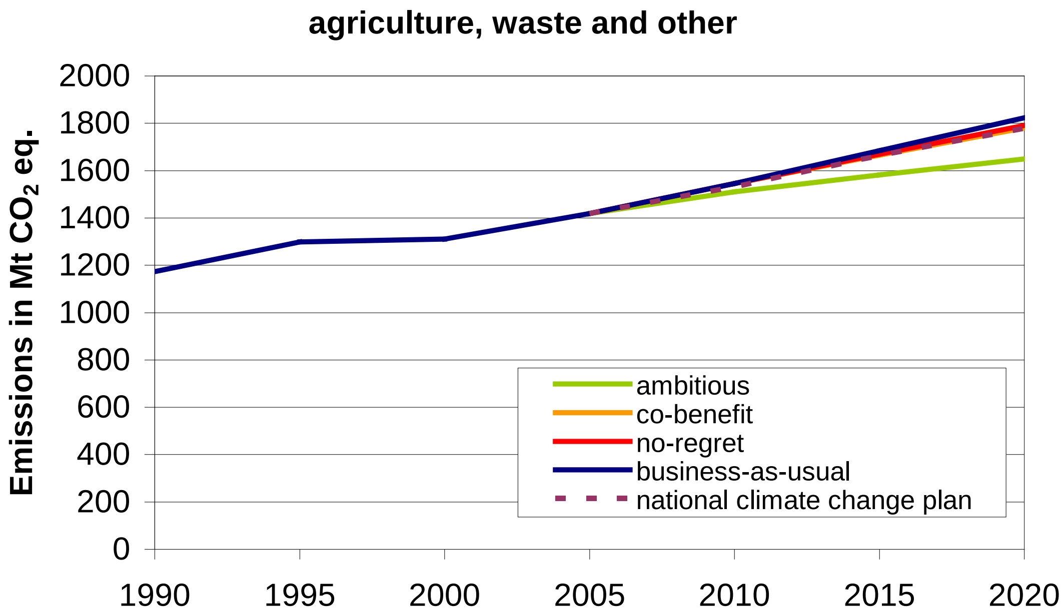

Figure 35 China's emissions and reduction potential under the BAU and all reduction scenarios in the agriculture, waste and other sector between 1990 and 2020

For the LUCF sector (Figure 36) only national plans were considered. These offer a considerable reduction potential based on afforestation.

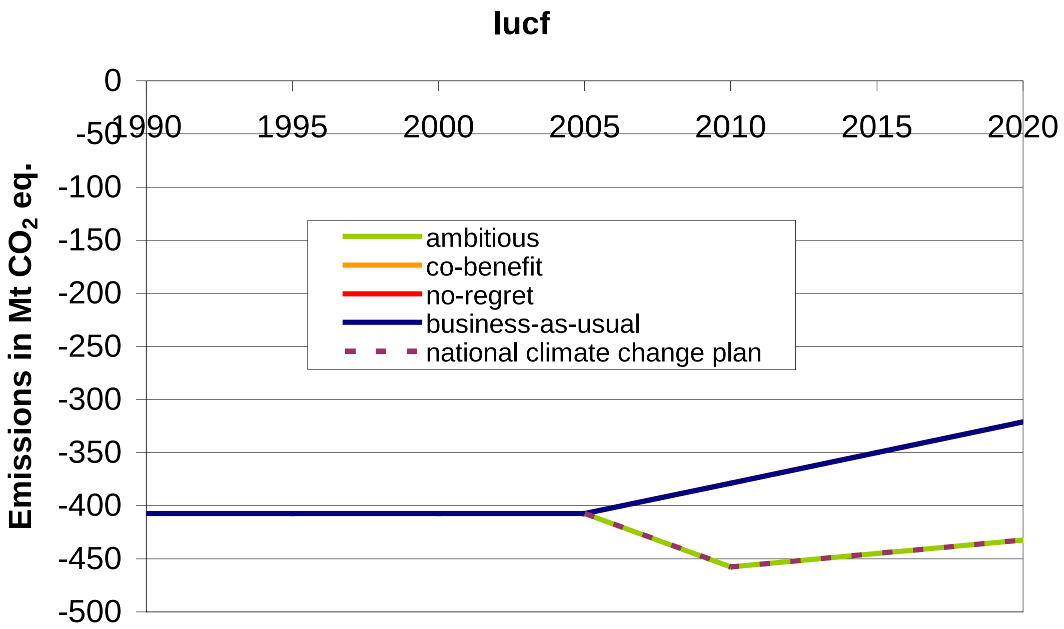

Figure 36 China's emissions and reduction potential under the BAU and all reduction scenarios in the LUCF sector between 1990 and 2020

Most important findings for China:

- China's emissions are projected to increase by about 5.6% per year between 2000 and 2020 under the business-as-usual scenario.
- In 2005, most emissions resulted from power production, industry and agriculture (35%, 29%, and 18% respectively). Under the business-as-usual scenario, this trend is projected to be more or less similar, although the importance of power production will increase slightly, while the share of agriculture and industry will decrease.
- The three sectors with the highest GHG emission-reduction potential between 2005 and 2020 under the ambitious potential are the power, industry and the other energy industry sector.
- Under the no-regret potential scenario reductions of 4% below BAU (80% above 2005 emissions) are possible. Under the co-benefit potential scenario reductions of 12% below BAU (65% above 2005 emissions) are feasible. Under the ambitious potential scenario reductions of 39% below BAU (15% above 2005 emissions) are possible. According to our interpretation of China's national climate change plan reductions of 28% below BAU (36% above 2005 emissions) are possible.

4.4 Comparison to other sources

4.4.1 Comparison to BAU scenarios from national reports and national climate strategy

China developed a National Climate Change Programme (NDRC 2008) and a White Paper on Policies and Actions for Addressing Climate Change (Government China

2008). China also develops national five year plans which also included measures on emissions reductions. However, these documents do not include national estimates on BAU development or impacts of the described emission reduction measures on national emissions.

4.4.2 Comparison to 2008 report

China experienced very high growth of emissions in the last available historic years. Because of applying available future growth rates estimates to these higher levels, future demand and the related emissions increased compared to Höhne et al. 2008. This can be seen especially in the power production and in the industry sector. Overall, China's BAU is about 800 Mt higher in 2005 and about 3900 Mt in 2020 in this report.

4.4.3 Comparison to World Energy Outlook data

The World Energy Outlook (WEO) (IEA 2009) provides a reference scenario for China and a reduction scenario to stabilise global emissions at 450 ppmv. The comparison of WEO data to the scenarios from this report is given in Figure 37 and Figure 38 below. These data include only Emissions from fuel combustion.

Historical CO_2 emissions from energy are well in line between this report and the WEO. However, our BAU projections are significantly higher than the WEO reference scenario (13% above the WEO data). This may be due to the fact that the WEO includes

- already planned measures to a further extent,
- the effects of the financial crisis, and
- a lower growth rate until 2020 while we partly applied extrapolated growth rates. These extrapolations are based on historic data until 2005. Especially between 2000 and 2005 several growth rates increased considerably in China.

The 450 scenario of the WEO is still higher than our interpretation of the Chinese climate plan. This may have different reasons. One could be that the WEO scenario is very conservative. Another reason could be that our interpretation of the climate plan is rather optimistic.

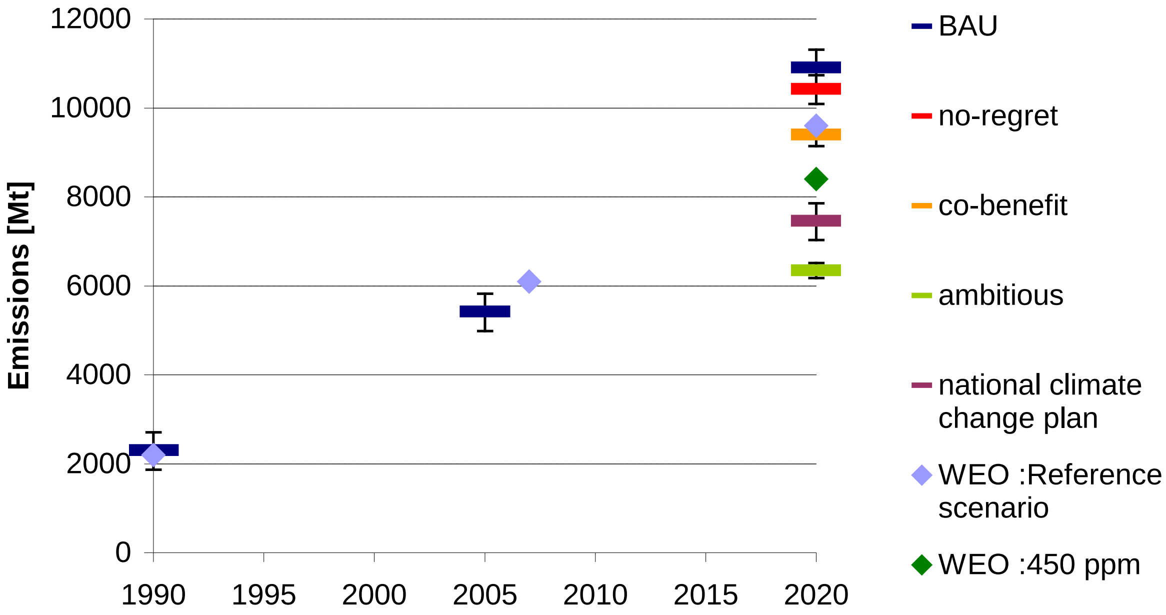

Figure 37 National emission scenarios between 1990 and 2020 for China compared to WEO data. Only emissions from fuel combustion are included.

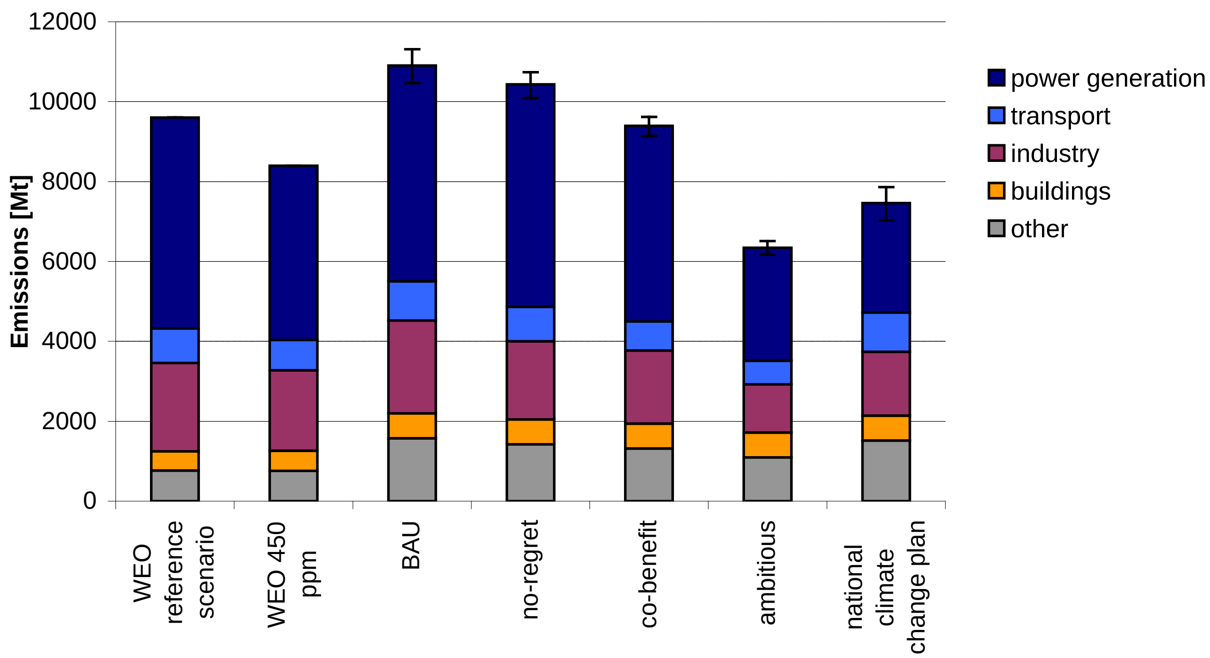

Figure 38 Emission scenarios per sector for 2020 for China compared to WEO data. Only emissions from fuel combustion are included.

4.4.4 Comparison to global effort-sharing approaches

Figure 39 compares the outcomes of the scenarios described above (left) to different global effort-sharing approaches (right) compatible with stabilisation of GHG concentrations at 450 ppmv CO_2eq.

Results for CDC and C&C are dominated by the per capita emissions, which are about average of developing countries for China. Therefore, they lead to allowances of about 6000 Mt CO_2eq. This is lower than all of the reduction scenarios for China considered in this report and lower than the current emission level. The Triptych approach requires significant reductions in emissions from coal, the South-North approach places China in a middle category of countries that start reducing relatively soon. Both approaches lead to allowances of about 8600 Mt CO_2eq. This lies between the national plan and our ambitious scenario. The largest amount of emission allowances is allocated under the GDRs approach. It considers the relatively low historical responsibility and the high share of population below a development threshold. The GDRs approach lies between the co-benefit and the national plans scenario.

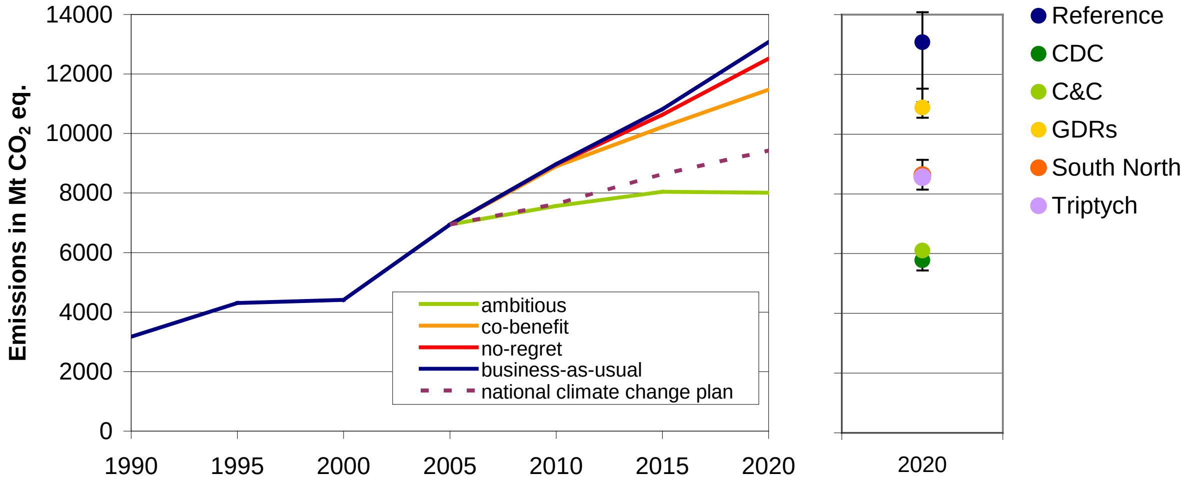

Figure 39 China's emission allowances according to the developed scenarios (left) compared to different global effort-sharing approaches in 2020 (right)

5 India

5.1 India's national climate change strategy

The 'National Action Plan on Climate Change' (NAPCC) (Government India 2008) provides a description of the Indian situation in relation to climate change. The National Action Plan is vague in its wording and does hardly provide clear actions and goals.

5.1.1 National Action Plan on Climate Change

The issue of climate change is broken down into 8 national missions:

- National solar mission (increase share of solar)
  - Specific goals for increasing use of solar thermal technologies in urban areas, industry, and commercial establishments;
  - Goal of increasing production of photovoltaics to 1000 MW/year;
  - Goal of deploying at least 1000 MW of solar thermal power generation.
- National mission for enhanced energy efficiency (building on the Energy Conservation Act 2001)
  - current energy efficient measures are assumed to lead to savings of 10,000 MW by the end of the 11th 5 year plan in 2012)
  - Mandating specific energy consumption decreases in large energy-consuming industries, with a system for companies to trade energy-savings certificates;
  - Energy incentives, including reduced taxes on energy-efficient appliances;
  - Financing for public-private partnerships to reduce energy consumption through demand-side management programs in the municipal, buildings and agricultural sectors.
- National mission on sustainable habitat (through energy efficient buildings, management of solid waste, modal shift to public transport)
  - Extending the existing Energy Conservation Building Code;
  - A greater emphasis on urban waste management and recycling, including power production from waste;
  - Strengthening the enforcement of automotive fuel economy standards and using pricing measures to encourage the purchase of efficient vehicles;
  - Incentives for the use of public transportation.
- National water mission (increase water use efficiency by 20% through pricing and other measures, no specific reference years mentioned; target year either 2012 or 2016)
- National mission for sustaining the Himalayan ecosystem (sustain the ecosystem by conserving biodiversity, forest cover, and other ecological values; the glaciers in the Himalayan region are a major source of India's water supply but are projected to recede as a result of global warming.)
- National mission for a 'green India' (target of increasing tree cover from currently 23% to 33%)
- National mission for sustainable agriculture (development of new crops)
- National mission for strategic knowledge for climate change (creation of research fund)

‘The focus will be on promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resources conservation.’ An Advisory Council with stakeholder representation has been set up lead by the Prime Minister.

The missions themselves have not been launched. The document outlines in very rough terms what actions could be taken for each of the missions but no quantitative goals are set. The technical documents lay out possible impact of climate change. Different policy measures are planned to support the following development:

- Promotion of energy efficiency in all sectors
- Emphasis on mass transport
- Emphasis on renewables including biofuels plantations
- Accelerated development of nuclear and hydropower for clean energy
- Focused R&D on several clean energy related technologies

It has been estimated that, if all the commercial space in India was to meet ECBC norms, energy consumption in this sector could be reduced by 30-40%. Compliance with this norm is voluntary at present but is expected to soon become mandatory.

5.1.2 Other programmes

Also other programmes are described in the NAPCC. These included:

- Power Generation: The government is mandating the retirement of inefficient coal-fired power plants and supporting the research and development of IGCC and supercritical technologies.
- Renewable Energy: Under the Electricity Act 2003 and the National Tariff Policy 2006, the central and the state electricity regulatory commissions must purchase a certain percentage of grid-based power from renewable sources.
- Energy Efficiency: Under the Energy Conservation Act 2001, large energy-consuming industries are required to undertake energy audits and an energy labelling program for appliances has been introduced.

5.2 Implementation of India’s national climate strategy

The national climate strategy of India (Government India 2008; Government India and Planning Commission 2008) provides several measures but only a few of them are quantified in terms of resulting emission reductions. However, detailed targets on the electricity sector are contained in the 11th 5 year plan. Most measures in the climate plan are rather general, e.g. promoting public transport or fuel switch in industry. The plan does not provide an overall baseline and mitigation scenario. Consequently, it is sometimes unclear which of the proposed measures are additional actions or already part of existing programmes. The comprehensiveness and level of detail of the plan corresponds with India’s development state: it focuses on development and gives rather qualitative options.

We included some measures from India’s climate strategy into this report (Table 8). Some are based on detailed estimates from the plan itself. For some measures we made rough assumptions ourselves. However, a number of non-quantifiable measures are included in the national strategy that could not be considered.

Table 8 Measures from India's national climate strategy as included in this report

Sector	Plans and measures	Implementation in this report
All	-46% reduction of energy intensity (toe/US$) by 2030	Considered as output, not reached; however, valued depends on various factors (such as GDP growth rates and conversion factors)
Power production	A number of schemes and programmes have been initiated and it is anticipated that these would result in a saving of 10,000 MW by the end of 11th Five Year Plan in 2012 (e.g. by exploiting hydro and PV)	Increase share of hydro (by two percentage points in 2015 and 2020) and solar wind and other renewables slightly
Industry	Increase energy efficiency in industries and small enterprises	Increase (specific) energy consumption slightly
LUCF	Increase the area of forest plantations by a total of 10 million ha by 2012	Reduce emissions due to afforestation; capacity of sinks decreases again after 2012

5.3 Results on reference emissions, mitigation potential and costs

Figure 40 shows India's greenhouse gas emissions under the business-as-usual (BAU) scenario and four different emission reduction scenarios as calculated in this report. The scenario parameters are based on national studies as far as possible. Major sources for future data in India are TERI and CCAP 2006, USEPA 2006b, the national climate change plan (Government India 2008) and trend extrapolation of official national and IEA statistics (IEA 2008b).

As illustrated in Figure 40, the reduction potential for India is 7% (no-regret), 20% (co-benefit) and 39% (ambitious potential) and 9% (national climate change plan) below BAU. The three sectors with the most important GHG emission reduction potential between 2005 and 2020 (ambitious potential) are the (1) power, (2) transport and (3) the industry sector. The ambitious mitigation potential in the power production sector is estimated at 912 MtCO_2eq in 2020. In transport, there exists an ambitious potential of 231 MtCO_2eq. The ambitious potential in the industry sector is estimated at 195 MtCO_2eq in 2020. The total ambitious mitigation potential in India is estimated at 1682 MtCO_2eq in the year 2020. A detailed overview of the potential per sector and scenario can be found in Appendix A 1, detailed mitigation measures and costs in Appendix A 2.

On the right side Figure 40 shows the high and low case results of the sensitivity analysis. The high case leads to 140 to 260 MtCO_2eq more compared to the default settings, which are about +4 to +7%. The low case leads to about -140 to -280 MtCO_2eq, which are about -5 to -7%.

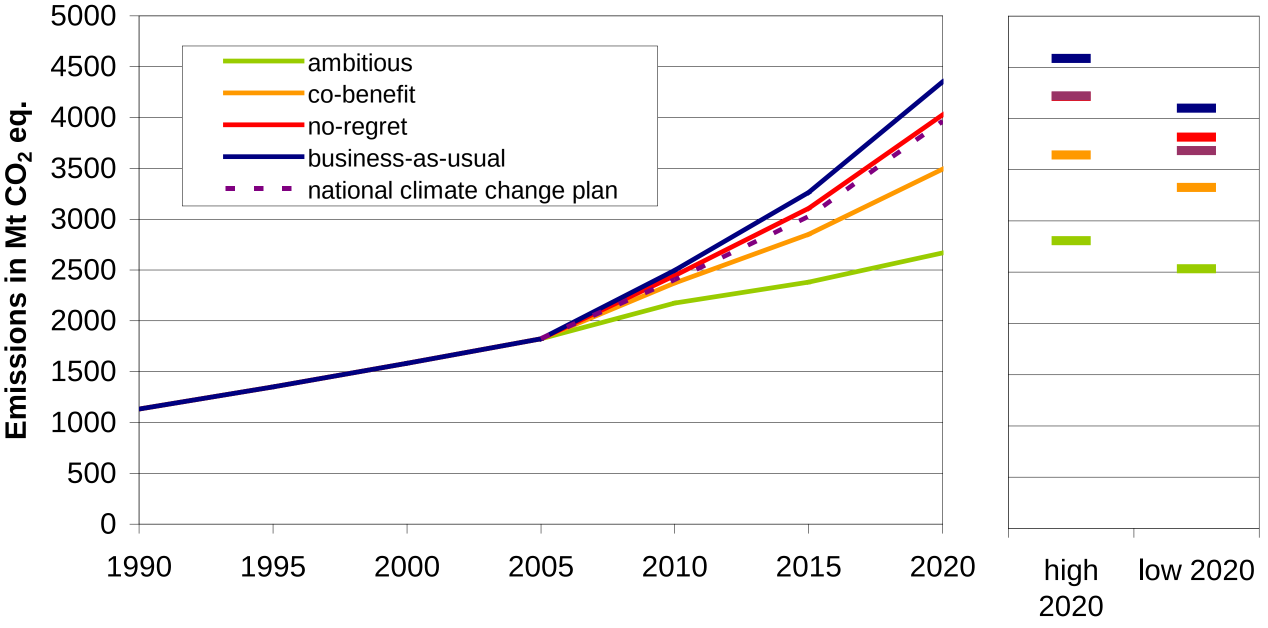

Figure 40 India's national emissions and reduction potential under the BAU and all reduction scenarios between 1990 and 2020 (left) and the sensitivity analysis (right)

5.3.1 Costs

Figure 41 provides India's emission reduction potential in 2020 per sector always compared to the reference scenario in relation to the indicative costs in €/year in 2020. The no-regret potential is more or less equally spread among sectors. Additional co-benefit potential is largely in the power sector and consists of moving to a higher share of renewables. Further reductions are then possible at higher costs in all sectors.

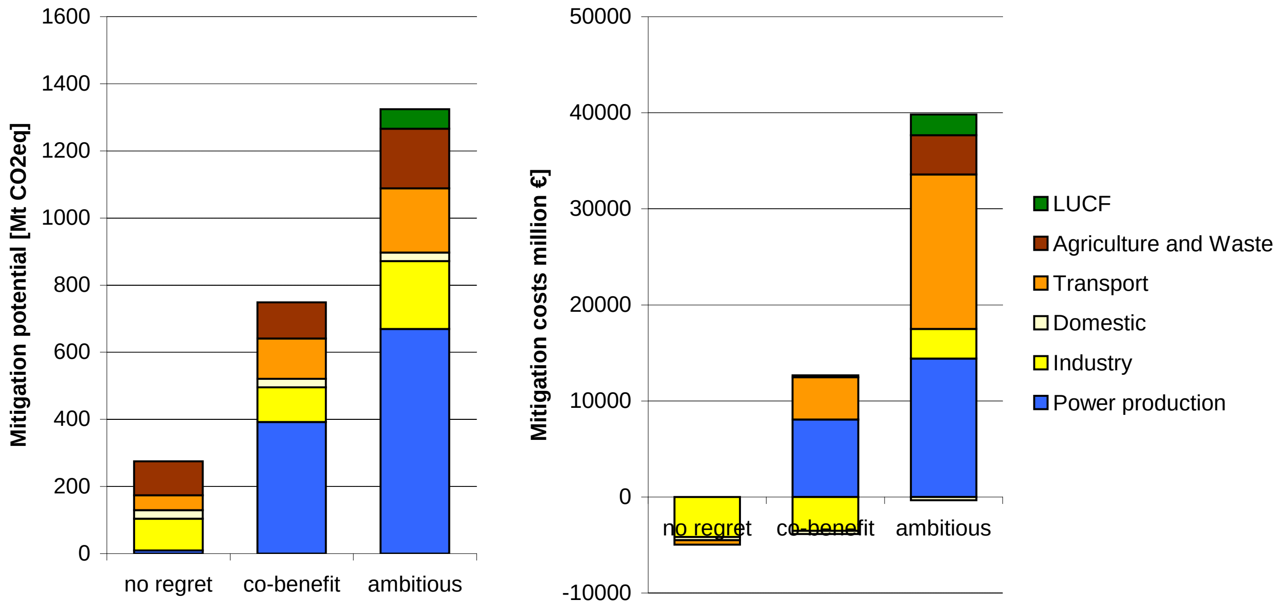

Figure 41 India's emission reduction potential in 2020 per sector always compared to the reference scenario and related indicative costs in €/year in 2020

Figure 42 gives an estimate of India's marginal abatement costs in 2020 under the three reduction scenarios. The no-regret scenario includes costs between -160 and 0 Euro per tonne of CO2 reduced (yellow curve). The co-benefit scenario includes costs between -160 and 130 Euro per tonne of CO2 reduced (yellow + orange curve). The ambitious scenario includes costs between -160 and 180 Euro per tonne of CO2 reduced (yellow + orange + green curve).

The dotted lines give the range of costs that result from the sensitivity analysis. For India a major part of this sensitivity range is below the costs given here for the no-regret potential. For the co-benefit and the ambitious scenario the sensitivity range is rather equally distributed above and below the costs given here.

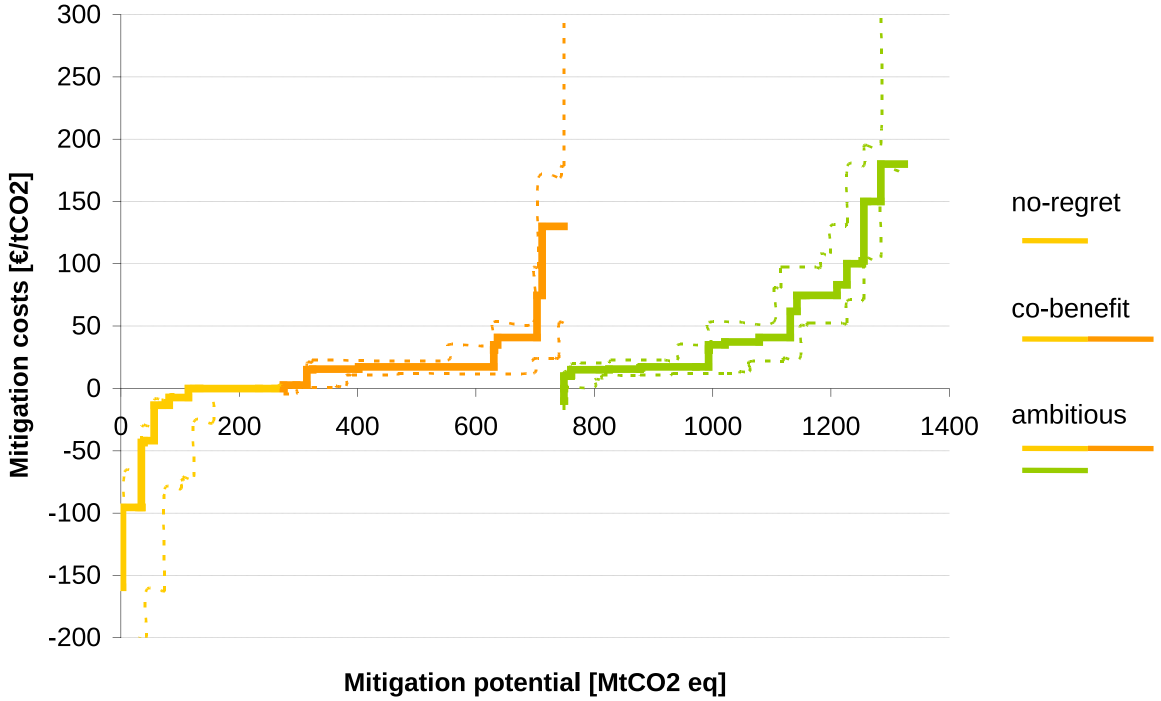

Figure 42 India's mitigation potential and indicative costs in 2020 as marginal abatement cost curve (dotted lines show the cost uncertainty range)

5.3.2 Results per sector

Figure 43 shows India's total reduction potential at sector level under the ambitious potential scenario compared to the business-as-usual scenario and the remaining emissions according to sectors. Figure 44 to Figure 49 show India's national emissions and reduction potential under the BAU and all reduction scenarios per sector.

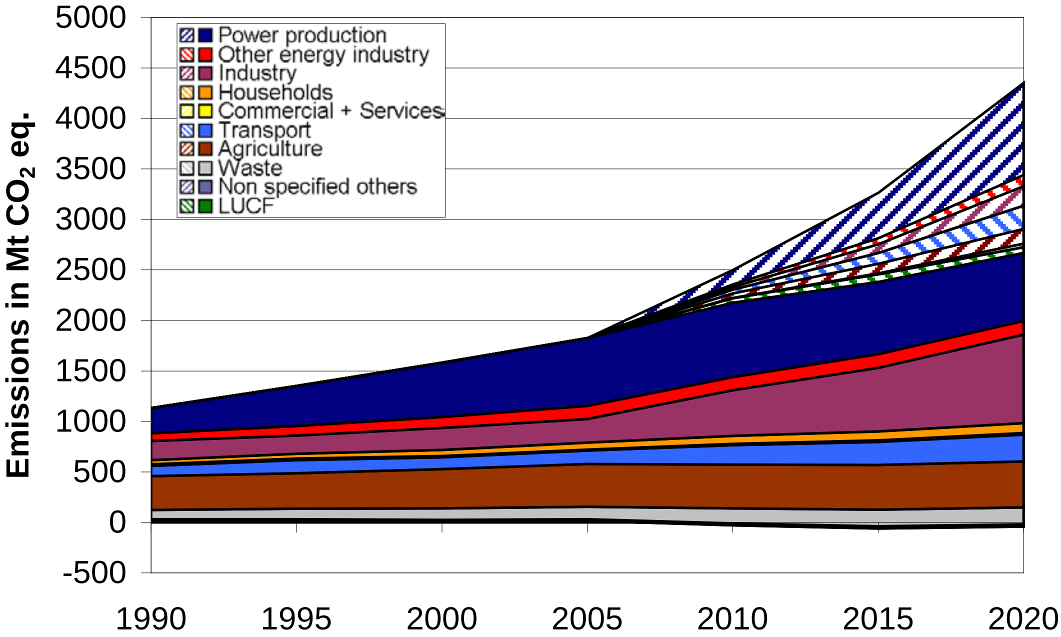

Figure 43 India's national emissions and reduction potential per sector under the BAU and the ambitious scenario between 1990 and 2020. Striped areas show the sectoral emission reduction potential under the ambitious potential scenario compared to BAU.

In the power sector (Figure 44), a major reduction opportunity would be to move away from coal to renewable energy sources. We also assumed 1% of electricity generation with CCS technology by 2020 as ambitious potential. Efficiency of current power plants can be increased substantially. In addition, the decrease of distribution losses is a major reduction option.

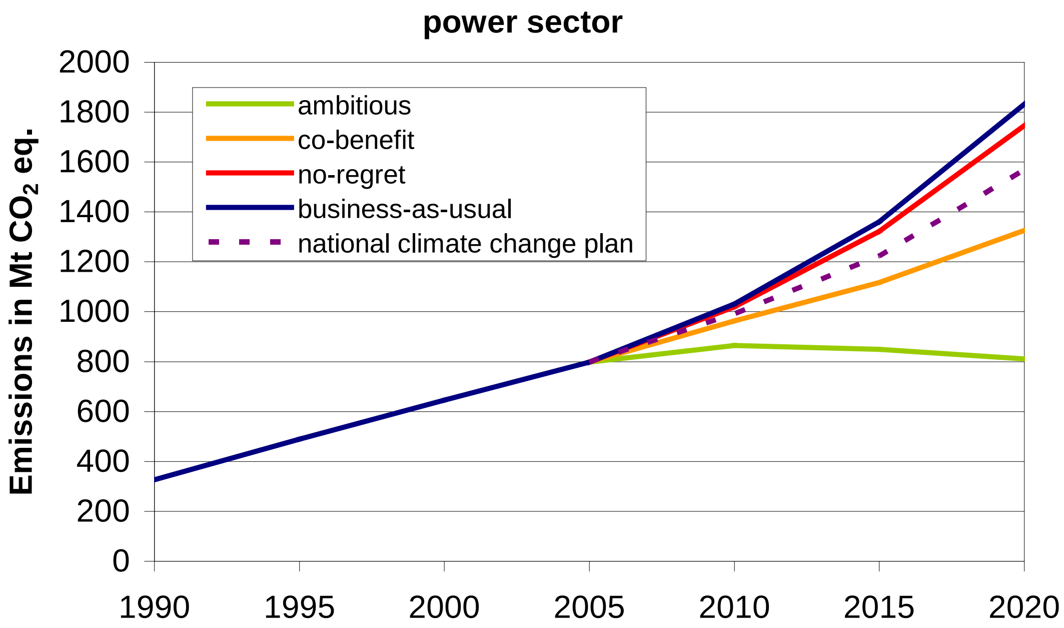

Figure 44 India's emissions and reduction potential under the BAU and all reduction scenarios in the power sector between 1990 and 2020

Major reductions in the industry sector (Figure 45) can be achieved by increasing efficiency and moving to renewable energy sources. It should be noted that our estimates for India's industry are lower compared to other estimates, c.f. TERI and CCAP 2006. These institutions may have used more disaggregated data.

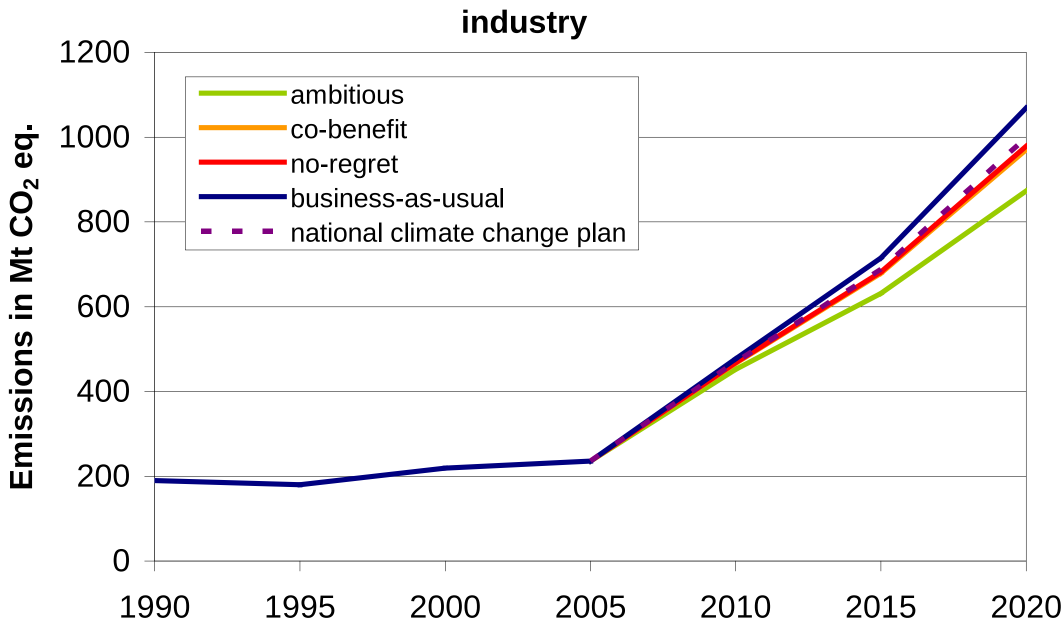

Figure 45 India's emissions and reduction potential under the BAU and all reduction scenarios in the industry sector between 1990 and 2020

For the domestic sector (Figure 46) the reduction potential might be high. Here, due to limited data availability, we included only the reduced electricity demand through more efficient appliances. However, the emission reductions are not visible in this sector but in the energy sector, where the electricity is produced. Further analysis on more disaggregated data might be useful.

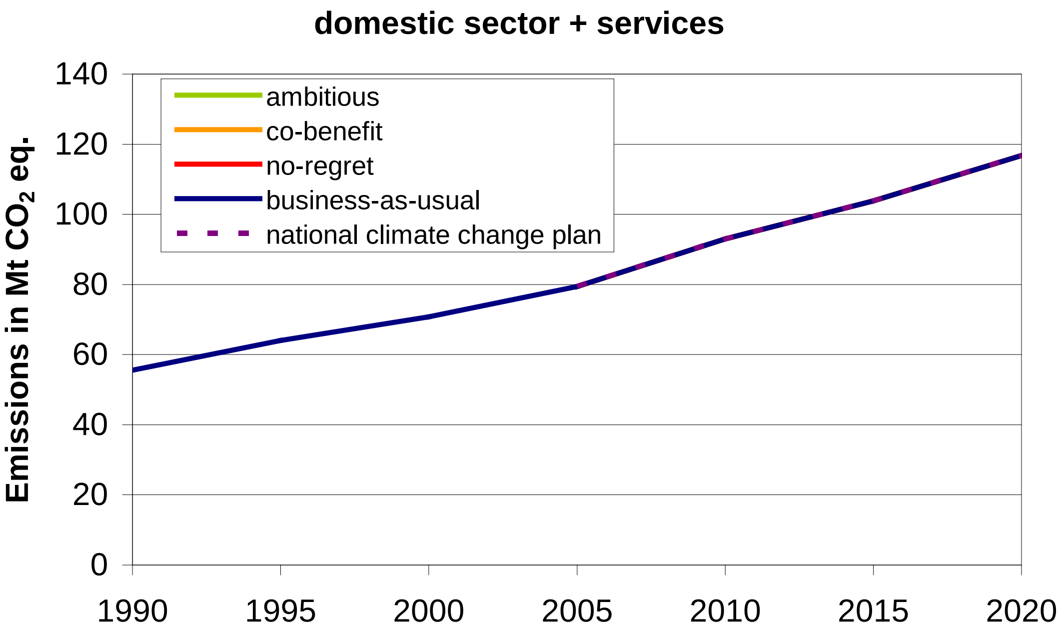

Figure 46 India's emissions and reduction potential under the BAU and all reduction scenarios in the domestic and services sector between 1990 and 2020

In the transport sector (Figure 47) reduction options are considerable. A shift to more natural gas and biomass is one emission reduction option. Another element is to increase efficiency, especially in aviation and road transport, a shift to increase the relative share of rail and shipping and telecommunication as a substitute for travelling.

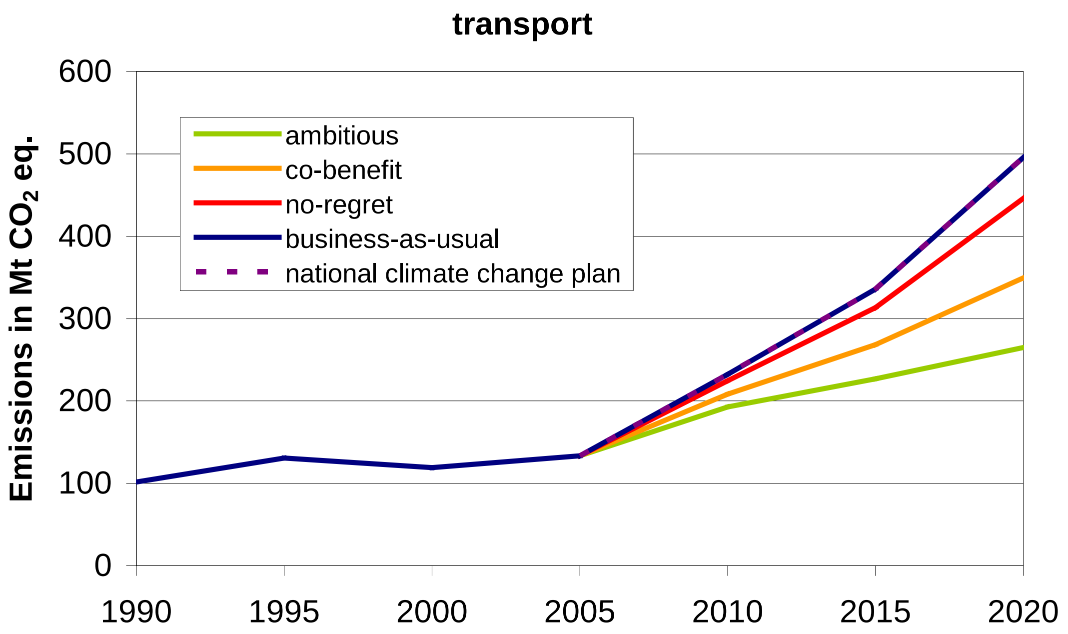

Figure 47 India's emissions and reduction potential under the BAU and all reduction scenarios in the transport sector between 1990 and 2020

Reduction options in agriculture and waste (Figure 48) are available but at comparatively high costs. The main focus is on CH_4 reduction due to better waste treatment.

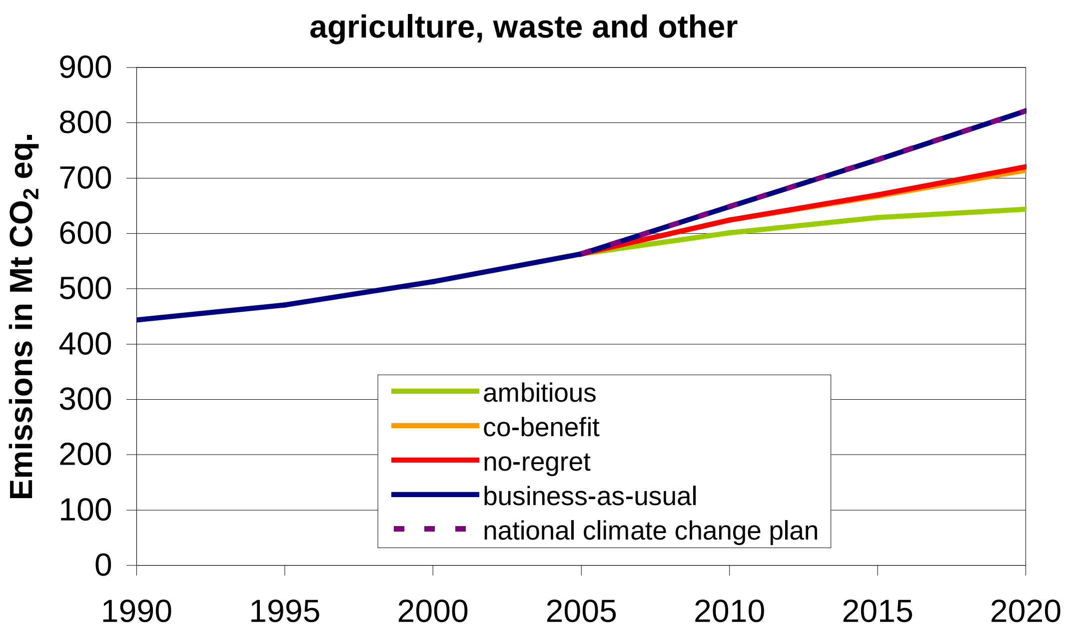

Figure 48 India's emissions and reduction potential under the BAU and all reduction scenarios in the agriculture, waste and other sector between 1990 and 2020

The LUCF sector (Figure 49) provides some reduction potential, mainly based on afforestation according to the national plan. It would change the direction of emissions quite significantly.

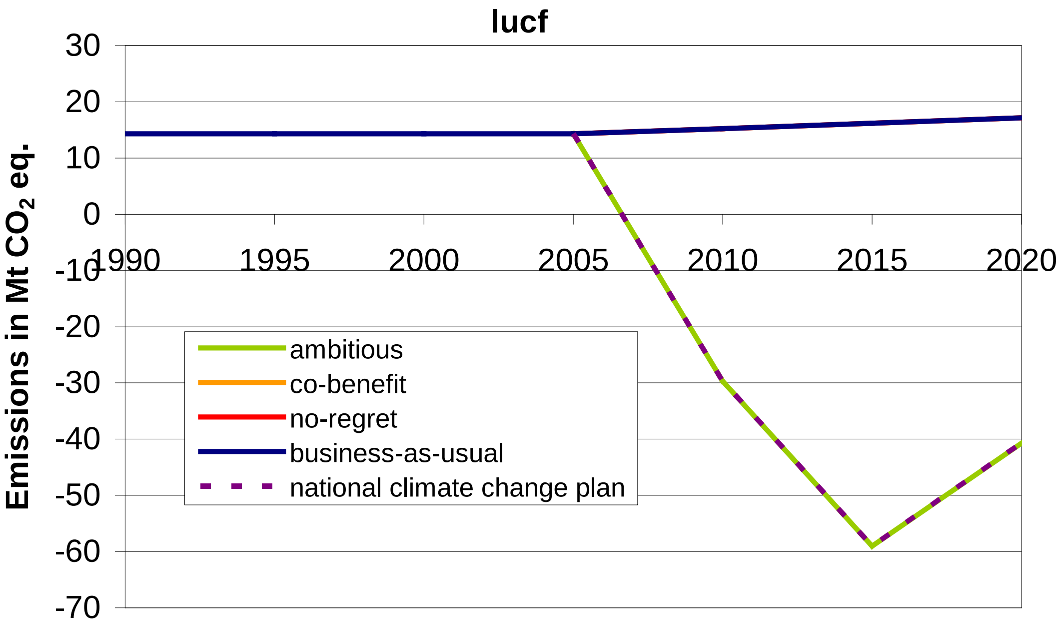

Figure 49 India's emissions and reduction potential under the BAU and all reduction scenarios in the LUCF sector between 1990 and 2020

Most important findings for India:

- India's emissions are projected to increase constantly by about 5.2% per year between 2000 and 2020 under the business-as-usual scenario.
- In 2005, most emissions resulted from power production (37%), agriculture (23%) and industry (13%). Under the business-as-usual scenario, this trend is projected to be more or less similar, although the importance of industry production will increase, while the share of agriculture will increase.
- The three sectors with the most important GHG emission-reduction potential between 2005 and 2020 under the ambitious potential are the power, transport and the industry sector.
- Under the no-regret potential scenario reductions of 7% below BAU (121% above 2005 emissions) are possible. Under the co-benefit potential scenario reductions of 20% below BAU (92% above 2005 emissions) are feasible. Under the ambitious potential scenario reductions of 39% below BAU (46% above 2005 emissions) are possible. According to our interpretation of India's national climate change plan reductions of 9% below BAU (117% above 2005 emissions) are possible.

5.4 Comparison to other sources

5.4.1 Comparison to BAU scenarios from national reports and national climate strategy

India published a national action plan on climate change (Government India 2008) and a national Five Year Plan until 2012 (Government India and Planning Commission 2008). However, this does not include national estimates on a BAU development or impacts of the described emission reduction measures on national emissions.

5.4.2 Comparison to World Energy Outlook data

The World Energy Outlook (WEO) (IEA 2009) WEO provides for India a reference scenario and a reduction scenario to stabilise global emissions at 450 ppmv. The comparison of WEO data to the scenarios from this report is given in Figure 50 and Figure 51 below. These data include only emissions from fuel combustion.

Historical CO_2 emissions from energy are well in line between our report and the WEO. BAU projections of our report are significantly higher than the WEO reference scenario (50% above the WEO data). This may be due to the fact that the WEO includes

- already planned measures to a further extent,
- the effects of the financial crisis, and
- a lower growth rate until 2020. We have used a relatively high growth rate until 2020.

Accordingly, the 450 scenario of the WEO is similar to our ambitious scenario but lower than the other reduction scenarios and our estimate of the national climate plan.

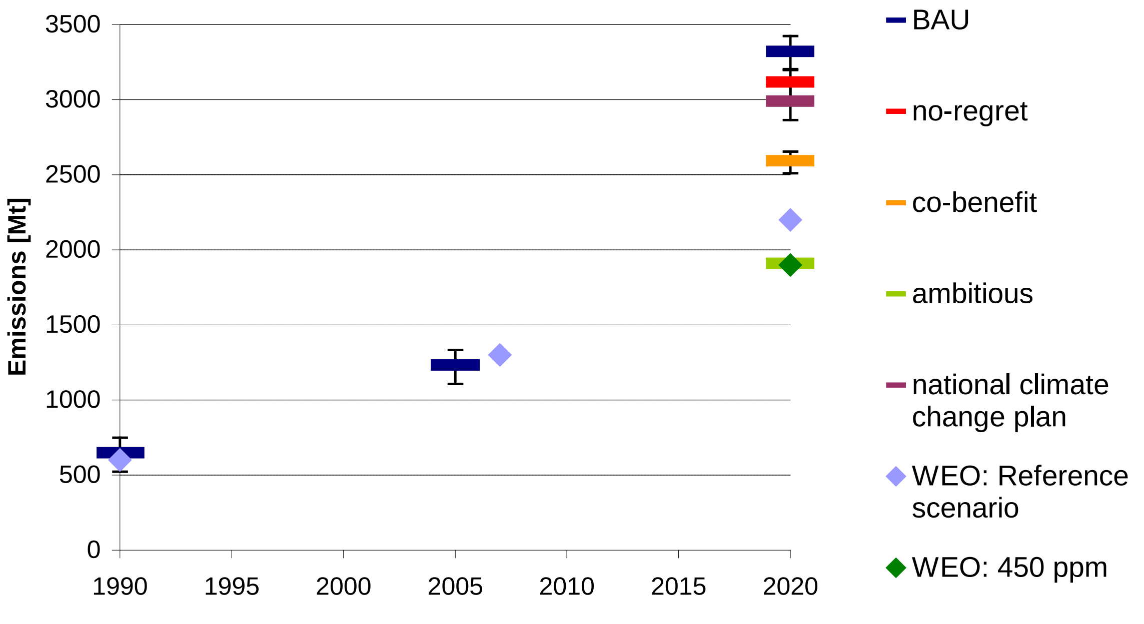

Figure 50 National emission scenarios between 1990 and 2020 for India compared to WEO data. Only emissions from fuel combustion are included.

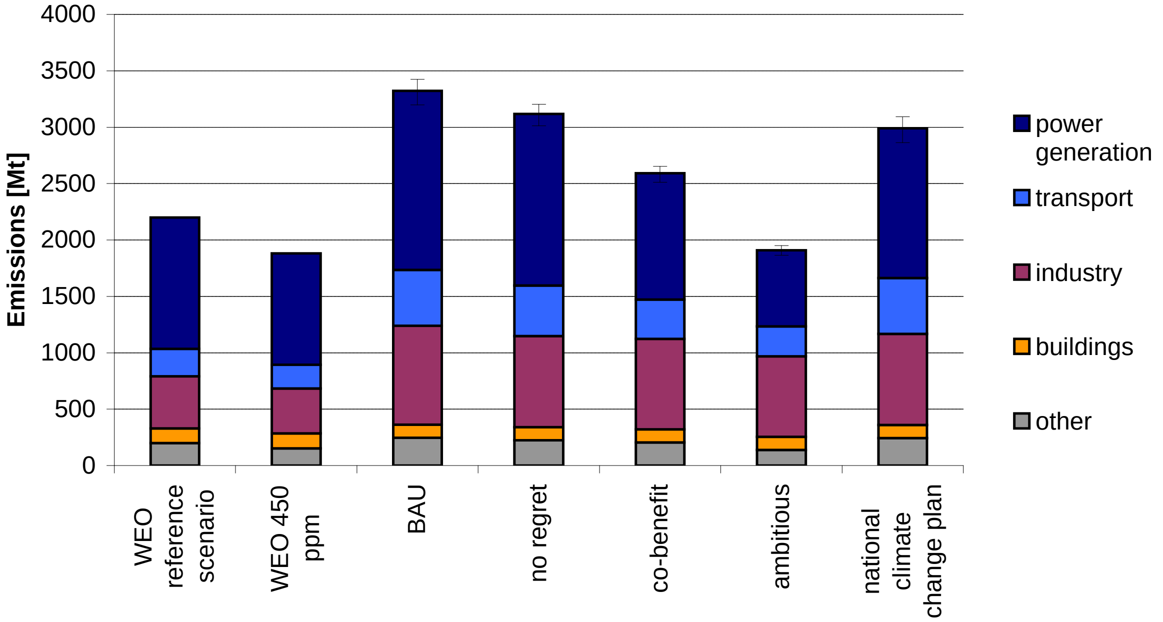

Figure 51 Emission scenarios per sector for 2020 for China compared to WEO data. Only emissions from fuel combustion are included.

5.4.3 Comparison to 2008 report

India experienced high growth of emissions in the last available historic years. Because of applying available future growth rates estimates to these higher levels, future demand and the related emissions increased compared to Höhne et al. 2008. This can be seen especially in the power production and in the industry sector. Overall, India's BAU is about 830 Mt higher in 2020 in this report.

LUCF was included only as a memo item in Höhne et al. 2008. In this report we considered the reduction plans for LUCF published in the national climate plan.

5.4.4 Comparison to global effort-sharing approaches

Figure 52 compares the outcomes of the scenarios described above (left) to different global effort-sharing approaches (right) consistent with stabilisation of GHG concentrations at 450 ppmv CO2eq. The Triptych approach is most stringent and leads to allowances of about 2500 MtCO2eq. This is a bit lower than our ambitious scenario. This approach requires a major shift away from coal for all countries, which would affect India significantly. Results for CDC and C&C are influenced by India's relatively low per-capita emissions and lead to allowances of about 3030 MtCO2eq. This lies between the co-benefit and national plan and our ambitious scenario. The South North approach leads to allowances of about 3700 MtCO2eq. This is less stringent and close to our co-benefit scenario, because this approach assumes delayed participation by developing countries. The largest amount of emission allowances, about 4080 MtCO2eq, is allocated under the GDRs approach. The result is driven by the large amount of population below a development threshold and the low historical emissions of India. The GDRs result is close to our no-regret scenario.

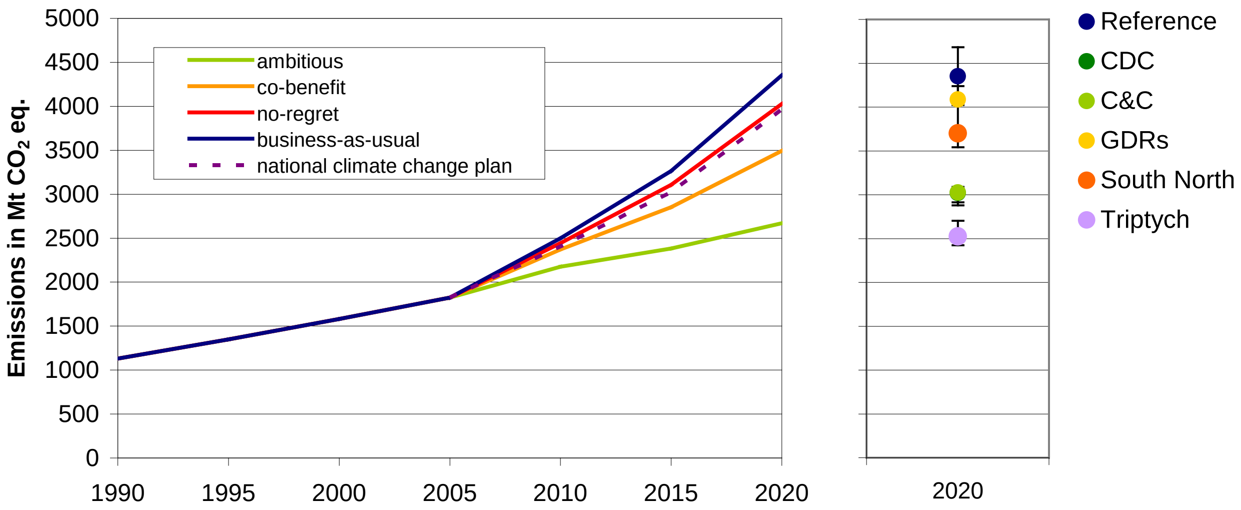

Figure 52 India's emission allowances according to the developed scenarios compared to different global effort-sharing approaches in 2020

6 Mexico

6.1 Mexico's national climate change strategy

6.1.1 National Strategy on Climate Change

The 'National Strategy on Climate Change' (SEMARNAT 2007) provides the position of the Mexican government on a climate change strategy. We interpret the stated targets as a minimum level in a revised strategy. The document provides a clear overview including specific targets and a clear position on what individual countries should contribute linked to the international situation.

> *'The National Strategy on Climate Change ('ENACC', for its acronym in Spanish) identifies specific measures for mitigation, with estimates of their potential for emissions reductions (see section below). It also proposes a suite of research objectives as a tool for laying out more precise mitigation targets and outlines national requirements for capacity building for adaptation to climate change. While the scope of the ENACC encompasses only those measures within the competence of the Federal Government, it nevertheless contributes to a nationwide and inclusive process of consensus building which will:*
>
> - *Identify opportunities for mitigation measures and emissions reductions.*
> - *Acknowledge the vulnerability of diverse economic and social sectors and geographic regions to climate change, and take measures to develop the necessary national and local-level capacity for response and adaptation.*
> - *Contribute to the development of strategies, priorities and policies for the Special Programme on Climate Change ('PECC', for its Spanish acronym), which will become an integral part of the National Development Plan, 2007-2012.'*

The document outlines Mexico's overall position on climate change, which is characterised by clear ideas on realisation e.g.:

- The international regime should be strengthened through political agreements at the highest level that involve major emitter countries.
- The current division between Annex I and non-Annex I countries has to move towards a more realistic differentiation.
- Mexico will employ every effort to implement measures to foster mitigation and adaptation in an equitable manner.
- The inaction of others should not be an excuse for one's own inaction.

In the context of developing the post-2012 regime, reviewing the commitments of advanced developing countries, such as Mexico, could be based on the following parameters:

1. Within the bounds of their existing capacities, they can undertake mitigation activities by voluntarily adopting policies and measures which, while aimed at achieving sustainable development, result in predictable co-benefits in terms of GHG emissions reductions.
2. Policies and measures adopted could be subject to review and monitoring by international entities ('pledge & review').
3. In adopting said policies and measures, countries could indicatively agree to quantitative emissions targets: either absolute or relative in terms of 'emissions

intensity' per unit of product; or for a given economic sector or subsector; or for given regions of the country which, when taken together, represent a significant share (at least 25%) of a nation's total GHG emissions.

4. Voluntary commitments shall not undermine the right to development or the legitimate aspiration to secure an energy supply commensurate with meeting the essential needs of the population.
5. The international regime will include mechanisms for cooperation and incentives to increase and complement mitigation efforts undertaken by these countries.
6. The voluntary adoption of mitigation policies and measures and their associated quantitative targets will not imply the incurrence of any type of penalty for possible non-compliance ('no-lose targets').
7. Target over-attainment could allow for the sale of carbon credits on the global market, under agreed conditions.

The adoption of binding, quantitative emissions reductions targets, relative to total national GHG emissions, would be the final phase of a 'step by step' process that comprises several intermediate phases as a prerequisite for the consolidation and strengthening of country commitments.

Emission reduction opportunities in Mexico

1. Energy generation and use

The following table provides an overview of the principal opportunities for emissions reductions based on a prospective analysis to the year 2014. Overall, these measures could lead to a reduction of about 107 $MtCO_2e$ by 2014.

Table 9 Energy sector opportunities for GHG mitigation until 2014

AREA OR ACTIVITY	PROPOSED MEASURES	ESTIMATED REDUCTION ($MtCO_2e$)
Energy efficiency		
Standards and programmes of the National Commission for Energy Conservation ("CONAE")	Continue application of current energy efficiency standards and develop and implement new ones.	24.0
Energy efficiency and savings programmes of the Trust Fund for Energy Saving ("FIDE").	Strengthen current FIDE programmes and promote new ones.	3.9
Mexican Oil Company (PEMEX)		
Combined Heat and Power (CHP)[1] in PEMEX	Install CHP plants in the facilities of the National Refining System and in other PEMEX facilities.	7.7
Centralized power supply to offshore platforms	Substitute individual generation plants for a 115 MW combined cycle plant connected to offshore platforms.	1.9
Improvement of energy performance in refineries	Increase PEMEX's energy efficiency target by 5%.	2.7
Fugitive emissions of methane (NH_4)	Reduce fugitive NH_4 emissions from natural gas production, transportation and distribution; increase efficiency of flares on offshore platforms.	2.4
Power generation and distribution (Federal Electricity Commission and Central Light and Power)		
Power transmission and distribution	Increase the efficiency of transmission and distribution lines by 2%.	6.0
Thermal efficiency in fuel oil-fired thermoelectric plants	Increase thermal efficiency of fuel oil-fired thermoelectric plants by 2%.	0.7
Conversion to natural gas and repowering of thermoelectric plants on the Pacific coast; modernization of the facilities of the National Refining System	This proposal requires simultaneous action: phase out and reorient fuel oil production incentives; install on the Pacific coast a gasification terminal for imported liquefied natural gas, and convert fuel oil-fired thermoelectric plants to combined cycle.	21.0
Industrial sector		
CHP	Develop the CHP potential of the national cement, steel and sugar industries, among others.	>25
Renewable energy		
Power generation from renewable energy sources	Install 7,000 MW of renewable energy capacity to generate 16,000 GWh per year (additional to the El Cajon and La Parota hydroelectric plants).	8.0
Biofuels	Introduce sustainably produced biofuels.	NA
Transport sector		
Vehicle replacement	Replace freight trucks and diesel busses ≥10 years old from 2008 onwards.	2.0
Freight by rail	Increase rail coverage for freight transportation by 10%.	1.5

[1] Combined Heat and Power (CHP) = Cogeneration

2. Vegetation and land use

In order to conserve carbon in forest ecosystems and reduce GHG emissions from land use, land use change, forestry and agriculture, three different categories of actions are considered: conservation of carbon stocks, carbon capture and carbon substitution. The following table presents a résumé of the opportunities identified in the ENACC to implement these actions (Table 10 and Table 11). Overall, these considered measures could lead to carbon conservation in forests of about 13,000 to 23,000 $MtCO_2eq$ by 2012. Furthermore, forestry-related measures could lead to an amount of 18 to 42 $MtCO_2eq$ of captured carbon and to annual reductions of about 12 $MtCO_2eq$ by 2012.

Table 10 Opportunities for carbon conservation in forests until 2012

TYPE OF ACTIVITY	PROPOSAL	CARBON CONSERVATION ($MTCO_2e$)
Sustainable Forest Development	Increase the area under sustainable forest management by 2.6 million hectares per year.	6,000-12,000
Payment for Environmental Services	Expand coverage of current programmes of payment for environmental services ("PSAH" and "PSA-CABSA", for their Spanish acronyms) to cumulatively reach 2.49 million hectares by 2012.	1,500-3,100
Conservation of forest ecosystems in Protected Areas	Increase coverage of Protected Areas by 500,000 hectares per year to accumulate 3 million hectares in the National Protected Areas System ("SINAP", for the Spanish acronym).	500-1,000
Wildlife Management Areas	Integrate approximately 6 million hectares of tropical, temperate and arid zone ecosystems within Wildlife Management Areas ("UMA").	3,000-4,250
Forest health	Carry out phytosanitary diagnosis and treatment in approximately 640,000 hectares of forest per year.	1,800-3000

Table 11 Opportunities for mitigation of GHG emissions in forestry and land use until 2012

TYPE OF ACTIVITY	PROPOSAL	CARBON CAPTURE ($MTCO_2e$)
Forestry		
Reforestation and recovery of lands apt for forestry	Reforest 285,000 hectares a year through the "ProÁrbol" Programme, to accumulate 1.71 million hectares by 2012.	10-20
Soil restoration with reforestation	Restore and reforest degraded soils in an area of 115,000 hectares annually, through ProÁrbol, to accumulate 690,000 hectares.	5-15
Commercial forestry plantations	Expand the area in commercial plantations at a rate of 100,000 hectares per year, to accumulate an additional 600,000 hectares.	3-7
Forest CDM	Identify opportunities for carbon capture projects in forest ecosystems under the CDM.	To be instrumented
Forest derived bioenergy		**Estimated reductions ($MTCO_2e$/year)**
Forest derived biofuels	Introduce 500,000 high efficiency wood burning stoves in rural communities.	2.5
Crop production		
Land use reconversion	Promote the reconversion of agricultural land to perennial and mixed crops in 900,000 hectares, through the Programme for Direct Support to Agriculture ("PROCAMPO").	4.2
Efficient use of chemical fertilizer	Develop standards for fertilizer use according to region and crop; produce a Manual of best practices and assess alternative options	NA
Prevention of forest fires from cropland burning	Promote alternatives to slash and burn agriculture in 100,000 hectares, to reduce from 50% to 35% slash and burn related forest fires.	NA
Conservation tillage	Employ conservation tillage and foster cover crops in 200,000 hectares.	0.9
Livestock production		
Rehabilitation of grazing and rangelands	Rehabilitate 450,000 hectares of grazing and rangelands through the Programme for support for cattle production ("PROGAN").	4.6

6.1.2 Latest developments

At the Ministerial Breakfast during COP14 (11 December 2008) the Mexican Government announced that it wants to reduce Mexico's emissions by 50% compared to 2002 levels by the year 2050. Mexico plans to do so through a national trans-sectoral cap-and-trade programme that would be operational by 2012. It will focus on oil, cement, electricity and steel.

So far Mexico's national climate plan is still under revision. However, it is assumed to be published soon.

6.2 Implementation of Mexico's national climate strategy

Mexico has a very detailed national plan until 2012 (Government Mexico 2007, SEMARNAT 2009). However, the final version is to be released soon. The provided measures are related to quantified emission reductions. Even though the resulting emission reductions are not extremely ambitious the plan is in line with the overall strategy to reduce emissions by 50% until 2050, which assumes moderate reductions in early years and more ambitions reductions in later years.

We included several measures from Mexico's climate strategy into this report (Table 12). Most are based on detailed estimates from the plan itself. For some measures we made rough assumptions ourselves, especially in order to meet the national emission path developed by Mexico itself. However, not all measures from the national strategy could be considered.

Table 12 Measures from Mexico's national climate strategy as included in this report

Sector	Plans and measures	Implementation in this report
All	50% below 2002 in 2050; Intermediate target: 700 Mt CO_2eq in 2020	Industry: Increase share of combustible renewables Industry : Reduce F-gases Agriculture: Decrease livestock slightly Waste: Increase share of recovered methane up to 20% in 2020 Transport: Increase share of combustible renewables in 2020
Power production	Install 7000 MW of renewable energy capacity to generate 16000 GWH	Increase solar, wind and other renewables
Power production	Increase CHP	Increase efficiency in power production
Power production	Reduce fugitive methane emissions from natural gas production, transportation and distribution; increase efficiency of flares on offshore platforms	Reduce emissions from fugitive methane from power production
Domestic sector (households)	Increase use of wind and solar water heating in commercial and residential	Reduce electricity demand Reduce electricity consumption by 16% in 2020 (-7% due to solar hot water neglected due to negative growth rates of electricity use per household), growth rates may not become negative before 2020
Domestic sector	Increase use of wind and solar water heating in commercial and residential	reduce electricity consumption by 16% in

Sector	Plans and measures	Implementation in this report
(commercial)		2020, growth rates may not become negative before 2021
LUCF	Afforestation: increase the area of forest plantations by a total of 3 million ha by 2017	Increase forest area by 3 million ha

6.3 Results on reference emissions, mitigation potential and costs

Figure 53 shows Mexico's greenhouse gas emissions under the business-as-usual (BAU) scenario and four different emission reduction scenarios as calculated in this report. The scenario parameters are based on national studies as far as possible. Major sources for future data in Mexico are USEPA 2006b, the national climate change plan (Government Mexico 2007) and trend extrapolation of official national and IEA statistics (IEA 2008b).

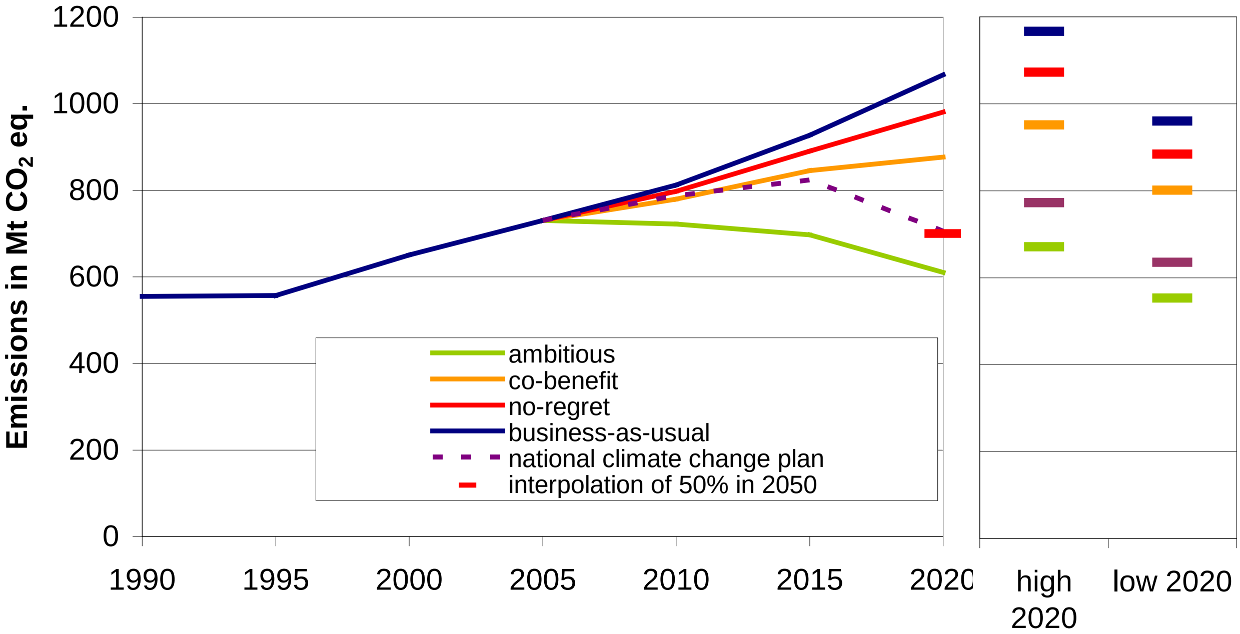

Figure 53 Mexico's national emissions and reduction potential under the BAU and all reduction scenarios between 1990 and 2020 (left) and the sensitivity analysis (right)

As illustrated in Figure 53, the reduction potential for Mexico is 8% (no-regret), 18% (co-benefit) and 43% (ambitious potential) and 34% (national climate change plan) below BAU. The three sectors with the highest GHG emission-reduction potential between 2005 and 2020 (ambitious potential) are (1) other energy industry, (2) transport and (3) the power production sector. The ambitious mitigation potential in the other energy industry sector is estimated at 152 $MtCO_2eq$ in 2020. In the transport sector, there exists an ambitious potential of 111 $MtCO_2eq$. The ambitious potential in the power production sector is estimated at 92 $MtCO_2eq$ in 2020. The total ambitious mitigation potential in Mexico is estimated at 457 $MtCO_2eq$ in the year 2020. A detailed overview of the potential per sector and scenario can be found in Appendix A 1, detailed mitigation measures and costs in Appendix A 2.

On the right side Figure 53 shows the high and low case results of the sensitivity analysis. The high case leads to 60 to 100 Mt CO_2eq more compared to the default settings, which are about +8 to +10%. The low case leads to about -60 to -110 Mt CO_2eq, which are about -9 to -10%.

6.3.1 Costs

Figure 54 provides Mexico's emission reduction potential in 2020 per sector always compared to the reference scenario in relation to the indicative costs in €/year in 2020. Significant no-regret potential exists in the power sector (oil and gas production) and in transport. Major additional co-benefit potential exists also in the power sector (renewables) and in transport. High-cost measures can reduce emissions further in all sectors.

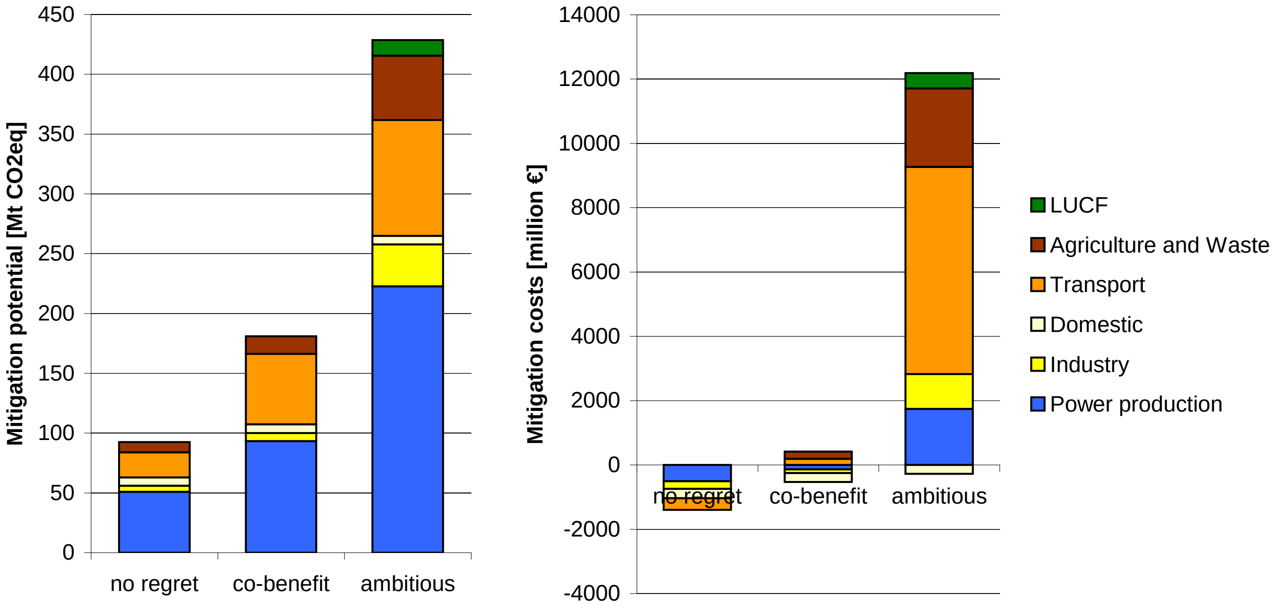

Figure 54 Mexico's emission reduction potential in 2020 per sector always compared to the reference scenario and related indicative costs in € / year in 2020

Figure 55 gives an estimate of Mexico's marginal abatement costs in 2020 under the three reduction scenarios. The no-regret scenario includes costs between -160 and 0 Euro per tonne of CO2 reduced (yellow curve). The co-benefit scenario includes costs between -160 and 75 Euro per tonne of CO2 reduced (yellow + orange curve). The ambitious scenario includes costs between -160 and 180 Euro per tonne of CO2 reduced (yellow + orange + green curve).

The dotted lines give the range of costs that result from the sensitivity analysis. For Mexico a major part of this sensitivity range is below the costs given here for the no-regret potential. For the co-benefit and the ambitious scenario the sensitivity range is rather equally distributed above and below the costs given here.

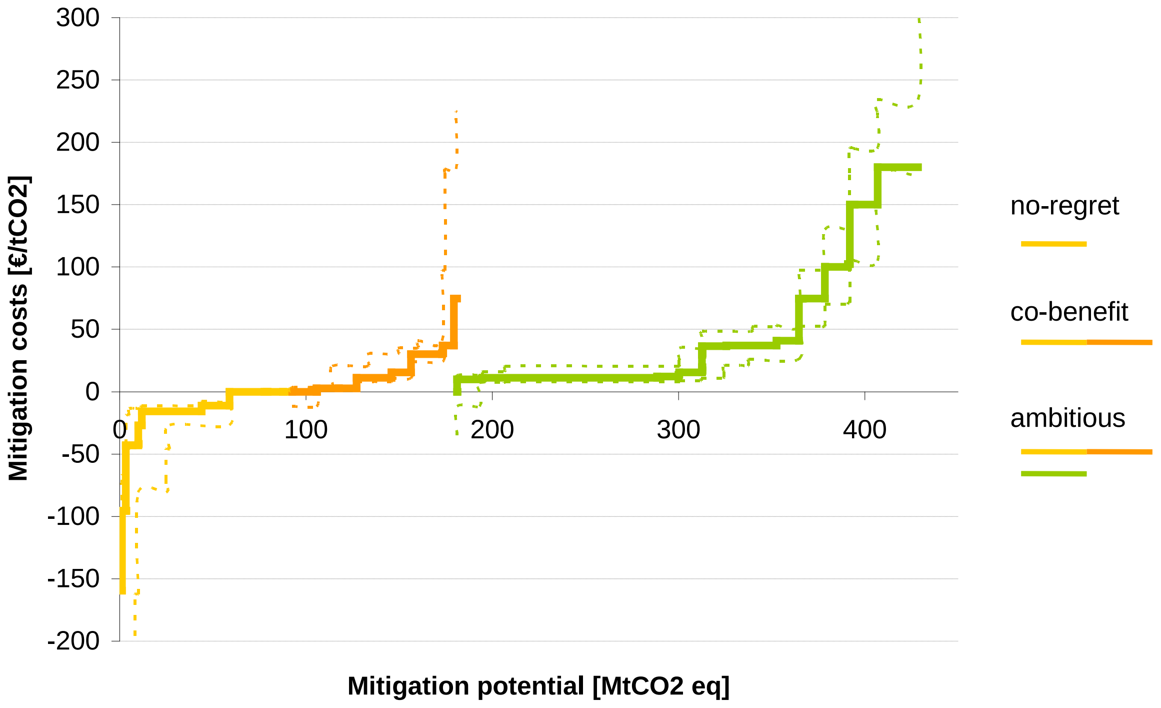

Figure 55 Mexico's mitigation potential and indicative costs in 2020 as marginal abatement cost curve (dotted lines show the cost uncertainty range)

6.3.2 Results per sector

Figure 56 shows Mexico's total reduction potential at sector level under the ambitious potential scenario compared to the business-as-usual scenario and the remaining emissions according to sectors. Figure 57 to Figure 62 show Mexico's national emissions and reduction potential under the BAU and all reduction scenarios per sector.

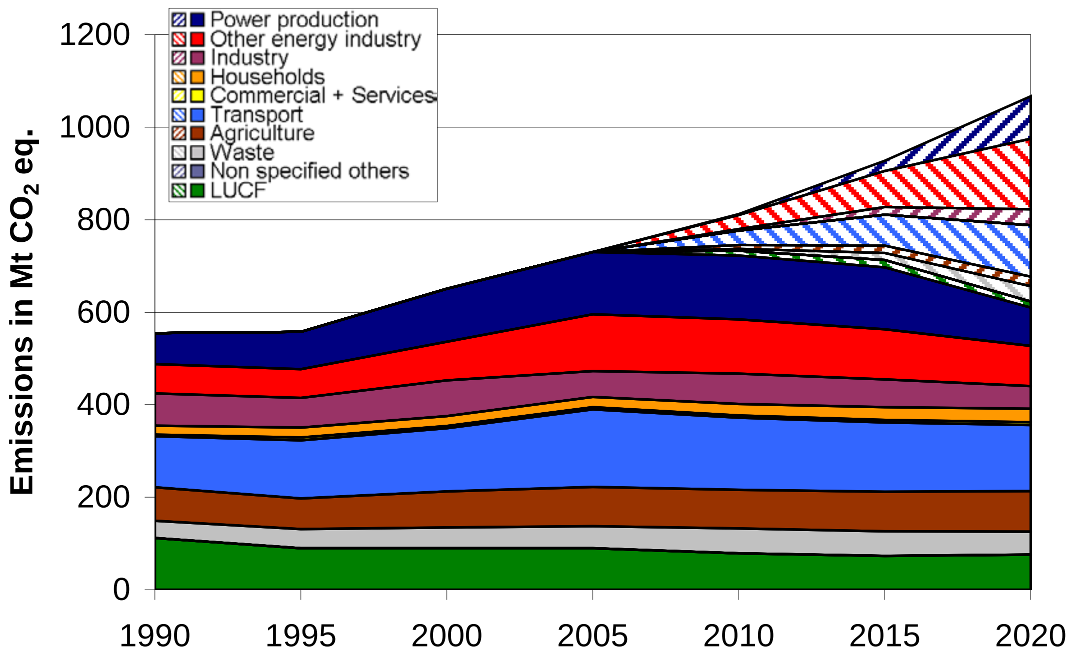

Figure 56 Mexico's national emissions and reduction potential per sector under the BAU and the ambitious scenario between 1990 and 2020. Striped areas show the sectoral emission reduction potential under the ambitious potential scenario compared to BAU.

In the power sector (Figure 57) a high reduction potential is available. Mexico has already a high share of gas in electricity production. But a shift to renewable energy sources would be a significant reduction option as well as reduction of distribution losses.

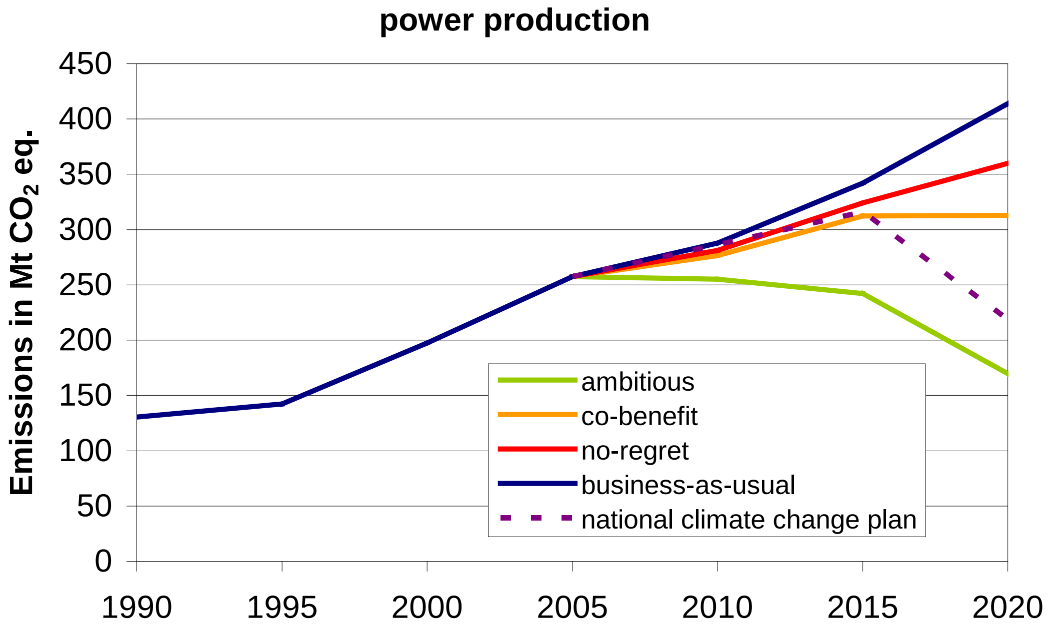

Figure 57 Mexico's emissions and reduction potential under the BAU and all reduction scenarios in the power sector

In the industry (Figure 58) sector major reductions can be achieved by increasing efficiency and moving to renewable energy sources.

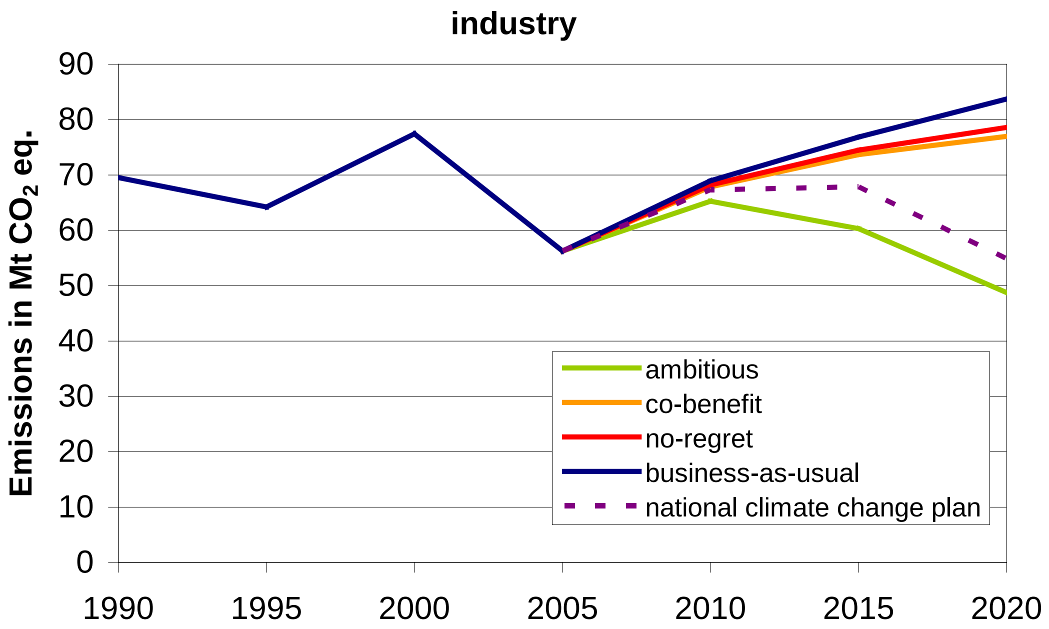

Figure 58 Mexico's emissions and reduction potential under the BAU and all reduction scenarios in the industry sector

In the domestic and services sector (Figure 59) the reduction potential might be high. Here, due to limited data availability, we included only the reduced electricity demand through more efficient appliances. However, the emission reductions are not visible in this sector but in the energy sector, where the electricity is produced. Further analysis on more disaggregated data might be useful.

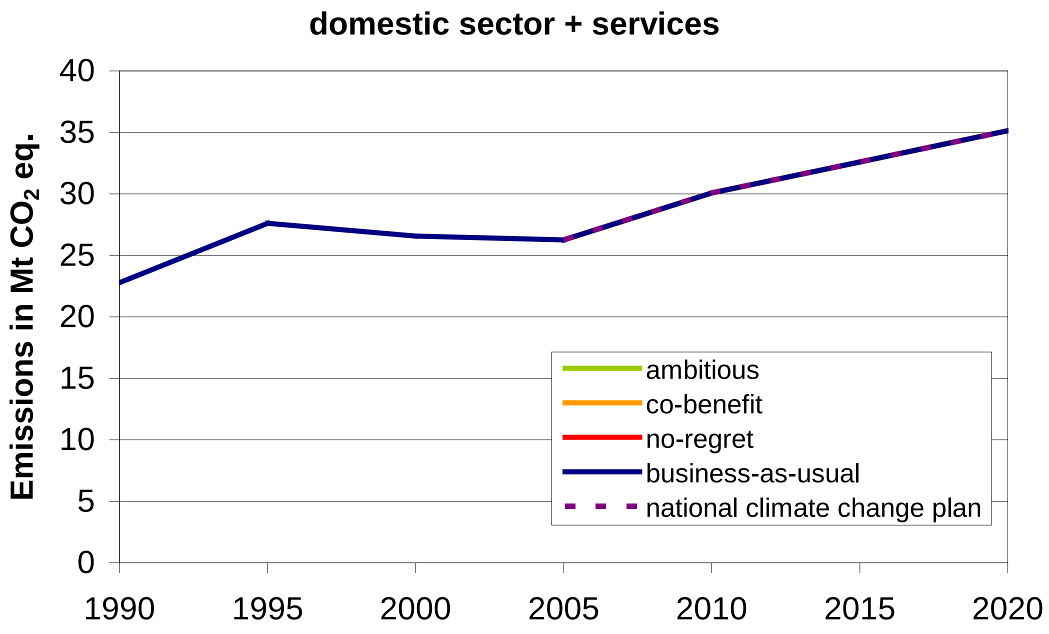

Figure 59 Mexico's emissions and reduction potential under the BAU and all reduction scenarios in the domestic and services sector

In the transport sector (Figure 60) reduction options are considerable. A shift to more biomass use is one emission reduction option. Another element is to increase efficiency, especially in aviation and road transport, and a shift to increase the absolute amount of rail transport.

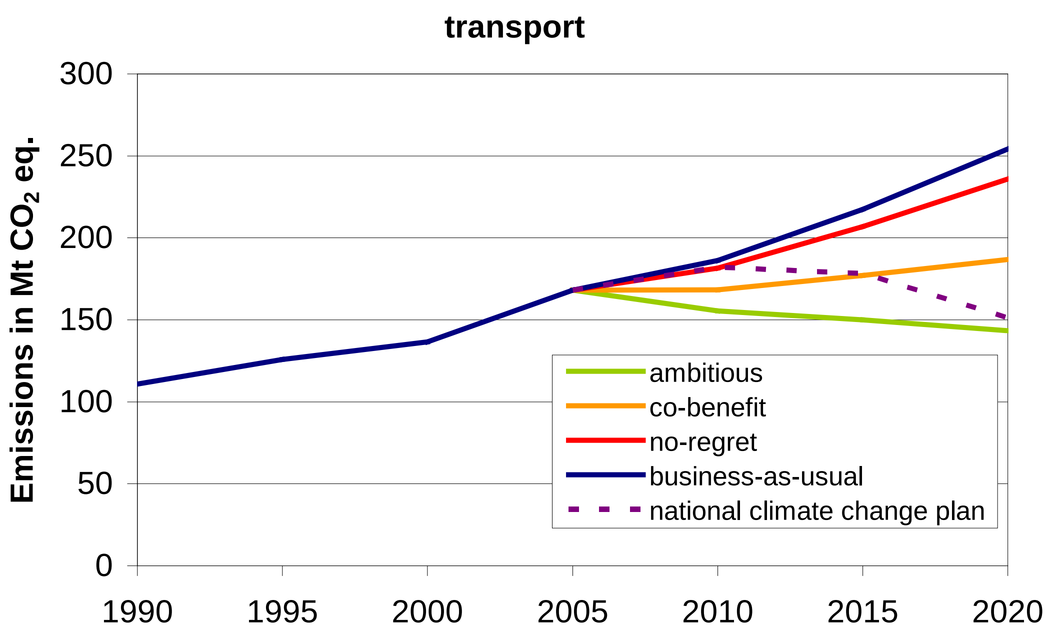

Figure 60 Mexico's emissions and reduction potential under the BAU and all reduction scenarios in the transport sector

In the agriculture and waste sector (Figure 61) some limited reduction potential is available mainly due to changing growth in livestock and recovered methane.

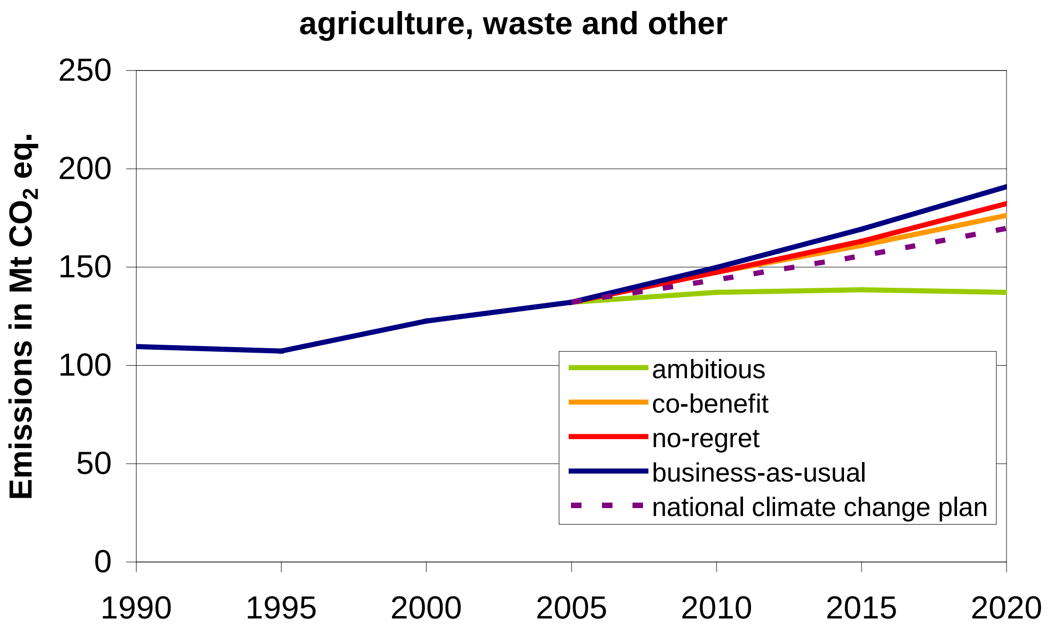

Figure 61 Mexico's emissions and reduction potential under the BAU and all reduction scenarios in the agriculture, waste and other sector

For the LUCF sector (Figure 62) the national plan includes a significant reduction potential of about 15 Mt compared to 2005 in 2020, mainly based on afforestation.

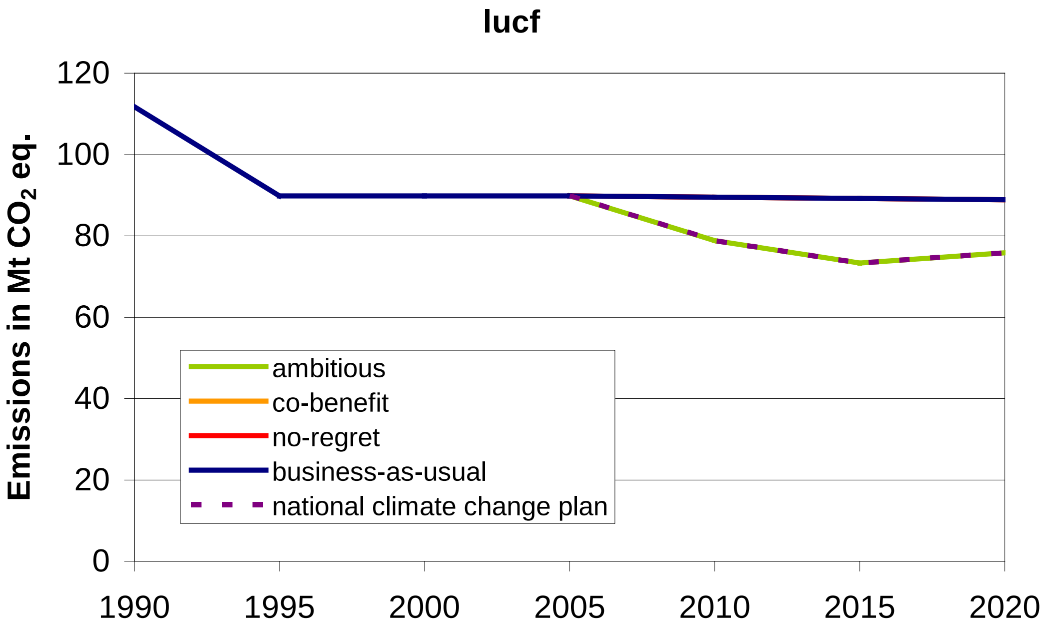

Figure 62 Mexico's emissions and reduction potential under the BAU and all reduction scenarios in the LUCF sector

Most important findings for Mexico:

- Mexico's emissions are projected to increase by about 2.5% per year between 2000 and 2020 under the business-as-usual scenario.
- In 2005 most emissions result from transport (23%), power production (18%), and industry (17%). Under the business-as-usual scenario, this trend is projected to be more or less similar although the importance of transport and other energy industries will increase slightly, while the shares of power production and LUCF will decrease a bit.
- The three sectors with the highest GHG emission reduction potential between 2005 and 2020 under the ambitious potential are other energy industry, transport and the power production sector.
- Under the no-regret potential scenario reductions of 8% below BAU (34% above 2005 emissions) are possible. Under the co-benefit potential scenario reductions of 18% below BAU (20% above 2005 emissions) are feasible. Under the ambitious potential scenario reductions of 43% below BAU (16% below 2005 emissions) are possible. According to our interpretation of Mexico's national climate change plan reductions of 34% below BAU (3% below 2005 emissions) are possible.

6.4 Comparison to other sources

6.4.1 Comparison to BAU scenarios from national reports and national climate strategy

In its last National Communication from 2006, Mexico included a BAU assumption as shown in Figure 63. This includes national emissions projections in Mt at least for power production, including combustion of fuels, industry, transport, cattle, energy transformation and fugitive emissions. Three scenarios where developed, which vary in their GDP growth: low (ALT2 PIB BAJO, annual GDP growth of 2.8%), medium (Prospec SENER, annual GDP growth of 4.3%) and high (ALT1 PIB ALTO, annual GDP growth of 5.2%). Even if the emissions do not seem to include LUCF these figures seem very low already for 2002.

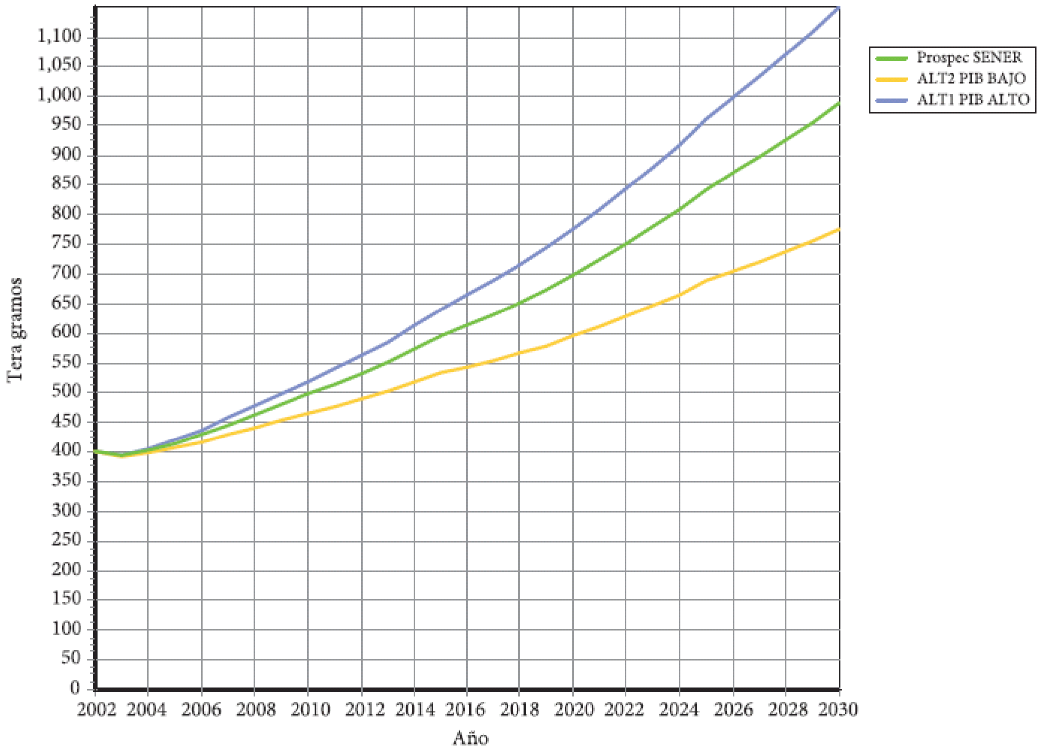

Figure 63 BAU from Mexico's National Communication 2006 (Government Mexico 2007)

In December 2008 Mexico announced to reduce its emissions by 50% below 2002 levels by 2050. Later, Mexico published a figure where also an intermediate 2030 target is included. We considered this and interpolated to have a rough indication for 2020 of about 620 Mt.

In August 2009, the Mexican environmental ministry published a Special Programme on Climate Change (SEMARNAT 2009). This report includes more recent figures (see Figure 64).

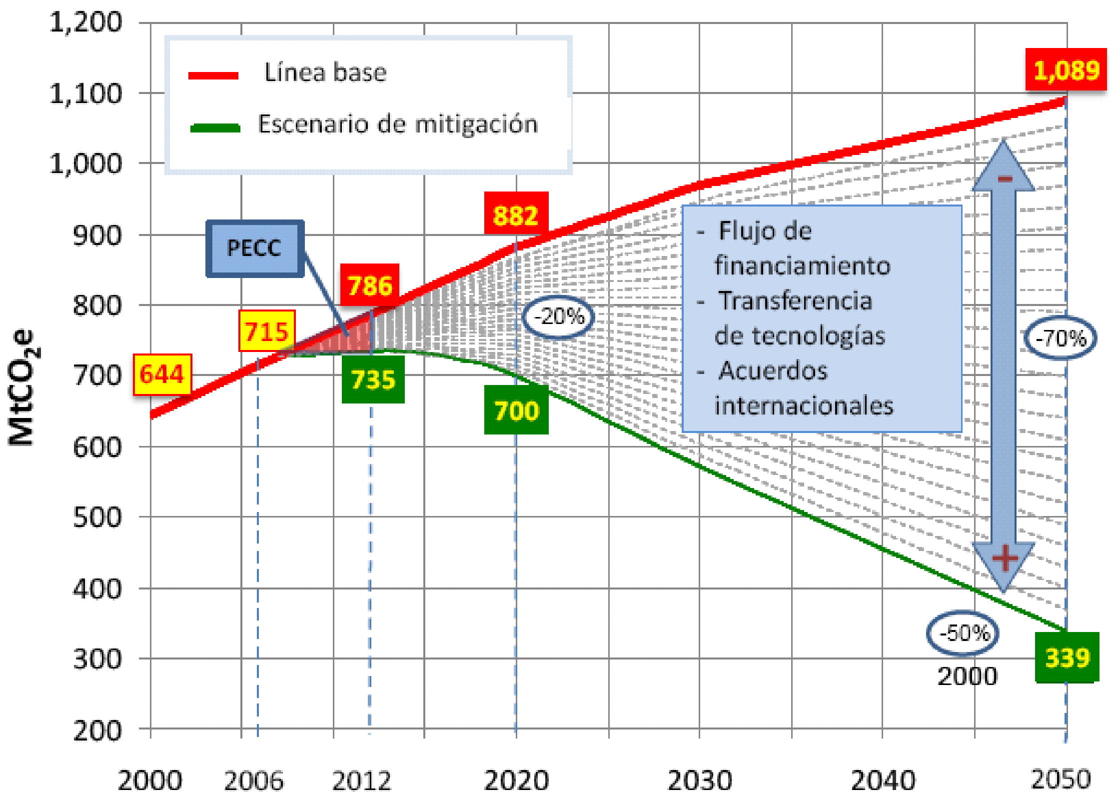

Figure 64 BAU and reduction scenario from Mexico's Programme on Climate Change (SEMARNAT 2009, p. 15)

Note: Until 2012 national estimates for Mexico are included. For 2020, 2030 and 2050 average global trend extrapolations from the Environmental Outlook 2030 (OECD 2008) are applied.

PECC - Programa Especial de Cambio Climático 2009-2012 (Special Programme on Climate Change 2009-2012)

The historic emissions in Figure 64 are based on Mexico's greenhouse gas inventory. Our estimates are about 15 $MtCO_2eq$ higher and come very close to this. In future years this difference increases, however. Until 2020 the difference becomes more considerable: about 880 Mt (SEMARNAT 2009) compared to about 1070 Mt (values from this report).

At the beginning of June 2009, Mexico's President Felipe Calderon announced that Mexico intends to cut its emissions by 50 $MtCO_2eq$ per year until 2012. According to the environment ministry this would add up to about 8% of Mexico's emissions. Major measures to reach this shall be more efficient cars and power plants, reduction of leakages and flaring in energy industry.

6.4.2 Comparison to 2008 report

Mexico experienced high growth of emissions in the last available historic years especially in other energy industry. Historic data for power production declined at the same time. Therefore, overall emissions are similar to Höhne et al. 2008.

6.4.3 Comparison to global effort-sharing approaches

Figure 65 compares the outcomes of the scenarios described above (left) to different global effort-sharing approaches (right) consistent with stabilising GHG concentrations at 450 ppmv CO_2eq. For Mexico all effort-sharing approaches come to very similar results. All of them are close to the national climate change plan scenario, which is well below the co-benefit potential. C&C and DCD lead to the least stringent reductions, since Mexico's per-capita emissions are average. The Triptych approach is most stringent with 610 MtCO_2eq, since this approach is very stringent on emissions from oil and gas production, which are significant for Mexico. GDRs and South North put Mexico in a similar category of countries and result in allowances somewhere in between the earlier two.

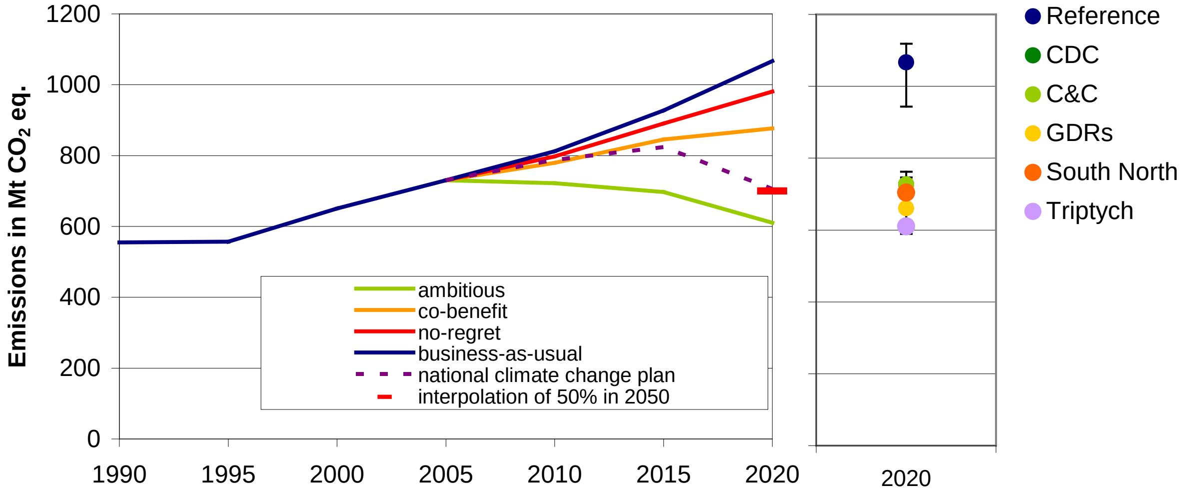

Figure 65 Mexico's emission allowances according to the developed scenarios compared to different global effort-sharing approaches in 2020

7 South Africa

7.1 South Africa's national climate change strategy

The information on South Africa was mainly taken from a PowerPoint presentation on the Government's Vision, Strategic Direction and Framework for Climate Policy based on the LTMS high level process (reference see above).

> *'South Africa needs to find opportunities in a carbon-constrained world – we must avoid the risks and turn our potential comparative advantages into competitive advantages.'*
>
> *'On mitigation, our immediate task: Start Now based on accelerated energy efficiency and conservation across all sectors (industry, commerce, transport, residential – incl. more stringent building standards); invest in Reach for the Goal by setting ambitious research & development targets focussing on carbon-friendly technologies, identifying new resources and affecting behavioural change; and combine regulatory mechanisms under Scale Up and economic instruments (taxes and incentives) under Use the Market.'*

While the report on Long Term Mitigation Scenarios (DEAT 2007) refers to targets, no targets are specified in the more recent presentation.

7.1.1 Policy Directions

The feedback from the LTMS high-level process, taken with Cabinet's direction and a policy alignment analysis, has been translated into 6 broad policy direction themes.

- Theme 1: Greenhouse gas emission reductions and limits
- Theme 2: Build on, strengthen and/or scale up current initiatives
- Theme 3: Implementing the 'Business Unusual' Call for Action
- Theme 4: Preparing for the future
- Theme 5: Vulnerability and Adaptation
- Theme 6: Alignment, Coordination and Cooperation

7.1.2 Process going forward: 2009 to 2012

- National Climate Change Response Policy Development Summit (February 2009) (Adopt Framework)
- Sectoral policy development work (February – June 2009)
- Post-2012 negotiation positions (Up to July 2009)
- UNFCCC post-2012 negotiations concluded (Copenhagen, December 2009)
- National policy updated for implementation of international commitments (March 2010)
- Green Paper published for public comment (April 2010)
- Final National Climate Change Response Policy published (end 2010)
- Policy translated into legislative, regulatory and fiscal package (from now up to 2012)

7.1.3 Government's vision for the road ahead on climate change

- Transition to climate resilient and low-carbon economy and society
- Limit global temperature increase to 2°C above pre-industrial levels
- Continue to pro-actively build the knowledge base and our capacity
- Long term: redefine our competitive advantage and structurally transform the economy by shifting from an energy-intensive to a climate-friendly path
- This would constitute a fair and meaningful contribution to the global efforts, demonstrating leadership in the multi-lateral system by committing to a 'substantial deviation from baseline', enabled by international funding and technology

On mitigation, South Africa's immediate task is: Start Now based on accelerated energy efficiency and conservation across all sectors (industry, commerce, transport, residential – incl. more stringent building standards); invest in Reach for the Goal by setting ambitious research & development targets focussing on carbon-friendly technologies, identifying new resources and affecting behavioural change; and combine regulatory mechanisms under Scale Up and economic instruments (taxes and incentives) under Use the Market with a view to:

1. Setting ambitious and mandatory (as distinct from voluntary) targets for energy efficiency and in other sub-national sectors. In the next few months each sector will be required to do work to enable it to decide on actions and targets in relation to this overall framework.
2. Based on the electricity-crisis response, government's energy efficiency policies and strategies must be continuously reviewed and amended to reflect more ambitious national targets aligned with the LTMS.
3. Increasing the price on carbon through an escalating CO_2 tax, or alternative market mechanism.
4. Diversifying the energy mix away from coal whilst shifting to cleaner coal, e.g. by introducing more stringent thermal efficiency and emissions standards for coal-fired power stations.
5. Setting similar targets for electricity generated from both renewable and nuclear [5]energy sources by the end of the next two decades.
6. Laying the basis for a net zero-carbon electricity sector in the long term.
7. Incentivising renewable energy through feed-in tariffs.
8. Exploring and developing carbon capture and storage (CCS) for coal fired power stations and all coal-to-liquid (CTL) plants, and not approving new coal fired power stations without carbon capture readiness.
9. Introducing industrial policy that favours sectors using less energy per unit of economic output and building domestic industries in these emerging sectors.
10. Setting ambitious and where appropriate mandatory national targets for the reduction of transport emissions, including through stringent and escalating fuel efficiency standards, facilitating passenger modal shifts towards public transport and the aggressive promotion of hybrids and electric vehicles.

[5] South Africa's national energy company ESKOM recently decided to stop the expansion of its nuclear plants for the time being due to high costs. ESKOM planned a modernisation programme providing 15 billion Euro (150 billion Rand) (dpa (Deutsche Presseagentur), 5 December 2008).

7.2 Implementation of South Africa's national climate strategy

South Africa developed a climate strategy including several reduction scenarios (DEAT 2007). These are only linked to some concrete measures. Some more possible polices and measures are given in ERC 2007. These give an indication of possible actions. However, they are not explicitly linked to South Africa's national climate strategy.

In addition, it is not clear which of these paths could be considered as South Africa's strategy that could be met without external support. We focused on the 'start now' scenario.

The measures for South Africa included in this report are included in Table 13. Only some general measure are taken from the scenarios, others should be considered as indicative because they are taken from the LTMS technical report (ERC 2007), not from the scenarios themselves.

Table 13 Measures from South Africa's national climate strategy (DEAT 2007, ERC 2007) as included in this report

Sector	Plans and measures	Implementation in this report
All	Increase the share of renewables, nuclear and clean coal to 27% each by 2050 ('start now', cost neutral or even at negative costs in the long term)	Power production: Increase renewable share in electricity production Industry: Increase share of combustible renewables in cement production
Industry	Increase industrial efficiency ('start now', cost neutral or even at negative costs in the long term)	Industry: Decrease specific energy consumption (in primary and secondary steel production, clinker production, pulp and paper production), decrease annual growth rate of energy consumption in rest of industry, decrease primary steel to total steel ratio, decrease clinker cement ratio
Domestic (households)	Efficiency measures in households, e.g. compact fluorescent lamps (LTMS technical report, 2007, p. 43)	Reduce electricity consumption by 16% in 2020 (-7% in co-benefit due to solar hot water neglected due to negative growth rates of electricity use per household), growth rates may not become negative before 2020
Domestic (commercial)	Efficiency and saving measures in services (LTMS technical report, 2007, p. 43 ff)	Decrease electricity use per employee
Waste	Manure management (LTMS technical report, 2007)	Increase share of recovered methane
LUCF	Increase the area of forest plantations by 10,000 ha per year between 2007 and 2017 (Taviv et al. 2007).	Forest area increased, resulting emission saving considered as carbon sink

7.3 Results on reference emissions, mitigation potential and costs

Figure 66 shows South Africa's greenhouse gas emissions under the business-as-usual (BAU) scenario and four different emission reduction scenarios as calculated in this report. The scenario parameters are based on national studies as far as possible. Major sources for future data in South Africa are EDRC 2003, Winkler et al. 2005, USEPA 2006b, the national climate change plan (DEAT 2007; ERC 2007) and trend extrapolation of official national and IEA statistics (IEA 2008b).

As illustrated in Figure 66, the reduction potential for South Africa is 16% (no-regret), 18% (co-benefit) and 30% (ambitious potential) and 19% (national climate change plan) below BAU. The three sectors with the highest GHG emission-reduction potential between 2005 and 2020 (ambitious potential) are (1) power, (2) industry and (3) the other energy industry sector. The ambitious mitigation potential in the power sector is estimated at 76 $MtCO_2eq$ in 2020. In the industry sector, there exists an ambitious potential of 37 $MtCO_2eq$. The ambitious potential in the other energy industry sector is estimated at 30 $MtCO_2eq$ in 2020. The total ambitious mitigation potential in South Africa is estimated at 198 $MtCO_2eq$ in the year 2020. A detailed overview of the potential per sector and scenario can be found in Appendix A 1, detailed mitigation measures and costs in Appendix A 2.

On the right side Figure 66 shows the high and low case results of the sensitivity analysis. The high case leads to 40 to 50 $MtCO_2eq$ more compared to the default settings, which are about +8 to +9%. The low case leads to about -40 to -50 $MtCO_2eq$, which are about -8 to -10%.

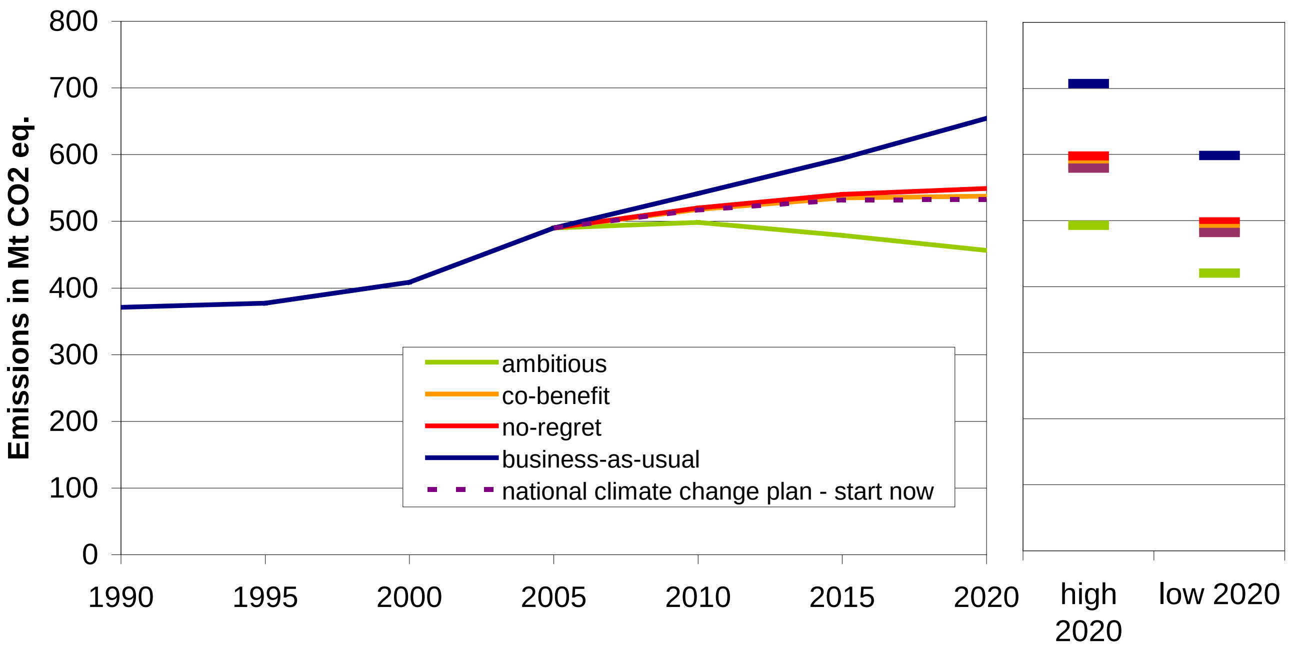

Figure 66 South Africa's national emissions and reduction potential under the BAU and all reduction scenarios between 1990 and 2020 (left) and the sensitivity analysis (right)

7.3.1 Costs

Figure 67 provides South Africa's emission reduction potential in 2020 per sector always compared to the reference scenario in relation to the indicative costs in €/year in 2020. Significant no-regret potential exists in the power and industry sectors. Major additional co-benefit potential exists in the transport and agriculture/waste sectors. High-cost measures can reduce emissions further in industry, transport and agriculture/waste.

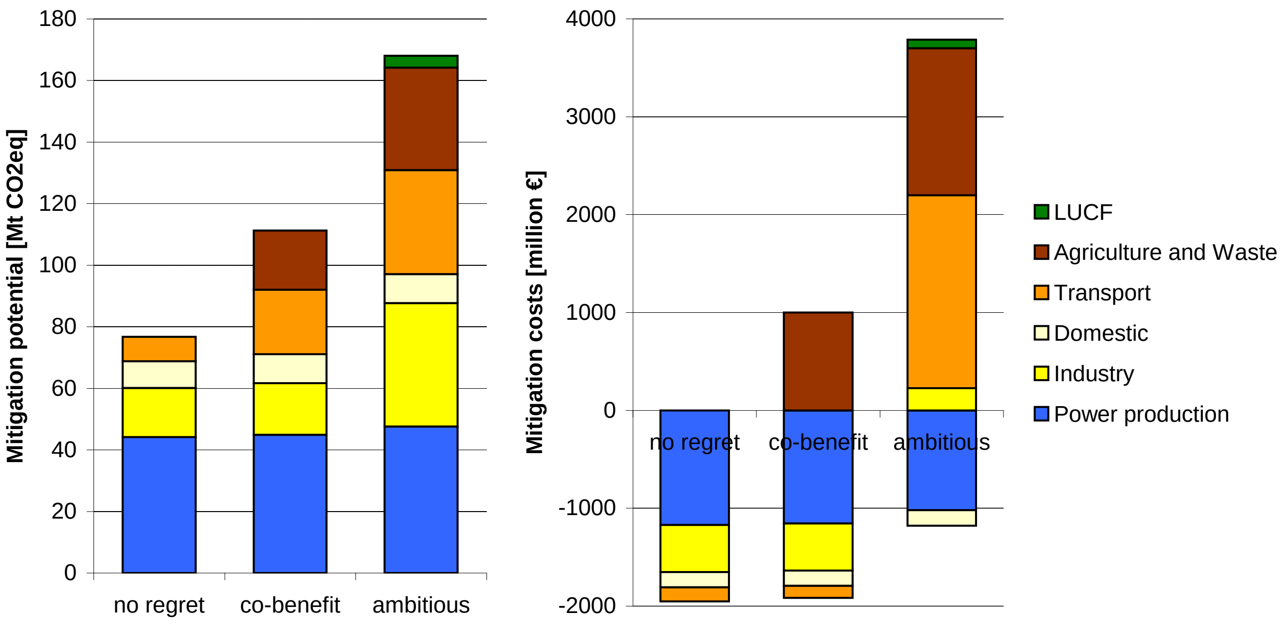

Figure 67 South Africa's emission reduction potential in 2020 per sector always compared to the reference scenario and related indicative costs in €/year in 2020

Figure 68 gives an estimate of South Africa's marginal abatement costs in 2020 under the three reduction scenarios. The no-regret scenario includes costs between -160 and 0 Euro per tonne of CO2 reduced (yellow curve). The co-benefit scenario includes costs between -160 and 100 Euro per tonne of CO2 reduced (yellow + orange curve). The ambitious scenario includes costs between -160 and 180 Euro per tonne of CO2 reduced (yellow + orange + green curve).

The dotted lines give the range of costs that result from the sensitivity analysis. For South Africa a major part of this sensitivity range is below the costs given here for the no-regret potential. For the co-benefit and the ambitious scenario the uncertainty is very high for a considerable part of the mitigation potential; a large part of the sensitivity range lies above the costs estimated here.

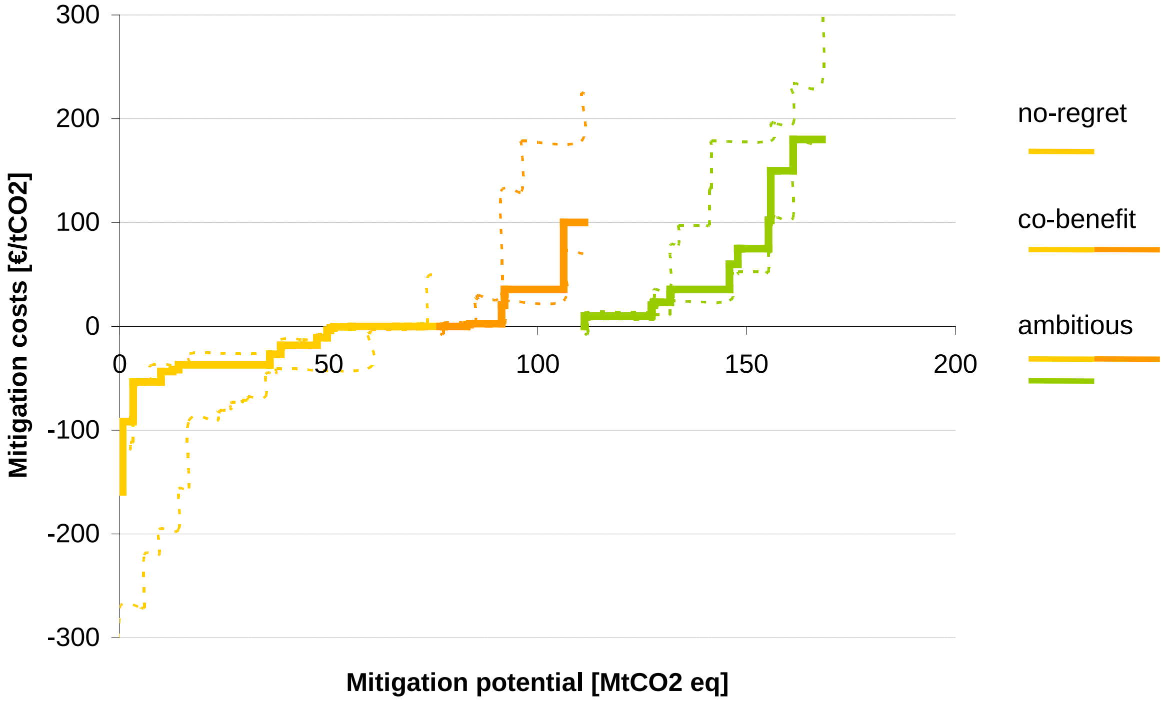

Figure 68 South Africa's mitigation potential and indicative costs in 2020 as marginal abatement cost curve (dotted lines show the cost uncertainty range)

7.3.2 Results per sector

Figure 69 shows South Africa's total reduction potential at sector level under the ambitious potential scenario compared to the business-as-usual scenario and the remaining emissions according to sectors. Figure 71 to Figure 75 show South Africa's national emissions and reduction potential under the BAU and all reduction scenarios per sector.

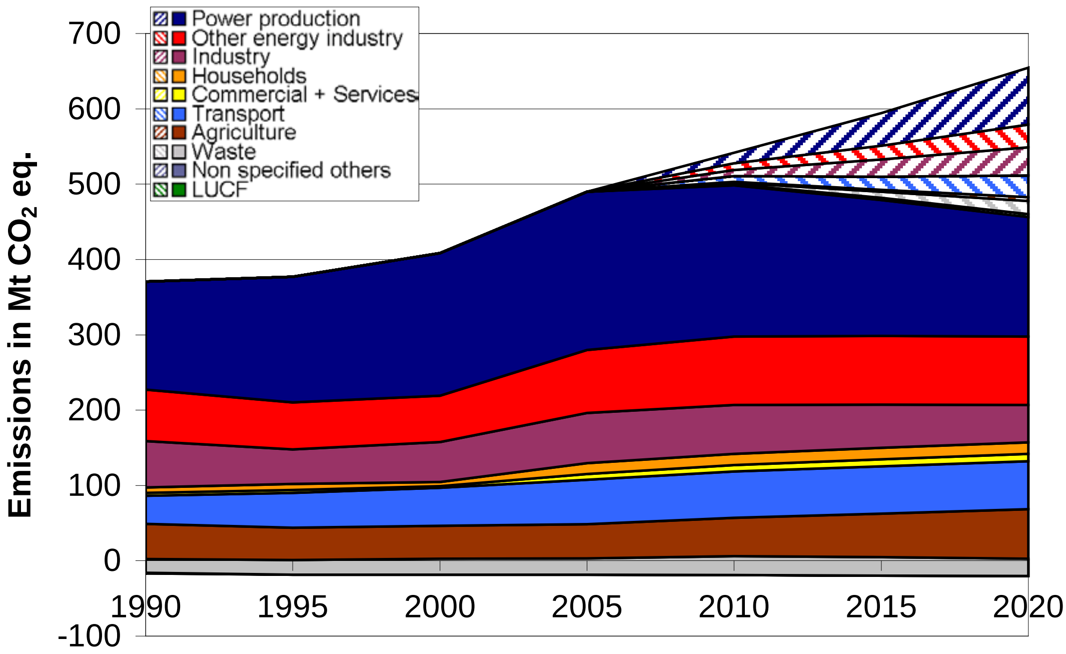

Figure 69 South Africa's national emissions and reduction potential per sector under the BAU and the ambitious scenario between 1990 and 2020. Striped areas show the sectoral emission reduction potential under the ambitious potential scenario compared to BAU.

South Africa's power production sector (Figure 70) offers a significant emission reduction potential. South Africa is highly dependent on domestic coal. Coal production and 'coal to liquid' are major sources of emissions. Movement to renewable energy sources would be a significant reduction option in power production.

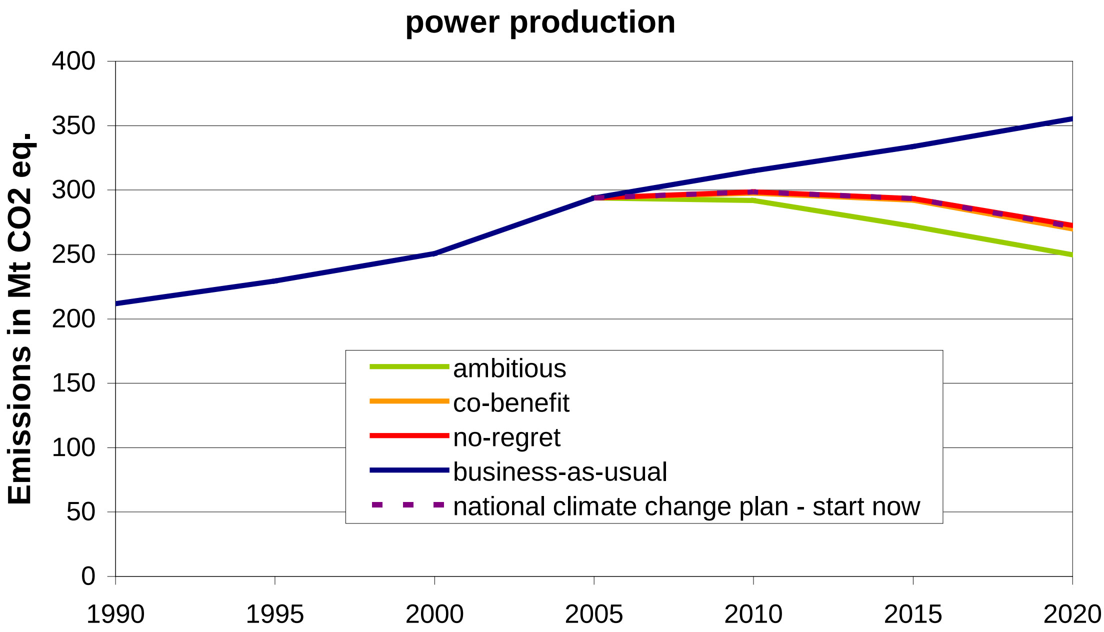

Figure 70 South Africa's emissions and reduction potential under the BAU and all reduction scenarios in the power sector between 1990 and 2020

In the industry sector (Figure 71) major reductions can be achieved by increasing efficiency and moving to renewable energy sources.

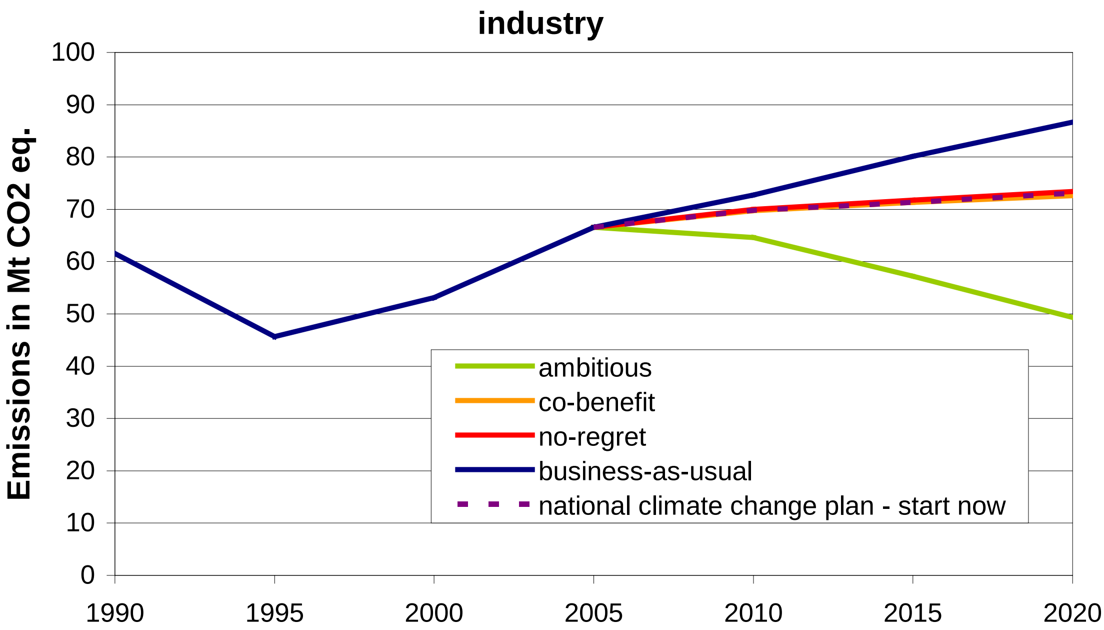

Figure 71 South Africa's emissions and reduction potential under the BAU and all reduction scenarios in the industry sector between 1990 and 2020

In the domestic sector (Figure 72) the increase of energy efficiency is considered under all reduction scenarios. However, the emission reductions are not visible in this sector but in the energy sector, where the electricity is produced. The reduction potential will probably be higher for this sector than what we considered. Due to limited data availability the potential could not be fully taken into account.

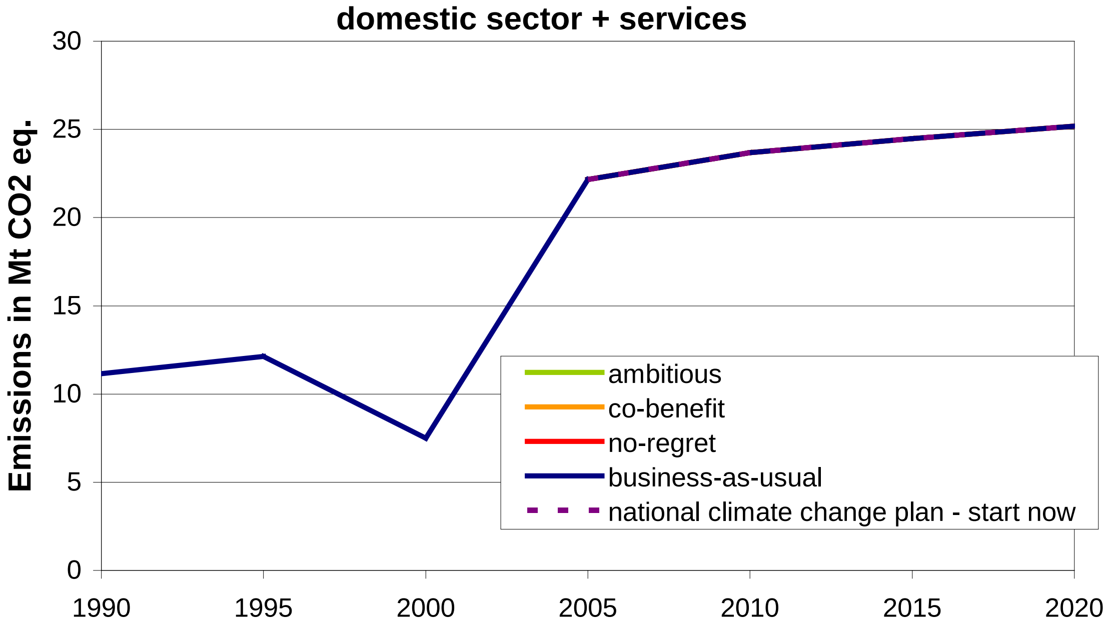

Figure 72 South Africa's emissions and reduction potential under the BAU and all reduction scenarios in the domestic and services sector between 1990 and 2020

In the transport sector (Figure 73) reduction options are considerable. A shift to more natural gas and biomass use is one emission reduction option. Another element is to increase efficiency, especially in aviation and road transport, and a shift to increase the absolute amount of rail transport.

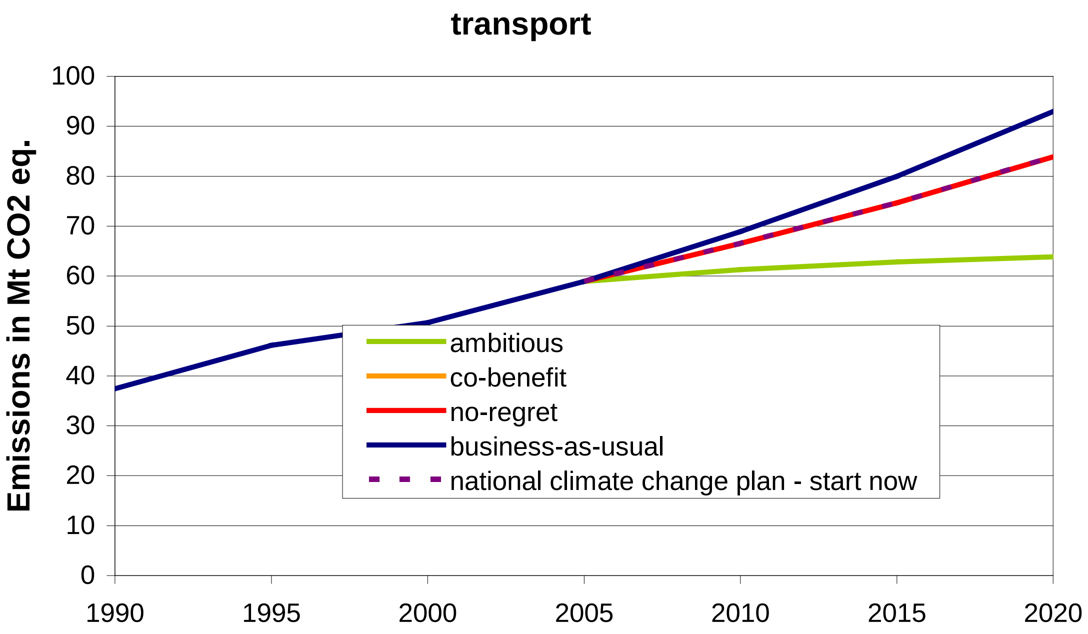

Figure 73 South Africa's emissions and reduction potential under the BAU and all reduction scenarios in the transport sector between 1990 and 2020

In the agriculture and waste sector (Figure 73) some limited reduction potential at relatively high costs is available.

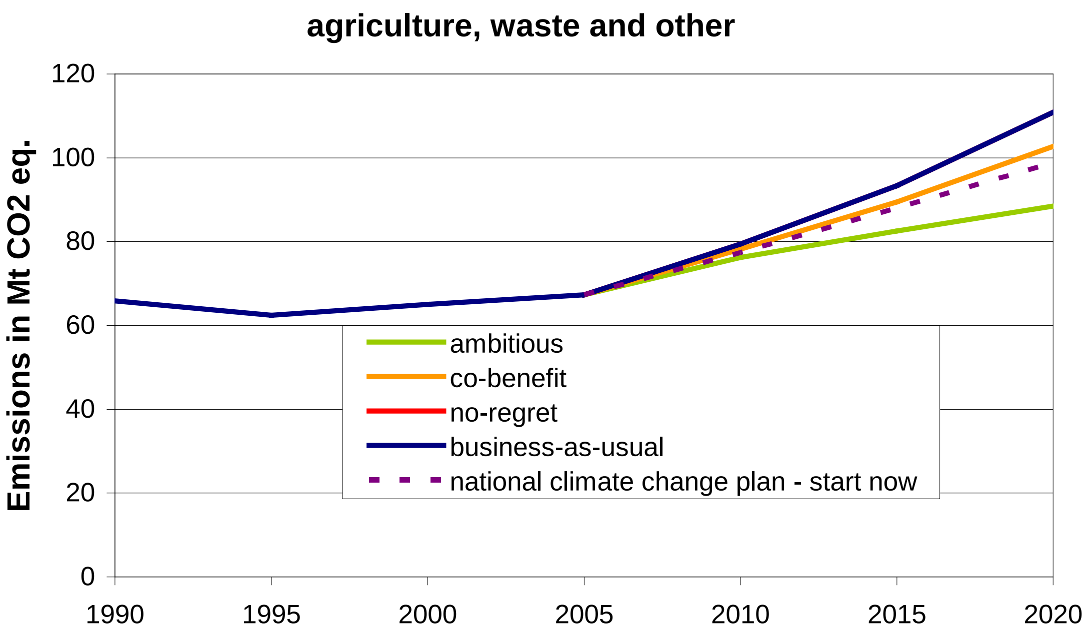

Figure 74 South Africa's emissions and reduction potential under the BAU and all reduction scenarios in the agriculture, waste and other sector between 1990 and 2020

For the LUCF sector (Figure 75) the national plan includes a reduction potential of about 4 Mt in 2020, mainly based on afforestation.

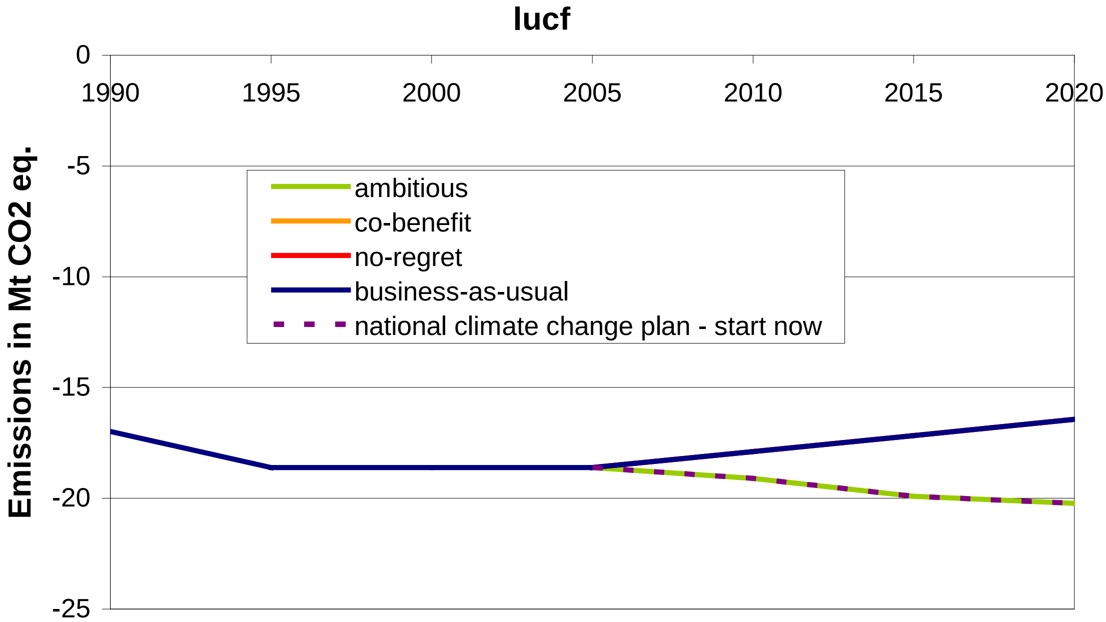

Figure 75 South Africa's emissions and reduction potential under the BAU and all reduction scenarios in the LUCF sector between 1990 and 2020

Most important findings for South Africa:

- South Africa's emissions are projected to increase by about 2.4% per year between 2000 and 2020 under the business-as-usual scenario.
- In 2005 most emissions result from power production (43%), other energy industry (17%) and industry (14%). Under the business-as-usual scenario, this trend is projected to be more or less similar, although the importance of power production will decrease, while the shares of most other sectors will increase by a few percentage points.
- The three sectors with the highest GHG emission-reduction potential between 2005 and 2020 under the ambitious potential are the power, the industry and the other energy industry sector.
- Under the no-regret potential scenario reductions of 16% below BAU (12% above 2005 emissions) are possible. Under the co-benefit potential scenario reductions of 18% below BAU (10% above 2005 emissions) are feasible. Under the ambitious potential scenario reductions of 30% below BAU (7% below 2005 emissions) are possible. According to South Africa's national climate change plan reductions of 19% below BAU (9% above 2005 emissions) are possible.

7.4 Comparison to other sources

7.4.1 Comparison to BAU scenarios from national reports and national climate strategy

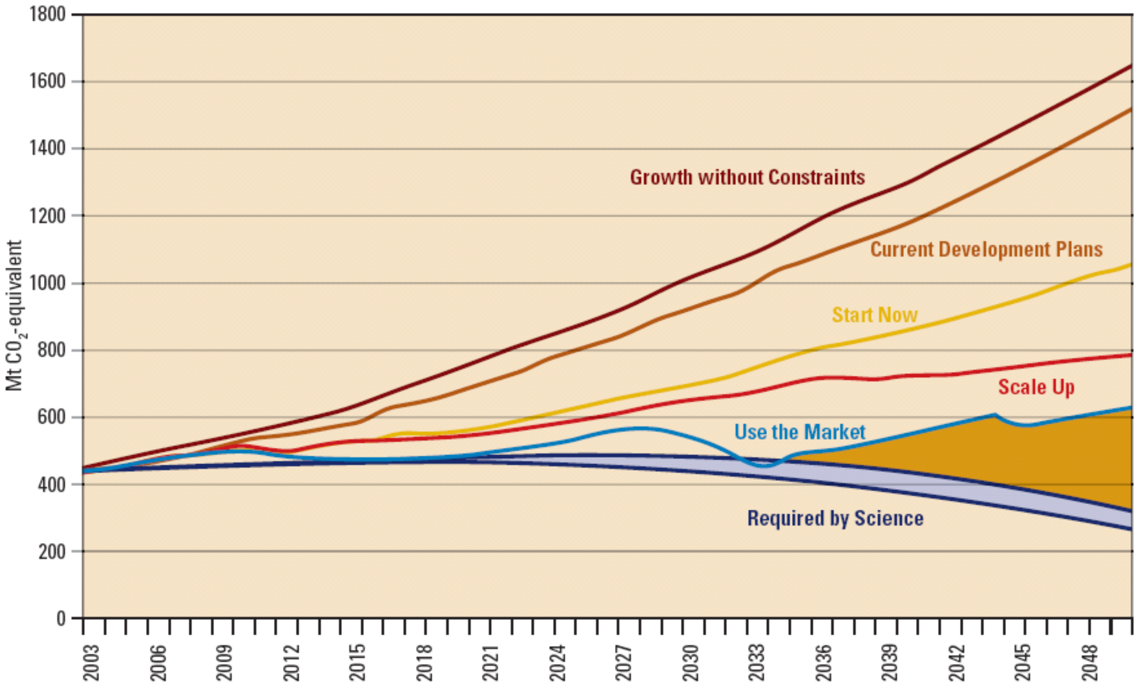

Figure 76 Long-Term mitigation scenarios for South Africa (DEAT 2007)

South Africa developed a detailed report on Long-Term Mitigation Scenarios (LTMS) covering its BAU emissions and describing different paths to achieve necessary emission reductions (DEAT 2007). Two BAU options exist: a path considering Growth without Constraints and a Current Development Plans path. The latter one seems to be a more realistic BAU as it reflects current political developments better than the Growth without Constraints path.

The following national emission reductions below BAU (Current Development Plans) are given in the national climate plan:

- ~ -30% by 2020 possible according to 'Stat now'
- ~ -60% by 2050 possible according to 'Use the Market'
- ~ -80% by required by 2050 required by science to stabilise the global climate

The following reduction scenarios are described:

- 'Start Now' includes energy efficiency measures and changes in the energy mix (27% nuclear, 27% renewables by 2050).
- 'Scale Up' includes measures from the 'Start Now' and adds further changes to in the energy mix (50% nuclear, 50% renewables by 2050)
- 'Use the Market' is an alternative scenario to 'Scale Up'. It applies a carbon tax and also includes incentive instruments.

In this report the reduction scenarios and the BAU development are very close to the Long Term Mitigations Scenarios (DEAT 2007). Our BAU estimates from Section 7.3 are close to the ‘Current Development Plans’ scenario. Our no-regret scenario is in large parts consistent with the South African ‘Start Now’ scenario. Our co-benefit scenario correlates with the ‘Scale Up’ scenario.

Some very detailed scenarios of possible measures and developments per sector are described in the LTMS. These are not reflected in such detail in our calculations as they are no explicit plans but should be regarded as possible scenarios. However, the overall trend and the developments of the LTMS and our scenarios fit to each other.

7.4.2 Comparison to 2008 report

Historic data for power production and industry changed a bit. Therefore 1990 emissions are slightly lower (about 30 Mt) than in Höhne et al. 2008. South Africa experienced a higher emission growth in historic years according to the data update. Therefore, emissions in 2020 are about 50 Mt higher in this latest report compared to Höhne et al. 2008. This is mainly due to higher increase in power production and other energy industry but also in industry.

In general, the scenarios are close to the LTMS (DEAT 2007), while these where not available early enough for the 2008 report.

7.4.3 Comparison to global effort-sharing approaches

Figure 77 compares the outcomes of the scenarios described above (left) to different global effort-sharing approaches (right) consistent with stabilisation of GHG concentrations at 450 ppmv CO_2eq. For South Africa all effort-sharing approaches come to very similar results with significant reductions below reference and also below today’s emissions, close to the ambitious scenario. GDRs are the least stringent approach, as it concentrates on the large share of population below a development threshold and the low level of historical responsibility. CDC and North South are next, since they are staged approaches, where South Africa enters later. C&C and Triptych are most stringent, because they consider the high per-capita emissions and the high share of coal.

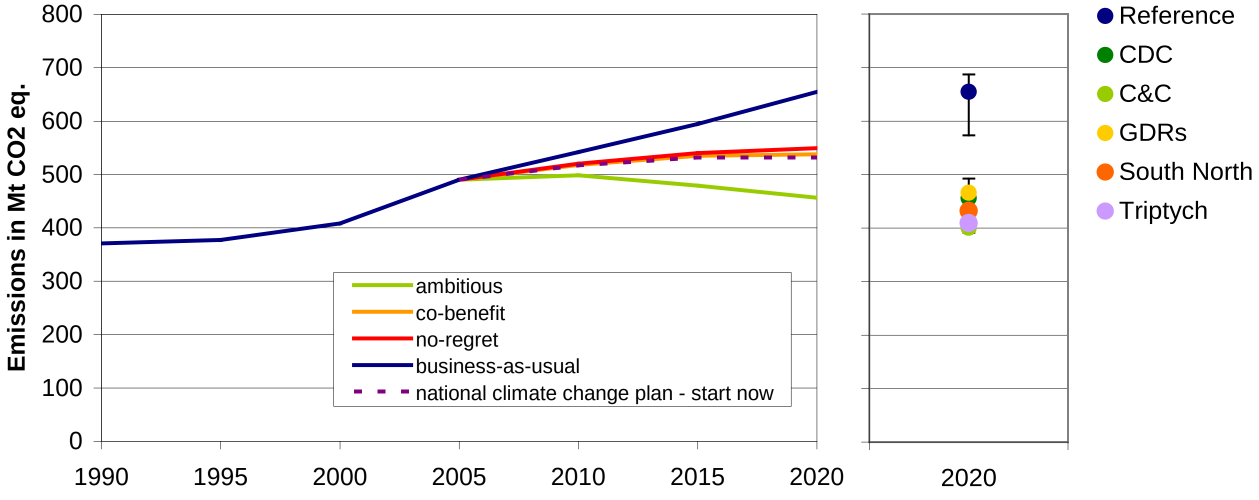

Figure 77 South Africa's emission allowances according to the developed scenarios compared to different global effort-sharing approaches in 2020

8 South Korea

8.1 South Korea's national climate change strategy

8.1.1 Latest developments

On 4th August 2009 South Korea announced three possible options for emission reduction targets. The government intends to choose one of them (see Figure 78). 2020 emissions shall lie

- 8% above the 2005 emission level
  (achieved through implementation of measures with short-term cost but potential long-term benefits)

- at the 2005 emission level
  (implementation of additional measures from scenario 1 which have mitigation cost less 50,000 KRW per ton of CO_2) or

- 4% below the 2005 emission level
  (implementation of aggressive measures with high mitigation cost). [6]

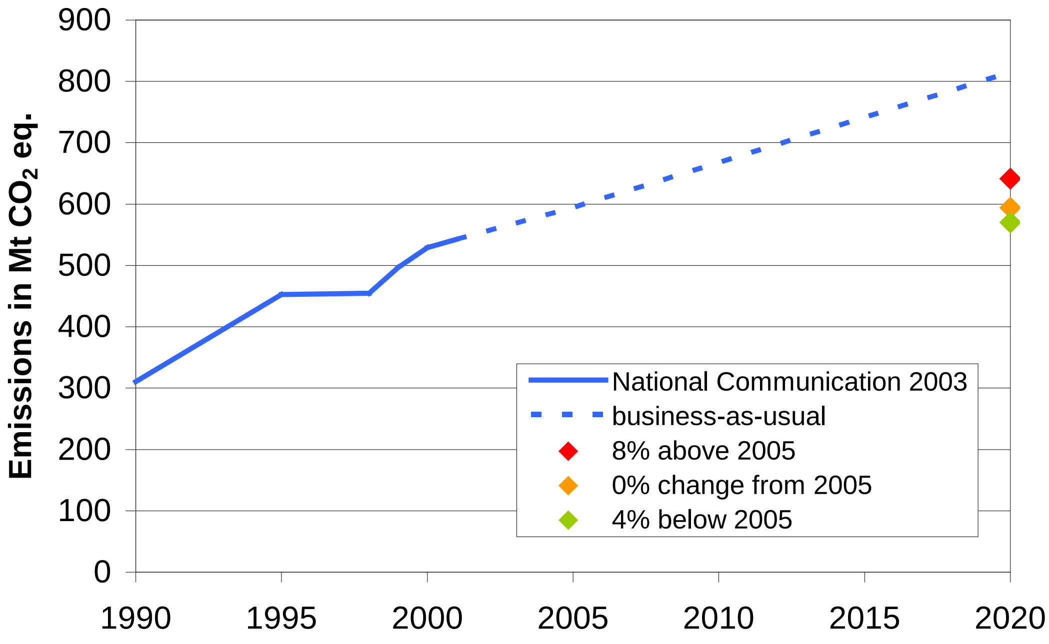

Figure 78 Assumptions on South Korea's emission reduction plans as announced in August 2009

The full report was published in Korean and came out too late for us to fully consider it in this report.

[6] More information on Korea's mitigation plans (in Korean): http://www.greengrowth.go.kr

8.1.2 Framework Act on Climate Change

In summer 2008 South Korea announced to pass a Framework Act on Climate Change, soon. If enacted, the Framework Act should include the monitoring of greenhouse gas emissions and provisions of a mandatory carbon credits system for business and public organisations. The government plans to increase the proportion of wind power, new energy and renewable energy to 9% of the total energy generation by the year 2030. Also it will push ahead with policies to raise energy efficiency across industries and advance economic growth across the country (http://www.korealaw.com).

8.1.3 4th National Action Plan for Climate Change

Since adopting the Kyoto Protocol South Korea set out national action plans for climate change within the context of the UNFCCC. The fourth plan will be valid from 2008 to 2012. It shall focus on adaptation and emission reduction. See below the major points included in the 4th National Action Plan for Climate Change (Jeong 2008):

- To establish low-carbon energy supply system
    - the proportion of renewable energy is aimed to increase from 2.3% in 2006 to 5% in 2011 and 9% in 2030 and
    - the percentage of bio diesel in fuel mix is aimed to increase from 0.5% in 2007 to 3.0% in 2012.
- To consider expanding nuclear power generation enhance the safety of nuclear power and set national mid and long-term target (Nuclear Power: Korea 39%, France 79%, Germany 31%, Japan 29%, US 9%)
- To encourage the creation of eco-friendly industrial structure
    - Services sector-oriented industrial structure and the nurture of eco-industry
    - New economic and industrial structure where manufacturing industry emits less CO_2 and services industry plays a central role
- To facilitate carbon markets through emissions trading scheme
    - conduct pilot projects
    - establish additional carbon funds investing in CDM business, and create carbon funds that directly invest in carbon credits
- Sector targets
    - Industry: to cut 1.8 $MtCO_2$ by 2012 (3.2% decrease from 2005)
    - Public organisation: to phase in a cap on total energy consumption
    - Residential/industrial complex: to expand supply of eco-friendly co-generation heating to 30 complexes by 2012
    - Transport, logistics: to improve fuel efficiency and promote the use of eco-friendly cars
    - Home appliance, industrial equipment: to raise energy efficiency standard for home appliances and industrial equipment
    - Building: to improve energy efficiency and expand recycling of construction waste
    - Agriculture: to cut N_2O emissions by 0.9 $MtCO_2$ by 2012
    - Livestock farming: to reduce CH4 emissions by improving animal waste treatment facilities
    - Forestry: to expand carbon sinks; an increase in carbon absorption of 17 $MtCO_2$
    - Waste: to change methane emitted by waste landfill sites into resources; a decrease of 2.3 $MtCO_2$ by 2012

8.1.4 Energy blueprint

A national energy blueprint is about to be released for Korea. The current information from newspapers provides some information on what can be expected from the blueprint (see below). The Environment Minister Lee Maan-ee said at the Ramsar Convention in November 2008 that:

> *'Since Korea is known for its growing emission of carbon, designating wetlands for preservation and showing them to the world will be the key to preventing worsening climate change.'* (http://www.treehugger.com/files/2008/10/new-ramsar-sites.php)

About 110 trillion won should be invested in reduce South Korea's dependence on fossil fuels and increase the portion of new and renewable energy to 11% in 2030. Already in 2006 the target was set to reduce Korea's dependence on crude oil from 44.3% in 2005 to 35% by 2030. Recently, a target has also been set to increase Korea's global market share in key sectors of renewable energy including solar energy, wind energy and hydrogen cells, raising it from the current 0.7% to 15% in 2030.

The plan for national energy shall also improve the energy intensity (the amount of energy spent on producing $1,000 GDP) from currently 0.341 to 0.185 in 2030. The share of fossil fuels in primary energy consumption shall be reduced from currently 83% to 61% in 2030, while the portion of renewable energy shall be extended from 2.4% to 11%. This is laid down in the action plan for 'Low Carbon, Green Growth' (08/2008). (http://www.nucwatch.com/platts/2006/platts061211.txt, http://wec2013.kr/htm/cyber_02.php)

It remains to be seen what the national blueprint really contains. Leem Sung-jin Professor of Energy and Environmental Policy, Jeonju University, however, stated in an interview that

> *'Korea's state energy blueprint, which will soon be released, doesn't appear to conform to President Lee's green growth vision. Government is planning to expand the share of atomic power generation in the nation's entire energy supply from the current 26 percent to over 40 percent by 2030 in anticipation of an increase of over 28 percent in domestic energy consumption. At least 10 atomic power plants will be additionally built and an astronomical amount of money will be spent for the supply of atomic power. The government's target for the share of new renewable energy in the entire energy consumption totals merely 9 to 11 percent by 2030, which falls quite short of embodying a green environment. We can hardly find any mention of a sustainable and new industrial restructuring in the government blueprint. The president's public declaration could make the nation's push for green growth much easier. However, watching a string of real estate development policies or market-oriented economic stimulus packages, we are led to believe that the government may view green growth merely as a means to attain quantitative growth.'*
>
> (Korea Focus, 22 August 2008, http://www.koreafocus.or.kr/design2/economy/view.asp?volume_id=76&content_id=102160&category=B)

8.2 Implementation of South Korea's national climate strategy

South Korea recently announced three possible options for emission reduction targets by 2020 (reduction to 8% above the 2005 emission level, stabilisation at the 2005 emission level or reduction to 4% below the 2005 emission level). However, this announcement was too late to be included into this report. Based on some indications on measures given in other sources (see Sections above) we included a very limited amount of measures into the climate strategy scenarios.

Table 14 Measures from South Korea's national climate strategy as included in this report

Sector	Plans and measures	Implementation in this report
All	Increase efficiency per GDP	Industry: decrease growth of specific energy demand in steel production, clinker production, pulp and paper production Power production: increase efficiency in production, other energy industry
All	Renewable energy will increase from 2.4 % in 2007 to 11% in 2030, 44-fold increase in the use of PV energy, compared with the 2007 levels, 37-fold increase of wind energy, 19-fold increase of biofuels, 51-fold increase in geothermal power	Industry: Increase share of combustible renewables in cement production, pulp and paper production, rest of industry Power production: increase share of solar, wind and combustible renewables
Power production	15,200 MW by 2022 through the construction of 12 new nuclear plants, nuclear share of power generation capacity up to 33 % from the current level of 24.8 per cent, nuclear power will account for 48 per cent of all electricity produced in South Korea	Increase already high share of nuclear power slightly
Domestic	Korea's energy-efficiency labelling programme will gradually be expanded to cover all buildings. Korea will also promote the development and construction of zero-energy, carbon neutral buildings; national plan	Increase share of geothermal and solar energy, decrease electricity demand per employee
LUCF	Net removals from LUCF between 2000 and 2020 are estimated to fall by 1.4% annually.	Annual decrease of removals by 1.4% per year (the same as in the BAU) emissions

In the following calculations the latest targets are included only indicatively. We considered former publications including more detailed reduction options. However, these preliminary plans are less ambitious.

8.3 Results on reference emissions, mitigation potential and costs

Figure 79 shows South Korea's greenhouse gas emissions under the business-as-usual (BAU) scenario and four different emission reduction scenarios as calculated in this report. The scenario parameters are based on national studies as far as possible. Major sources for future data in South Korea are USEPA 2006b, documents on national developments (Government South Korea 2003; Jeong 2008) and trend extrapolation of official national and IEA statistics (IEA 2008b).

As illustrated in Figure 79, the reduction potential for South Korea is 7% (no-regret), 16% (co-benefit) and 41% (ambitious potential) and 17% (national climate change plan) below BAU. The three sectors with the highest GHG emission-reduction potential between 2005 and 2020 (ambitious potential) are the (1) power, (2) transport and (3) the industry sector. The ambitious mitigation potential in the power sector is estimated at 132 MtCO_2eq in 2020. The ambitious potential in the transport sector is estimated at 80 MtCO_2eq in 2020. In the industry sector we identified an ambitious potential of 79 MtCO_2eq. The total ambitious mitigation potential in South Korea is estimated at 338 MtCO_2eq in the year 2020. A detailed overview of the potential per sector and scenario can be found in Appendix A 1, detailed mitigation measures and costs in Appendix A 2.

On the right side Figure 79 shows the high and low case results of the sensitivity analysis. The high case leads to 15 to 20 MtCO_2eq more compared to the default settings, which are about +2 to +3%. The low case leads to about -15 to -20 MtCO_2eq, which are about -2 to -3%.

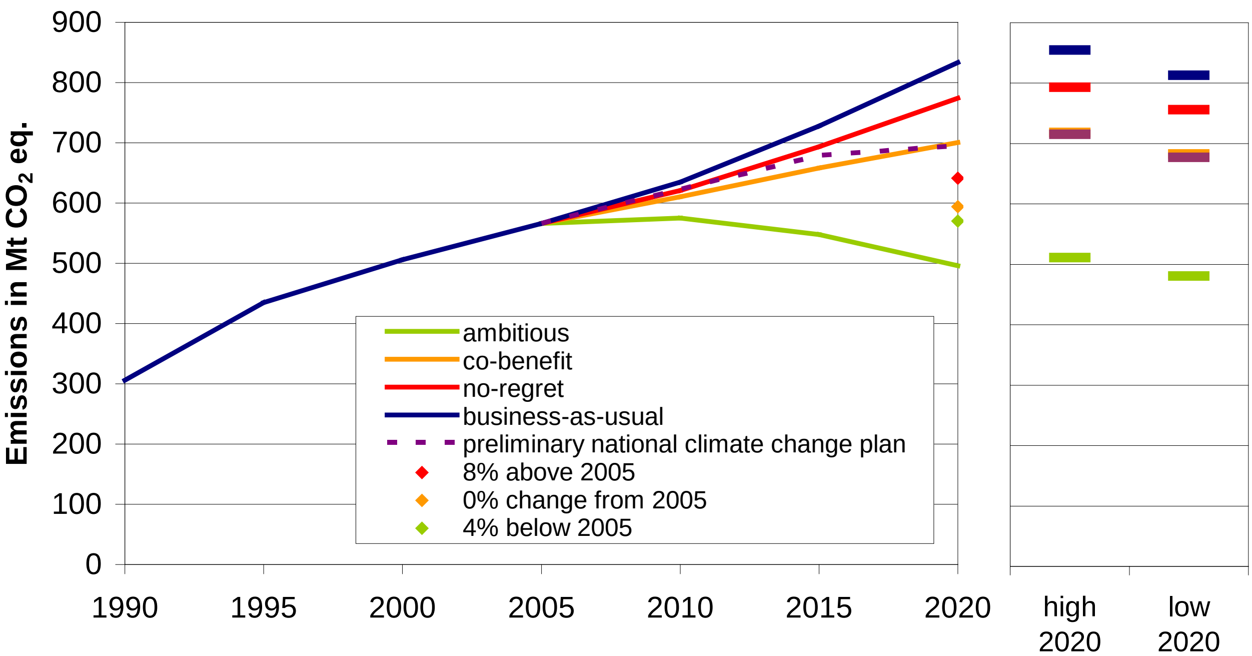

Figure 79 South Korea's national emissions and reduction potential under the BAU and all reduction scenarios between 1990 and 2020 (left) and the sensitivity analysis (right)

8.3.1 Costs

Figure 80 provides South Korea's emission reduction potential in 2020 per sector, always compared to the reference scenario in relation to the indicative costs in €/year in 2020. Significant no-regret potential exists in all sectors except power. Major additional co-benefit potential exists in the power sector and transport sector. High-cost measures can reduce emissions further in all sectors.

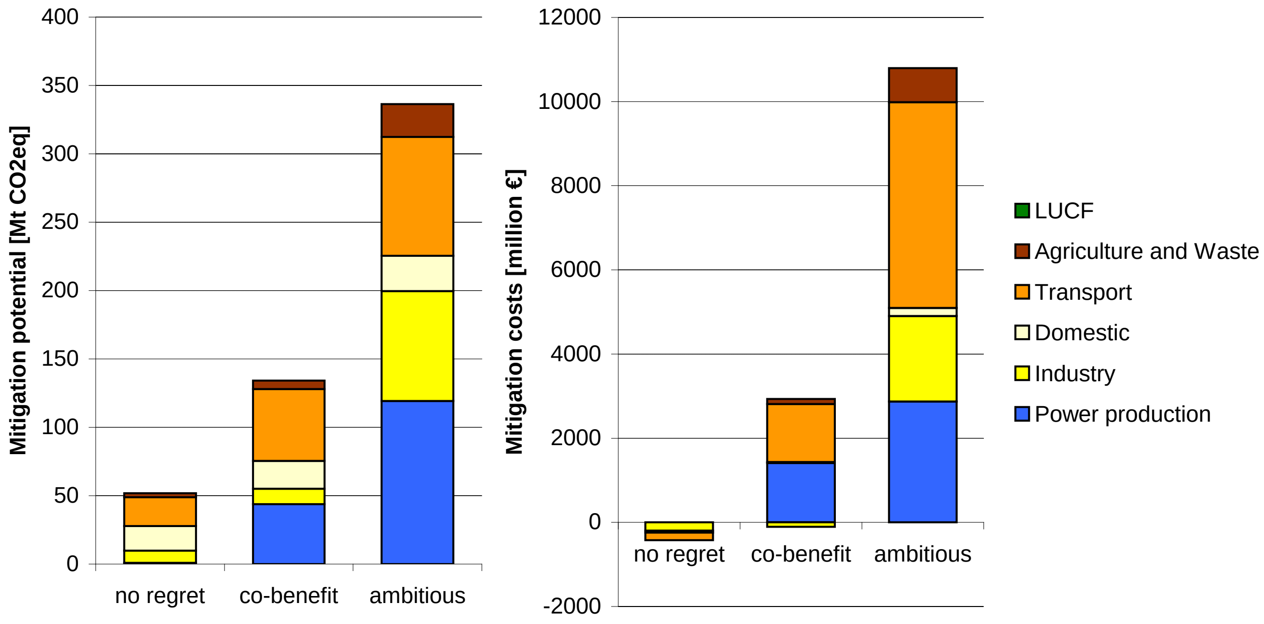

Figure 80 South Korea's emission reduction potential in 2020 per sector always compared to the reference scenario and related indicative costs in €/year in 2020

Figure 81 gives an estimate of South Korea's marginal abatement costs in 2020 under the three reduction scenarios. The no-regret scenario includes costs between -95 and 0 Euro per tonne of CO2 reduced (yellow curve). The co-benefit scenario includes costs between -95 and 100 Euro per tonne of CO2 reduced (yellow + orange curve). The ambitious scenario includes costs between -95 and 180 Euro per tonne of CO2 reduced (yellow + orange + green curve).

The dotted lines give the range of costs that result from the sensitivity analysis. For South Korea a major part of this sensitivity range is below the costs given here for the no-regret potential. For the ambitious scenario the uncertainty is very high for a considerable part of the mitigation potential; a large part of the sensitivity range lies above the costs estimated here.

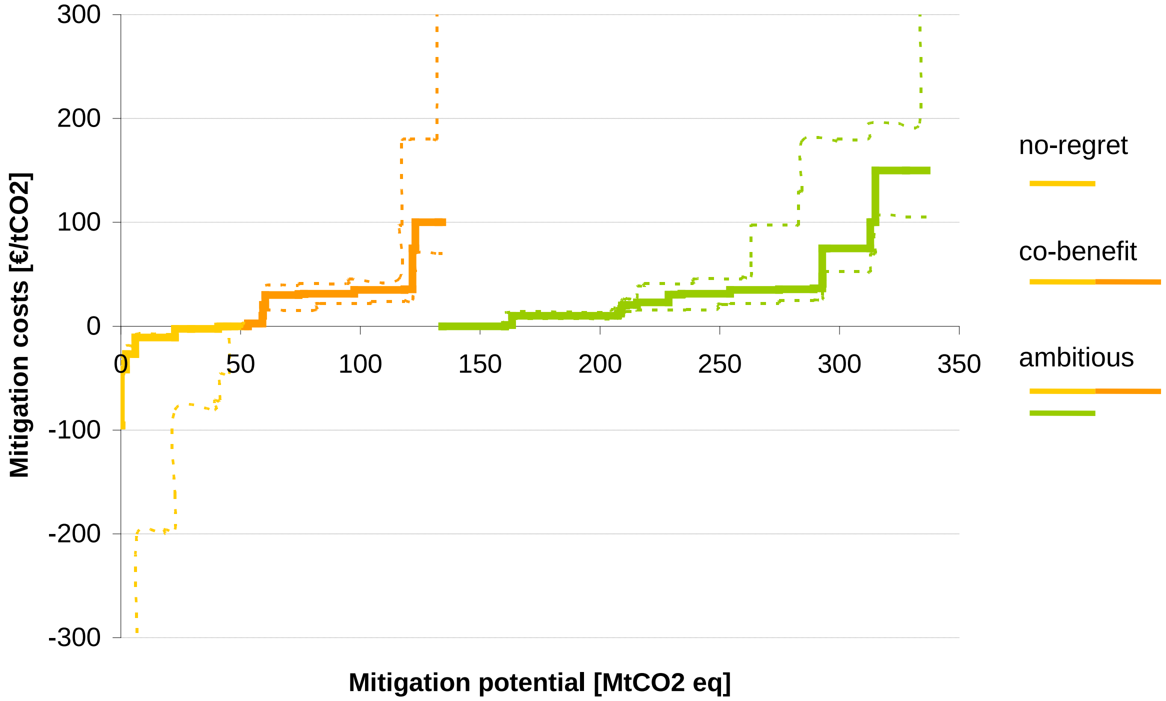

Figure 81 South Korea's mitigation potential and indicative costs in 2020 as marginal abatement cost curve (dotted lines show the cost uncertainty range)

8.3.2 Results per sector

Figure 82 shows South Korea's total reduction potential at sector level under the ambitious potential scenario compared to the business-as-usual scenario and the remaining emissions according to sectors. Figure 83 to Figure 88 show Korea's national emissions and reduction potential under the BAU and all reduction scenarios per sector.

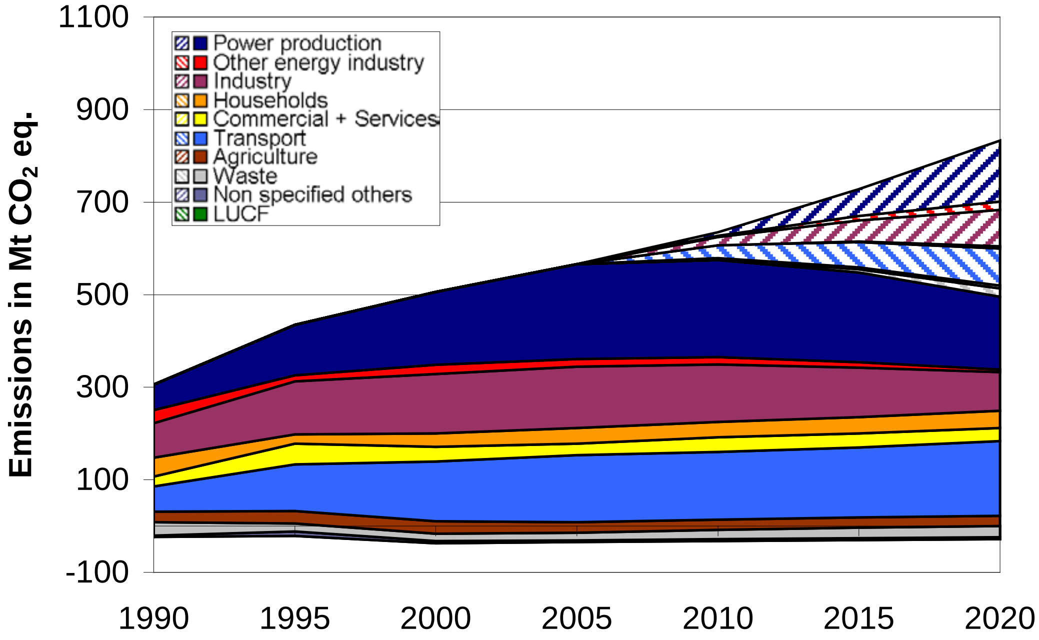

Figure 82 South Korea's national emissions and reduction potential per sector under the BAU and the ambitious scenario between 1990 and 2020. Striped areas show the sectoral emission reduction potential under the ambitious potential scenario compared to BAU.

The development of South Korea's power sector is shown in Figure 83. South Korea has a high share of nuclear energy in the electricity mix, high efficiency, some use of combined heat and power generation and low distribution losses. A major reduction option is to move to renewable energy sources.

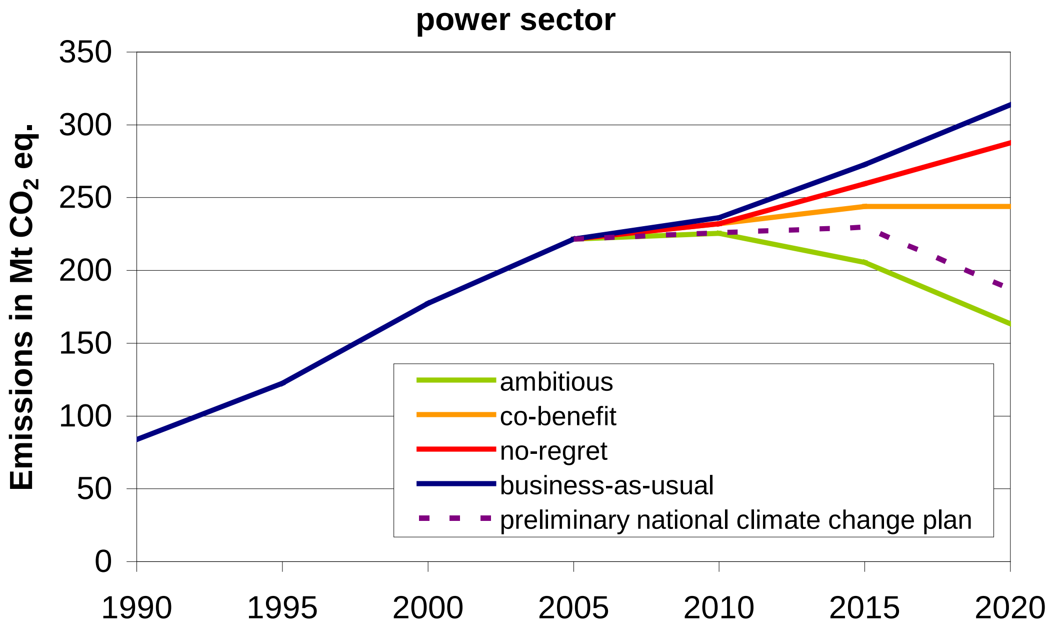

Figure 83 South Korea's emissions and reduction potential under the BAU and all reduction scenarios in the power sector

South Korea's industry (Figure 84) is already very efficient but is growing very fast. Moving to more use of renewable energy could compensate for the growth.

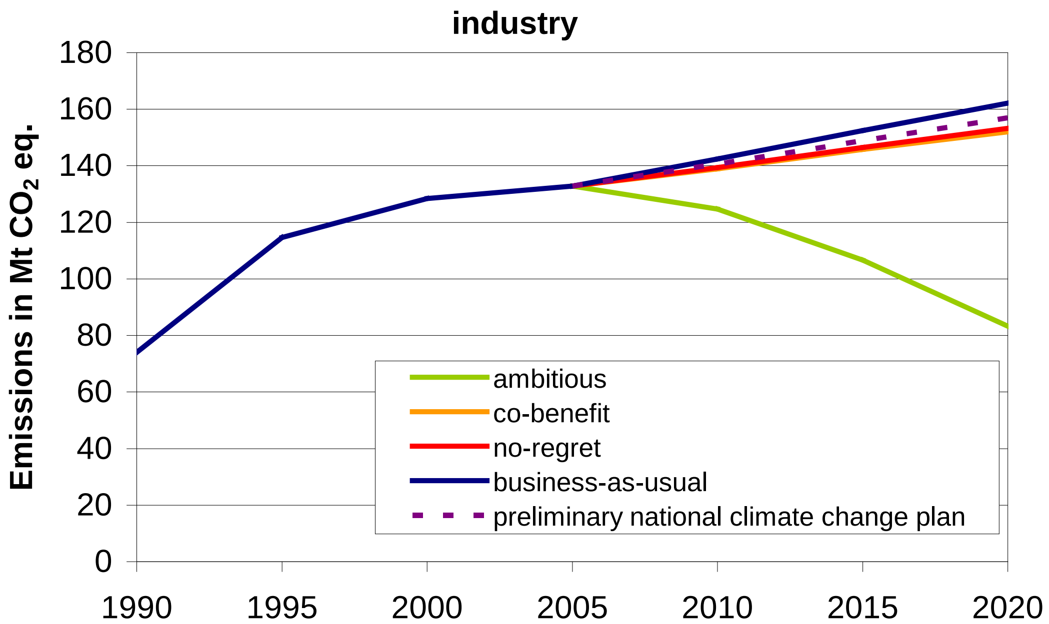

Figure 84 South Korea's emissions and reduction potential under the BAU and all reduction scenarios in the industry sector

In the domestic sector (Figure 85) the reduction potential might be high. Here, due to limited data availability, we included only the reduced electricity demand through more efficient appliances. However, the emission reductions are not visible in this sector but in the energy sector, where the electricity is produced. Further analysis on more disaggregated data might be useful.

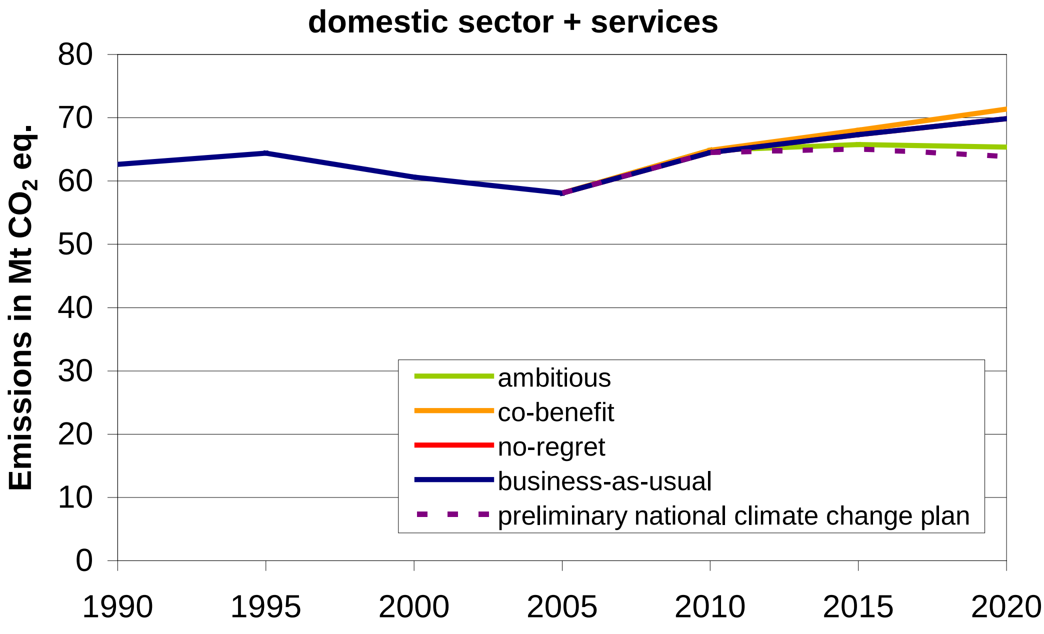

Figure 85 South Korea's emissions and reduction potential under the BAU and all reduction scenarios in the domestic and services sector

In the transport sector (Figure 86) reduction options are considerable. A shift to more natural gas and biomass use is one emission reduction option. Another element is to increase efficiency, especially in aviation and road transport, and a shift to increase the absolute amount of rail transport.

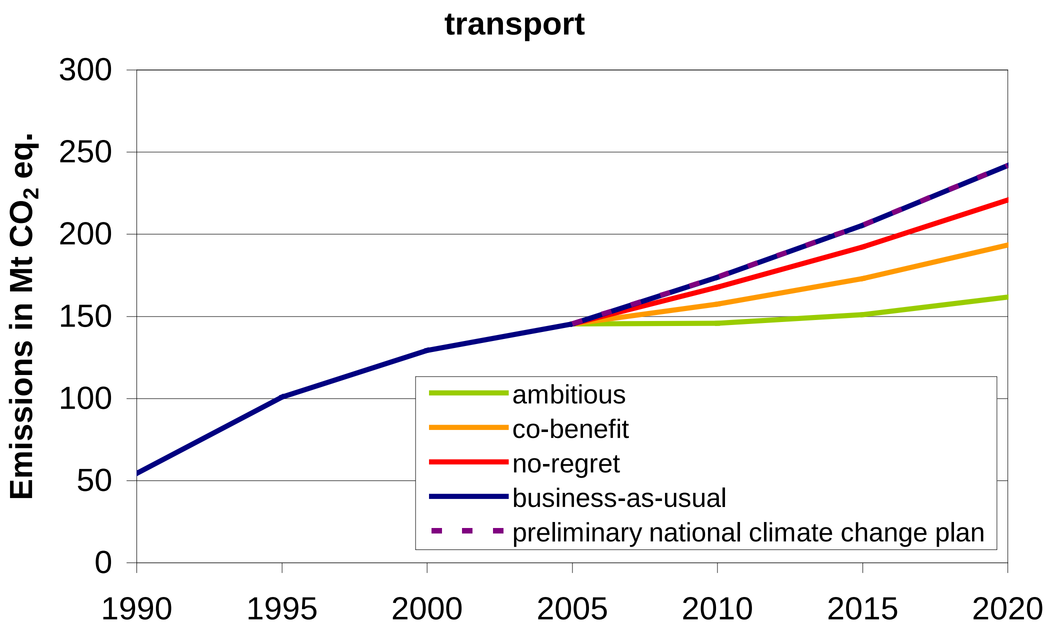

Figure 86 South Korea's emissions and reduction potential under the BAU and all reduction scenarios in the transport sector

In the agriculture and waste sector (Figure 87) some limited reduction potential is available.

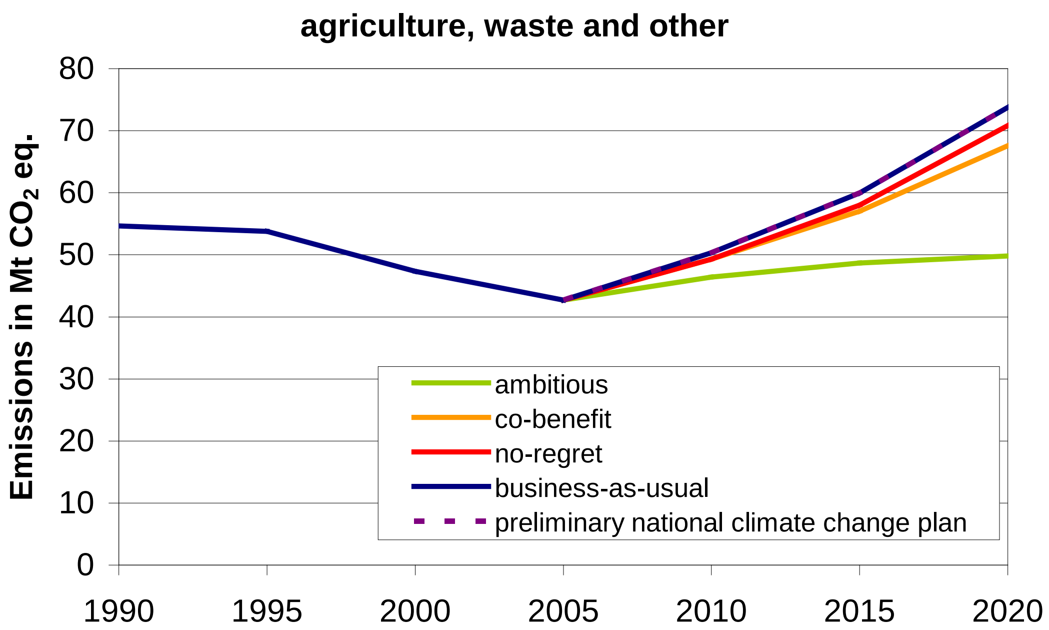

Figure 87 South Korea's emissions and reduction potential under the BAU and all reduction scenarios in the agriculture, waste and other sector

For the LUCF sector (Figure 88) we assumed no deviation from BAU. The BAU development is based on the moderate change in LUCF emissions described in the available national plans.

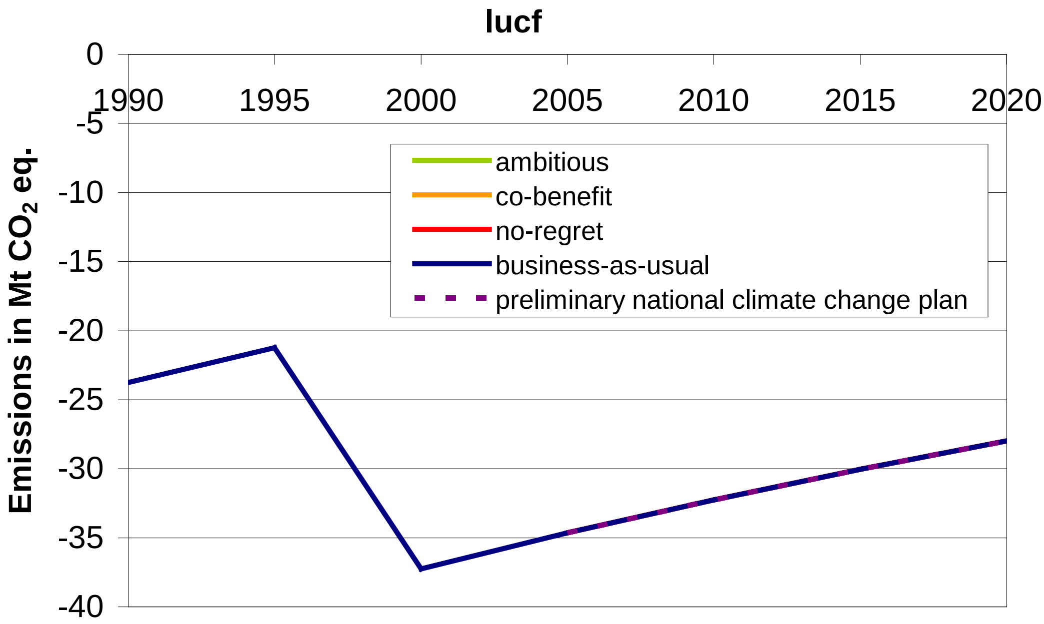

Figure 88 South Korea's emissions and reduction potential under the BAU and all reduction scenarios in the LUCF sector

Most important findings for South Korea:

- South Korea's emissions are projected to increase by about 2.5% per year between 2000 and 2020 under the business-as-usual scenario.
- In 2005 most emissions result from power production (36%), transport (26%) and industry (23%). Under the business-as-usual scenario, the share is projected to be more or less constant although the importance of industry will decrease, while the share of transport will increase.
- The three sectors with the highest GHG emission-reduction potential between 2005 and 2020 under the ambitious potential are power production, transport and the industry sector.
- Under the no-regret potential scenario reductions of 7% below BAU (37% above 2005 emissions) are possible. Under the co-benefit potential scenario reductions of 16% below BAU (24% above 2005 emissions) are feasible. Under the ambitious potential scenario reductions of 41% below BAU (12% below 2005 emissions) are possible. According to South Korea's national climate change plan reductions of 17% below BAU (23% above 2005 emissions) are possible.

8.4 Comparison to other sources

8.4.1 Comparison to BAU scenarios from national reports and national climate strategy

South Korea is currently developing a national plan on climate change. Some data is already available in English (cp. Section 8.1.1). A rough estimate on the BAU can be derived (see Figure 89). These data are very close to our estimates.

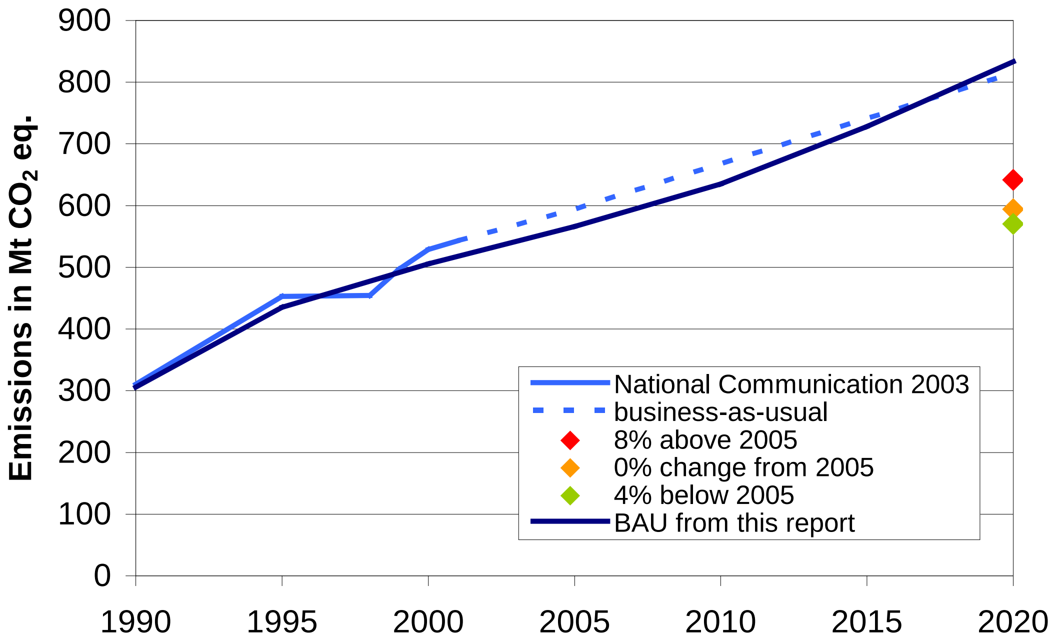

Figure 89 Estimates on South Korea's BAU emissions from the government publication and this report

8.4.2 Comparison to 2008 report

Mainly due to changes in the IEA data (IEA 2008b) the absolute amount of energy (and related emissions) in industry is lower in this report update than in Höhne et al. 2008. Therefore, emissions from the rest of industry (excluding iron and steel, cement, pulp and paper), based on IEA statistics (IEA 2008b), are much lower as well (-20 Mt in 1990 and -250 Mt in 2020).

Due to changes in IEA data non-energy use up to 2005 is twice as high in this update version than in Höhne et al. 2008. However, this does not influence emissions directly.

Historic emissions on LUCF are taken from South Korea's national communication (Government South Korea 2003). Future data are assumed to decline slightly, based on assumptions from national plans. Former data in Höhne et al. 2008 were based on Houghton 2003 with the assumptions that future emissions stay constant. However, this has only a very small effect on national emissions.

8.4.3 Comparison to global effort-sharing approaches

Figure 90 compares the outcomes of the scenarios described above (left) to different global effort-sharing approaches (right) consistent with stabilisation of GHG concentrations at 450 ppmv CO_2eq. For South Korea all effort-sharing approaches come to very similar results, significantly below the reference scenario and around the ambitious scenario. Least stringent are CDC, as it includes delayed participation for South Korea, and Triptych, because it acknowledges that South Korea is already very efficient. CDC, C&C and Triptych come close to the reduction plans at or below 2005 emission levels. The South-North proposal considers South Korea already in the category of Annex I countries. GDRs lead to the most stringent reduction requirement as it is most influenced by the high share of population above the development threshold.

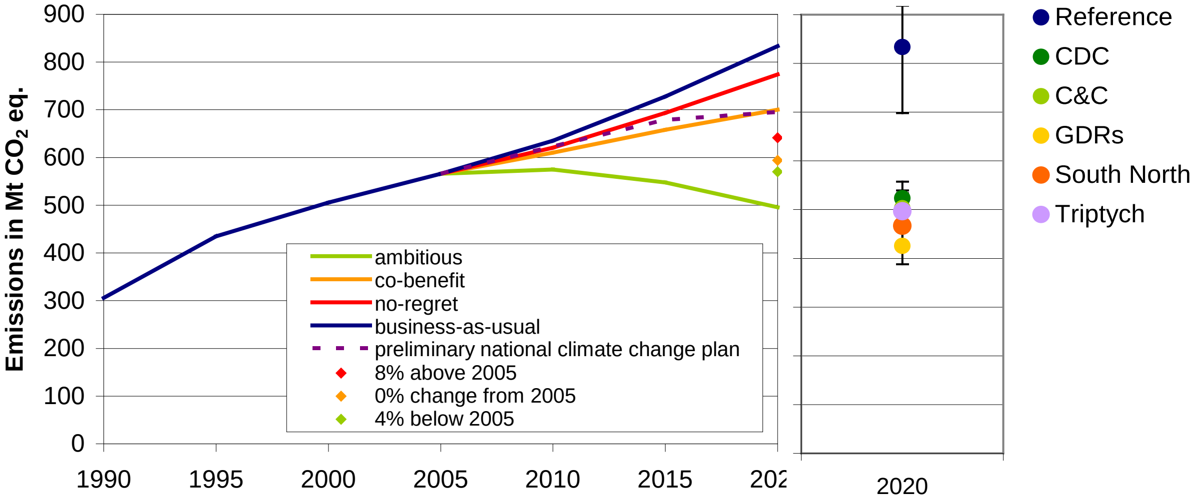

Figure 90 South Korea's emission allowances according to the developed scenarios compared to different global effort-sharing approaches in 2020

9 Possible Elements of Low-Carbon Development Strategies

9.1 Defining Nationally Appropriate Mitigation Actions and Low-Carbon Development Strategies

The basic balance of the deal between Annex I and Non-Annex I countries was struck already in Art. 4 of the Convention. Art. 4.1 (b) commits all Parties to "Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change...;" Furthermore, Art. 4 requires Annex II countries to financially and technologically support non-Annex I countries to enable them to implement the Convention and clarifies that "The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology..."

This balance was further developed in the Bali Action Plan, which calls for "nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner."

The key provision for developing countries in the Bali Action Plan can be broken down into the following elements:

- Developing countries are to undertake mitigation actions.
- These are to be nationally appropriate, i.e. tailored to countries' national circumstances and in line with the Convention's principle of common but differentiated responsibilities.
- They are to take place in the context of sustainable development, meaning they are to be embedded in the countries' broader sustainable development strategies.
- They are to be measurable, reportable and verifiable, i.e. quantifiable.
- They are to be supported by developed countries in an equally quantifiable manner.

While the Bali Action Plan thus reiterates the core balance at the heart of the Annex I-non-Annex I debate, it significantly raises the bar for both sides. For developing countries, the debate has shifted from the qualitative commitments under Art. 4.1 of the Convention to mitigation actions that are quantifiable. For developed countries, the BAP also constitutes a step change from the past, where support for developing countries was mainly delivered through voluntary contributions to funds and any technology transferred was neither measurable nor reportable nor verifiable.

A clear consensus on the exact nature of NAMAs and mechanisms for support has yet to emerge. Developed countries as well as some developing countries stress that these actions should lead to an appropriate deviation from the projected emissions baseline. Nevertheless, developing countries emphasise that NAMAs should be voluntary and correspond to the capabilities of each Party. By contrast, industrialised countries and in particular the USA have put forward the position that at least for some countries (such as major emitters and emerging economies) NAMAs should be of the same kind as actions by developed countries. Moreover, the USA has stressed that actions by all countries should be of the same legal character, i.e. either voluntary or binding, only the substantive content may differ between countries. Also Australia and

Canada have demanded legally binding actions by developing countries (UNFCCC 2009a).

According to the EU, developing countries should limit their emissions to 15-30% below business-as-usual projections. To this end, all developing countries, except least developed countries (LDCs), should commit to adopting low-carbon development strategies by the end of 2011. Robust and verifiable low-carbon development strategies would be a prerequisite for access to international support for mitigation action.

Overall, there seems to be growing consensus that NAMAs should be inscribed into some form of international registry and that this registry could be used as a platform to bring together actions by the South and resources from the North. It also seems clear that NAMAs may be of many different types. The negotiation text lists, for example (UNFCCC 2009b):

- Development of national action plans
- Low-emission or low-carbon development strategies and plans
- Sustainable development policies and measures
- Renewable energy policies and measures, including financial schemes
- Energy efficiency programmes
- Technology deployment programmes or standards
- Energy pricing measures
- Programmatic CDM
- Cap-and-trade schemes, carbon taxes and the use of new and existing carbon-market mechanisms
- Economy-wide or sectoral intensity targets
- No-lose sectoral crediting baselines
- National sector-based mitigation actions and standards
- REDD-plus activities and other mitigation actions implemented in different areas and sectors
- Mitigation actions at the sub national or local level, in particular in cities and rural communities

For the purpose of this report, we define a NAMA as any kind of measure that reduces emissions. We distinguish the following three basic types of NAMAs:

- Emission-target based NAMAs, which may take the form of binding or voluntary ("no-lose") sectoral or national emission targets.
- Technology-specific NAMAs, such as targets for the share of renewable energy sources in power production, efficiency targets or standards.
- Policy-based NAMAs, such as feed-in tariffs, financial incentives or pricing instruments.

The suggested elements for LCDS in this report are restricted to emission-target based and technology-specific NAMAs. Discussing reasonable policy-based NAMAs would require having detailed information about the current policy landscape in each individual country, which is not feasible within the framework of this project.

In addition, as target-based approaches require robust emissions data, they are here applied only to the sectors with large point sources, energy and industry, where emissions can be most easily MRVed.

Apart from the different types of NAMAs, there may also be layers of NAMAs. Several countries including the EU have proposed that there should be three layers of NAMAs:

- Unilateral NAMAs, i.e. actions implemented unilaterally by a country
- Supported NAMAs, i.e. additional actions supported by technology, financing and capacity building
- Credited NAMAs, i.e. further actions supported through the carbon market

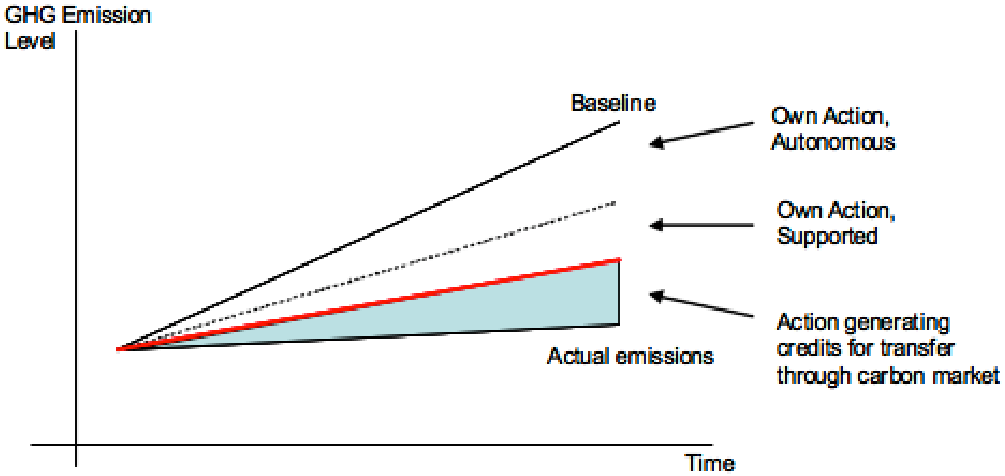

Figure 91 EU View of Future Developing Country Emissions (European Commission 2009)

The proposals for credited NAMAs do not yet seem well defined, however. They would seem to be related to earlier discussions about introducing a policy-based CDM, i.e. introduce crediting for the introduction of specific policy instruments such as fleet emission limits or fuel efficiency standards. In contrast to sectoral no-lose targets, which would credit the aggregate performance of whole sectors, this option would hence retain the current CDM approach of crediting individual actions such as policies and programmes.

How the three layers would fit to together also has yet to be defined. Critics argue that the suggested approach would set up the carbon market to compete with autonomous efforts by developing countries since the carbon market would capture low-cost emission reduction potential and the reductions would then be counted towards Annex I targets rather than towards non-Annex I efforts (Third World Network 2009).

9.2 Suggested modalities for the development of Low-Carbon Development Strategies

To give clear directions for all future investments and make strategic use of the resources to be provided by industrialised countries, developing countries should ideally develop integrated LCDS. These should set out a long-term vision for low-emission development as well as comprehensive NAMAs covering all the key emitting sectors that are needed to implement this vision.

Ideally, national plans should be developed in a transparent and participatory process through high level cross-ministerial and multi-stakeholder groups for two reasons (UN DESA 2009):

- To actually achieve the necessary radical step-change, broad-based support and ownership within each country will be needed. The vision and policies and measures pursued by government will need to be actively shared by society as a whole, or otherwise the programmes will have a high risk of never making it beyond the paper stage. Indeed, the national discussion itself can be a major stimulus for the needed changes.
- In addition, demonstrably broad-based popular support can be a powerful vehicle to persuade donors to tailor their support to the recipients' priorities, rather than cherry-picking measures according to their own priorities.

The actions taken by developing countries should be inscribed into an international register under the UNFCCC and would need to be "MRVable" – measurable, reportable and verifiable – to qualify for financial and technological support. The guidance and requirements for elaborating NAMAs as well as the assessment process could be inspired by the reporting infrastructure that is already in place under the FCCC. However, the current provisions for non-Annex I reporting are probably not adequate for robustly assessing NAMAs, so the process could also incorporate elements of current Annex I reporting and reviewing. The following modalities for the elaboration of LCDS and NAMAs could be envisioned:

- LCDS should be grounded in a strategic long-term vision to limit national emissions in line with a long-term goal that should be included in the shared vision of the future agreement.
- LCDS should be organised by sectors and subdivided by greenhouse gas.
- Proposed NAMAs should include a robust assessment of their mitigation potential.
- Furthermore, they should include an elaboration of the costs and benefits of implementation and, where applicable, other constraints to implementation. In particular, NAMAs should clearly identify where financial and technological support is required.
- The description of the mitigation potential, costs and required support should include a description of the methodology and assumptions used.
- Proposed NAMAs should also include proposals for indicators and methods to ex-post measure the success of each NAMA.
- The review process could build on the procedures already in place for the assessment of Annex I national communications, initial communications, GHG inventories etc. (see below).

Development of comprehensive LCDS may be too onerous for many developing countries, at least in the short term. Development of comprehensive LCDS should therefore be voluntary for most developing countries, leaving them the option to propose specific individual NAMAs rather than comprehensive plans if they prefer.

To safeguard the environmental effectiveness of the agreement, however, development of comprehensive plans should be a requirement for countries exceeding a certain threshold, such as contributing at least 1% to global emissions. In addition, from a political point of view, ratification of a future agreement by industrialised countries will probably hinge on knowing what the large developing countries are prepared to do. Therefore, for these countries the following additional provisions should apply:

- These countries should commit to submitting a LCDS by a specific date.
- In addition, the LCDS of these countries should establish credible pathways to limit emissions and indicate their level of ambition. To this end, two emission projections should be provided:
    - A projection without implementation of the proposed LCDS; and
    - A projection with implementation.

9.3 Suggested modalities for Measuring, Reporting and Verification

The Bali Action Plan placed measuring, reporting and verification at the heart of the future agreement. However, provisions for MRV need to be designed light so as not to block the speedy implementation of measures. Care should be taken to not create a cumbersome MRV bureaucracy that would delay the implementation of measures for years.

The rigour of the current MRV regime varies widely between Annex I and non-Annex I and between different aspects. As for their emissions, industrialised countries are required to submit annual inventories according to IPCC methodologies and reporting guidelines adopted by the Parties. These inventories are reviewed annually by independent expert teams, with in-country reviews taking place at least every five years. Intense focus has been put into improving the inventories over several years. By contrast, while industrialised countries are also required to report on their policies and measures and their impacts as well as on the financial and technological support they provide to developing countries, so far no specific standards and metrics have been agreed and the quality of reporting differs widely.

Non-Annex I inventories are prepared using less rigorous standards, are submitted less frequently and not subject to an international review. Most developing countries have serious capacity constraints. While they are entitled to full cost coverage in the preparation of their inventories, this support is project-based for each individual submission. It is therefore episodic, which makes it difficult to maintain inventory capacity on a continuous basis. The reporting guidelines for policies and measures in developing countries are also less rigorous than for industrialised countries and the quality of reporting varies widely (Breideneich and Bodansky 2009).

What is emerging for developing countries in the negotiations is a framework for highly diversified actions, based on countries' differing national circumstances. While some more advanced developing countries may adopt actions like sectoral no-lose targets, for the most part developing country actions will probably not be target-based but consist of specific policies and measures. This makes MRV far more challenging.

Attempting to measure the impacts of a specific action is not at all straightforward. While it is possible to determine whether a certain measure such as a vehicle efficiency standard has been introduced and it is also possible to measure whether emissions from cars are declining, it is not possible to know for certain to what extent the decline of emissions is attributable to the policy or to other influencing factors, such as changing fuel prices. While it will be necessary to get a clear picture of both the implementation of NAMAs as well as the development of emissions in developing countries, it might therefore be recommendable to separate MRV of the two, especially at the beginning while no strong technical capacities are in place neither nationally in developing countries nor internationally for the review process.

To avoid establishing a massive review mechanism that would require substantial resources to assess the emission impact of NAMAs and would nevertheless only yield approximate results, NAMAs could be MRVed not as regards their emission impact but as regards their implementation. The Conference of the Parties could develop guidelines for what constitutes a robust NAMA, such as setting goals, implementing related actions, ensuring sufficient human and financial resources for these actions, documentation requirements and tracking progress over time. One possible approach has been proposed by the United Nations Foundation. According to this proposal the COP could request the International Organisation for Standardisation (ISO) to develop a management system standard for NAMAs. Developing countries could then develop a comprehensive climate management system according to this standard and request international certification. NAMAs that are developed within a successfully certified national management system would be automatically deemed to be MRVable. This approach would mirror the relationship the COP has with the IPCC as regards the development of emission inventory requirements (Kimble and Arquit Niederberger 2009).

How successful developing countries are in reducing their emissions could then be assessed at the aggregate level through much more robust and frequent emission inventories and an international review process. All non-Annex I countries except LDCs and SIDS should commit to prepare robust emission inventories as early as possible and by 2013 at the latest, with at least biannual updates thereafter. Requirements for newly industrialised countries that assume a binding national target (see section below) should be the same as for Annex I countries. Requirements for countries that do not assume a target would not need to be as strict, but inventories should nevertheless follow the IPCC good practice guidance, include a full time-series of emissions data and document the methodologies and assumptions used.

One proposal that is currently on the table is to integrate the international reporting and verification of NAMAs into the national communications. However, much of the information contained in national communications is not needed for the MRV requirements of the Bali Action Plan and more frequent submission would be very burdensome for countries. Instead, more narrow NAMA implementation reports could be submitted regularly, for example biannually. They could be modelled on the policies and measures chapter currently required for Annex I national communications (Breideneich and Bodansky 2009). However, they would need more detailed requirements, for example through a management system standard approach as outlined above.

The reports as well as the emission inventories should be internationally reviewed by independent experts, though resource-intensive in-country reviews might not be necessary for countries that do not assume a target. As a further layer of verification, the national multi-stakeholder groups referred to in section 9.2 could monitor implementation of the plans and actions and report to the FCCC, in parallel to the reporting by governments (APRODEV 2009).

9.4 Newly Industrialised Countries: binding targets and Commitment Achievement Plans

Several non-Annex I countries have in the meantime attained levels of development and per capita emissions that are comparable to or even exceeding those of a number of Annex I countries. A situation where countries with comparable responsibility and capability are required to make contributions of a differing legal and substantive nature is clearly not equitable.

The South-North dialogue therefore defined a category of countries called "newly industrialised countries" and proposed that these countries should be required to assume legally binding quantified emission targets. The group is composed of the countries that score highest on the South-North index, which includes criteria for responsibility, capability and mitigation potential. According to the South-North proposal, the list of newly industrialised countries would include: Bahrain, Brunei, Cuba, Israel, Kazakhstan, South Korea, Kuwait, Qatar, Saudi Arabia, Singapore, Suriname, Trinidad & Tobago, Turkmenistan, United Arab Emirates and Uzbekistan (Ott et al. 2004).

Similarly, Meyer et al. 2009 propose that the Conference of the Parties should define a threshold, and countries that exceed this threshold should be required to assume legally binding quantified emission targets. They suggest that a GDP at purchasing power parity per capita higher than 20,000 USD could be an appropriate indicator. According to this threshold, this group of countries would include: Bahamas, Bahrain, Brunei, Kuwait, Oman, Qatar, Saudi-Arabia, Seychelles, Singapore, South Korea, Trinidad & Tobago and the United Arab Emirates.

Evidently, both approaches require further refinement as for some countries the appearance on these lists is rather surprising. In particular, the lists include small island developing states that will have to bear a heavy burden because of the impacts of climate change.

The European Union has proposed that at least all member countries of the OECD should adopt binding targets.

As the first commitment period has shown, commitments to legally binding emission targets do not automatically mean that countries will in fact reduce their emissions. The Wuppertal Institute has therefore proposed that all countries with binding targets – Annex I countries and newly industrialised countries – should develop commitment achievement plans (CAPs) (Sterk et al. 2009). These should essentially contain a coherent vision and action programme for how each country wants to achieve a rapid transition to a low-carbon society.

Like LCDS, these should be developed in a participatory process. In addition, the CAPs should be submitted to an international review process. Such a process could help to achieve at least three goals:

- Scrutiny by independent external experts would probably improve the quality of the plans and thus help to facilitate compliance with the commitments

- It would help to build the much needed international trust by demonstrating that industrialised countries are indeed taking the lead as mandated by the Convention, and putting into effect the necessary short- and long-term measures to drastically reduce their emissions
- It could be very helpful for facilitating policy learning between countries

The modalities for the development and review of the CAPs should build on the modalities already in place for the development and review of national communications, GHG inventories etc. In particular, the modalities for CAPs could include the following elements:

- Under the future climate agreement, all developed countries should commit to adopting Commitment Achievement Plans at least two years prior to the start of each new commitment period. To ensure that the CAPs have a level of ambition sufficient to meeting the country's obligations, the CAPs should be submitted to an independent technical analysis.
- These CAPs should set out a credible pathway to limit the country's emissions in line with its reduction target through mitigation actions that cover all sectors. Ideally, the CAPs should break the national targets down to sectoral targets to end the current situation where for example transport emissions have been growing with hardly any constraint.
- Where the technical analysis finds that a CAP is not line with meeting the country's obligations, the analysis should explore options to raise the level of ambition of the CAP.
- The Conference of the Parties should review the results of the technical analysis and may decide to request industrialised countries to revise their CAPs to ensure that they are consistent with meeting their obligations.

10 Possible elements of Low-Carbon Development Strategies for Brazil, China, India, Mexico, South Africa and South Korea

The following chapter aims to outline possible elements of Low-Carbon Development Strategies (LCDS) for the six countries until 2020. The elements are based on the analysis of emission reduction potential and related costs as outlined in the previous chapters.

Regarding the level of ambition, the discussed elements of LCDS are based on the following two considerations:

- Where possible, the level of ambition is matched to the analysis of global effort sharing proposals as outlined above. For several countries the effort sharing proposals come to very similar results: Mexico, South Africa and South Korea. In these cases, the effort that would be required according to the effort sharing proposals was taken as guideline.
- In other cases the effort sharing proposals show very different results. Some countries would have very steep requirements according to some effort sharing approaches and very lenient ones according to others. This applies to Brazil, China and India. In these cases, we considered that the countries should as a minimum aim at mobilising their co-benefit potential, as these measures would yield macro-economic benefits for their economies.

If the text uses high amounts of comparative data, tables are provided for quick reference at the end of the respective section. The data is assessed using the following rough scale.

Level of Effort	Score
National Climate Change Plan (NCCP) scenario is substantially less ambitious than, as applicable, the allocation from the effort sharing approaches or the co-benefit potential scenario	-2
NCCP scenario is less ambitious than, as applicable, the allocation from the effort sharing approaches or the co-benefit potential scenario	-1
NCCP scenario is about equal to, as applicable, the allocation from the effort sharing approaches or the co-benefit potential scenario	+1
NCCP scenario is substantially more ambitious than, as applicable, the allocation from the effort sharing approaches or the co-benefit potential scenario	+2

In practice, this detailed level of assessment is pursued for overall emissions and for the power and industry sectors. For the other sectors the data availability was not sufficient and therefore a less elaborate approach is taken which focuses on individual actions.

10.1 Brazil

10.1.1 Overall level of ambition

The global effort sharing approaches analysed in the 2nd interim report show very different results for Brazil. According to CDC and C&C, which are based on per capita emissions – which are very low in Brazil – Brazil's NCCP scenario is already going much further than it would be required to. According to the Triptych, South-North and GDR approaches, which factor in Brazil's high GDP per capita, Brazil would have to step up its efforts. The allocations according to these three approaches are between the NCCP and the ambitious scenario (see Figure 26).

As explained in the introduction, the level of ambition of the NCCP scenario is therefore measured against the co-benefit potential scenario.

Under the co-benefit potential scenario, 2020 emissions could be reduced 9% below BAU (17% above 2005 emissions). According to the interpretation of Brazil's NCCP done in this project (see 2nd interim report), reductions of 25% below BAU (5% below 2005 emissions) might be possible in 2020. Under the ambitious potential scenario reductions of 37% below BAU (20% below 2005 emissions) might be possible.

Brazil's plan is therefore going substantially beyond the co-benefit potential scenario. However, the reductions according to the NCCP scenario heavily depend on the achievement of the ambitious goal to reduce deforestation. The reduction in the industry sector is also ambitious and close to the ambitious potential scenario. By contrast, in the transport, agriculture and waste sectors emissions according to the NCCP scenario are nearly the same as in the BAU scenario. For the power sector, the NCCP scenario shows a significant deviation from BAU, but the reductions are lower than those in the co-benefit scenario.

Overall level of ambition (reduction vs. BAU)	**National Climate Change Plan**	**Co-benefit**	**Ambitious**	**Assess-ment of NCCP**
Projected 2020 emissions in Mt CO_2-eq.	25% (5% below 2005 emissions)	9% (17% above 2005 emissions)	37% (20% below 2005 emissions)	+1

10.1.2 Possible NAMAs in power production and other energy industries

10.1.2.1 Emission target-based approaches

The measures included in the national plan are close to but still below the co-benefit scenario: Under the co-benefit scenario, 2020 emissions could be reduced from 125 Mt CO2-eq. in the BAU scenario to 67 Mt CO2-eq. Under the NCCP scenario, a reduction to 77 Mt CO2-eq. is envisaged. Negotiation of a sectoral no-lose target at about the level of the co-benefit potential scenario might therefore be viable. According to the ambitious potential scenario, a further reduction to 32 Mt CO2-eq. could be possible.

Emission-Target Based	**BAU**	**National Climate Change Plan**	**Co-benefit**	**Ambitious**	**Assess-ment of NCCP**
Projected 2020 emissions in Mt CO_2-eq.	125	77	67	32	-1

10.1.2.2 Technology-specific NAMAs

Individual technology-specific NAMAs could be envisaged as follows:

The NCCP scenario already includes reducing the annual growth in (non-CHP) electricity generation through demand-side efficiency measures, from 4% in the BAU scenario to 3%, which is in line with the ambitious potential scenario.

On the supply side, the NCCP scenario foresees ambitious shares of 77% for hydropower (up from 67% in the BAU scenario) and 10% for combustible renewables and waste (up from 4%), both of which are broadly in line with the ambitious potential scenario. As a result, the share of gas would be reduced from 23% in the BAU scenario to 6%.

In addition, the NCCP scenario includes a significant reduction of distribution losses, from 17% in the BAU scenario to 3%. This goes well beyond the co-benefit potential scenario (13%) as well as the ambitious potential scenario (8%).

By contrast, the NCCP scenario contains a share of 0% for solar, wind and others, whereas the co-benefit and ambitious potential scenario contain a share of 5%. The NCCP could therefore be strengthened in this regard.

Technology based	BAU	National Climate Change Plan	Co-benefit	Ambi-tious	Assess-ment of NCCP
Annual growth in (non-CHP) electricity generation through DSM efficiency	4% p.a.	3% p.a.	3% p.a.	3% p.a.	+1
Share of hydropower	67%	77%	74%	79%	+1
Other REN (solar, wind and others)	0%	0%	5%	5%	-2
Share of combustible renewables and waste	4%	10%	10%	10%	+1
Share of gas	23%	6%	5%	2%	+1
Distribution losses	17%	3%	13%	8%	+2

10.1.3 Possible NAMAs in the industry sector

10.1.3.1 Emission target-based approaches

Under the co-benefit scenario, a reduction from 183 Mt CO2-eq. (BAU scenario) to 174 Mt CO2-eq. might be possible. Under the ambitious scenario, further reductions down to 140 Mt CO2-eq. could be achieved. Under the NCCP scenario a reduction to 149 Mt CO2-eq. could be possible. Here as well it might therefore be viable to negotiate a sectoral no-lose target at about this level.

Target based	BAU	National Climate Change Plan	Co-benefit	Ambitious	Assess-ment of NCCP
Projected 2020 emissions in Mt CO_2-eq.	181	149	174	140	+2

10.1.3.2 Technology-specific NAMAs

Individual technology-specific NAMAs could be envisaged as follows:

The NCCP scenario already includes a strong increase of renewables: from 49% (BAU scenario) to 55% in the iron and steel sector, from 25% to 27% in the cement sector, from 69% to 71% in pulp and paper and from 41% to 43% in “other industries”. This is generally in line with or even beyond the ambitious potential scenario.

In addition, the NCCP scenario includes a reduction of HFC emissions from 20 Mt (BAU scenario) to 2 Mt CO2-eq., which is also in line with the ambitious potential scenario.

By contrast, the NCCP scenario does not include reducing the share of clinker in cement production. According to the co-benefit scenario, the share could be reduced from 73% (BAU scenario) to 65%. This could yield an emission reduction of 4.6 Mt CO2. The NCCP could therefore be strengthened in this regard.

Furthermore, N2O emissions could be reduced from 7 Mt CO2-eq. in the BAU scenario to 6 Mt CO2-eq. in the co-benefit scenario domestically, or even down to 1 Mt CO2-eq. in the ambitious scenario.

Technology based	BAU	National Climate Change Plan	Co-benefit	Ambi-tious	Assess-ment of NCCP
Share of combustible renewables and waste in iron and steel production	49%	55%	49%	55%	+2
Share of combustible renewables and waste in cement sector	25%	27%	25%	30%	+1
Share of combustible renewables and waste in pulp and paper sector	69%	71%	69%	69%	+2
Share of combustible renewables and waste in other industries	41%	43%	41%	41%	+2
Share of clinker in cement production	73%	73%	65%	65%	-1
N_2O output in Mt	7	7	6	1	-1
HFC output in Mt	20	2	20	2	+2

10.1.4 Possible NAMAs in the domestic sector

In the domestic sector, the analysis in chapter 3 considered electricity efficiency measures from the national climate plan. They have already been outlined in the section on the power sector above (reduced growth in electricity generation). The overall potential for this sector is bound to be higher, in particular through more energy efficient buildings and heating and use of renewables (e.g. solar water heating), but no data is available.

10.1.5 Possible NAMAs in the transport sector

In the transport sector, reduction options are considerable, but hardly quantified in the NCCP scenario. Therefore, the following measures from the no-regret and co-benefit potential scenarios might be appropriate for inclusion in a LCDS:

- A stronger use of natural gas use could achieve emission reductions of about 10 Mt CO_2-eq.
- Modal shifts from road to rail and individual transport to public transport could achieve reductions of about 27 Mt CO_2-eq.
- Increasing energy efficiency of aviation and road transport could achieve reductions of about 22 Mt CO_2-eq.
- Finally, an increased use of renewable sources could achieve reductions of about 30 Mt CO_2-eq.

Under the ambitious scenario, a further 20 Mt CO2-eq. could be saved through use of telecommunication instead of travelling and 28.4 Mt through further vehicle efficiency gains that go beyond those mentioned above. However, these mitigation measures would be very expensive, with costs of 100€/t CO2 and higher.

10.1.6 Possible NAMAs in the agriculture and waste sectors

Some reduction potential is available in the agricultural and waste sectors but not included in the NCCP scenario. Therefore, according to the no-regret and co-benefit potential scenarios, the following NAMAs might be appropriate for inclusion in a LCDS:

- Reduction in methane enteric fermentation could yield reductions of 8.3 Mt CO_2-eq. in 2020
- Reductions in the use of fertilizer could yield reductions of 5.6 Mt CO_2-eq
- Reduction of the amount of waste generated per capita could yield reductions of 5.6 Mt CO_2-eq.
- Increased methane recovery from landfills could yield reductions of 0.9 Mt CO_2-eq.

Under the ambitious potential scenario, a further 31 Mt CO2-eq. could be saved through further reduction in enteric fermentation, 7 Mt through further reduced use of fertilizer and 15.3 Mt through increased recovery from landfills.

10.1.7 Possible NAMAs in the LUCF sector

The national plan on the LUCF sector includes a significant emission reduction, mainly based on avoided deforestation and some increased afforestation. The total projected mitigation amounts to about 480 Mt CO2. It is the largest mitigation achieved from the national plan. Implementation of this ambitious goal requires a significant change from the past trend with actual enforcement of forest protection policies. From the analysis of the NCCP in chapter 3 achievement of these reductions does not seem to be conditional on support from Annex I countries.

10.2 China

10.2.1 Overall level of ambition

China's allocations according to different effort sharing proposals vary widely. CDC and C&C are based on per capita emissions, which in China are at about the average of developing countries. They lead to an allocation that is lower than all of the reduction scenarios for China considered in this report and lower than the current emission level. The Triptych approach requires significant reductions in emissions from coal, the South-North proposals places China in a middle category of countries that start reducing relatively soon. The allocations according to these proposals lie between the NCCP and the ambitious potential scenario. According to the GDR approach, which factors in China's relatively low historical responsibility and the high share of population below the GDR development threshold, China's plan is already going beyond what would be required (see Figure 39).

As explained in the introduction, the level of ambition of the NCCP scenario is therefore measured against the co-benefit potential scenario.

Under the co-benefit potential scenario, 2020 emissions could be reduced 12% below BAU (65% above 2005 emissions). According to the interpretation of China's national climate change plan, as done in this project, reductions of 28% below BAU (36% above 2005 emissions) might be possible in 2020. Under the ambitious potential scenario reductions of 39% below BAU (15% above 2005 emissions) might be possible.

China's plan is therefore going substantially beyond the co-benefit scenario. This deviation is mainly based on reductions in the power, industry and forestry sectors. In the domestic, transport and waste sectors, emissions according to the NCCP scenario are the same as in the BAU scenario.

Overall level of ambition (reduction vs. BAU)	**National Climate Change Plan**	**Co-benefit**	**Ambi-tious**	**Assess-ment of NCCP**
Projected 2020 emissions in Mt CO_2-eq.	28% (36% above 2005 emissions)	12% (65% above 2005 emissions)	39% (15% above 2005 emissions)	+1

10.2.2 Possible NAMAs in power production and other energy Industries

10.2.2.1 Target-based approaches

The measures included in the NCCP scenario are already close to the ambitious potential scenario. Under the co-benefit potential scenario, emissions could be reduced from 6821 Mt CO2-eq. (BAU scenario) to 6220 Mt CO2-eq. According to the ambitious potential scenario, a reduction to 3931 Mt CO2-eq. could be possible. Under the NCCP scenario, a reduction to 4259 Mt CO2-eq. is envisaged. Negotiation of a sectoral no-lose target somewhere between the levels in the co-benefit and NCCP scenarios might therefore be viable.

Emission-Target Based	**BAU**	**National Climate Change Plan**	**Co-benefit**	**Ambi-tious**	**Assess-ment of NCCP**
Projected 2020 emissions in Mt CO_2-eq.	6821	4259	6220	3931	+2

10.2.2.2 Technology-specific NAMAs

Individual technology-specific NAMAs could be envisaged as follows:

The NCCP already foresees ambitious shares of 25% for hydro (up from 15%), 10% for solar, wind and others (up from 0%), and 10% for combustible renewables and waste (up from 0%), all of which are in line with the ambitious potential scenario. As a result, the share of coal use without CCS would be reduced from 80% in the BAU scenario to 50%.

In addition, the NCCP scenario includes significant increases in the efficiency of power generation: from 40% to 44% for coal use without CCS, from 46% to 49% for petroleum products and from 66% to 70% for natural gas.

In summary, the potential to further strengthen the current NCCP for the power sector seems limited.

Technology-Based	**BAU**	**National Climate Change Plan**	**Co-benefit**	**Ambi-tious**	**Assess-ment of NCCP**
Share of hydropower	15%	25%	15%	25%	+2
Other REN (solar, wind and others)	0%	10%	5%	10%	+2
Combustible renewables and waste	0%	10%	5%	10%	+2
Share of coal use w/out CCS	80%	50%	71%	49%	+2
Increases in efficiency of power generation: coal w/out CCS	40%	44%	40%	44%	+2
Increases in efficiency of power generation: petroleum products	46%	49%	46%	49%	+2
Increases in efficiency of power generation: natural gas	66%	70%	66%	70%	+2

10.2.3 Possible NAMAs in the industry sector

10.2.3.1 Emission target-based approaches

Under the co-benefit potential scenario, a reduction from 2993 Mt CO_2-eq. (BAU scenario) to 2447 Mt CO_2-eq. might be possible. Under the NCCP scenario a reduction to 2212 Mt CO_2-eq. could be possible. Here as well it might therefore be viable to negotiate a sectoral no-lose target at about this level. Under the ambitious potential scenario, further reductions down to 1651 Mt CO_2-eq. could be achieved.

Emission Target-Based	BAU	National Climate Change Plan	Co-benefit	Ambitious	Assess-ment of NCCP
Projected 2020 emissions in Mt CO_2-eq.	2993	2212	2447	1651	+1

10.2.3.2 Technology-specific NAMAs

Individual technology-specific NAMAs could be envisaged as follows:

In the iron and steel industries, the NCCP scenario already includes a strong energy efficiency improvement, raising the annual improvement in energy consumption per primary steel output from 1.1% (BAU and co-benefit scenarios) to 2.7%. Similarly, in the cement industry the annual change in energy consumption per clinker in the NCCP scenario amounts to 3.5%, compared to 0% in the BAU scenario and 0.2% in the co-benefit scenario. In “other industries”, the NCCP scenario includes a decrease in the annual growth in energy use, from 4% in the BAU scenario to 3% in the NCCP scenario, which is at the level of the ambitious potential.

In the cement sector, the NCCP scenario includes reducing the share of clinker from 72% (BAU scenario) to 65%.

In addition, there is significant potential that is not addressed in the NCCP scenario. The NCCP could therefore be strengthened in the following areas.

The share of combustible renewables and waste could be significantly increased in all sectors and under all scenarios. According to the co-benefit potential scenario, this could yield reductions of about 190 Mt CO2-eq. in 2020. The NCCP scenario includes this potential only partially. According to the ambitious potential scenario further reductions of about 370 Mt CO2-eq. could be possible.

Furthermore, while the co-benefit potential to reduce N2O emissions is zero, according to the ambitious potential scenario they could be significantly reduced, from 37 Mt CO2-eq. (BAU scenario) to 3 Mt CO2-eq. (ambitious potential scenario). The NCCP scenario includes a reduction of N2O emissions to 32 Mt CO2-eq.

In addition, HFC emissions could be reduced from 149 Mt (BAU scenario) to 10 Mt CO2-eq. (ambitious potential scenario).

Technology based	BAU	National Climate Change Plan	Co-benefit	Ambi-tious	Assess-ment of NCCP
Energy efficiency gains in iron and steel production	1.1% p.a.	2.7% p.a.	1.1% p.a.	2.7%	+2
Energy efficiency gains in cement production	0% p.a.	3.5% p.a.	0.2% p.a.	2%	+2
Share of clinker in cement production	72%	65%	65%	65%	+1
Growth in energy use of other industries	4%	3%	4%	3%	+2
N_2O emissions, all sectors, in 2020	37 Mt CO_2-eq.	32 Mt CO_2-eq.	37 Mt CO_2-eq.	3 Mt CO_2-eq.	+1
HFC emissions, all sectors, in 2020	149 Mt CO_2-eq	149 Mt CO2-eq	149 Mt CO_2-eq	10 Mt CO_2-eq.	-1

10.2.4 Possible NAMAs in the domestic sector

For the domestic sector the reduction potential is probably high but data availability is low. This report therefore only considers electricity savings from efficient appliances, which are part of the reductions in the power sector (reduced growth in electricity generation). The overall potential for this sector is bound to be higher, in particular through more energy efficient buildings and heating, but no data is available.

10.2.5 Possible NAMAs in the transport sector

In the transport sector, reduction options are considerable, but not included in the NCCP scenario. Therefore, the following measures from the no-regret and co-benefit potential scenarios might be appropriate for inclusion in a LCDS:

- A stronger use of liquefied petroleum gas could achieve emission reductions of 6.7 Mt CO_2-eq. and stronger use of natural gas could yield another 10.1 Mt.
- Modal shifts from road to rail and individual transport to public transport could achieve reductions of 59 Mt CO_2-eq.
- Increasing energy efficiency of aviation and road transport could achieve reductions of about 46.7 Mt CO_2-eq.
- Finally, an increased use of renewable energy sources could achieve reductions of about 48.6 Mt CO_2-eq.

Under the ambitious potential scenario, a further 45.5 Mt CO2-eq. could be saved through use of telecommunication instead of travelling and 64 Mt through further efficiency gains that go beyond those listed above. However, these mitigation measures would be very expensive, with costs of 100€/t CO2 and higher.

10.2.6 Possible NAMAs in the agriculture and waste sectors

According to the available data, reduction options in agriculture and waste are available but limited. The current NCCP could in particular be strengthened with regard to increasing the fraction of CH_4 emissions recovered from landfills. According to the co-benefit potential scenario, this fraction could be increased from 1% (BAU scenario) to 10%.

According to the ambitious potential scenario, a further increase to 50% would be possible.

10.2.7 Possible NAMAs in the LUCF sector

For the LUCF sector only national plans were considered. These include a considerable sequestration through afforestation. In 2020, the net sequestration according to the NCCP scenario amounts to 432 Mt CO_2, up from 321 Mt in the BAU scenario.

10.3 India

10.3.1 Overall level of ambition

Similar to Brazil and China, India's allocations according to different global effort sharing approaches also vary widely. The GDR proposal would lead to an allocation in line with the NCCP scenario. This is due to India's low historic responsibility and the large share of the population below the GDR's development threshold. Allocations according to the second-least stringent approach, the South-North proposal, would already be substantially below the 2020 emissions in the NCCP scenario. Allocations based on the CDC and C&C approaches would be between the co-benefit and ambitious potential scenarios. According to the Triptych approach, which requires a major shift away from coal for all countries, reductions would even need to go beyond the ambitious scenario (see Figure 52 in the 2nd interim report). Under the ambitious potential scenario, reductions of 39% below BAU (46% above 2005 emissions) might be possible.

As explained in the introduction, the level of ambition of the NCCP scenario is therefore measured against the co-benefit potential scenario.

According to the interpretation of India's national climate change plan done in this project, 2020 emissions could be reduced 9% below BAU (117% above 2005 emissions). This is significantly less ambitious than the co-benefit potential scenario, according to which reductions of 20% below BAU (92% above 2005 emissions) could be feasible in 2020. This overall assessment also holds for all individual sectors.

As a caveat it has to be noted that India has been progressively strengthening its national plan over the course of 2009, but these changes could not be considered in this report.

Overall level of ambition (reduction vs. BAU)	National Climate Change Plan	Co-benefit	Ambitious	Assess-ment of NCCP
Projected 2020 emissions in Mt CO_2-eq.	9% (117% above 2005 emissions)	20% (92% above 2005 emissions)	39% (46% above 2005 emissions)	-2

10.3.2 Possible NAMAs in power production and other energy industries

10.3.2.1 Emission target-based approaches

The reductions in the NCCP scenario stay well below the co-benefit potential for the power sector. Under the co-benefit scenario, emissions could be reduced from 1833 Mt CO2-eq. (BAU scenario) to 1326 Mt CO2-eq. Under the NCCP scenario, a reduction to 1570 Mt CO2-eq. might be possible. The level of ambition could therefore be scaled up and negotiation of a sectoral no-lose target at the co-benefit level be aimed for.

Emission Target-Based	BAU	National Climate Change Plan	Co-benefit	Ambitious	Assess-ment of NCCP
Projected 2020 emissions in Mt CO_2-eq.	1833	1570	1326	811	-2

10.3.2.2 Technology-specific NAMAs

Individual technology-specific NAMAs could be envisaged as follows:

The NCCP scenario already includes reducing the annual growth in (non-CHP) electricity generation through demand-side efficiency improvements, from 7% in the BAU scenario to 5%, which is in line with the ambitious scenario.

On the production side, the NCCP foresees ambitious shares of 17% for hydro (up from 15% in the BAU scenario), and 7% for solar, wind and others (up from 1%), both of which are more ambitious than the co-benefit potential scenario. As a result, the share of coal use without CCS would be reduced from 69% in the BAU scenario to 61%.

By contrast, the NCCP scenario includes no increase in the share of combustible renewables and waste, while the co-benefit potential scenario implies a potential of 5%.

Further action beyond the NCCP scenario is possible in terms of the efficiency of power generation. While the NCCP scenario includes no changes compared to BAU, the co-benefit potential scenario includes an increase of the efficiency of coal use without CCS from 29% to 36%.

The ambitious potential scenario contains further reduction options. Their implementation would probably require support from the international community.

For one, the share of combustible renewables and waste could be increased to 10%. Furthermore, a further increase of the efficiency of power generation to 41% might be possible. In addition, according to the ambitious potential scenario increasing the efficiency of the use of petroleum products from 31% to 52% could be possible.

Technology-based	BAU	National Climate Change Plan	Co-benefit	Ambi-tious	Assess-ment of NCCP
Growth in (non-CHP) electricity generation through demand-side efficiency improvements	7% p.a.	5% p.a.	5% p.a.	5% p.a.	+1
Share of hydropower	15%	17%	15%	17%	+2
Other REN (solar, wind and others)	1%	7%	5%	10%	+1
Share of combustible renewables and waste	0%	0%	5%	10%	-2
Share of coal use w/out CCS	69%	61%	60%	47%	+1
Increases in efficiency of power generation: coal w/out CCS	29%	29%	36%	41%	-2
Increases in efficiency of power generation: petroleum products	31%	31%	31%	52%	+1

10.3.3 Possible NAMAs in the industry sector

10.3.3.1 Emission target-based approaches

In the industry sector, the ambition of the NCCP scenario is close to the co-benefit potential. Under the co-benefit scenario a reduction from 1069 Mt CO2-eq. (BAU scenario) to 970 Mt CO2-eq. might be possible. Under the NCCP scenario a reduction to 999 Mt CO2-eq. could be possible. It might therefore be viable to negotiate a sectoral no-lose target at about this level. Under the ambitious potential scenario, further reductions down to 873 Mt CO2-eq. could be possible.

Emission Target-Based	BAU	National Climate Change Plan	Co-benefit	Ambitious	Assess-ment of NCCP

Projected 2020 emissions in Mt CO_2-eq.	1069	999	970	873	-1

10.3.3.2 Technology-specific NAMAs

Individual technology-specific NAMAs could be envisaged as follows:

In the iron and steel industry, the NCCP scenario includes an annual improvement in energy consumption per primary steel output of 0.5%, which is at the level of the co-benefit potential and up from 0.1% in the BAU scenario. According to the ambitious potential scenario an increase of 1%/a could be possible. In "other industries", the NCCP scenario includes a decrease in the annual growth in energy use from 9% (BAU scenario) to 8%, which is in line with the ambitious potential scenario.

In addition, there is significant potential that is not included in the NCCP scenario:

The share of combustible renewables and waste could be significantly increased in all sectors and under all scenarios. This could yield reductions of about 66 Mt CO2-eq. in 2020.

In the cement sector, the share of clinker could be reduced from 80% (BAU scenario) to 70%.

In addition, while the co-benefit potential to reduce N2O emissions is zero, they could be reduced from 4 Mt CO2-eq. (BAU scenario) to 1 Mt CO2-eq. (ambitious potential scenario), and HFC emissions could be significantly reduced from 14 Mt to 4 Mt CO2-eq.

Technology-Based	BAU	National Climate Change Plan	Co-benefit	Ambi-tious	Assess-ment of NCCP
Energy efficiency improvement primary steel	0.1% p.a.	0.5% p.a.	0.5% p.a.	1.0%	+1
Share of clinker in cement production	80%	80%	70%	70%	-2
Growth in energy use of other industries	9%	8%	9%	8%	+2
N_2O emissions, all sectors, in 2020	4 Mt CO_2-eq.	4 Mt CO_2-eq.	4 Mt CO_2-eq.	1 Mt CO_2-eq.	+1
HFC emissions, all sectors, in 2020	14 Mt CO_2-eq	14 Mt CO_2-eq	14 Mt CO_2-eq	4 Mt CO_2-eq.	+1

10.3.4 Possible NAMAs in the domestic sector

For the domestic sector the reduction potential is probably high but data availability is low. This report therefore only considers electricity savings from efficient appliances, which are part of the reductions in the power sector (reduced growth in electricity generation). The overall potential for this sector is bound to be higher, in particular through more energy efficient buildings and heating, and use of renewables (e.g. solar water heating), but no data is available.

10.3.5 Possible NAMAs in the transport sector

In the transport sector reduction options are considerable, but not included in the NCCP scenario. Therefore, the following measures from the no-regret and co-benefit potential scenarios might be appropriate for inclusion in a LCDS:

- A stronger use of natural gas could achieve emission reductions of 14.2 Mt CO_2-eq.
- Modal shifts from road to rail and individual transport to public transport could achieve reductions of 39.5 Mt CO_2-eq.
- Increasing energy efficiency of aviation and road transport could achieve reductions of about 30 Mt CO_2-eq.
- Finally, an increased use of renewable sources could achieve reductions of about 36.5 Mt CO_2-eq.

Under the ambitious potential scenario, a further 71 Mt CO2-eq. could be saved through use of telecommunication instead of travelling and further vehicle efficiency gains. However, these mitigation measures would be very expensive, with costs of 100€/t CO2 and higher.

10.3.6 Possible NAMAs in the agriculture and waste sectors

Reduction options in agriculture and waste are available but limited. The current NCCP could in particular be strengthened with regard to increasing the fraction of CH4 emissions recovered from landfills. According to the co-benefit potential scenario, this fraction could be increased from 1% (BAU scenario) to 10%. According to the ambitious potential scenario, a further increase to 50% could be possible.

10.3.7 Possible NAMAs in the LUCF Sector

The LUCF sector provides some reduction potential, mainly based on afforestation. In 2020, the mitigation according to the NCCP scenario amounts to about 60 Mt CO2, from a net loss of 17 Mt in the BAU scenario to a net sequestration of 41 Mt in the NCCP scenario.

10.4 Mexico

10.4.1 Overall level of ambition

For Mexico, the global effort sharing approaches come to broadly similar results. As explained in the introduction, the level of ambition of the NCCP scenario is therefore measured against these allocations.

On this basis, the NCCP scenario can be seen as being sufficiently ambitious, as 2020 emissions in this scenario are broadly in line with the allocations. The NCCP scenario and the allocations are roughly in the middle between the co-benefit and the ambitious potential scenarios (see Figure 65). Under the co-benefit potential scenario, 2020 emissions could be reduced 18% below BAU (20% above 2005 emissions). According to the NCCP scenario, reductions of 34% below BAU (3% below 2005 emissions) might be possible. According to the ambitious potential scenario further reductions going up to 43% below BAU (16% below 2005 emissions) might be possible.

It also should be noted that Mexico has in the meantime further updated its NCCP, which could not be taken into account in this report.

Overall level of ambition (reduction vs. BAU)	**National Climate Change Plan**	**Co-benefit**	**Ambitious**	**Assess-ment of NCCP**
Projected 2020 emissions in Mt CO_2-eq.	34% (3% below 2005 emissions)	18% (20% above 2005 emissions)	43% (16% below 2005 emissions)	+1

10.4.2 Possible NAMAs in power production and other energy industries

10.4.2.1 Emission target-based approaches

The NCCP scenario goes well beyond the co-benefit potential scenario for the power sector. Under the co-benefit potential scenario, emissions could be reduced from 414 Mt CO2-eq. (BAU scenario) to 313 Mt CO2-eq. Under the NCCP scenario, a reduction to 218 Mt CO2-eq. might be possible. Taking up current discussions in Mexico, emissions in this sector could therefore be capped at the NCCP scenario level and a sectoral emissions trading system be introduced.

Emission Target-Based	**BAU**	**National Climate Change Plan**	**Co-benefit**	**Ambitious**	**Assess-ment of NCCP**
Projected 2020 emissions in Mt CO_2-eq.	414	218	313	170	+1

10.4.2.2 Technology-specific NAMAs

For Mexico, the following shares in electricity generation may be possible according to the co-benefit and ambitious potential scenarios: gas 61% (up from 46% in the BAU scenario) and hydro energy 12% (same as BAU). Differences exist for solar, wind and others and combustible renewables and waste, where according to the co-benefit potential scenario an increase up to 5% each may be possible (up from 1%), and according to the ambitious potential scenario further increases to 10%.

The NCCP scenario is broadly in line with the ambitious potential scenario, with the exception of solar, wind and others, which are at the level of the co-benefit potential scenario. The NCCP could therefore be strengthened in this aspect.

As result of an increased renewables' share in electricity generation, the share of coal without CCS would decrease from 14% in the BAU scenario to 0% in the NCCP scenario, and the share of petroleum products would equally decrease from 22% to 0%.

The NCCP scenario also includes significant increases of the efficiency of energy generation at the level of the ambitious potential scenario, from 40% to 45% for coal without CCS and 44% to 50% for natural gas.

Technology based	**BAU**	**National Climate Change Plan**	**Co-benefit**	**Ambi-tious**	**Assess-ment of NCCP**
Share of gas	46%	60%	61%	61%	+1
Share of hydropower	12%	12%	12%	12%	+1
Other REN (solar, wind and others)	0%	5%	5%	10%	-1
Share of combustible renewables and waste	1%	10%	5%	10%	+2
Share of coal use w/out CCS	14%	0%	0%	0%	+2
Share of petroleum	22%	0%	10%	0%	+2
Increases in efficiency of power generation: coal w/out CCS	40%	45%	40%	45%	+2
Increases in efficiency of power generation: gas	44%	50%	44%	50%	+2

10.4.3 Possible NAMAs in the industry sector

10.4.3.1 Emission target-based approaches

Here as well the NCCP scenario goes well beyond the co-benefit potential scenario. Under the co-benefit potential scenario, emissions could be reduced from 84 Mt CO2-eq. (BAU scenario) to 77 Mt CO2-eq. Under the NCCP scenario, a reduction to 55 Mt CO2-eq. might be possible. Taking up current discussions in Mexico, emissions in this sector could potentially be capped at the NCCP scenario level and a sectoral emissions trading system be introduced.

Emission Target-Based	BAU	National Climate Change Plan	Co-benefit	Ambitious	Assess-ment of NCCP
Projected 2020 emissions in Mt CO_2-eq.	84	55	77	49	+1

10.4.3.2 Technology-specific NAMAs

The use of combustible renewables and waste in industry in the NCCP scenario is at the level of the ambitious potential in all sectors.

In addition, the NCCP scenario includes a reduction of HFC emissions from 14 Mt CO2-eq. (BAU scenario) to 5 Mt. According to the ambitious scenario, a further reduction to 2 Mt CO2-eq. could be possible.

By contrast, the co-benefit and ambitious potential scenarios highlight options related to process-related emissions that are not included in the NCCP scenario: In the cement sector, the share of clinker could be reduced from 86% (BAU scenario) to 76% (co-benefit and ambitious scenario). This could yield reductions on top of the NCCP of about 2 Mt CO2-eq. in 2020.

10.4.4 Possible NAMAs in the domestic sector

For the domestic sector the reduction potential is probably high but data availability is low. This report therefore only considers electricity savings from efficient appliances, which are part of the reductions in the power sector (reduced growth in electricity generation). The overall potential for this sector is bound to be higher, in particular through more energy efficient buildings and heating, and use of renewables (e.g. solar water heating), but no data is available.

10.4.5 Possible NAMAs in the transport sector

In the transport sector reduction options are considerable, and mostly included in the NCCP scenario.

- A stronger use of liquefied petroleum gas could achieve emission reductions of about 5 Mt CO_2-eq.
- Modal shifts from road to rail and individual transport to public transport could achieve reductions of about 22 Mt CO_2-eq.
- Increasing energy efficiency of aviation and road transport could achieve reductions of about 16 Mt CO_2-eq.
- Finally, an increased use of renewable sources could achieve reductions of about 16.5 Mt CO_2-eq.

Under the ambitious potential scenario, a further 37.7 Mt CO2-eq. could be saved through increased use of telecommunication instead of travelling and further efficiency gains. However, these mitigation measures would be very expensive, with costs of 100€/t CO2 and higher.

10.4.6 Possible NAMAs in the agriculture and waste sectors

There are some limited reduction options available in the agriculture and waste sectors, part of which are included in the NCCP scenario. In particular, the NCCP scenario foresees increasing the fraction of CH4 emissions recovered from landfills from 1% in the BAU scenario to 20%, which goes substantially beyond the co-benefit scenario (10%). According to the ambitious potential scenario, a further increase to 50% would be possible.

10.4.7 Possible NAMAs in the LUCF Sector

For the LUCF sector the national plan includes some limited reduction potential of about 13 Mt CO2 in 2020, mainly based on afforestation.

10.5 South Africa

10.5.1 Overall level of ambition

For South Africa, the global effort sharing approaches all come to very similar results and would require reductions close to or even beyond the ambitious potential scenario (see Figure 77). As explained in the introduction, the level of ambition of the NCCP scenario is therefore measured against the allocation according to the effort sharing approaches.

On this basis, the NCCP scenario can be seen as not being sufficiently ambitious. Under the co-benefit potential scenario, 2020 emissions could be reduced 18% below BAU (10% above 2005 emissions). The national climate change plan scenario as interpreted in this project (based on the “start now” pathway) is somewhat stronger, with possible reductions of 19% below BAU in 2020 (9% above 2005 emissions). However, according to the ambitious potential scenario, reductions of 30% below BAU (7% below 2005 emissions) could be possible and would indeed be required according to the allocations from the effort sharing proposals.

Overall level of ambition (reduction vs. BAU)	National Climate Change Plan	Co-benefit	Ambitious	Assess-ment of NCCP
Projected 2020 emissions in Mt CO_2-eq.	19% (9% above 2005 emissions)	18% (10% above 2005 emissions)	30% (7% below 2005 emissions)	-2

10.5.2 Possible NAMAs in power production and other energy industries

10.5.2.1 Emission target-based approaches

For the power sector, the NCCP scenario is at the level of the co-benefit potential. Under the co-benefit potential scenario, emissions could be reduced from 355 Mt CO2-eq. (BAU scenario) to 269 Mt CO2-eq. Under the NCCP scenario, a reduction to 271 Mt CO2-eq. might be possible. According to the ambitious potential scenario, a further reduction to 250 Mt CO2-eq. could be possible. It might therefore be politically viable to negotiate a sectoral no-lose target at about the level of the NCCP scenario, but based on the global effort sharing approaches it might be more appropriate to aim for the ambitious potential scenario.

Emission Target-Based	BAU	National Climate Change Plan	Co-benefit	Ambitious	Assess-ment of NCCP
Projected 2020 emissions in Mt CO_2-eq.	355	271	269	250	-1

10.5.2.2 Technology-specific NAMAs

Individual technology-specific NAMAs could be envisaged as follows:

The NCCP scenario already foresees reducing the annual growth in (non-CHP) electricity generation through efficiency improvements on the demand side, from 3% (BAU scenario) to 0%, which is in line with the ambitious potential scenario.

On the production side, the NCCP scenario foresees shares of 2% for hydro, 10% for solar, wind and others, and 2% for combustible renewables and waste, all of which are also in line with the ambitious scenario.

As a result, the share of coal use without CCS would be reduced from 94% (BAU scenario) to 73% in the NCCP scenario.

The main difference between the co-benefit and ambitious potential scenarios lies in the use of CCS. According to the ambitious potential scenario, a share of coal use with CCS of 1% might be possible in 2020.

Technology-based	BAU	National Climate Change Plan	Co-benefit	Ambi-tious	Assess-ment of NCCP
Growth in (non-CHP) electricity generation through efficiency improvements on the demand side	3% p.a.	0% p.a.	0%	0% p.a.	+1
Share of hydropower	1%	2%	2%	2%	+1
Other REN (solar, wind and others)	0%	10%	10%	10%	+1
Share combustible renewables and waste	0%	2%	2%	2%	+1
Share of coal use w/out CCS	94%	73%	73%	72%	-1

10.5.3 Possible NAMAs in the industry sector

10.5.3.1 Emission target-based approaches

In the industry sector, the ambition of the NCCP scenario is also at the co-benefit potential scenario. Under the co-benefit potential scenario a reduction from 87 Mt CO2-eq. (BAU scenario) to 73 Mt CO2-eq. might be possible. Under the NCCP scenario a reduction at the same level could be possible. Under the ambitious scenario, further reductions down to 49 Mt CO2-eq. could be achieved and should be aimed for according to the allocations from the global effort sharing proposals.

Emission Target-Based	**BAU**	**National Climate Change Plan**	**Co-benefit**	**Ambi-tious**	**Assess-ment of NCCP**
Projected 2020 emissions in Mt CO_2-eq.	87	73	73	49	-1

10.5.3.2 Technology-specific NAMAs

Individual technology-specific NAMAs could be envisaged as follows:

One potential measure is to decrease the ratio of iron over steel production from 83% (BAU scenario) to 66% (co-benefit and ambitious potential scenarios), which is in fact included in the NCCP scenario. In the cement sector, the NCCP scenario foresees reducing the share of clinker from 90% (BAU scenario) to 80%, which is in line with the ambitious potential scenario.

Technology based	**BAU**	**National Climate Change Plan**	**Co-benefit**	**Ambi-tious**	**Assess-ment of NCCP**
Ratio of iron over steel production	83%	66%	66%	66%	+1
Share of clinker in cement production	90%	80%	80%	80%	+1
HFC emissions, all sectors	17 Mt CO_2-eq.	17 Mt CO_2-eq.	17 Mt CO_2-eq.	2 Mt CO_2-eq.	-2

In addition, there is significant potential that is not addressed in the NCCP. The share of combustible renewables and waste could be significantly increased in all sectors and under all scenarios.

Furthermore, while the co-benefit potential to reduce HFC emissions is zero, they could be significantly reduced from 17 Mt CO2-eq. (BAU scenario) to 2 Mt (ambitious scenario).

10.5.4 Possible NAMAs in the domestic sector

For the domestic sector the reduction potential is probably high but data availability is low. This report therefore only considers electricity savings from efficient appliances, which are part of the reductions in the power sector (reduced growth in electricity generation). The overall potential for this sector is bound to be higher, in particular through more energy efficient buildings and heating, and use of renewables (e.g. solar water heating), but no data is available.

10.5.5 Possible NAMAs in the transport sector

In the transport sector, reduction options are considerable, though not included in the NCCP scenario. Therefore, the following measures from the no-regret and co-benefit potential scenarios might be appropriate for inclusion in a LCDS:

- A stronger use of natural gas could achieve emission reductions of 4.7 Mt CO_2-eq.
- Modal shifts from road to rail and individual transport to public transport could achieve reductions of 7.5 Mt CO_2-eq.
- Increasing the energy efficiency of aviation and road transport could achieve reductions of about 3 Mt CO_2-eq.
- Finally, an increased use of renewable sources could achieve reductions of about 5.5 Mt CO_2-eq.

Under the ambitious potential scenario, a further 12.8 Mt CO2-eq. could be saved through increased use of telecommunication instead of travelling and further vehicle efficiency gains. However, these mitigation measures would be very expensive, with costs of 100€/t CO2 and higher.

10.5.6 Possible NAMAs in the agriculture and waste sectors

According to the available data, there is some limited reduction potential available in the agriculture and waste sectors, most of which is included in the NCCP scenario. In particular, the NCCP foresees increasing the fraction of CH4 emissions recovered from landfills from 1% in the BAU scenario to 35%, which goes substantially beyond the co-benefit potential scenario (10%). According to the ambitious scenario, a further increase to 50% would be possible.

10.5.7 Possible NAMAs in the LUCF Sector

For the LUCF sector the national plan includes a reduction potential of about 4 Mt in 2020. This is based on increasing removals through increased afforestation from 16 to 20 Mt CO2.

10.6 South Korea

10.6.1 Overall level of ambition

For South Korea, the global effort sharing approaches come to similar results at around the ambitious potential scenario. As explained in the introduction, the level of ambition of the NCCP scenario is therefore measured against the allocation according to the effort sharing approaches.

On this basis, the NCCP scenario could be seen as not being sufficiently ambitious. Under the co-benefit potential scenario, 2020 emissions could be reduced 16% below BAU (24% above 2005 emissions). According to South Korea's national climate change plan as interpreted in this project roughly the same level of reductions, 17% below BAU (23% above 2005 emissions), might be possible. Under the ambitious potential scenario, reductions of 41% below BAU (12% below 2005 emissions) might be possible.

As a caveat it has to be noted that South Korea has in the meantime updated its NCCP, which could not be taken into account in this report. In particular, South Korea has announced possible targets in the range of 8% above 2005 levels to 4% below 2005 levels. However, even the target of 4% below 2005 levels would not yet be sufficient when judged against the global effort sharing approaches (see Figure 90).

On the basis of the global effort sharing approaches, Seoul should agree to a legally binding absolute emission target at about the level of the ambitious potential scenario and develop a commitment achievement plan. The following lays out possible measures in South Korea based on the scenario analysis in this report.

Overall level of ambition (reduction vs. BAU)	**National Climate Change Plan**	**Co-benefit**	**Ambitious**	**Assess-ment of NCCP**
Projected 2020 emissions in Mt CO_2-eq.	17% (23% above 2005 emissions)	16% (24% above 2005 emissions)	41% (12% below 2005 emissions)	-2

10.6.2 Possible NAMAs in power production and other energy industries

10.6.2.1 Emission target-based approaches

The NCCP is already relatively ambitious for the power sector. Under the co-benefit potential scenario, emission could be reduced from 314 Mt CO2-eq. (BAU scenario) to 244 Mt CO2-eq. Under the NCCP scenario, a reduction to 177 Mt CO2-eq. might be possible, which is close to the ambitious potential scenario (164 Mt). Taking up current discussions in South Korea, emissions in this sector could therefore potentially be capped at the NCCP scenario level and a sectoral emissions trading system be introduced.

Emission Target-Based	**BAU**	**National Climate Change Plan**	**Co-benefit**	**Ambi-tious**	**Assess-ment of NCCP**
Projected 2020 emissions in Mt CO_2-eq.	314	177	244	164	+1

10.6.2.2 Technology-specific NAMAs

The NCCP already foresees reducing the annual growth in (non-CHP) electricity generation through efficiency improvements on the demand side, from 5% in the BAU scenario to 3%, which is in line with the ambitious potential scenario.

On the production side, under the co-benefit potential scenario, the following shares in electricity generation may be possible: hydro energy 1% (equal to the BAU scenario), solar, wind and others 5%, combustible renewables and waste 5% (both up from 0% in the BAU scenario). The NCCP scenario goes significantly beyond these figures, with shares of 3% for hydro, 8% for solar, wind and others, and 8% for combustible renewables and waste. According to the ambitious potential scenario, some further upscaling may be possible, with 10% each for solar, wind and others and combustible renewables and waste. For the share of CHP in total electricity generation the NCCP scenario includes a share of 15%, which is slightly above the ambitious potential scenario.

For the share of coal use without CCS, the NCCP scenario foresees a reduction from 38% in the BAU scenario to 20%. This goes significantly beyond the figure in the co-benefit scenario (28%) and is close to the ambitious scenario (18%).

Technology based	**BAU**	**National Climate Change Plan**	**Co-benefit**	**Ambi-tious**	**Assess-ment of NCCP**
Growth in (non-CHP) electricity generation through efficiency improvements on the demand side	5% p.a.	3% p.a.	3% p.a.	3% p.a.	+1
Share of hydropower	1%	3%	1%	3%	+1
Other REN (solar, wind and others)	0%	8%	5%	10%	+1
Share of combustible renewables and waste	0%	8%	5%	10%	+1
share of CHP in total electricity generation	13%	15%	14%	14%	+1
Share of coal use w/out CCS	38%	20%	28%	18%	+1

10.6.3 Possible NAMAs in the industry sector

10.6.3.1 Emission target-based approaches

South Korea’s industry is already very efficient. Nevertheless, there is significant mitigation potential, which the NCCP scenario does not include. Projected emissions in the NCCP scenario are almost equal to the BAU scenario: 157 vs. 162 Mt CO_2-eq. Under the co-benefit potential scenario a reduction to 152 Mt and under the ambitious potential scenario a reduction to 83 Mt CO_2-eq. could be possible. Based on the allocations according to the global effort sharing approaches and taking into account current discussions in South Korea, industry emissions could potentially be capped at about the ambitious potential level and a sectoral emissions trading system be introduced.

Emission Target-Based	BAU	National Climate Change Plan	Co-benefit	Ambi-tious	Assess-ment of NCCP
Sum in Mt CO_2-eq.	162	157	152	83	-2

10.6.3.2 Technology-specific NAMAs

As regards the share of combustible renewables and waste, the NCCP already foresees ambitious levels going beyond the co-benefit potential scenario in all sectors. According to the ambitious potential scenario, some further scaling-up may be possible in the pulp and paper sector and other industries. Mobilising the ambitious potential to use renewable energy sources in industry could yield reductions of about 22.4 Mt CO2-eq. below BAU.

In addition, there are several options that are not addressed in the NCCP scenario.

One potential measure is to decrease the ratio of iron over steel production. Under the co-benefit potential scenario a decrease from 57% (BAU scenario) to 51% could be possible. Under the ambitious potential scenario a further decrease to 41% could be possible.

Technology based	BAU	National Climate Change Plan	Co-benefit	Ambi-tious	Assess-ment of NCCP
Ratio of iron over steel production	57%	57%	51%	41%	-2
Share of clinker in cement production	89%	89%	79%	79%	-2
N_2O emissions, all sectors	10 Mt CO_2-eq.	10 Mt CO_2-eq.	8 Mt CO_2-eq.	2 Mt CO_2-eq.	-2
HFC emissions, all sectors	43 Mt CO_2-eq.	43 Mt CO_2-eq	43 Mt CO_2-eq	5 Mt CO_2-eq.	-2

In the cement sector, the share of clinker could be reduced from 89% (BAU scenario) to 79% (co-benefit and ambitious potential scenarios).

N2O emissions could be reduced from 10 Mt CO2-eq. (BAU scenario) to 8 Mt in the co-benefit potential scenario and 2 Mt in the ambitious potential scenario. HFC emissions could be reduced from 43 Mt CO2-eq. (BAU scenario) to 5 Mt in the ambitious scenario.

10.6.4 Possible NAMAs in the domestic sector

In the domestic sector the NCCP is very ambitious.

The NCCP foresees a decrease of the share of petroleum products in line with the ambitious potential. For households, a reduction from 27% (BAU scenario) to 22% is foreseen, in the commercial and services sector from 52% to 42%.

For electricity use in households, the NCCP already foresees a reduction from 0.57 toe/capita in the BAU scenario to 0.48 toe/capita, which is in line with the ambitious potential. For the commercial and services sector, the NCCP foresees a reduction from 1135 to 953 ktoe/employee, again in line with the ambitious potential scenario. These reductions are part of the power sector reductions (reduced growth in electricity consumption).

10.6.5 Possible NAMAs in the transport sector

In the transport sector reduction options are considerable, though not included in the NCCP scenario. In line with the ambitious potential scenario the following measures could be envisaged:

- A stronger use of natural gas could achieve emission reductions of 4.5 Mt CO_2-eq.
- Modal shifts could achieve reductions of 6 Mt CO_2-eq.
- Increasing energy efficiency of railways and road transport could achieve reductions of about 29 Mt CO_2-eq.
- Achieving a share of 15% of renewable sources could achieve reductions of about 14 Mt CO_2-eq.

Further reductions could be achieved through increased use of telecommunication instead of travelling, but at very high costs.

10.6.6 Possible NAMAs in the agriculture and waste sectors

There is some limited reduction potential available in the agriculture and waste sectors that is not included in the NCCP scenario. In particular, the fraction of CH4 emissions recovered from landfills could be increased from 1% (BAU scenario) to 10% in the co-benefit scenario and 50% in the ambitious scenario. This measure could yield emission reductions of 3.2 and 14.4 Mt CO2-eq. respectively.

10.6.7 Possible NAMAs in the LUCF sector

For the LUCF sector no further possible deviation from BAU was identified. The BAU development is based on the moderate change in LUCF emissions described in the available national plans, which yield a CO2 storage through afforestation of 28 Mt CO2 in 2020.

10.7 Discussion

The above discussion has shown that the level of ambition varies significantly between countries. While the plans of Brazil, China, and Mexico are at or even go beyond the levels of effort suggested by the global effort sharing approaches, the plans of India, South Africa, and South Korea are less ambitious.

The level of ambition also varies between sectors. On the one hand, even the countries that are not very ambitious overall usually have one or two sectors where ambitious plans have been developed. In particular the plans for the power sector are in each country the most detailed and the most ambitious.

On the other hand, even the plans of the more ambitious countries all have some “blind spots”, that is, emission reduction potential that does not appear to be addressed in the national plans. Significant further improvements of the level of ambition may therefore be possible without too much effort.

Table 15 summarises the assessments for overall emissions and the energy and industry sectors. In addition, it seems that all countries should be able to take further measures in the domestic, transport and agriculture and waste sectors that go beyond their current national plans but only limited data was available in this project.

Table 15 Summary NAMA assessment

	Brazil	China	India	Mexico	South Africa	South Korea
Power / Energy Ind.	-1	+1	-2	+1	-1	+1
Industry	+2	+2	-1	+1	-1	-2
Overall	+1	+1	-2	+1	-2	-2

As outlined in the methodology section this assessment is therefore only indicative. If sufficient data was available, it would be possible to do a detailed analysis of the mitigation potential also in those sectors where only very limited data was available in this project. It would also be possible to do a detailed projection of the impacts of existing and planned policies and measures sector by sector. If these projections fell significantly short of mobilising the available mitigation potential, further research steps could analyse possible ways of increasing a country’s efforts. Such an analysis would need detailed and reliable data on emissions and emission drivers as well as detailed information on existing and planned policies and measures

A further question is to what extent existing policies and measures will be able to actually achieve the goals outlined in the national plans. But here as well an assessment would require detailed data on emissions and knowledge of the current policy landscape.

This problem once again reemphasises the benefits of enhancing non-Annex I inventories and national communications. Enhancing MRV is thus a valuable goal in and of itself, as having a clear picture of the current situation is an indispensable prerequisite for being able to develop and implement appropriate emission reduction policies and measures. At a side event at the June 2010 session of the Subsidiary Bodies in Bonn, a representative from Chile highlighted how her country had approached developing its national communication not as an inconvenient imposition from the international level but instead used it as a key tool in the development of its climate strategy.

11 Overview and conclusions

11.1 Reference emissions and mitigation potential

Figure 92 and Figure 93 show greenhouse gas emissions for all six countries under the business-as-usual (BAU) scenario and the four different emission reduction scenarios as calculated in this report. Results for the group are dominated by China. The aggregate numbers have to be treated carefully, as all reduction numbers in this report are based on many, often very vague assumptions.

Figure 92 includes LUCF and shows that a joint reduction of 25% below BAU could be achieved by 2020 according to our interpretation of the countries' national plans. According to the ambitious scenario a reduction of 40% below BAU would be possible.

For comparison, Figure 93 excludes LUCF, as this is the sector with the most uncertain development of emissions. This would lead to a joint reduction of 21% below BAU according to our interpretation of the countries' national climate change plans. According to the ambitious scenario a reduction of 37% below BAU would be possible.

For all six considered countries together the sensitivity range is about 4 to 7% around the default settings for both cases, including and excluding LUCF.

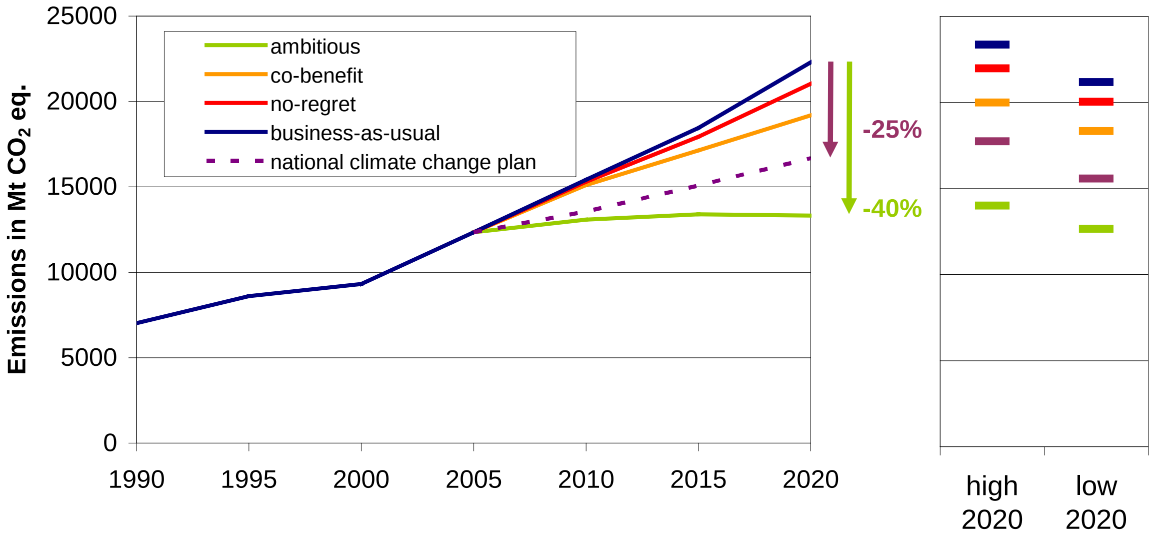

Figure 92 Reduction potential for the combined emissions of Brazil, China, India, Mexico, South Africa and South Korea under a range of scenarios *including LUCF* and sensitivity analysis (right). Note that aggregate reductions are estimates and therefore need to be interpreted with care

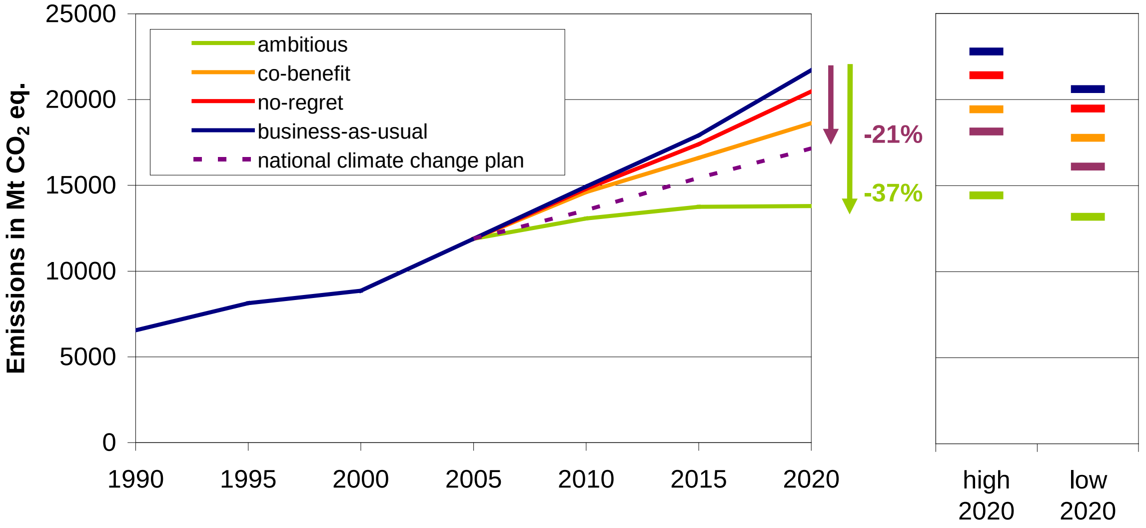

Figure 93 Reduction potential for the combined emissions of Brazil, China, India, Mexico, South Africa and South Korea under a range of scenarios *excluding LUCF* and sensitivity analysis (right). Note that aggregate reductions are estimates and therefore need to be interpreted with care)

11.2 Comparison to global effort-sharing approaches

Figure 94 compares the outcomes of the scenarios described above (left) to different global effort-sharing approaches (right). Results for the group are dominated by China. For all six countries as a group the effort-sharing approaches lead to a broad range of results. The least stringent is the CDC approach, the most moderate the GDRs approach. However, all approaches lead to results that are below the no-regret scenario. Most lie between the national plans scenario and the ambitious scenario.

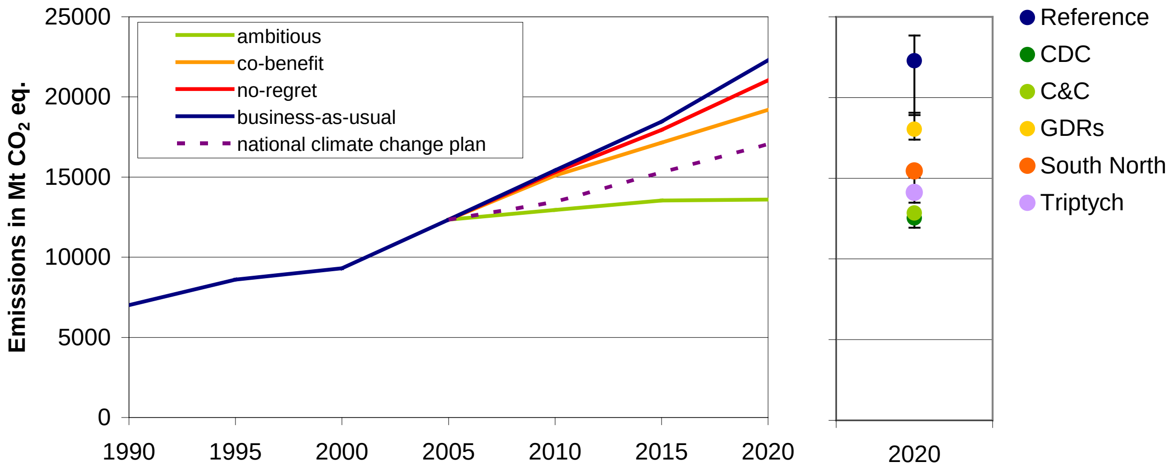

Figure 94 Emission allowances *including LUCF* according to the developed scenarios compared to different global effort-sharing approaches in 2020

11.3 Nationally Appropriate Mitigation Actions

This report provides in addition a method to identify possible further action, as indicated by the analysis of mitigation potential, as NAMAs: We compared the mitigation potential per sector with the reductions achieved through the national plans.

For the purpose of this report, we define a NAMA as any kind of measure that reduces emissions. We distinguish the following three basic types of NAMAs:

- Emission-target based NAMAs, which may take the form of binding or voluntary ("no-lose") sectoral or national emission targets.
- Technology-specific NAMAs, such as targets for the share of renewable energy sources in power production, efficiency targets or standards.
- Policy-based NAMAs, such as feed-in tariffs, financial incentives or pricing instruments.

The discussion in this report is restricted to emission-target based and technology-specific NAMAs. Discussing reasonable policy-based NAMAs would require having detailed information about the current policy landscape in each individual country, which was not feasible within the framework of this project.

Due to data availability the most detailed assessment was pursued for overall emissions and for the power and industry sectors. For the other sectors much less data was available and therefore a less elaborate approach was taken which focuses on individual actions.

Priority areas for further action should be those sectors where national plans are less ambitious than at least the no-regret or the co-benefit potential. Table 16 summarises the assessments for overall emissions and the energy and industry sectors. In addition, it seems that all countries should be able to take further measures in the domestic, transport and agriculture and waste sectors that go beyond their current national plans but only limited data was available in this project.

Table 16 Summary NAMA assessment

	Brazil	China	India	Mexico	South Africa	South Korea
Power / Energy Ind.	-1	+1	-2	+1	-1	+1
Industry	+2	+2	-1	+1	-1	-2
Overall	+1	+1	-2	+1	-2	-2

While our results are sensitive to the (often scarce) data availability, the method as such could be further explored in the future. If sufficient data was available, it would be possible to do a detailed analysis of the mitigation potential also in those sectors where only very limited data was available in this project. These are in particular the domestic, transport and waste sectors. It would also be possible to do a detailed projection of the impacts of existing and planned policies and measures sector by sector. If these projections fell significantly short of mobilising the available mitigation potential, further steps could analyse possible ways of increasing a country's efforts.

Such an analysis would need detailed and reliable data on emissions and emission drivers as well as detailed information on existing and planned policies and measures.

11.4 Conclusions

This report shows for the first time a comparable overview of the national climate plans of Brazil, China, India, Mexico, South Africa and South Korea. As most of these countries have not provided aggregated scenarios for their plans, the scenarios in this report are our interpretation of the national climate plans.

The aggregated reductions of the climate plans are quite substantial and would lead to substantive emission reductions if implemented as planned. It shows that national climate plans could lead to a joint reduction of 25% below BAU by 2020 including LUCF. According to the ambitious scenario a reduction of 40% below BAU would be possible. The aggregated results are dominated by those projected for China.

We also compared for the first time the mitigation potential scenarios to what various effort-sharing approaches would suggest.

China's climate plan is very ambitious according to our interpretation. It is well beyond the co-benefit potential, many measures of the plan are already implemented and it is in line with results of most effort-sharing approaches.

Under all effort sharing approaches, Mexico, South Africa and South Korea have to achieve a significant deviation from the reference by 2020 that goes well beyond the co-benefit potential. Only Mexico has proposed action in its climate plan that is in line with these results.

Brazil's climate plan can be judged as ambitious, but depends on the successful halting of deforestation. First results of a new policy have already achieved a reduction in deforestation rates.

India's plan is the least concrete, reflecting the relative development state of India compared to the other countries. Nevertheless, according to our interpretation India's plan does not even attain the level of the co-benefit potential and should therefore be further strengthened.

A closer analysis of the details of the national plans reveals that the level of ambition varies significantly between sectors. On the one hand, even the countries that are not very ambitious overall usually have one or two sectors where ambitious plans have been developed. In particular the plans for the power sector are in each country the most detailed and the most ambitious. On the other hand, even the plans of the more ambitious countries all have some "blind spots", that is, emission reduction potential that does not appear to be addressed in the national plans. Significant further improvements of the level of ambition may therefore be possible without too much effort.

The lack of data encountered in this project reemphasises the benefits of enhancing non-Annex I inventories and national communications. Enhancing MRV is a valuable goal in and of itself, as having a clear picture of the current situation is an indispensable prerequisite for being able to develop and implement appropriate emission reduction policies and measures.

References

APRODEV. (2009). *The United Nations Climate Fund, Discussion paper: An equitable financial mechanism under the UNFCCC*. Association of World Council of Churches related Development Organisations in Europe (APRODEV).

Baer, P., T. Athanasiou, and S. Kartha. (2007). *The right to development in a climate constrained world. The Greenhouse Development Rights framework*. Publication series on ecology, volume 1, Berlin: Heinrich-Böll-Foundation, Christian Aid, EcoEquity and the Stockholm Environment Institute.

Baer, P., T. Athanasiou, S. Kartha, and E. Kemp-Benedict. (2008). *The Greenhouse Development Rights framework. The right to development in a climate constrained world*. Revised second edition. Publication series on ecology, volume 1, Berlin: Heinrich-Böll-Foundation, Christian Aid, EcoEquity and the Stockholm Environment Institute.

Blok, K., G. J. M. Phylipsen, and J. W. Bode. (1997). *The Triptique approach. Burden differentiation of CO2 emission reduction among European Union member states. Discussion paper*. Utrecht University, Department of Science, Technology and Society. Paper presented at the Informal workshop for the European Union Ad Hoc Group on Climate, 1/16/1997,

Breideneich, C. and D. Bodansky. (2009). *Measurement, Reporting and Verification in a Post-2012 Climate Agreement*. Arlington: Pew Center on Global Climate Change.

Centro Clima, T. Krug, M. A. Lima, L. G. Barioni, G. Martha, and H. M. Filho. (2006). *Greenhouse gas mitigation in Brazil: Scenarios and opportunities through 2025*. Washington DC: Center for Clean Air Policy (CCAP).

Chen, J., C. Wang, K. Wang, W. Cai, Y. Zhang, and Y. Cao. (2006). *Greenhouse gas mitigation in China: Scenarios and opportunities through 2030*. Washington DC: Tsinghua University of China, Center for Clean Air Policy (CCAP).

DEAT. (2007). *Long Term Mitigation Scenarios. Strategic Options for South Africa*. Pretoria, South Africa: Department of Environment Affaires and Tourism (DEAT).

den Elzen, M. G. J. and P. Lucas. (2003). *FAIR 2.0: a decision-support model to assess the environmental and economic consequences of future climate regimes*. No. MNP-report 550015001, www.mnp.nl/fair. Bilthoven, the Netherlands: Netherlands Environmental Assessment Agency (MNP).

EDRC. (2003). *Sustainable development and climate change in South Africa. Two case studies for the development and climate change project*. Cape Town, South Africa: Energy & Development Research Centre, University of Cape Town. Developent and climate change project.

ERC. (2007). *Long Term Mitigation Scenarios: Technical Summary*. For the Department of Environment Affairs and Tourism (DEAT), Pretoria: Energy Research Centre.

European Commission. (2009). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Towards a comprehensive climate change agreement in Copenhagen. Provisonal version. COM(2009) 39/3*.

GCI. (2005). *GCI Briefing: Contraction & Convergence*. Global Commons Institute.

Government Brazil. (2008a). National Plan on Climate Change Brazil, Executive Summary.In: Interministerial Committee on Climate Change (Ed.) Decree No. 6263 , http://www.mma.gov.br/estruturas/imprensa/_arquivos/96_11122008040728.pdf.

Government Brazil. (2008b). *Plano Nacional Sombre Mudança Do Clima*. Versão para Consulta Pública, Brasilia: Governo Federal, Comitê Interministerial Sobre Mudança Do Clima.

Government China. (2004). *The People's Republic of China initial national communication on climate change. Executive Summary*. Beijing, China: Government of the People's Republic of China.

Government China. (2008). *China's Policies and Actions for Addressing Climate Change*. White Paper, Beijing, China: Government of the People's Republic of China.

Government China and National Development and Reform Commission. (2007). *China's National Climate Change Program*.

Government India. (2008). *National Action Plan on Climate Change*. New Delhi: Government of India, Prime Minister's Council on Climate Change.

Government India and Planning Commission. (2008). *Eleventh Five Year Plan 2007-12 Volume III*. http://planningcommission.nic.in/plans/planrel/11thf.htm.

Government Mexico, S. (2007). *National Strategy on Climate Change, Mexico*. Mexico City: Government of Mexico.

Government South Korea. (2003). *Second national communication of the Republic of Korea under the United Nations Framework Convention on Climate Change*. Seoul: Government of the Republic of Korea.

Groenenberg, H. (2002). *Development and Convergence: a bottom-up analysis for the differentiation of future commitments under the Climate Convention.* Unpublished PhD, Utrecht University, Utrecht, the Netherlands.

Höhne, N. (2006). *What is next after the Kyoto Protocol? Assessment of options for international climate policy post 2012.* Amsterdam, The Netherlands: Techne Press.

Höhne, N., K. Blok, J. Harnisch, D. Phylipsen, and C. Galleguillos. (2003). *Evolution of commitments under the UNFCCC: Involving newly industrialized countries and developing countries*. No. Research-report 20141255, UBA-FB 000412. Berlin: ECOFYS Gmbh.

Höhne, N., M. G. J. den Elzen, and M. Weiss. (2006). Common but differentiated convergence (CDC), a new conceptual approach to long-term climate policy. *Climate Policy*, *6* , 181-199.

Höhne, N., C. Michelsen, S. Moltmann, H. E. Ott, W. Sterk, S. Thomas, and R. Watanabe. (2008). *Proposals for contributions of emerging economies to the climate regime under the UNFCCC post 2012*. Cologne, Germany: Ecofys, Wuppertal Institut.

Höhne, N., D. Phylipsen, S. Ullrich, and K. Blok. (2005). *Options for the second commitment period of the Kyoto Protocol, research report for the German Federal Environmental Agency*. Climate Change 02/05, ISSN 1611-8855, Berlin: ECOFYS GmbH.

Höhne, N. and S. Ullrich. (2005). *Emission allowances under the proposal of the "South north dialogue - equity in the greenhouse"*. No. Research-report DM 70096. Cologne, Germany: ECOFYS.

Houghton, R. A. (2003). *Emissions (and Sinks) of Carbon from Land-Use Change. (Estimates of national sources and sinks of carbon resulting from changes in land use, 1950 to 2000)*. Report to the World Resources Institute from the Woods Hole Research Center, Woods Hole, Massachusetts, USA: Woods Hole Research Center.

IEA. (2008a). *CO2 Emissions from Fuel Combustion (2008 edition).* International Energy Agency.

IEA. (2008b). *Energy balances*. CD database, Paris: International Energy Agency.

IEA. (2009). *How the energy sector can deliver a climate agreement in Copenhagen. Special early excerpt of the World Energy Outlook 2009 for the Bankok UNFCCC meeting.* Paris: http://www.worldenergyoutlook.org/.

IMAGE team. (2001). *The IMAGE 2.2 implementation of the SRES scenarios. A comprehensive analysis of emissions, climate change and impacts in the 21st century*. CD-ROM publication 481508018, Bilthoven, the Netherlands:

IPCC. (2006). *IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme.* Japan: Institute For Global Environmental Strategies.

IPCC. (2007). *Climate Change 2007. Mitigation of climate change*. IPCC Assessment Reports, Geneva, Switzerland: Working Group III, IPCC Secretariat (International Panel on Climate Change).

Jeong, H. S. (2008). Climate Change Policy in Korea.In: Korean Society of Environmental Policy & Administration.

Kimble, M. and A. Arquit Niederberger. (2009). Ensuring "MRVable" National Actions: An MRV Model with a Focus on Continual Improvement in Climate Performance.In: Washington, DC: United Nations Foundation.

Meinshausen, M. (2005). *On the risk of overshooting 2°C*. Paper presented at the Scientific Symposium “Avoiding Dangerous Climate Change”, MetOffice,

Meyer, A. (2000). *Contraction & convergence. The global solution to climate change*. Schumacher Briefings, No. 5. Bristol, UK:

Meyer, A., A. Ballasteros, B. Hare, C. A. d. Maltos Scaramuzza, and et al. (2009). *A Copenhagen Climate Treaty. Version 1.0*. The NGO community.

Nakicenovic, N., J. Alcamo, G. Davis, B. de Vries, J. Fenhann, S. Gaffin, K. Gregory, A. Grübler, T. Y. Jung, T. Kram, E. Emilio la Rovere, L. Michaelis, S. Mori, T. Morita, W. Pepper, H. Pitcher, L. Price, K. Riahi, A. Roehrl, H. Rogner, A. Sankovski, M. Schlesinger, P. Shukla, S. Smith, R. Swart, S. van Rooyen, N. Victor, and Z. Dadi. (2000). *Special report on emissions scenarios.* Cambridge, UK: Cambridge University Press.

NDRC. (2008). *China's National Climate Change Programme*. National Development and Reform Commission, Government of China.

Niklas Höhne and Sara Moltmann. (2008). *Distribution of emission allowances under the greenhouse development rights and other effort sharing approaches*. http://www.boell.de/ecology/resources/resource-governance-ecology-5430.html.

OECD. (2008). *Environmental Outlook 2030*.

Olivier, J. G. J. and J. J. M. Berdowski. (2001). Global emissions sources and sinks. In Berdowski, J., Guicherit, R., and Heij, B. J. (Eds.), *The Climate System* pp. 33-78) A.A. Balkema Publishers/Swets & Zeitlinger Publishers, Lisse, The Netherlands. ISBN 90 5809 255 0.

Ott, H. E., H. Winkler, B. Brouns, S. Kartha, M. J. Mace, S. Huq, Y. Kameyama, A. P. Sari, J. Pan, Y. Sokona, P. M. Bhandari, A. Kassenberg, E. L. La Rovere, and A. Rahman. (2004). *South-North dialogue on equity in the greenhouse. A proposal for an adequate* *and equitable global climate agreement*. S. Eschborn: Gesellschaft für Technische Zusammenarbeit.

Phylipsen, D., J. W. Bode, K. Blok, H. Merkus, and B. Metz. (1998). A Triptych sectoral approach to burden differentiation; GHG emissions in the European bubble. *Energy Policy*, *26* (12), 929-943.

Phylipsen, D., N. Höhne, and R. Janzic. (2004). *Implementing Triptych 6.0 - Technical report*. Project, No. DM70046 and ICC03080. Utrecht, The Netherlands: Ecofys.

SEMARNAT. (2007). *Estrategia Nacional de Cambio Climático Mexico 2007*. Mexico D.F.: SEMARNAT.

SEMARNAT. (2009). *Programa especial de cambio climático 2008-2012*. Mexico D.F.: SEMARNAT.

Sterk, W., H. E. Ott, R. Watanabe, and B. Wittneben. (2007). The Nairobi Climate Change Summit (COP 12 – MOP 2): Taking a Deep Breath before Negotiating Post-2012 Targets? *Journal for European Environmental & Planning Law (JEEPL)*, *2/2007* , 139-148.

Sterk, W., Christof Arens, Christiane Beuermann, Daniel Bongardt, Sylvia Borbonus, Carmen Dienst, Urda Eichhorst, Dagmar Kiyar, Hans-Jochen Luhmann, Hermann E.Ott, Frederic Rudolph, Tilman Santarius, Ralf Schüle, Meike Spitzner, Stefan Thomas, and Rie Watanabe. (2009). Towards an Effective and Equitable Climate Change Agreement. A Wuppertal Proposal for Copenhagen.In: (Vol.40,). Wuppertal: Wuppertal Institut für Klima, Umwelt und Energie.

Taviv, R., M. van der Merve, R. Scholes, and G. Collet. (2007). *Non-energy Emissions Agriculture, Forestry and Waste, South Africa*. Energy Research Center, University of Cape Town. http://www.erc.uct.ac.za/Research/publications/07Taviv-etal-LTMS-Non-energy%20emissions_Agriculture_Forestry_Waste.pdf.

TERI and CCAP. (2006). *Greenhouse Gas Mitigation in India: Scenarios and Opportunities through 2031*. The Energy and Resources Institute (TERI), The Center for Clean Air Policy (CCAP), New Delhi, India.

Third World Network. (2009). Understanding the European Commission's Climate Communication.In: Penang:

UN. (2008). *World Population Prospects: the 2008 revision*. United Nations Department for Economic and Social Information and Policy Analysis, New York, USA.

UN DESA. (2009). World Economic and Social Survey 2009. Promoting Development, Saving the Planet.In: New York: UN DESA (United Nations Department of Economic and Social Affairs).

UNFCCC. (2008). *Greenhouse gas inventories submitted to the UNFCCC*. UNFCCC.

UNFCCC. (2009a). Ideas and proposals on paragraph 1 of the Bali Action Plan, Revised note by the Chair. Advance Version.In: (Vol.FCCC/AWGLCA/2008/16/Rev.1,). Bonn: United Nation Framework Convention on Climate Change (UNFCCC).

UNFCCC. (2009b). Reordering and consolidation of text in the revised negotiating text.In: (Vol.FCCC/AWGLCA/2009/INF.2,). Bonn: United Nation Framework Convention on Climate Change (UNFCCC).

USEPA. (2006a). *Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990 – 2020*. Appendix A-D, Washington, D.C., USA: United States Environmental Protection Agency. http://www.epa.gov/climatechange/economics/downloads/GlobalMitigationFullReport.pd

f
http://www.epa.gov/climatechange/economics/downloads/GlobalAnthroEmissionsAppendices.zip.

USEPA. (2006b). *Global Mitigation of Non-CO2 Greenhouse Gases*. Washington, D.C., USA: United States Environmental Protection Agency.

Winkler (ed.), H. (2007). *Long Term Mitigation Scenarios. Technical Report.*

Winkler, H., T. Alfstad, and M. Howells. (2005). *South African Energy Policies for Sustainable Development*. Phase 2, final report, Cape Town: Energy Research Centre, University of Cape Town.

World Bank. (2008). *World Development Indicators 2008.* Washington D.C.: World Bank.

Appendix A Data

A 1 Reference emissions and mitigation potential per country and sector

Table 17 Overview of scenario results per country and sector

	1990	2005	2020												
	BAU [Mt]	BAU [Mt]	BAU [Mt]	No-regret [Mt]	Reduction below BAU [Mt]	Reduction below BAU [%]	Co-benefit [Mt]	Reduction below BAU [Mt]	Reduction below BAU [%]	Ambitious potential [Mt]	Reduction below BAU [Mt]	Reduction below BAU [%]	National climate change plan [Mt]	Reduction below BAU [Mt]	Reduction below BAU [%]
Brazil															
Power production	10	30	80	30	51	63%	32	48	60%	12	68	84%	33	47	59%
Other energy industry	20	25	45	39	6	12%	35	10	23%	20	24	55%	44	1	2%
Industry	65	90	181	174	7	4%	174	7	4%	140	40	22%	149	31	17%
Iron & Steel (CO2)	*12*	*24*	*33*	*32*	*1*	*4%*	*32*	*1*	*4%*	*26*	*7*	*22%*	*26*	*7*	*22%*
Cement (CO2)	*17*	*0*	*40*	*36*	*5*	*11%*	*36*	*5*	*11%*	*34*	*7*	*17%*	*40*	*0*	*1%*
Pulp & Paper (CO2)	*2*	*4*	*5*	*5*	*0*	*0%*	*5*	*0*	*0%*	*3*	*2*	*36%*	*4*	*1*	*13%*
Rest (CO2)	*34*	*62*	*102*	*101*	*1*	*1%*	*101*	*1*	*1%*	*78*	*24*	*24%*	*79*	*23*	*22%*
Households	14	16	23	23	0	0%	23	0	0%	23	0	0%	23	0	0%
Commercial + Services	2	3	5	5	0	0%	5	0	0%	5	0	0%	5	0	0%
Transport	101	171	320	286	35	11%	209	112	35%	152	169	53%	307	13	4%
Agriculture	436	606	753	739	14	2%	739	14	2%	701	52	7%	753	0	0%
Waste	35	43	73	67	6	9%	64	9	13%	49	25	34%	69	4	6%
Non specified others	1	0	0	0	0	0%	0	0	0%	0	0	0%	0	0	0%
LUCF	796	818	827	827	0	0%	827	0	0%	-22	850	103%	-22	850	103%
Total excl LUCF	**684**	**983**	**1481**	**1363**	**118**	**8%**	**1281**	**200**	**13%**	**1104**	**377**	**25%**	**1385**	**96**	**7%**
Total incl. LUCF	**1479**	**1801**	**2308**	**2190**	**118**	**5%**	**2109**	**200**	**9%**	**1081**	**1227**	**53%**	**1362**	**946**	**41%**
China															
Power production	635	2440	5398	5569	-170	-3%	4900	498	9%	2833	2565	48%	2740	2659	49%
Other energy industry	358	693	1575	1423	152	10%	1320	255	16%	1098	477	30%	1520	55	4%
Industry	911	2029	2993	2572	421	14%	2447	546	18%	1651	1342	45%	2212	782	26%
Iron & Steel (CO2)	*168*	*679*	*1036*	*795*	*241*	*23%*	*795*	*241*	*23%*	*624*	*412*	*40%*	*771*	*265*	*26%*
Cement (CO2)	*182*	*773*	*999*	*840*	*159*	*16%*	*791*	*209*	*21%*	*668*	*331*	*33%*	*686*	*313*	*31%*
Pulp & Paper (CO2)	*29*	*36*	*58*	*42*	*16*	*27%*	*42*	*16*	*27%*	*16*	*42*	*72%*	*47*	*11*	*19%*
Rest (CO2)	*532*	*541*	*900*	*895*	*5*	*1%*	*819*	*81*	*9%*	*343*	*557*	*62%*	*707*	*193*	*21%*
Households	337	260	391	391	0	0%	391	0	0%	391	0	0%	391	0	0%
Commercial + Services	37	100	232	232	0	0%	232	0	0%	232	0	0%	232	0	0%
Transport	130	405	986	861	125	13%	726	260	26%	591	395	40%	986	0	0%
Agriculture	983	1229	1548	1515	32	2%	1515	32	2%	1433	115	7%	1503	45	3%
Waste	152	174	260	260	0	0%	249	11	4%	202	59	23%	260	0	0%
Non specified others	38	16	16	16	0	0%	16	0	0%	16	0	0%	16	0	0%
LUCF	-407	-407	-321	-321	0	0%	-321	0	0%	-432	111	-35%	-432	111	-35%
Total excl LUCF	**3582**	**7347**	**13398**	**12839**	**559**	**4%**	**11796**	**1602**	**12%**	**8446**	**4952**	**37%**	**9858**	**3540**	**26%**
Total incl. LUCF	**3175**	**6940**	**13077**	**12518**	**559**	**4%**	**11475**	**1602**	**12%**	**8014**	**5063**	**39%**	**9426**	**3651**	**28%**
India															
Power production	250	669	1587	1523	63	4%	1121	465	29%	674	912	57%	1326	260	16%
Other energy industry	76	129	246	224	22	9%	205	40	16%	137	109	44%	243	2	1%
Industry	190	236	1069	979	90	8%	970	99	9%	873	195	18%	999	70	7%
Iron & Steel (CO2)	*49*	*80*	*284*	*238*	*45*	*16%*	*238*	*45*	*16%*	*222*	*62*	*22%*	*267*	*17*	*6%*
Cement (CO2)	*44*	*0*	*263*	*222*	*41*	*16%*	*214*	*50*	*19%*	*205*	*58*	*22%*	*263*	*0*	*0%*
Pulp & Paper (CO2)	*7*	*7*	*21*	*18*	*4*	*18%*	*18*	*4*	*18%*	*11*	*10*	*47%*	*21*	*0*	*0%*
Rest (CO2)	*90*	*148*	*500*	*500*	*0*	*0%*	*500*	*0*	*0%*	*435*	*65*	*13%*	*448*	*53*	*11%*
Households	41	68	99	99	0	0%	99	0	0%	99	0	0%	99	0	0%
Commercial + Services	15	12	17	17	0	0%	17	0	0%	17	0	0%	17	0	0%
Transport	102	134	496	446	50	10%	349	146	30%	265	231	47%	496	0	0%
Agriculture	333	421	600	499	101	17%	499	101	17%	456	144	24%	600	0	0%
Waste	94	124	199	199	0	0%	193	6	3%	165	34	17%	199	0	0%
Non specified others	16	18	23	23	0	0%	23	0	0%	23	0	0%	23	0	0%
LUCF	14	14	17	17	0	0%	17	0	0%	-41	58	337%	-41	58	337%
Total excl LUCF	**1117**	**1809**	**4335**	**4009**	**326**	**8%**	**3477**	**858**	**20%**	**2710**	**1624**	**37%**	**4003**	**332**	**8%**
Total incl. LUCF	**1132**	**1824**	**4352**	**4026**	**326**	**7%**	**3494**	**858**	**20%**	**2670**	**1682**	**39%**	**3962**	**390**	**9%**
Mexico															
Power production	67	134	175	143	32	18%	121	54	31%	83	92	53%	83	92	52%
Other energy industry	63	123	239	217	22	9%	192	47	20%	87	152	64%	135	104	43%
Industry	70	56	84	79	5	6%	77	7	8%	49	35	42%	55	29	34%
Iron & Steel (CO2)	*12*	*13*	*13*	*11*	*2*	*14%*	*11*	*2*	*14%*	*11*	*2*	*16%*	*11*	*2*	*14%*
Cement (CO2)	*13*	*0*	*15*	*12*	*3*	*21%*	*10*	*5*	*31%*	*8*	*7*	*45%*	*10*	*5*	*34%*
Pulp & Paper (CO2)	*3*	*2*	*2*	*2*	*0*	*9%*	*2*	*0*	*9%*	*1*	*1*	*38%*	*1*	*1*	*34%*
Rest (CO2)	*41*	*42*	*53*	*53*	*0*	*0%*	*53*	*0*	*0%*	*28*	*25*	*47%*	*32*	*21*	*40%*
Households	19	22	29	29	0	0%	29	0	0%	29	0	0%	29	0	0%
Commercial + Services	3	5	6	6	0	0%	6	0	0%	6	0	0%	6	0	0%
Transport	111	168	254	236	18	7%	187	67	27%	143	111	44%	151	103	41%
Agriculture	72	84	108	100	9	8%	100	9	8%	88	21	19%	100	9	8%
Waste	37	48	83	83	0	0%	77	6	7%	50	33	40%	70	13	15%
Non specified others	0	0	0	0	0	0%	0	0	0%	0	0	0%	0	0	0%
LUCF	112	90	89	89	0	0%	89	0	0%	76	13	15%	76	13	15%
Total excl LUCF	**443**	**640**	**978**	**892**	**86**	**9%**	**788**	**190**	**19%**	**534**	**444**	**45%**	**629**	**348**	**36%**
Total incl. LUCF	**555**	**730**	**1067**	**981**	**86**	**8%**	**877**	**190**	**18%**	**610**	**457**	**43%**	**705**	**361**	**34%**
South Africa															
Power production	143	210	234	163	71	30%	162	72	31%	159	76	32%	162	72	31%
Other energy industry	68	83	121	109	12	10%	107	14	11%	91	30	25%	109	12	10%
Industry	62	67	87	73	13	15%	73	14	16%	49	37	43%	73	14	16%
Iron & Steel (CO2)	*29*	*20*	*15*	*10*	*4*	*31%*	*10*	*4*	*31%*	*10*	*4*	*31%*	*11*	*3*	*22%*
Cement (CO2)	*7*	*12*	*24*	*18*	*6*	*25%*	*17*	*7*	*28%*	*16*	*7*	*31%*	*16*	*7*	*31%*
Pulp & Paper (CO2)	*0*	*0*	*0*	*0*	*0*	*43%*	*0*	*0*	*43%*	*0*	*0*	*87%*	*0*	*0*	*28%*
Rest (CO2)	*25*	*35*	*48*	*45*	*3*	*6%*	*45*	*3*	*6%*	*23*	*25*	*53%*	*45*	*3*	*6%*
Households	8	15	16	16	0	0%	16	0	0%	16	0	0%	16	0	0%
Commercial + Services	4	8	10	10	0	0%	10	0	0%	10	0	0%	10	0	0%
Transport	37	59	93	84	9	10%	84	9	10%	64	29	31%	84	9	10%
Agriculture	47	45	70	70	0	0%	65	5	7%	65	5	7%	70	0	0%
Waste	18	22	41	41	0	0%	37	3	8%	23	17	43%	28	12	30%
Non specified others	1	0	0	0	0	0%	0	0	0%	0	0	0%	0	0	0%
LUCF	-17	-19	-16	-16	0	0%	-16	0	0%	-20	4	-23%	-20	4	-23%
Total excl LUCF	**388**	**509**	**671**	**566**	**105**	**16%**	**554**	**117**	**17%**	**477**	**194**	**29%**	**552**	**119**	**18%**
Total incl. LUCF	**371**	**490**	**655**	**549**	**105**	**16%**	**538**	**117**	**18%**	**456**	**198**	**30%**	**532**	**122**	**19%**
South Korea															
Power production	55	205	290	266	24	8%	223	67	23%	158	132	46%	172	118	41%
Other energy industry	28	16	24	22	2	9%	21	3	13%	6	18	75%	15	9	36%
Industry	74	133	162	153	9	5%	152	10	6%	83	79	49%	157	5	3%
Iron & Steel (CO2)	*8*	*24*	*20*	*18*	*2*	*11%*	*18*	*2*	*11%*	*14*	*6*	*30%*	*20*	*0*	*1%*
Cement (CO2)	*25*	*35*	*35*	*30*	*5*	*15%*	*28*	*6*	*18%*	*27*	*8*	*22%*	*31*	*4*	*12%*
Pulp & Paper (CO2)	*3*	*3*	*3*	*3*	*0*	*0%*	*3*	*0*	*0%*	*2*	*1*	*36%*	*2*	*1*	*18%*
Rest (CO2)	*39*	*71*	*104*	*102*	*2*	*2%*	*102*	*2*	*2%*	*40*	*64*	*62%*	*104*	*0*	*0%*
Households	19	22	29	29	0	0%	29	0	0%	29	0	0%	29	0	0%
Commercial + Services	3	5	6	6	0	0%	6	0	0%	6	0	0%	6	0	0%
Transport	55	146	242	221	21	9%	194	48	20%	162	80	33%	242	0	0%
Agriculture	23	23	28	25	3	10%	25	3	10%	22	6	22%	28	0	0%
Waste	29	16	42	42	0	0%	38	3	8%	24	18	43%	42	0	0%
Non specified others	3	4	4	4	0	0%	4	0	0%	4	0	0%	4	0	0%
LUCF	-24	-35	-28	-28	0	0%	-28	0	0%	-28	0	0%	-28	0	0%
Total excl LUCF	**330**	**601**	**861**	**802**	**59**	**7%**	**728**	**133**	**15%**	**524**	**338**	**39%**	**724**	**138**	**16%**
Total incl. LUCF	**306**	**566**	**833**	**774**	**59**	**7%**	**700**	**133**	**16%**	**496**	**338**	**41%**	**696**	**138**	**17%**
Total excl LUCF	**6544**	**11889**	**21724**	**20471**	**1253**	**6%**	**18625**	**3099**	**14%**	**13795**	**7929**	**37%**	**17151**	**4573**	**21%**
Total incl. LUCF	**7017**	**12351**	**22292**	**21039**	**1253**	**6%**	**19193**	**3099**	**14%**	**13327**	**8965**	**40%**	**16683**	**5609**	**25%**

A 2 Mitigation measures and costs

Table 18 Mitigation measures and costs in the power sector

		Mitigation Option	MtCO2 eq mitigation achieved			Costs €/tCO2eq			
			2010	2015	2020	used	ECN country	ECN average	SERPEC
Brazil	no regre	increase of RE elec share solar/wind/others	0.0	4.2	11.1	-37.0	-115.7	-37.0	-40.7
		increase of RE elec share combustibles	-0.3	1.5	12.4	-0.4		-0.4	-67.7
		reduction in fugitive emissions (CH4)	0.3	0.8	1.6	-0.3		-0.3	
	co-bene	increase of RE elec share solar/wind/others	0.0	0.0	0.2	51.1	51.1	41.0	31.3
		increase of RE elec share combustibles	0.0	0.1	0.3	30.9	30.9	15.4	35.0
		reduction in fugitive emissions (CH4)	0.3	0.8	1.6	28.0	28.0	20.4	
	ambi	increase of RE elec share hydropower	-2.3	-7.5	0.0	28.1		28.1	
		reduction in fugitive emissions (CH4)	9.8	26.1	47.7	28.0	28.0	20.4	
China	no regre	increase of RE elec share solar/wind/others	0.4	0.4	0.4	-37.0		-37.0	-40.7
		increase of RE elec share combustibles	0.2	0.3	0.2	-0.4		-0.4	-67.7
		reduction in fugitive emissions (CH4)	5.5	12.6	21.0	0.0	0.0	-0.3	
	co-bene	increase of RE elec share solar/wind/others	0.0	83.7	272.4	53.3	53.3	41.0	31.3
		increase of RE elec share combustibles	0.0	86.0	275.3	31.0	31.0	15.4	35.0
		reduction in fugitive emissions (CH4)	5.5	12.6	21.0	7.0	7.0	20.4	
	ambitious	increase of CCS coal share elec			38.1	60.4	50.4	49.9	
		increase in energy efficiency coal (elec)	123.2	195.8	240.3	10.3	10.3	17.4	
		increase in energy efficiency petroleum products (elec)	1.2	2.8	4.9	10.3			
		increase in energy efficiency gas (elec)	0.2	0.5	0.9	32.7	32.7	12.3	
		increase of RE elec share hydropower	96.5	79.8	274.3	31.0	31.0	28.1	
		increase of RE elec share solar/wind/others	149.1	96.1	165.7	53.3	53.3	41.0	31.3
		increase of RE elec share combustibles	-0.3	96.1	165.7	31.0	31.0	15.4	35.0
		increase of share of nuclear	48.5	45.5	36.8	19.2	19.2	12.2	
		reduction in fugitive emissions (CH4)	27.3	62.9	104.8	7.0	7.0	20.4	
India	no regret	reduction in fugitive emissions (CH4)	2.0	5.2	9.5	0.0	0.0	-0.3	
	co-benefit	increase in energy efficiency coal (elec)	53.4	125.7	228.6	17.4		17.4	
		increase of RE elec share solar/wind/others	0.0	27.1	66.7	41.0	1.0	41.0	31.3
		increase of RE elec share combustibles	0.0	36.0	77.9	15.4		15.4	35.0
		reduction in fugitive emissions (CH4)	2.0	5.2	9.5	15.0	15.0	20.4	
	ambitious	increase in energy efficiency coal (elec)	33.2	65.5	91.9	17.4		17.4	
		increase in energy efficiency petroleum products (elec)	0.0	12.6	21.7	17.4			
		increase of RE elec share solar/wind/others	19.5	19.0	52.4	41.0	1.0	41.0	31.3
		increase of RE elec share combustibles	-0.1	19.0	52.4	15.4		15.4	35.0
		increase of CCS coal share elec			11.2	61.8	51.8	49.9	
		reduction in fugitive emissions (CH4)	9.8	26.1	47.7	15.0	15.0	20.4	
Mexico	no re	increase of share of gas	-1.8	-5.1	32.3	-15.8	-15.8	-15.8	
		reduction in fugitive emissions (CH4)	3.5	9.3	18.7	0.0	0.0	-0.3	
	co-bene	increase of RE elec share solar/wind/others	0.0	0.0	13.0	0.0	-11.9	41.0	31.3
		increase of RE elec share combustibles	0.0	0.0	10.6	15.4		15.4	35.0
		reduction in fugitive emissions (CH4)	3.5	9.3	18.7	11.3	11.3	20.4	
	ambitious	increase in energy efficiency coal (elec)	0.0	1.7	0.0	17.4		17.4	
		increase in energy efficiency gas (elec)	0.0	4.4	11.6	12.3		12.3	
		increase of RE elec share solar/wind/others	0.0	7.4	12.1	41.0	-11.9	41.0	31.3
		increase of RE elec share combustibles	0.0	0.0	12.1	15.4		15.4	35.0
		reduction in fugitive emissions (CH4)	17.6	46.7	93.6	11.3	11.3	20.4	
South Africa	no regret	increase of share of nuclear	0.3	-0.1	10.6	0.0		-3.6	
		increase of RE elec share hydropower	-0.1	-0.2	0.8	-1.4		-1.4	-82.6
		increase of RE elec share geothermal	2.2	2.2	6.7	-53.7			-53.7
		increase of RE elec share solar/wind/others	1.7	12.8	21.8	-37.0		-37.0	-40.7
		increase of RE elec share combustibles	0.0	2.0	4.2	-0.4		-0.4	-67.7
		reduction in fugitive emissions (CH4)	0.0	0.0	0.0	-0.3		-0.3	
	co-	reduction in fugitive emissions (CH4)	0.4	0.3	0.7	20.4	-7.2	20.4	
	ambi	increase of CCS coal share elec			2.0	59.9		49.9	
		reduction in fugitive emissions (CH4)	0.7	0.7	0.7	20.4	-7.2	20.4	
South Korea	no	reduction in fugitive emissions (CH4)	0.2	0.5	0.9	-0.3		-0.3	
	co-bene	increase of RE elec share solar/wind/others	0.0	7.4	20.9	31.3		41.0	31.3
		increase of RE elec share combustibles	0.0	7.5	21.0	35.0		15.4	35.0
		reduction in fugitive emissions (CH4)	0.2	0.5	0.9	20.4		20.4	
	ambitious	increase in energy efficiency coal (elec)	1.5	2.6	3.0	1.2	1.2	17.4	
		increase in energy efficiency gas (elec)	0.3	0.7	1.1	12.3		12.3	
		increase efficiency other energy							
		increase of RE elec share solar/wind/others	0.0	11.4	20.4	31.3		41.0	31.3
		increase of RE elec share combustibles	0.0	11.4	20.4	35.0		15.4	35.0
		increase of RE CHP share combustibles	0.0	2.1	26.1				
		reduction in fugitive emissions (CH4)	1.1	2.7	4.5	20.4		20.4	

Table 19 Mitigation measures and costs in the industry sector

		Mitigation Option	MtCO2 eq mitigation achieved				Costs €/tCO2eq		
			2010	2015	2020	Used	ECN country	ECN average	SERPEC
Brazil	no regret	Iron and Steel: reduced growth of SEC primary steel	0.4	0.9	1.5	-41.8			-41.8
		Iron and Steel: reduced growth of SEC secondary steel	0.0	0.1	0.1	-43.4			-43.4
		Iron and Steel: 10% of energy input can be taken from RE and waste	-0.4	0.0	0.0	-95.6			-95.6
		Cement: Clinker cement ratio down to 65% in 2020	1.1	2.7	4.6	-5.2	-5.2		-27.0
		Cement: 10% renewable and waste in 2020	0.0	0.0	0.0	0.0			2.5
		pulp and paper: 5% renewables	0.0	0.0	0.0	-95.6			-95.6
		Other sectors: share of RE 5%	0.0	0.0	0.0	-95.6			-95.6
		Other sectors: reduction in non-CO2 emissions	0.0	0.0	0.7	0.0			0.0
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
	co-be	Cement: 20% renewable and waste in 2020	0.0	0.0	0.0	74.8			74.8
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
	ambitious	Iron and Steel: reduced growth of SEC primary steel	0.7	1.4	2.3	13.4			13.4
		Iron and Steel: reduced growth of SEC secondary steel	0.1	0.2	0.1	16.6			16.6
		Iron and Steel:share of RE 20% (except if current level is already higher)	0.0	1.5	3.7	74.8			74.8
		Cement: reduced growth of SEC	0.4	1.0	1.6	10.7			10.7
		Cement: share of RE 30% (except if current level is already higher)	0.0	0.0	0.7	74.8			74.8
		pulp and paper: energy efficiency increases (EEI)	0.2	0.6	1.8	0.1	0.1	319.7	
		pulp and paper: 20% renewables (except Brazil, current share constant)	0.0	0.0	0.0	74.8			74.8
		Other sectors: share of RE 20% (except if current level is already higher)	0.0	0.0	0.0	74.8			74.8
		Other sectors: reduction in non-CO2 emissions	5.9	14.6	23.3	10.0			
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
China	no regret	Iron and Steel: reduced primary steel ratio	66.3	105.7	148.7	0.0			
		Iron and Steel: 10% of energy input can be taken from RE and waste	18.6	46.8	92.3	-95.6			
		Cement: Clinker cement ratio down to 65% in 2020	28.2	60.1	96.0	0.0	5.6		-27.0
		Cement: reduced growth of SEC	7.8	10.7	13.8	-3.2	-3.2		-91.9
		Cement: 10% renewable and waste in 2020	9.5	24.3	49.5	-3.8	-3.8		2.5
		pulp and paper: 15% renewables in 2020	3.8	8.9	15.5	-95.6			-95.6
		Other sectors: share of RE 0%	0.0	0.0	0.0	-95.6			-95.6
		Other sectors: reduction in non-CO2 emissions	2.1	3.5	5.0	0.0			
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
	co-bene	Cement: 20% renewable and waste in 2020	14.3	24.3	49.5	74.8			74.8
		Other sectors: share of RE 5%	0.0	37.7	75.7	74.8			
		all: energy efficiency increases depending on current efficiency in country	14.3	24.3	49.5				
	ambitious	Iron and Steel: reduced growth of SEC primary steel	156.6	183.4	170.9	30.8	30.8		
		Iron and Steel: reduced growth of SEC secondary steel	116.9	169.2	164.7	16.6			16.6
		Iron and Steel:share of RE 10% (except if current level is already higher)	0.0	0.0	0.0	74.8			74.8
		Cement: reduced growth of SEC	35.8	66.0	84.8	8.7	8.7		
		Cement: 30% renewable and waste in 2020	21.7	40.4	37.7	74.8			74.8
		pulp and paper: energy efficiency increases (EEI)	6.1	3.8	0.7	100.0			319.7
		pulp and paper: 40% renewables (except Brazil, current share constant)	3.1	12.0	25.3	74.8			74.8
		Other sectors: share of RE 20% (except if current level is already higher)	92.4	153.4	308.3	74.8			74.8
		Other sectors: reduction in non-CO2 emissions	1.8	88.9	168.3	10.0			
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
India	no regret	Iron and Steel: reduced growth of SEC primary steel	0.0	4.6	17.6	-41.8			-41.8
		Iron and Steel: reduced growth of SEC secondary steel	0.0	1.2	4.4	-43.4			-43.4
		Iron and Steel: 10% of energy input can be taken from RE and waste	2.5	9.4	27.7	-95.6			-95.6
		Cement: Clinker cement ratio down to 70% in 2020	4.8	14.3	32.2	-7.2	-7.2		-27.0
		Cement: 10% renewable and waste in 2020	0.9	3.2	8.6	0.0			2.5
		pulp and paper: 15% renewables	0.7	1.8	3.8	-95.6			-95.6
		Other sectors: share of RE 0%	0.0	0.0	0.0	-95.6			-95.6
		Other sectors: reduction in non-CO2 emissions	0.0	0.0	0.0	0.0			
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
	co-be	Cement: 20% renewable and waste in 2020	1.4	3.2	8.6	74.8			74.8
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
	ambitious	Iron and Steel: reduced growth of SEC primary steel	2.6	8.0	16.7	83.1	83.1		13.4
		Iron and Steel: reduced growth of SEC secondary steel	0.6	1.5	2.3	16.6			16.6
		Iron and Steel:share of RE 0% (except if current level is already higher)	0.0	0.0	0.0	74.8			74.8
		Cement: reduced growth of SEC	0.0	0.0	0.0	10.7			10.7
		Cement: 30% renewable and waste in 2020	2.3	6.4	8.6	74.8			74.8
		pulp and paper: energy efficiency increases (EEI)	0.0	0.0	0.0	-10.0	-10.0		319.7
		pulp and paper: 40% renewables (except Brazil, current share constant)	0.7	2.8	6.3	74.8			74.8
		Other sectors: share of RE 20% (except if current level is already higher)	7.8	23.4	52.7	74.8			74.8
		Other sectors: reduction in non-CO2 emissions	0.6	7.1	12.4	10.0			
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
Mexico	no regret	Iron and Steel: reduced growth of SEC primary steel	0.0	0.0	0.0	-41.8			-41.8
		Iron and Steel: reduced growth of SEC secondary steel	0.0	0.0	0.0	-43.4			-43.4
		Iron and Steel: 10% of energy input can be taken from RE and waste	0.4	0.9	1.8	-95.6			-95.6
		Cement: Clinker cement ratio down to 76% in 2020	0.4	1.0	1.8	-27.0			-27.0
		Cement: 10% renewable and waste in 2020	0.0	0.4	1.4	0.0			2.5
		pulp and paper: 5% renewables	0.0	0.1	0.2	-95.6			-95.6
		Other sectors: share of RE 5%	0.0	0.0	0.0	-95.6			-95.6
		Other sectors: reduction in non-CO2 emissions	0.0	0.0	0.0	0.0			0.0
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
	co-be	Cement: 20% renewable and waste in 2020	0.3	0.8	1.6	74.8			74.8
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
	ambitious	Iron and Steel: reduced growth of SEC primary steel	0.1	0.2	0.3	13.4			13.4
		Iron and Steel: reduced growth of SEC secondary steel	0.0	0.1	0.1	16.6			16.6
		Iron and Steel:share of RE 10% (but no inclear over older scenarios)	0.0	0.0	0.0	74.8			74.8
		Cement: reduced growth of SEC	0.2	0.4	0.6	10.7			10.7
		Cement: 30% renewable and waste in 2020	0.7	1.3	1.5	74.8			74.8
		pulp and paper: energy efficiency increases (EEI)	0.0	0.0	0.1	100.0			319.7
		pulp and paper: 20% renewables (except Brazil, current share constant)	0.1	0.2	0.5	74.8			74.8
		Other sectors: share of RE 20% (except if current level is already higher)	-0.2	3.7	12.0	74.8			74.8
		Other sectors: reduction in non-CO2 emissions	1.6	7.5	13.2	10.0			
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
South Africa	no regret	Iron and Steel: reduced primary steel ratio	0.0	2.1	3.0	0.0			36.3
		Iron and Steel: reduced growth of SEC primary steel	0.5	1.0	1.5	-41.8			-41.8
		Iron and Steel: reduced growth of SEC secondary steel	1.3	2.2	2.7	-43.4			-43.4
		Cement: Clinker cement ratio down to 80% in 2020	0.6	1.5	2.6	-27.0			-27.0
		Cement: reduced growth of SEC	0.6	1.5	2.5	-91.9			-91.9
		Cement: 10% renewable and waste in 2020	0.1	0.4	0.8	-3.8	-3.8		2.5
		pulp and paper: EEI	0.0	0.0	0.0	-89.7			-670.0
		Other sectors: reduced annual growth rate of energy consumption	0.9	1.9	2.9	0.0			
		Other sectors: reduction in non-CO2 emissions	0.0	0.0	0.0	0.0			
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
	co-be	Cement: 20% renewable and waste in 2020	0.2	0.4	0.8				
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
	ambitious	Iron and Steel: reduced growth of SEC primary steel	0.0	0.0	0.0	13.4			13.4
		Iron and Steel: reduced growth of SEC secondary steel	0.0	0.0	0.0	16.6			16.6
		Iron and Steel:share of RE 20% (except if current level is already higher)	0.0	0.0	0.0	74.8			74.8
		Cement: reduced growth of SEC	0.0	0.0	0.0	10.7			10.7
		Cement: 30% renewable and waste in 2020	0.3	0.8	0.8	74.8			74.8
		pulp and paper: energy efficiency increases (EEI)	0.0	0.0	0.0	100.0			319.7
		pulp and paper: 20% renewables (except Brazil, current share constant)	0.0	0.0	0.0	74.8			74.8
		Other sectors: share of RE 20% (except if current level is already higher)	0.0	3.0	6.5	74.8			74.8
		Other sectors: reduction in non-CO2 emissions	4.8	10.4	16.0	10.0			
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
South Korea	no regret	Iron and Steel: reduced growth of SEC primary steel	0.8	1.5	2.1	-41.8			
		Iron and Steel: reduced growth of SEC secondary steel	0.0	0.0	0.0	-43.4			
		Iron and Steel: 10% of energy input can be taken from RE and waste	0.0	0.0	0.0	-95.6			
		Cement: Clinker cement ratio down to 79% in 2020	1.3	2.6	3.9	-27.0			
		Cement: 10% renewable and waste in 2020	0.3	0.7	1.2	0.0			2.5
		pulp and paper: 5% renewables	0.0	0.0	0.0	-95.6			
		Other sectors: share of RE 5%	0.0	0.0	0.0	-95.6			
		Other sectors: reduction in non-CO2 emissions	0.7	1.1	1.6	0.0			
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.0				
	co-be	Cement: 20% renewable and waste in 2020	0.4	0.7	1.2	74.8			74.8
		all: energy efficiency increases depending on current efficiency in country	0.4	0.7	1.2				
	ambitious	Iron and Steel: reduced primary steel ratio	1.6	2.7	3.6	36.3			36.3
		Iron and Steel: reduced growth of SEC primary steel	0.1	0.2	0.2	13.4			
		Iron and Steel: reduced growth of SEC secondary steel	0.1	0.1	0.2	16.6			
		Cement: reduced growth of SEC	0.1	0.1	0.1	10.7			
		Cement: 30% renewable and waste in 2020	0.7	1.3	1.2	74.8			74.8
		pulp and paper: energy efficiency increases (EEI)	0.1	0.4	0.6	100.0			319.7
		pulp and paper: 20% renewables (except Brazil, current share constant)	0.0	0.2	0.4	74.8			
		Other sectors: share of RE 20% (except if current level is already higher)	0.0	6.9	18.4	74.8			
		Other sectors: reduction in non-CO2 emissions	11.6	27.4	44.1	10.0			
		all: energy efficiency increases depending on current efficiency in country	0.0	0.0	0.1				

Table 20 Mitigation measures and costs in the domestic sector

		Mitigation Option	MtCO2 eq mitigation achieved				Costs €/tCO2eq		
			2010	2015	2020	Used	ECN country	ECN average	SERPEC
Brazil	no re	Households: energy efficiency in electricity	0.3	0.6	1.2	-13.3		-13.3	-271.6
		Commercial & Services: energy efficiency in electricity	0.1	0.1	0.2	-13.3			-220.3
	co-be	Households: energy efficiency in electricity	0.0	0.0	0.0	31.0		31.0	224.3
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			175.3
	ambitic	Households: energy efficiency in electricity	0.0	0.0	0.0	31.0		31.0	224.3
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			175.3
China	no re	Households: energy efficiency in electricity	7.0	51.5	180.9	-13.3		-13.3	-339.6
		Commercial & Services: energy efficiency in electricity	3.0	9.1	23.0	-13.3			-200.3
	co-be	Households: energy efficiency in electricity	0.0	23.4	70.9	31.0		31.0	447.2
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			457.0
	ambitic	Households: energy efficiency in electricity	40.7	95.9	185.4	31.0		31.0	447.2
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			457.0
India	no re	Households: energy efficiency in electricity	2.9	7.1	12.7	-13.3		-13.3	-339.6
		Commercial & Services: energy efficiency in electricity	0.0	3.7	12.6	-13.3			-200.3
	co-be	Households: energy efficiency in electricity	0.0	0.0	0.0	31.0		31.0	447.2
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			457.0
	an	Households: energy efficiency in electricity	0.0	0.0	0.0	31.0		31.0	447.2
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			457.0
Mexico	no re	Households: energy efficiency in electricity	1.0	2.2	3.6	-42.8	-42.8	-13.3	-271.6
		Commercial & Services: energy efficiency in electricity	0.3	1.3	3.2	-42.8			-220.3
	co-be	Households: energy efficiency in electricity	0.0	0.0	0.5	31.0	-35.0	31.0	224.3
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			175.3
	ambitic	Households: energy efficiency in electricity	0.0	0.0	0.0	31.0	-35.0	31.0	224.3
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			175.3
South Africa	no re	Households: energy efficiency in electricity	1.3	3.0	5.2	-18.3	-18.3	-13.3	-271.6
		Commercial & Services: energy efficiency in electricity	0.5	1.7	3.5	-18.3			-220.3
	co-be	Households: energy efficiency in electricity	0.0	0.0	0.8	1.7	1.7	31.0	224.3
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			175.3
	ambitic	Households: energy efficiency in electricity	0.0	0.0	0.0	31.0	1.7	31.0	224.3
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			175.3
South Korea	no re	Households: energy efficiency in electricity	0.7	2.6	6.6	-2.5	-2.5	-13.3	-339.6
		Commercial & Services: energy efficiency in electricity	1.7	5.9	11.5	-2.5			-200.3
	co-be	Households: energy efficiency in electricity	0.5	1.2	2.3	31.0		31.0	447.2
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			457.0
	ambitious	Households: energy efficiency in electricity	0.0	0.0	0.0	31.0		31.0	447.2
		Commercial & Services: energy efficiency in electricity	0.0	0.0	0.0	31.0			457.0
		Households: increase in share or RE (non combustibles)	0.0	0.8	2.3	30.1		30.1	341.1
		Commercial & Services: increase in share or RE (non combu	0.0	1.5	3.1	30.1			38.1

Table 21 Mitigation measures and costs in the agriculture and waste sectors

Country	Scenario	Mitigation Option	MtCO2 eq Mitigation achieved 2010	2015	2020	Cost €/tCO2 Used	ECN country	ECN average	SERPEC
Brazil	no regret	agriculture: reduction in methane enteric fermentation	2.5	5.2	8.3	0.0	0.0	0.0	0.0
Brazil	no regret	agriculture: reduction in the use of fertilizer	1.0	3.1	5.6	0.0	0.0	0.0	-150.9
Brazil	co-benefit	waste: reduction waste generated per capita	1.0	3.6	5.6	10.0			
Brazil	co-benefit	waste: CH4 recovery from landfills	0.5	0.6	0.9	40.7	40.7	35.4	178.5
Brazil	ambitious	agriculture: reduction in methane enteric fermentation	9.6	19.9	30.8	36.7	36.7	27.0	918.4
Brazil	ambitious	agriculture: reduction in the use of fertilizer	1.4	3.6	7.1	30.0	30.0	29.1	15.0
Brazil	ambitious	waste: CH4 recovery from landfills	1.8	7.0	15.3	40.7	40.7	35.4	178.5
China	no regret	agriculture: reduction in growth rate of annual livestock	0.0	14.4	32.1	0.0			
China	co-benefit	waste: CH4 recovery from landfills	0.0	3.7	10.8	32.7	32.7	35.4	178.5
China	ambitious	agriculture: reduction in growth rate of annual livestock	6.3	25.4	35.2	0.0			
China	ambitious	agriculture: change in rice cultivation	22.5	36.0	47.6	15.5	15.5	19.7	
China	ambitious	waste: CH4 recovery from landfills	6.1	23.0	47.8	32.7	32.7	35.4	178.5
India	no regret	agriculture: reduction in growth rate of annual livestock	24.4	63.4	101.0	0.0			
India	co-benefit	waste: CH4 recovery from landfills	0.0	2.0	6.2	35.1	35.1	35.4	178.5
India	ambitious	agriculture: reduction in growth rate of annual livestock	17.6	21.8	26.4	100.0			
India	ambitious	agriculture: change in rice cultivation	2.2	9.6	16.4	15.0	15.0	19.7	
India	ambitious	waste: CH4 recovery from landfills	3.4	7.5	27.7	35.1	35.1	35.4	178.5
Mexico	no regret	agriculture: reduction in growth rate of annual livestock	2.4	6.1	8.6	0.0			
Mexico	co-benefit	waste: CH4 recovery from landfills	0.0	2.1	6.0	37.1	37.1	35.4	178.5
Mexico	ambitious	agriculture: reduction in growth rate of annual livestock	6.3	9.1	12.2	100.0			
Mexico	ambitious	agriculture: change in rice cultivation	0.0	0.0	0.1	19.7		19.7	
Mexico	ambitious	waste: CH4 recovery from landfills	3.9	13.3	26.9	37.1	37.1		
South Africa	co-benefit	waste: CH4 recovery from landfills	2.0	7.0	14.2	35.4		35.4	178.5
South Africa	co-benefit	agriculture: reduction in growth rate of annual livestock	1.2	2.7	5.0	100.0			
South Africa	ambitious	waste: CH4 recovery from landfills	2.0	7.0	14.2	35.4		35.4	178.5
South Korea	no regret	agriculture: reduction in growth rate of annual livestock	1.0	2.0	2.9	0.0			
South Korea	co-benefit	waste: CH4 recovery from landfills	0.0	1.0	3.2	35.4		35.4	178.5
South Korea	ambitious	agriculture: reduction in growth rate of annual livestock	0.6	1.0	1.5	100.0			
South Korea	ambitious	agriculture: change in rice cultivation	0.8	1.4	1.8	19.7		19.7	
South Korea	ambitious	waste: CH4 recovery from landfills	1.4	6.0	14.4	35.4		35.4	178.5

Table 22 Mitigation measures and costs in the transport sector

		Mitigation Option	MtCO2eq mitigation achieved			Cost €/tCO2			
			2010	2015	2020	Used	ECN country	ECN average	SERPEC
Brazil	no regre	Aviation: intensified efficiency progress	0.4	1.0	1.8	-159.5			-159.5
		Road transport: intensified efficiency progress	4.6	11.0	19.9	-11.1	-182.5	-11.1	-80.9
		Road transport: stronger growing shares of natural gas in road transport	2.4	5.5	9.8	0.0		-195.7	
	co-bene	additional modal changes from road to rail	3.8	8.9	16.0	2.6			
		additionally modal changes from individual transport to public transport	3.0	7.2	12.8	2.6		2.6	
		Road transport: growing shares of renewables	6.9	16.1	29.5	53.6	53.6	30.1	23.9
	ambitious	Additional modal change from aviation to telecomm.	0.7	1.9	3.5	150.0			
		Additional modal change from road to telecomm.	4.3	9.8	16.8	150.0			
		Aviation; efficiency gains	0.3	0.7	1.3	102.3			102.3
		Road transport: efficiency gains	7.7	16.8	27.1	180.2		180.2	173.2
China	no regre	Aviation: intensified efficiency progress	0.9	2.6	5.7	-159.5			-159.5
		Road transport: intensified efficiency progress	7.5	20.5	41.0	-12.5	-12.5	-11.1	-80.9
		Road transport: stronger growing shares of LPG in road transport	1.3	3.5	6.7	0.0			
		Road transport: stronger growing shares of natural gas in road transport	1.9	5.2	10.1	0.0		-195.7	
	co-bene	additional modal changes from road to rail	6.1	16.6	32.8	2.6			
		additionally modal changes from individual transport to public transport	4.9	13.3	26.2	2.6	2.6	2.6	
		Road transport: growing shares of renewables	9.8	25.6	48.6	36.3	36.3	30.1	23.9
	ambitious	Additional modal change from aviation to telecomm.	1.8	5.2	11.1	150.0			
		Additional modal change from road to telecomm.	7.0	18.3	34.4	150.0			
		Aviation; efficiency gains	0.8	2.3	4.6	102.3			102.3
		Road transport: efficiency gains	13.5	33.2	59.4	180.2		180.2	173.2
India	no regre	Aviation: intensified efficiency progress	0.4	1.3	2.9	-159.5			-159.5
		Road transport: intensified efficiency progress	4.4	12.6	27.4	0.0	0.0	-11.1	-80.9
		Road transport: stronger growing shares of natural gas in road transport	2.3	6.6	14.2	0.0	-208.0	-195.7	
	co-bene	additional modal changes from road to rail	3.6	10.2	21.9	2.6	-4.4		
		additionally modal changes from individual transport to public transport	2.9	8.2	17.6	2.6		2.6	
		Road transport: growing shares of renewables	6.0	17.0	36.5	130.0	130.0	30.1	23.9
	ambitious	Additional modal change from aviation to telecomm.	0.8	2.5	5.7	150.0			
		Additional modal change from road to telecomm.	4.2	11.2	23.0	150.0			
		Aviation; efficiency gains	0.4	1.1	2.3	102.3			102.3
		Road transport: efficiency gains	8.0	20.4	39.8	180.2	486.7	180.2	173.2
Mexico	no regre	Aviation: intensified efficiency progress	0.3	0.7	1.2	-159.5			-159.5
		Road transport: intensified efficiency progress	3.8	8.7	14.9	-11.1		-11.1	-80.9
		Road transport: stronger growing shares of LPG in road transport	1.3	2.9	4.8	0.0			
	co-bene	additional modal changes from road to rail	3.1	7.1	12.0	2.6			
		additionally modal changes from individual transport to public transport	2.5	5.6	9.6	2.6		2.6	
		Road transport: growing shares of renewables	4.9	10.4	16.5	30.1		30.1	23.9
	ambitious	Additional modal change from aviation to telecomm.	0.6	1.3	2.4	150.0			
		Additional modal change from road to telecomm.	3.6	7.8	12.6	150.0			
		Aviation; efficiency gains	0.3	0.6	1.0	102.3			102.3
		Road transport: efficiency gains	6.9	14.1	21.7	180.2		180.2	173.2
South Africa	no regre	Aviation: intensified efficiency progress	0.2	0.4	0.7	-159.5			-159.5
		Road transport: intensified efficiency progress	0.7	1.5	2.4	-11.1		-11.1	-80.9
		Road transport: stronger growing shares of natural gas in road transport	1.2	2.8	4.7	0.0		-195.7	
	co-bene	additional modal changes from road to rail	1.2	2.7	4.5	2.6			
		additionally modal changes from individual transport to public transport	0.8	1.8	3.0	2.6	2.6	2.6	
		growing shares of renewables in road transport	1.5	3.3	5.5	0.0	0.0	30.1	23.9
	ambitious	Additional modal change from aviation to telecomm.	0.3	0.8	1.4	150.0			
		Additional modal change from road to telecomm.	1.2	2.5	4.0	150.0			
		Aviation; efficiency gains	0.2	0.3	0.6	102.3			102.3
		Road transport: efficiency gains	2.2	4.5	6.8	180.2		180.2	173.2
South Korea	no re	Road transport: intensified efficiency progress	4.7	10.3	16.5	-11.1		-11.1	-80.9
		Road transport: stronger growing shares of natural gas in road transport	1.3	2.8	4.5	0.0		-195.7	
	co-benefit	additional modal change from aviation to road and rail	0.6	1.3	1.6	2.6			
		additional modal changes from road to rail	0.7	2.7	1.5	2.6			
		Railway: efficiency gains	0.1	0.2	0.3	10.0			
		additionally modal changes from individual transport to public transport	0.5	0.9	1.3	2.6		2.6	
		Commercial bus: increase occupation	0.5	1.0	1.6	2.6			
		Bus: decrease specific fuel consumption	0.6	1.1	1.6	100.0		180.2	173.2
		Cars: Decrease in average annual millage	3.7	6.9	9.7	100.0			
		total: 15% share of RE in the transport sector	4.6	9.3	13.9	30.1		30.1	23.9
	ambitiou	Additional modal change from aviation to telecomm.	3.0	7.1	12.7	150.0			
		Additional modal change from road to telecomm. (av. Annual milage)	4.0	6.9	8.7	150.0			
		Road transport: efficiency gains (cars, bus, truck)	5.1	9.4	13.2	22.8	22.8	180.2	173.2

Table 23 Mitigation measures and costs in the LUCF sector

		Mitigation Option	MtCO2 eq mitigation achieved 2010	2015	2020	Cost $/tCO2 Used	ECN country	ECN average	SERPEC
Brazil	ambitious	LUCF afforestation	12.4	31.1	49.7	36.5			
		LUCF avoided deforestation	333.3	666.7	800.0	29.7			
China	ambitious	LUCF afforestation	78.7	95.0	111.2	37.3			
		LUCF avoided deforestation	0.0	0.0	0.0	32.0			
India	ambitious	LUCF afforestation	45.0	75.2	57.9	37.3			
		LUCF avoided deforestation	0.0	0.0	0.0	32.0			
Mexico	ambitious	LUCF afforestation	10.7	15.8	13.0	36.5			
		LUCF avoided deforestation	0.0	0.0	0.0	29.7			
South Afri	ambitious	LUCF afforestation	1.2	2.7	3.8	23.1			
		LUCF avoided deforestation	0.0	0.0	0.0	21.9			
South Kor	ambitious	LUCF afforestation	0.0	0.0	0.0	47.7			
		LUCF avoided deforestation	0.0	0.0	0.0	40.7			

A 3 Emission allowances according to global effort-sharing approaches

450 ppmv	CDC			C&C			GDRs		
Year	Mt CO2eq 2020			Mt CO2eq 2020			Mt CO2eq 2020		
Country group	Min	Median	Max	Min	Median	Max	Min	Median	Max
Brazil	1977	2031	2138	2023	2089	2151	1396	1522	1631
China	5437	5778	5888	5791	6104	6158	10545	10889	11524
India	2878	3020	3090	2914	3026	3082	4024	4087	4238
Mexico	709	727	762	705	727	746	611	660	721
South Africa	452	456	457	391	401	402	438	466	492
South Korea	490	523	534	474	503	509	388	425	467
all 6	11943	12534	12869	12297	12850	13048	17402	18049	19074

450 ppmv	South North			Triptych			Reference		
Year	Mt CO2eq 2020			Mt CO2eq 2020			Mt CO2eq 2020		
Country group	Min	Median	Max	Min	Median	Max	Min	Median	Max
Brazil	1524	1524	1592	1477	1514	1576	2093	2308	2364
China	8631	8631	8631	8140	8557	9138	11070	13077	14079
India	3699	3699	3699	2422	2525	2704	3543	4352	4683
Mexico	704	704	704	589	610	655	943	1067	1119
South Africa	432	432	479	396	409	440	573	655	687
South Korea	423	467	557	461	497	539	698	833	918
all 6	15413	15457	15663	13485	14113	15052	18921	22292	23850

Appendix B Global effort-sharing approaches

B 1 EVOC

This section describes the Evolution of Commitments tool (EVOC) version 8, developed by Ecofys, that is used to quantify emission allowances under the various approaches in this report. It includes emissions of CO_2, CH_4, N_2O, hydroflourocarbons (HFCs), perflourocarbons (PFCs) and sulphur hexafluoride (SF_6) for 192 individual countries. Historical emissions are based on national emission inventories submitted to the UNFCCC and, where not available, other sources such as the International Energy Agency. Future emissions are based on the IPCC Special Report on Emissions Scenarios (Nakicenovic et al. 2000). The greenhouse gas emission data for 1990 to 2006 is derived by an algorithm that combines emission estimates from various sources.

We first collected historical emission estimates by country, by gas and by sector from the following sources and ordered them in the following hierarchy:

1. National submissions to the UNFCCC as collected by the UNFCCC secretariat and published in the GHG emission database available at their web site. For Annex I countries, the latest available year is usually 2006. (UNFCCC 2008).
2. CO_2 emissions from fuel combustion as published by the International Energy Agency. The latest available year is 2006 (IEA 2008a).
3. Emissions from land-use change as published by Houghton in the WRI climate indicator analysis tool (Houghton 2003).
4. Emissions from CH_4 and N_2O as estimated by the US Environmental Protection Agency. Latest available year is 2005 (USEPA 2006a)
5. CO_2, CH_4, N_2O, HFC, PFC and SF_6 emissions from the EDGAR database version 3.2 available for 1990 and 1995 (Olivier and Berdowski 2001).[7]

Future emissions are derived from the MNP/RIVM IMAGE implementation of the SRES scenarios (IMAGE team 2001).

The datasets vary in their completeness and sectoral split. We first defined which of the sectors provided in the datasets correspond to seven sectors. This definition is provided in Table 24. Note that CO_2 emissions from the IEA do not include process emissions from cement production. Hence, if IEA data is chosen, process emissions from cement production are not included.

For each country, gas and sector, the algorithm completes the following steps:

1. For all data sets, missing years in-between available years within a data set are linearly interpolated and the growth rate is calculated for each year step.

[7] For CH_4 and N_2O, the values of EPA are largely based on the EDGAR database (1990 and 1995), but extended to the year 2000.

2. The data source is selected, which is highest in hierarchy and for which emission data are available. All available data points are chosen as the basis for absolute emissions.
3. Still missing years are filled by applying the growth rates from the highest data set in the hierarchy for which a growth rate is available.

As future emissions are only available on a regional basis and not country-by-country, the resulting set of emissions is then extended into the future by applying the growth rates of the respective sectors and gas of the region to which the country belongs. (See Table 24 on page 200 for detailed information on data sources and definition of sectors.)

For population, GDP in purchase power parities and electricity demand, the country base year data was taken from the United Nations (UN 2008), World Bank 2008 and IEA 2008a, respectively. These data are extended into the future by applying the growth rates from the IMAGE model for the region to which the country belongs.

Emissions until 2010 are estimated as follows: It is assumed that Annex I countries implement their Kyoto targets by 2010. Further, it is assumed that the reductions necessary to meet the Kyoto target are achieved equally in all sectors. In 2010, the level of the domestic sector is taken from the relevant reference scenario. The level of the other sectors are taken from the reference scenario and reduced, so that the Kyoto target is met. The years from the last available year to 2010 are linearly interpolated. All non-Annex I countries follow their reference scenario until 2010.

As a default setting, all Annex I countries are assumed to reach the lower of their Kyoto target and their reference scenarios in 2010. Only the USA is assumed to follow its BAU emissions until 2010. All non-Annex I countries also follow their reference scenario until 2010. After 2010, the emission allowances per country are calculated according to the effort-sharing approaches.

A limitation of the tool is the unknown future development of emissions of individual countries. Here, we have used the standard set of future emissions scenarios, the IPCC SRES scenarios, as a basis. They provide a broad range of storylines and therefore a wide range of possible future emissions. We cover this full range of possible future emissions, economic and population development in a consistent manner. But the SRES scenarios are only available at the level of up to 17 regions (as in the IMAGE implementation) and scaling them down to individual countries introduces an additional element of uncertainty. We applied the growth rates provided for 17 world regions to the latest available data points of the individual countries within the respective regions. So, on the level of regions, we cover the full-range uncertainty about future emissions. When again aggregating the regions, the effect of downscaling cancels out. But the full level of uncertainty is not covered on the national level as substantial differences may exist for expected growth for countries within one of the 17 regions.

The future reference development of emissions, economic and population is affected by the starting values (which is data available from the countries or other international sources and which can be substantially different for countries in one region) and the assumed growth rates (which are derived from the 17 regions).

Table 24 Data sources and definition of sectors

	UNFCCC		Edgar 3.2 database		USEPA		LUCF Houghton		IEA		IMAGE CD	
	Regional:	country by country	**Regional:**	country by country	**Regional:**	country-by country	**Regional:**	country-by country	**Regional:**	country by country	**Regional:**	17 regions
	Temporal:	1990 to 2002 (various)	**Temporal:**	1990 and 1995	**Temporal:**	1990-2020	**Temporal:**	1950-2000	**Temporal:**	1970-2000	**Temporal:**	1970 to 2100
	Gas:	CO2, CH4, N2O, HFCs, PFCs, SF6	**Gas:**	CO2, CH4, N2O; HFCs, PFCS, SF6	**Gas:**	CH4, N2O	**Gas:**	CO2	**Gas:**	CO2	**Gas:**	CO2, CH4, N2O, HFCs, PFCs, SF6
Industry												
	1A2	Manufacturing Industries and Construction	**F10**	Industry					3T Other Energy Industries		ENERGY 01 Industry	
	2A0	Mineral Products	**F30**	Other transformation sectors					401 Iron and Steel		ENERGY 07 Other energy transformation	
	2B0	Chemical Industry	**B10 CH4N2O**	Biofuel industry CH4 N2O					402 Chemical and Petrochemical		INDUS 01 Feedstocks	
	2C0	Metal Production	**B30 CH4N2O**	Biofuel charcoal production CH4 N2O					403 Non-Ferrous Metals		INDUS 02 Industrial activities	
	2D0	Other Production	**I10**	Iron and steel					404 Non-Metallic Minerals			
	2G0	Other (Industrial Processes)	**I20**	Non-ferrous metals					409 Paper, Pulp and Printing			
			I30	Chemicals					405 Transport Equipment			
			I40	Building materials					406 Machinery			
			I50	Pulp and paper					407 Mining and Quarrying			
			I60	Food					408 Food and Tobacco			
			I70	Solvent use/Miscellaneous					410Wood and Wood Products			
			I80	Transport evaporation					411 Construction			
			I90	Miscellaneous industry					412 Textile and Leather			
			F60	non-energy use and feedstocks					413 Non-specified Industry			
									414 Non-Energy Use Ind/Transl/Energy			
									If the IEA data set is chosen, process emissions from industry (e.g. from cement) are not covered			
Electricity												
	1A1	Energy Industries	**F20**	Power generation					11 Public Electricity Plants		ENERGY 06 Electric power generation	
			B20 CH4N2O	Biofuel power generation CH4 N2O					12 Public CHP Plants			
									13 Public Heat Plants			
									14 Own Use in Electricity, CHP and heat plants			
									21 Autoproducer Electricity Plants			
									22 Autoproducer CHP Plants			
									23 Autoproducer Heat Plants			
Domestic												
	1A3	Transport	**F40**	Residential, commercial and other sectors					5T Transport		ENERGY 02 Transport	
	1A4	Other Sectors (Fuel Combustion)	**F51**	Transport road					6T Other Sectors		ENERGY 03 Residential (households)	
	1A5	Other (Fuel Combustion)	**F54**	Transport land non-road					*MB Memo: International Marine Bunkers*		ENERGY 04 Services (commercial and public)	
	2E0	Production of Halocarbons and Sulphur Hexafluoride	**F57**	Transport air (international and domestic)					*AB Memo: International Aviation Bunkers*		ENERGY 05 Agriculture and other enduse	
	2F0	Consumption of Halocarbons and Sulphur Hexafluoride	***F58***	*Transport international shipping*							*ENERGY 09 Marine bunkers*	
	3TT	TOTAL Solvent and Other Product Use	**B40 CH4N2O**	Biofuel residential CH4 N2O							FGAS	
	9TT	*TOTAL International Bunkers*	**B51 CH4N2O**	Biofuel transport road CH4 N2O								
			C10	HFC-byprod.								
			C20	HFC use								
			C30	PFC-byprod.								
			C40	PFC use								
			C50	SF6 use								
	Secotors in italics are excluded when the user chooses to exclude international transport											
Fossil fuel production												
	1BT	TOTAL Fugitive Emissions from Fuels	**F70**	Coal production	02 Coal production				7T Differences due to Losses and/or Transformation		ENERGY 08 Fossil fuel production	
			F80	Oil production, transmission and handling	03 Natural gas production							
			F90	Gas production and transmission	04 Oil production							
			F95	Fossil fuel fires								
Agriculture												
	4TT	TOTAL Agriculture	**L10**	Fertiliser use	06 Manure management						LAND 10 wetland rice	
			L15	Rice cultivation	07 Enteric fermentation						LAND 11 animals	
			L20	Enteric fermentation	08 Rice production						LAND 12 animal waste	
			L30	Animal waste management (confined N2O, all CH4)	09 Agricultural soils						LAND 14 fertilizer	
			L50	Crop production							LAND 15 indirect fertilizer	
			L60	Animal waste management (deposited on soil- N2O)							LAND 16 indirect animal waste	
			L71	Atmospheric deposition							LAND 17 crop residues	
			L75	Leaching and run-off							LAND 18 biological N-fixation	
LUCF												
	5TT	TOTAL Land-Use Change & Forestry	**L41**	BB-Deforestation	10 Biomass combustion		Land-use				LAND 01 biomass burning	
			L42	BB-Savanna burning							LAND 02 burning of traditional biomass / fuelwood burning	
			L43	BB-Agricultural waste burning							LAND 03 timber pool (short lifetime)	
			L44	BB-Vegetation fires							LAND 04 timber pool (long lifetime)	
			L45	BB-deforestation post burn effects							LAND 05 carbon release by regrowing vegetation (-NEP)	
											LAND 06 agricultural waste burning	
											LAND 07 savanna burning	
											LAND 13 land clearing	
Waste												
	6TT	TOTAL Waste	**W10**	Landfills	11 Landfills						LAND 08 landfills	
			W15	Humans/pets	12 Wastewater						LAND 09 (domestic) sewage	
			W20	Waste water treatment								
			W30	Human waste disposal								
			W40	Waste incineration								
			W50	Miscelaneous waste handling (hazardous waste)								
	CO2 emissions from Biomass buring (UNFCCC sector 1A5 and EGRAR sectors B10 to B51) are not included as they are not to be included in the national totals according to teh IPCC guidelines and the UNFCCC repoting guidelines)											

The assumed growth rates may affect the results of countries to a different extent. Some countries are less affected as they dominate their regional group, such as Brazil, Mexico, Egypt, South Africa, Nigeria, Saudi Arabia, China and India. It is for second or third largest countries in a region or for members of an inhomogeneous group, for which this method may lead to an over or underestimation of the future development.

Second or third largest countries in a region are e.g. Argentina, Venezuela, United Arab Emirates and South Korea. Under the Contraction and Convergence (C&C) approach, the error would be small as countries follow their reference scenario only until 2010 and converge afterwards. For Common but Differentiated Convergence (CDC), Multistage and the Greenhouse Development Rights (GDRs) approach, the downscaling method may influence the time of participation. But the countries listed above would all participate at the earliest possible moment, based on their already today high per capita emissions. In the Triptych approach, growth in industrial and electricity production and a reduction below reference for agriculture is used, which may be affected by the downscaling method.

Members of an inhomogeneous group would be those of South East Asia, which includes Indonesia and the Philippines as lower-income countries and Malaysia, Singapore and Thailand as higher-income countries. Here the growth is averaged over the region, probably underestimated for Indonesia and the Philippines and overestimated for Singapore. The dominant element here is the starting point. The low per-capita emissions of the Philippines and Indonesia lead to their late participation, while the high per-capita emissions in Malaysia, Singapore and Thailand lead to their immediate participation. In the Triptych approach, growth in industrial and electricity production and a reduction below reference for agriculture is used, which may be affected by the downscaling method.

For Annex I countries, the future reference development is not as relevant since they always participate in the regime on the highest stage and have to reduce emissions independent of the reference development. Future values are only relevant for intensity targets (GDP) or for the Triptych approach (industrial and electricity production and agriculture).

A different uncertainty is introduced since our future emissions are static, meaning that emissions in non-participating developing countries do not change as a result of ambitious or relaxed emission reductions in developed countries. Stringent reductions could affect emissions of non-participating countries in two ways. There could be increased emissions through migration of energy-intensive industries or decreased emissions due to technology spill-over. Overall, we assume that this effect is small and not significantly influencing the results of this analysis.

B 2 Parameters

This section presents the parameters applied for five different effort-sharing approaches consistent with the long-term emission stabilisation level of 450 ppmv. This means that the calculation outcomes have to meet the global reference emissions of 10% above to 1990 levels in 2020 and. The following approaches are included in the calculation of emission allowances:

- Greenhouse Development Rights
- Common but differentiated convergence
- Contraction and convergence by 2050
- Global Triptych
- South North approach

For this comparison of the emission rights under different distribution approaches in a future architecture the Evolution of Commitments tool (EVOC) is used.

B 2.1 Greenhouse development rights (GDRs)

The Greenhouse Development Rights (GDRs) approach to share the effort of global greenhouse gas emissions reduction was developed by Baer et al. (Baer et al. 2007, 2008; cp. also Niklas Höhne and Sara Moltmann 2008). It is based on three main pillars:

The right to develop: Baer et al. assume the right to develop as the essential part for any future global climate regime in order to be successful. Therefore a development threshold is defined. Below this level individuals must be allowed to make development their first priority and do not need to contribute to the global effort of emission reduction or adaptation to climate change impacts. Those above this threshold will have to contribute regardless their nationality. This means that individuals above this threshold will have to contribute even if they live in a country that has an average per capita income below this level. The level for this development threshold would have to be matter of international debate. However Baer et al. 2008 suggest an income-level of $7,500 per capita and year. Based on this, the effort sharing of the GDRs is based on the capacity and the responsibility of each country.

Capacity: The capacity (C) of a county is reflected by its income. The income distribution among individuals is taken into account by the gini coefficient of a country. A gini coefficient close to 1 indicates low equality while a value close to 0 indicates a high equality in income distribution. As the countries capacity is needed to define per-country emission allowances the sum of income of those individuals per country above the development threshold is summed and considered to calculate each countries capacity.

Responsibility: The responsibility (R) is based on the 'polluter pays' principle. For the GDRs according to Baer et al. it is measured as cumulative per capita CO_2 emissions from fossil fuel consumption since 1990. However, it should be distinguished between survival emissions and luxury emissions. Baer et al. assume that emissions are proportional to consumption, which again is linked to income. Emissions related to that share of income below the development threshold are equivalent to the part of national income that is not considered in calculating a country's capacity. Therefore, they shall be considered as survival emissions. Those emissions linked to income above the development threshold are luxury emissions and shall account for a country's responsibility.

Allocation of emission rights: The allocation of emission reduction obligations and resulting emission rights is based on each country's responsibility and capacity, combined in the Responsibility Capacity Index (RCI). This is defined as $RCI = R^a \cdot C^b$, where *a* and *b* are weighting factors. Baer et al. assume and equal weighting of 0.5 for *a* and 0.5 for *b*, which gives capacity and responsibility an equal weight.

Two global emissions development paths are considered. First, the business-as-usual (BAU) case and second the reduction path necessary to reach the emission level in order to stabilise global emissions (see Figure 95). The difference of these two is the amount of emissions that need to be reduced globally. Each country's annual share of this reduction is determined by the relative share of its RCI compared to the sum of RCIs of all other countries.

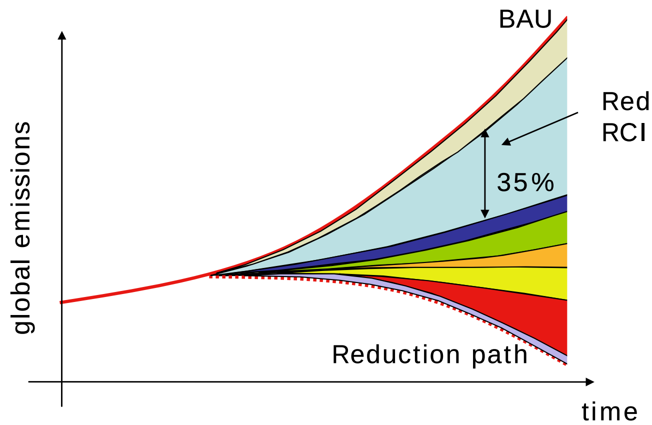

Figure 95 Effort sharing under the Greenhouse Development Rights (GDRs) approach according to the Responsibility Capacity Index (RCI)

Table 25 includes the parameters chosen for the calculations on the GDRs approach in this report.

Table 25 Parameters chosen for the Greenhouse Development Rights approach

Parameter	Unit	
Development threshold	USD (2005) / capita / year	7,500
Start year for cumulative emissions		1990
Weighting of Capacity	%	50%
Weighting of Responsibility	%	50%

B 2.2 Contraction and convergence (C&C)

Under Contraction and convergence (C&C) (GCI 2005; Meyer 2000), all countries participate in the regime with quantified emission targets. As a first step, all countries agree on a path of future global emissions that leads to an agreed long-term stabilisation level for greenhouse gas concentrations ('contraction'). As a second step, the targets for individual countries are set in such a way that per capita emission allowances converge from the countries' current levels to a level equal for all countries within a given period ('convergence'). The convergence level is calculated at a level that resulting global emissions follow the agreed global emission path. It might be more difficult for some countries to reduce emissions compared to others, e.g. due to climatic conditions or resource availability. Therefore, emission trading could be allowed to level off differences between allowances and actual emissions. However, C&C does not explicitly provide for emission trading.

As current per-capita emissions differ greatly between countries some developing countries with very low per capita emissions, (e.g. India, Indonesia or the Philippines) could be allocated more emission allowances than necessary to cover their emissions ('hot air'). This would generate a flow of resources from developed to developing countries if these emission allowances are traded.

To meet the global emission path of +10% (2020) a convergence at about 1 tCO_2eq per capita in 2050 is necessary (see Table 26). In this case the average per-capita emissions will have to lie around 4.5 tCO_2eq per capita in 2020.

Table 26 Global convergence levels of per-capita emissions rights in tCO_2eq/cap in 2050 (the global emission level is the same but global population is different per scenario)

Scenario	Average in 2020 [tCO_2eq/cap]	Convergence level in 2050 [tCO_2eq/cap]
A1B	4.6	1
A1FI	4.6	1
A1T	4.6	1
A2	4.4	1
B1	4.4	1
B2	4.5	1

B 2.3 Common but differentiated convergence (CDC)

Common but differentiated convergence (CDC) is an approach presented by Höhne et al. (Höhne et al. 2006). Annex I countries' per capita emission allowances converge within, e.g., 40 years (2010 to 2050) to an equal level for all countries. Individual non-Annex I countries' per-capita emissions also converge within the same period to the same level but convergence starts from the date, when their per-capita emissions reach a certain percentage threshold of the (gradually declining) global average. Non-Annex I countries that do not pass this percentage threshold do not have binding emission reduction requirements. Either they take part in the CDM or they voluntarily take on positively binding emission reduction targets. Under the latter, emission allowances may be sold if the target is overachieved, but no emission allowances have to be bought if the target is not reached.

The CDC approach, similarly to C&C, aims at equal per capita allowances in the long run (see Figure 96). In contrast to C&C it considers more the historical responsibility of countries. Annex I countries would have to reduce emissions similarly to C&C, but many non-Annex I countries are likely to have more time to develop until they need to reduce emissions. Non-Annex I country participation is conditional to Annex I action through the gradually declining world average threshold. No excess emission allowances ('hot air') would be granted to least developed countries.

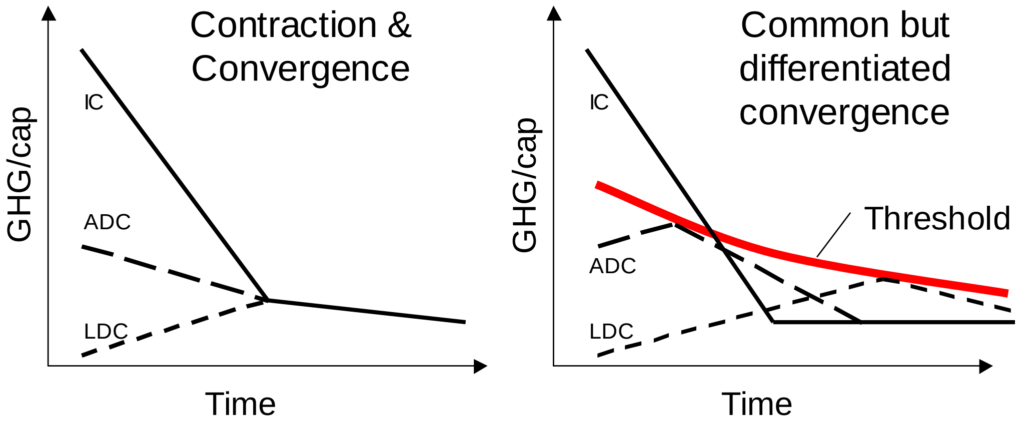

Figure 96 Schematic representation of GHG emissions per capita for three types of countries (an industrialised country (IC), an advanced developing country (ADC) and a least developed country (LDC)) under contraction and convergence (left) and under common but differentiated convergence (right)

The parameters for the convergence time, the threshold for participation and the convergence level used in this report are provided in Table 27.

Table 27 Parameters used for the Common but differentiated convergence approach

Parameter	Unit	
Convergence time	Years	29
Threshold	% difference from world average	-60%
Convergence level	tCO_2eq/cap	1

B 2.4 Global Triptych

This approach was originally developed at the University of Utrecht (Blok et al. 1997) to share the emission allowances of the first commitment period within the European Union. It has been updated and revised subsequently (Phylipsen et al. 1998, Groenenberg 2002, den Elzen and Lucas 2003, Höhne et al. 2003, Phylipsen et al. 2004, Höhne et al. 2005, Höhne 2006).

Analogue to the first Triptych approach, the global Triptych approach is a method for allocating emission allowances among a group of countries based on several national indicators.[8] It takes into account the main differences in national circumstances between countries that are relevant to emissions and emission reduction potential. The Triptych approach as such does not define which countries should participate, but we have applied it here to all countries equally.

If the approach is applied globally, substantial reductions for the industrialised countries, especially those with carbon intensive industries (i.e. Eastern Europe and Russian Federation), are required. Substantial emission increases are allowed for most

[8] Unlike e.g. the Multistage approach which is more a framework of stages that can be filled with different allocation methods for the several stages or C&C which is based only on per-capita emissions.

developing countries. But for lower concentration targets (e.g. 450 ppmv CO_2) these are rarely above BAU emissions.

The Triptych methodology calculates emission allowances for the various sectors which are added to obtain a national target. Not individual sector targets but only the national targets are binding. This provides countries the flexibility to pursue any cost-effective emission reduction strategy.

The emissions of the sectors are treated differently: For 'electricity production' and 'industrial production', a growth in the physical production is assumed together with an improvement in production efficiency. This takes into account the need for economic development but constant improvement of efficiency. For the 'domestic' sectors, convergence of per-capita emissions is assumed. This takes into account the converging living standard of the countries. For the remaining sectors, 'fossil fuel production', 'agriculture' and 'waste', similar reduction and convergence rules are applied.

Table 28 provides the parameters chosen for the calculation in this report. Details on the applied methodology can be found in Phylipsen et al. 2004. The choice of parameter values is subjective but should reflect a reasonable effort sharing of emission reductions. Several other options are possible.

Table 28 Parameter choices for 2020 for the Triptych cases aiming at 450 ppmv CO_2eq concentration

Sector	Quantity	2020
Industry	Maximum deviation of total industrial production at country level in 2050	45%
	Maximum deviation of total industrial production at global level in 2050	10%
	Convergence of Energy Efficiency Indicator in 2050	0.2
	Structural change factor	0.1
Electricity	Maximum deviation of total power production at country level in 2050	45%
	Maximum deviation of total power production at global level in 2050	10%
	Share of renewables and emission free fossil in 2050	100%
	Share of CHP in 2050	100%
	Reduction of solid fuels in 2050 compared to base year	100%
	Reduction of liquid fuels in 2050 compared to base year	100%
	Amount of nuclear energy	Absolute unchanged
	Amount of natural gas	Remainder
	Total efficiency of CHP	90%
	Convergence of power generation efficiency of solid fuels in 2050	50%
	Convergence of power generation efficiency of liquids fuels in 2050	55%
	Convergence of power generation efficiency of gas in 2050	70%
Domestic Sector	Domestic convergence level – per-capita emissions in tCO_2/cap/yr in 2050	0.4
Fossil fuel production	Fossil fuel emission level – % total emissions below base year in 2050	95%
Agriculture	Reduction below reference scenario emissions in 2050 – low GDP/cap	80%
	Reduction below reference scenario emissions in 2050 – high GDP/cap	90%
Waste	Waste convergence level – per-capita emissions in 2050	0

B 2.5 South North approach

The South-North proposal (Ott et al. 2004) defines six groups of countries that should take differentiated types of commitments in a future climate regime (Figure 97).

	Annex II	Annex I, but not Annex II	NICs	RIDCs	Other DCs	LDCs
Potential to mitigate CO_2/GDP, 2000 GHG/capita, 2000 CO_2 emissions growth, 1991-2000	Medium Very high Narrow range	Very high High Wide range	High High Wide range	Medium Medium Wide range	Medium Low Wide range	Low Low Wide range
Responsibility to mitigate Cumulative CO_2/capita, 1990–2000	Very high	High	High	Low	Low	Very low
Capability to mitigate GDP/capita, 2000 HDI, 2000	Very high Very high	Medium High	Medium High	Medium Medium	Low Medium	Very low Low
Mitigation commitments Type of quantitative commitment	Binding (strict) absolute reduction targets, domestic reduction	Binding absolute reduction targets, domestic reduction	Absolute limitation or reduction targets, domestic mitigation*	Absolute limitation targets, if funding and technology provided from Annex I*	No targets	No targets
Qualitative action			SD-PAMs (obligatory), Sector CDM, Non-binding RE & EE targets	SD-PAMs (obligatory, co-funded), Sector CDM, Non-binding RE & EE targets	SD-PAMs (obligatory, co-funded), Sector CDM, Non-binding RE & EE targets	SD-PAMs (optional, funded), Sector CDM, Non-binding RE & EE targets
Financial transfers to support mitigation activities	High direct payments (out) to non-Annex I.	Low / no payments.	NIC co-funds mitigation, but some transfers from Annex II.	High direct payments from Annex II.	Direct payments from Annex II.	Direct payments from Annex II.

* Targets only could become binding if all major Annex I countries have binding quantified emission reduction obligations.

Figure 97 Regions and their responsibility according to the proposal 'South- North Dialogue – Equity in the Greenhouse' (Source: Ott et al. 2004)

We implemented the proposal as described in Höhne and Ullrich 2005. Our assumptions on how much the country groups reduce are given in Table 29. We used the division of countries into groups as provided in the original proposal.

Table 29 Parameters used in the South-North proposal

Region	% in 2020
Annex II	45% below 1990
Annex I but not Annex II	40% below 1990
Newly industrialised countries	5% below 2000
Rapidly industrialising developing countries	34% below BAU
Other developing countries	15% below BAU
Least developed countries	BAU