INTERNATIONAL

DEVELOPING COUNTRY ANALYSIS AND DIALOGUE

Greenhouse Gas Mitigation in Brazil, China and India: Scenarios and Opportunities through 2025

Conclusions and Recommendations

CENTER FOR CLEAN AIR POLICY

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Acknowledgments

This report was written by Matthew Ogonowski, Mark Houdashelt, Jake Schmidt, Jin Lee, and Ned Helme of the Center for Clean Air Policy (CCAP). The authors would like to thank CCAP staff members Steve Winkelman, Mac Wubben, Alesia Call, Troy Reinhalter, Kim Barnashuk, and Andrew Fromknecht for help with key elements of this report.

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About the Center for Clean Air Policy

As a recognized world leader in air quality and climate policy since 1985, the Center for Clean Air Policy, an independent non-profit entity, seeks to promote and implement innovative solutions to major environmental and energy problems which balance both environmental and economic interests. The Center's work is guided by the belief that market-based approaches to environmental problems offer the greatest potential to reach common ground between these often conflicting interests. CCAP staffs have participated in the Framework Convention on Climate Change negotiations, helping to shape the Joint Implementation provisions of the Rio Treaty and the Kyoto Protocol Mechanisms. CCAP has also developed a series of papers, the *Airlie Papers*, on domestic carbon trading in the US, the *Leiden Papers* on international emissions trading, and the *Clean Development Mechanism Papers*, on the design of the CDM, and the *Future Actions Dialogue Papers* on future international climate policy. For more information on CCAP, see: www.ccap.org

Executive Summary

SHATTERING MYTHS

This report shatters a commonly held myth among critics of the Kyoto Protocol that developing countries are not taking meaningful action to reduce greenhouse gases.

Working closely with policymakers and researchers both within and outside the governments of Brazil, China and India, the Center for Clean Air Policy (CCAP) has led an analysis of the costs and implications of policies to reduce GHG emissions. *Greenhouse Gas Mitigation In Brazil, China and India: Scenarios And Opportunities Through 2025* presents the results of that analysis. It reveals that Brazil and China have adopted "unilateral actions" since 2000 that have already reduced emissions and are expected to reduce emissions through 2020 in those nations below projected levels. Reductions in Brazil and China alone in 2010, if fully implemented, are projected to be greater than those to be achieved by the United States' voluntary carbon intensity reduction goal.[1] India is projected to achieve emissions reductions by 2020 in the transportation and iron and steel sectors below "business as usual" levels, but these reductions are projected to be offset principally by emissions increases in the electricity sector.

Most of these reductions in the three nations have been financed domestically, independent of the Kyoto Protocol's Clean Development Mechanism (CDM) under which developing countries can sell emission reductions achieved from approved projects to developed nations. While questions remain about how effective implementation of these new policies will be in each country, they nonetheless demonstrate the broad scope of policies that reduce greenhouse gases underway in key developing countries.

This revelation of unilateral action supports arguments for setting more challenging emissions reduction goals for developed countries, as it should help to allay concerns about the non-participation of developing countries in carbon reduction. China in particular has focused an important portion of its environmental effort in internationally competitive industries including iron and steel, cement, pulp and paper. This undercuts, to a degree, the argument that industries facing international competition will shift production to China and other developing countries from developed nations to avoid the costs of carbon reductions.

FUTURE CLIMATE POLICY OPPORTUNITIES

The study also details an array of additional cost-effective emission reductions that these three leading developing nations could pursue in the future -- unilaterally, under the CDM or a new international policy structure. Projected aggregate emissions reductions that could be achieved in the electricity, cement, transportation, paper, and steel industries in these nations range from 17 to 29 percent below business as usual levels in 2020. Modeling conducted for CCAP by Ecofys Consulting[2] suggests that this level of reduction by Brazil, China and India, coupled with major reductions in developed countries, a significant effort by the United States and comparable efforts by major developing countries, would keep the world on track to stabilize global carbon dioxide concentrations at 450 ppm. Also, it would keep open the possibility of achieving the European Union's goal of holding global average temperature increases due to climate change to 2 degrees Centigrade.[3]

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[1] This study estimates that Brazil and China are projected to achieve more than 210 million metric tons of CO_2 reduction in 2010 from existing unilateral policies while the U.S. voluntary target is slated to achieve 183 million metric tons of CO_2-equivalent reduction/year on average over the life of the voluntary program according to the U.S. Administration. Brazil and China were responsible for 17% of global anthropogenic greenhouse gas emissions in 1990 (not including emissions from deforestation) while the U.S. was responsible for 25% in 1990.

[2] Details on this analysis are in: Schmidt et al. (2006), available at http://www.ccap.org/international/Sector%20Straw%20Proposal%20-%20FINAL%20for%20FAD%20Working%20Paper%20%7E%208%2025%2006.pdf.

[3] Stabilizing emissions at 450ppm CO_2 is roughly equivalent to stabilizing emissions at 500 ppm CO_2 equivalent. Source: den Elzen and Meinshausen (2005), *Meeting the EU 2°C climate target: global and regional emission implications*

The study suggests there is an unprecedented opportunity for future international climate policy to:

- Recognize and encourage "unilateral actions" by developing countries
- Provide incentives for more expensive emissions reduction opportunities that are not likely to be pursued unilaterally by developing countries, and
- Establish a global policy structure coupling needed incentives for developing country action with tough emission reduction goals for developed nations that will be sufficient to protect the climate.

BACKGROUND

At the annual UNFCCC meeting in Montreal in November 2005, Parties agreed to begin formal discussions under both the Kyoto Protocol and UNFCCC on the future international climate policy structure for the post-2012 period. One of the key elements of this discussion will be what role developing countries will play in the international response to climate change. In many developing countries, discussions about concrete policy steps to reduce greenhouse gas (GHG) emissions are already underway, often motivated by concerns about energy security, air quality, and economic development. This report is intended as a contribution to that ongoing dialogue.

Greenhouse Gas Mitigation In Brazil, China and India: Scenarios And Opportunities Through 2025, summarizes the results of the first phase of the CCAP's **"Developing Country Project."** A key goal of the project is to strengthen the capacity of developing countries to take action to reduce greenhouse gases and to prepare for and participate in negotiations on the future structure of climate policy under the UNFCCC and the Kyoto Protocol. The project also will assist developing countries by identifying specific "win-win" opportunities where they can reap substantial economic and other development-related benefits through cost-effective actions that will also reduce GHG emissions.

Since the inception of the Developing Country Project in February 2005, CCAP has worked with in-country teams in Brazil, China, India and Mexico to identify technologies and approaches that are feasible and cost-effective in reducing GHG emissions and in providing co-benefits (e.g., air quality and energy security).[4] By engaging in-country teams, key government officials and stakeholders, CCAP is building each nation's capacity to continue this type of analysis following the end of the project. The partners in the research are: the Center for Integrated Studies on Climate Change and the Environment (Centro Clima) at the Federal University of Rio de Janeiro and several independent researchers in Brazil; The Institute for Environmental Systems Analysis at Tsinghua University of China; The Energy and Resources Institute (TERI) of India; and the Centro Mario Molina of Mexico.

This report—and the companion reports prepared by the teams in each country—evaluate the emissions trends and reduction opportunities in key sectors of the economies of these countries, and suggest some preliminary insights on politically practical domestic and international approaches for achieving these reductions. The next phase of the research will study in more detail the barriers to the introduction of the most promising emission reduction options identified in Phase I and will suggest domestic and international implementation strategies.

KEY RESULTS

a) Emissions Are Projected To Grow In Brazil, China, And India

Emissions of greenhouse gases in these countries are projected to more than double from 2000 levels in the electricity, industrial, transportation, and residential and commercial sectors[5] over the next two decades due to increases in population, economic activity, and urbanization.

b) Unilateral Efforts Undertaken Since 2000 Will Slow This Trend

If fully implemented, government policies and programs adopted since 2000 in China and Brazil will slow this projected growth in GHG emissions and reduce emissions by seven and 14 percent below projected levels, respectively. In India, overall emissions are expected to increase slightly on a net basis as a result of new policies.

Specific actions undertaken by these countries include:

- China's Renewable Energy Law and the Tenth Five-Year Plan are expected to reduce electricity sector emissions by five percent below BAU levels—a reduction equivalent to shutting down more than 20 large coal-fired Chinese power plants—in 2020.

[4] The analysis in Mexico began nine months later than the other three countries, and will be completed in 2007.
[5] Emissions data for China do not include residential and commercial numbers.

- China's Medium and Long Term Energy Conservation Plan is estimated to reduce cement sector emissions by 15 percent below BAU levels in 2020—a reduction equivalent to shutting down half of the shaft kiln cement facilities that existed in China in 2000. This Plan also is estimated to reduce iron and steel sector emissions by nine percent below BAU levels in 2020—a reduction equivalent to shutting down approximately 750 existing iron and steel facilities.
- China's fuel efficiency standards for passenger cars, SUVs, and multi-purpose vans are estimated to reduce transportation sector emissions by five percent below BAU levels in 2020.
- Brazil's Program for Incentive of Alternative Electric Energy Sources (PROINFA) is estimated to reduce electricity sector emissions by 14 percent below BAU levels—a reduction equivalent to closing 42 percent of Brazil's current oil-fired electricity generation—in 2020.
- Brazil's ethanol program, which has led to the development of flex fuel vehicles and cost competitive ethanol, is estimated to reduce transportation emissions by 18 percent below BAU levels in 2020—a reduction equivalent to almost 1.5 times the total emissions from light-duty vehicles in 2000.
- India's transportation policies are estimated to reduce transportation sector emissions by up to 15 percent below BAU levels—a reduction equivalent to the sector's emissions in 2000—in 2020.
- India's Electricity Act 2003 is estimated to increase electricity sector emissions by 12 percent above BAU in 2020 due to expanded electricity generation, driven in part by increased electricity access.

c) These Actions Have Been Taken Principally For Reasons Other Than Climate-Related Considerations And In Some Cases At Real Net Economic Cost:

- China's actions taken in the electricity and iron and steel sectors were aimed to increase reliability of the power network, enhance economic productivity and competitiveness, and improve air and water quality. Many of the renewable opportunities in China are estimated to cost more than $10 per ton, and a number of the mitigation options in the iron and steel sector being pursued today are priced in the $5 to $10 per ton range.
- The Chinese vehicle standards and the Brazilian ethanol and flex fuel vehicle programs primarily have been driven by the goal of reducing the use of imported oil.
- Brazil's flex fuel vehicle program is estimated to achieve its reductions at greater than $30 per ton, yet has been pursued aggressively.

d) Many Of The Emissions Reductions Achieved Through These Policies Are Not Being Developed As Clean Development Mechanism (CDM) Projects And Thus Represent These Countries' "Contribution To The Protection Of The Atmosphere":

- China currently has around 14 $MMTCO_2$ per year in the CDM pipeline from hydro and wind generation projects—and around 5 $MMTCO_2$ in industrial energy efficiency projects—both of which are significantly below the level of reductions estimated to be achieved as a result of China's post-2000 policy initiatives.
- China's vehicle efficiency standard and Brazil's flex-fuel vehicles are not being developed into CDM projects.
- While India only has one transportation CDM project in the pipeline, it does have a number of industrial energy efficiency and carbon reduction projects pending approval as CDM projects.

e) Opportunities Exist To Make Significant Additional Emission Reductions To Help Slow The Rapid Increase In GHG Emissions Projected In These Countries

- On an aggregate basis, the study projects cost-effective reductions (below $10/ton CO_2) of four percent in India, four percent in Brazil and 10 percent in China below BAU levels in 2020 totaling more than 625 million tons of CO_2 per year – the equivalent of avoiding the construction of more than 150 coal-fired power plants.[6]
- In China, major potential targets include nearly 200 million tons of CO_2 reductions in each of the transport and cement sectors
- In India and Brazil, transport, cement and electricity options stand out as top targets for further cost-effective action.
- This year, China also has adopted several new policies (thus beyond the scope of this study) that promise to produce significant additional reductions:

[6] These aggregate estimates include both reductions due to existing policies and reductions due to potential new measures.

- Eleventh Five Year Plan requires the 1000 highest energy-consuming enterprises to install equipment to attain a 20 percent efficiency improvement by 2010.
- Vehicle excise taxes are now based on vehicle engine size and have increased significantly (e.g., the SUV tax has quadrupled to about $8,000 per vehicle).
- The National Development and Reform Commission has set new goals for the cement industry: increase the share of cement produced by dry kilns from 40 to 70 percent, close more than 250 million tons of inefficient capacity and reduce energy intensity 15 percent by 2010.

f) If China, Brazil And India Chose To Make The Reductions Outlined In This Study By 2020, Their Efforts, Coupled With Other Countries' Efforts, Could Be Sufficient To Stay On Track To Stabilize Global Atmospheric Carbon Dioxide Concentrations At 450 ppm.

To meet this concentration goal, other nations would need to make reductions along the lines of:

- EU and other developed nations cutting their emissions to 30 percent below 1990 levels by 2020
- The U.S. cutting its emissions to 1990 levels by 2020, and
- The other major developing countries making efforts similar to China, India and Brazil.

This proposed combination of emission reductions is simply illustrative. Any combination of reductions from developed and developing nations that achieves the same aggregate reduction can keep the achievement of a 450 ppm global atmospheric carbon dioxide concentration in play. Even given the huge projected growth in emissions in these three developing countries through 2020, the key point here is that the potential, largely cost-effective reductions identified in this study are significant – their achievement would mark important progress toward achieving the goal of limiting global increases in temperature to 2 degrees Centigrade.

ROLE OF INTERNATIONAL POLICY

A future international policy that recognizes and encourages further "unilateral actions" is needed. Countries could be encouraged to "pledge" GHG policies and reductions. The future international policy also needs to provide incentives for action to implement the more expensive emissions reductions options available in these countries. These options could benefit from financial support, technology development and transfer assistance, and capacity building. A variety of international policy options under discussion for developing countries could achieve this, including: voluntary pledges to take action on sustainable development policies and measures (SD-PAMs), pledges to achieve no-lose sector-based intensity levels with countries able to sell reductions achieved in excess of these targets, and new sectoral approaches to the CDM which could encourage greater unilateral emission reductions.[7]

[7] See CCAP paper, "Sector-based Approach to the Post-2012 Climate Change Policy Architecture", August 2006.

GREENHOUSE GAS MITIGATION IN BRAZIL, CHINA AND INDIA: SCENARIOS AND OPPORTUNITIES THROUGH 2025

I.A Conclusions and Recommendations

This report shatters a commonly held myth among critics of the Kyoto Protocol that developing countries are not taking meaningful action to reduce greenhouse gases.

Working closely with policymakers and researchers both within and outside the governments of Brazil, China and India, the Center for Clean Air Policy (CCAP) has led an analysis of the costs and implications of policies to reduce GHG emissions. *Greenhouse Gas Mitigation In Brazil, China and India: Scenarios And Opportunities Through 2025* presents the results of that analysis. It reveals that Brazil and China have adopted “unilateral actions” since 2000 that have already reduced emissions and are expected to reduce emissions through 2020 in those nations below projected levels. Reductions in Brazil and China alone in 2010, if fully implemented, are projected to be greater than those to be achieved by the United States’ voluntary carbon intensity reduction goal. India is projected to achieve emissions reductions by 2020 in the transportation and iron and steel sectors below “business as usual” levels, but these reductions are projected to be offset principally by emissions increases in the electricity sector.

Most of these reductions in the three nations have been financed domestically, independent of the Kyoto Protocol’s Clean Development Mechanism (CDM) under which developing countries can sell emission reductions achieved from approved projects to developed nations. While questions remain about how effective implementation of these new policies will be in each country, they nonetheless demonstrate the broad scope of policies that reduce greenhouse gases underway in key developing countries.

This revelation of unilateral action supports arguments for setting more challenging emissions reduction goals for developed countries, as it should help to allay concerns about the non-participation of developing countries in carbon reduction. China in particular has focused an important portion of its environmental effort in internationally competitive industries including iron and steel, cement, pulp and paper. This undercuts, to a degree, the argument that industries facing international competition will shift production to China and other developing countries from developed nations to avoid the costs of carbon reductions.

The study also details an array of additional cost-effective emission reductions that these three leading developing nations could pursue in the future—unilaterally, under the CDM or a new international policy structure. Projected aggregate emissions reductions that could be achieved in the electricity, cement, transportation, paper, and steel industries and the residential and commercial sectors in these nations range from 17 to 29 percent below business as usual levels in 2020. Modeling conducted for CCAP by Ecofys Consulting suggests that this level of reduction by Brazil, China and India, coupled with major reductions in developed countries, a significant effort by the United States and comparable efforts by major developing countries, would keep the world on track to stabilize global CO_2 concentrations at 450 ppm. Also, it would keep open the possibility of achieving the European Union's goal of holding global average temperature increases due to climate change to 2 degrees Centigrade.

The study suggests there is an unprecedented opportunity for future international climate policy to:

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- Establish a global policy structure coupling needed incentives for developing country action with tough emission reduction goals for developed nations that will be sufficient to protect the climate.

Background

Greenhouse Gas Mitigation In Brazil, China and India: Scenarios And Opportunities Through 2025, summarizes the results of the first phase of the CCAP's "Developing Country Project. This project was financed by the United Kingdom's Department for International Development (DFID), the Tinker Foundation, and the Hewlett Foundation. The project developed comprehensive analysis of greenhouse gas (GHG) projections and potential mitigation options, costs, co-benefits, and implementation policies in Brazil, China, India, and Mexico, led by the Center for Clean Air Policy and eading partner organizations in these four countries:

The in-country partners in this project consist of:

- a team at the Center for Integrated Studies on Climate Change and the Environment (Centro Clima) at the Institute for Research and Postgraduate Studies of Engineering at the Federal University of Rio de Janeiro (COPPE/UFRJ), Haroldo Machado Filho, Thelma Krug, Magda Aparecida de Lima, Luiz Gustavo Barioni, and Geraldo Martha;
- a team from the Institute for Environmental Systems Analysis within the Department of Environmental Science and Engineering at Tsinghua University of China;
- The Energy and Resources Institute (TERI) of India; and
- the Centro Mario Molina of Mexico.

The project is conducted in two phases. In Phase I of this project, the teams conducted individual GHG emission mitigation analyses for major economic sectors. The results of Phase I have been presented in a series of reports. The reports for Brazil, China and India will be released in conjunction with this report, while the report for Mexico will be released in 2007. This integrated report presents the results of Phase I (GHG Mitigation Option and Cost Analysis) of the project analysis for Brazil, China and India. In the next phase of the project, the teams will build upon Phase I by: evaluating the implications of specific international climate change policy options for GHG mitigation in these four countries; development of a suite of potential policies and approaches for implementation of each option; and comprehensive and in-depth analysis of the key actors, barriers and co-benefits associated with each.

Methodology

The GHG mitigation analysis was conducted using country-specific scenarios for annual population and gross domestic product (GDP). The teams developed two alternative GHG reference case scenarios for each sector, partly based on the A2 and B2 scenarios in the

Intergovernmental Panel on Climate Change (IPCC) *Special Report on Emissions Scenarios* (in this integrated report, we refer only to the B2 scenario data[8]).

Three different scenarios were developed:

- **"Pre-2000 Policy" scenario** which considered only policies and programs adopted prior to 2000. For the analysis of mitigation options this scenario was used as the "business as usual" (BAU) scenario.
- **"Recent Policy" scenario** (also called "unilateral actions") which considered the impact with implementation of all policies announced before 2006.
- "**Advanced Options" scenarios**. Where appropriate, each country analysis conducted up to four variations of the Advanced Options scenario, based on the potential cost effectiveness (measured in $/metric ton CO_2e reduced) of the mitigation measures analyzed. The first three Advanced Options scenarios assumed implementation of all measures costing, respectively, less than $0 per ton (<$0 per ton), less than $5 per ton (<$5/ton), and less than $10 per ton (<$10/ton). The fourth scenario was the most aggressive and considered all feasible (in the team's judgment) mitigation options.

I.B Emissions are projected to grow in all three countries

Brazil, China, and India combined account for 40% of the world's population, 7% of world economy, and an estimated 23% of current global GHG emissions (Schmidt et al., 2006).[9] As the powerful developing economies of China, India and Brazil continue to grow and develop, production and consumption of energy will all rise as well. This analysis considered emissions projections and reduction opportunities in key sectors of the economy: China included electricity, iron and steel, cement, pulp and paper, and on-road vehicles; Brazil considered electricity, iron and steel, cement, pulp and paper, residential, commercial, transportation, methane from enteric fermentation, and land-use change and forestry (this analysis includes discussion of projected future deforestation rates in Brazil, but these were not included in Brazilian emission estimates discussed below); and India included electricity, iron and steel, cement, pulp and paper, residential, commercial, transportation, and agriculture pumping. While not economy-wide, emissions from these sectors account for a sizeable share of each country's CO_2 emissions from fuel combustion in 2000: 74% in China, 77% in India, and 71% in Brazil[10].

Under business-as-usual conditions considered in this analysis, **emissions of greenhouse gases in these countries are projected to increase significantly in the electricity, industrial,**

[8] While analysis of an "A2-like" scenario was calculated, the team's and the in-country reviewers considered the "B2-like" scenario a more realistic representation of emissions projections. The "A2-like" scenario produces significantly larger growth in emissions as it is "dirtier" scenario.

[9] This excludes emissions from land-use change. Including these would increase the share to 22% (Schmidt et al., 2006).

[10] Note that values for China and Brazil include emissions from electricity, iron and steel, cement, pulp and paper, and transportation; share for India includes commercial and residential. It should also be noted that Brazil share does not include emissions from deforestation, which are a significant share of the country's overall greenhouse gas emissions.

transportation, and residential and commercial sectors[11] **over the next two decades** (see Figure 1)**.**

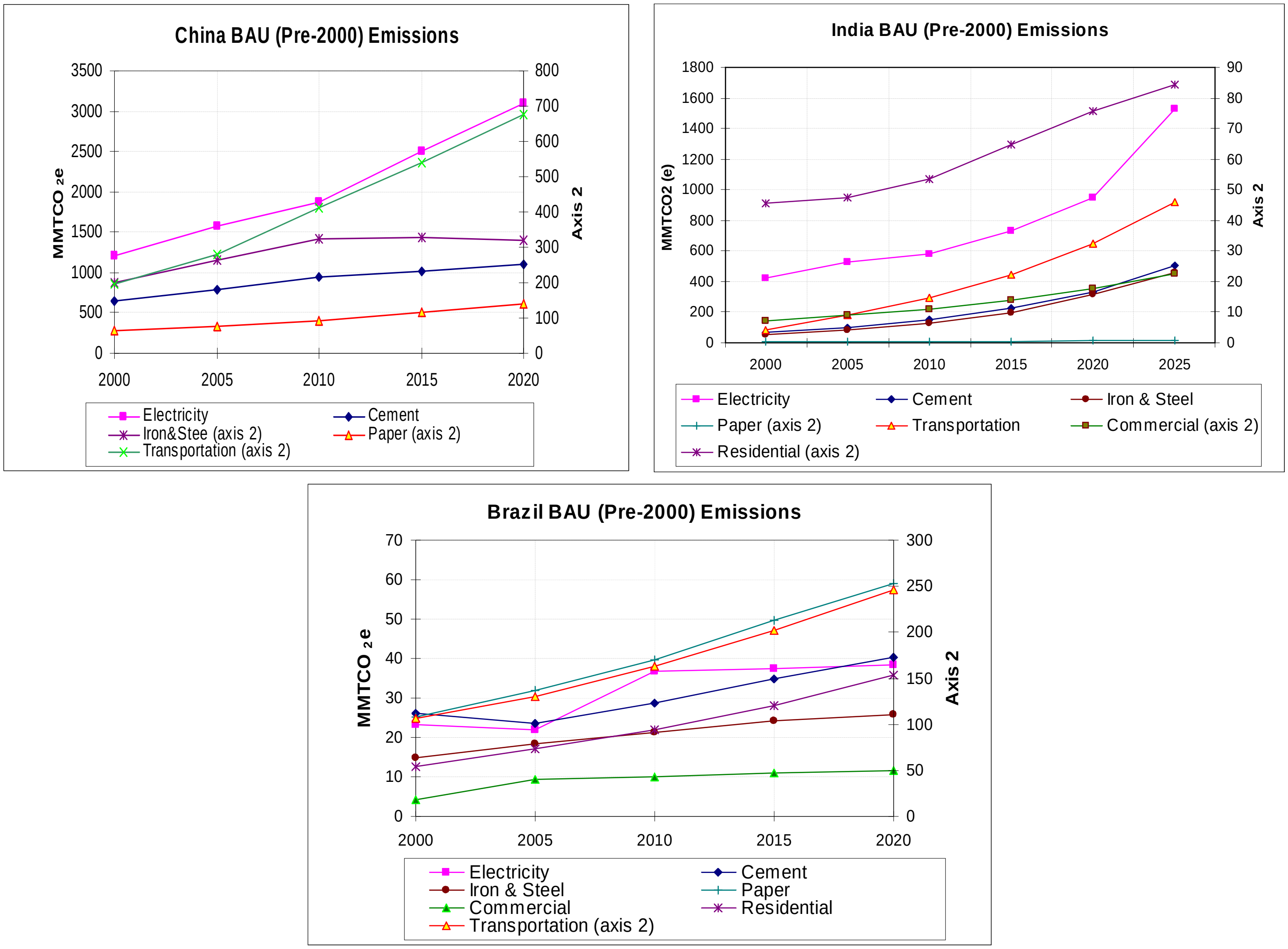

Figure 1. Sector CO_2 Emissions Under the Pre-2000 Policy and Recent Policy Scenarios

As Figure 1 demonstrates, when considering only policies adopted before year 2000, emissions from these sectors are projected to increase over the period in all three countries due to increases in economic activity, population, and urbanization. As a result, compared to 2000 levels the combined emissions from the sectors analyzed in China and Brazil are projected to more than double by 2020 as GDP and population increase in both countries. In China, GDP and population increase by 285% and 14%, respectively, between 2000 and 2020. Likewise, Brazilian GDP and population are projected to grow significantly by 118% and 29%, respectively, over this timeframe. Indian emissions will rise even faster, increasing by almost 3.5 times, due to a larger projected increase in GDP and population of over 360% and 30%, respectively. It should be noted, however, that this is based on the assumption of a relatively

[11] Emissions data for China do not include residential and commercial numbers.

high rate of national economic growth—8% per year through 2026—compared to that in other studies.[12] The actual estimated emissions growth in India may thus be significantly lower than the projected levels in this analysis if the Indian economy should fail to maintain this level of growth over the time period.

In the BAU scenario, transportation emissions in China are projected to increase by 250%— due to a more than four times increase in the number of cars, trucks, and buses—and electricity emissions by 160%—driven by an almost doubling of electricity production—from 2000 to 2020, with large increases expected in the other sectors as well. As a result, compared to 2000 levels the combined emissions from these sectors in China are projected to more than double by 2020. Electricity is expected to be a sizeable share of these emissions in the future—accounting on average for over one-half of total annual emissions from the sectors analyzed in the 2000 to 2020 period—with cement accounting for about 30% in 2000 but only one-fifth in 2020.

The increases are equally dramatic in India, with transportation emissions rising by a factor of 6.5—due to an increase in the number vehicles and the usage per vehicle—electricity emissions more than doubling—driven by a 255% increase in electricity production—and cement and iron and steel emissions rising by about 5 times in both sectors. As a result, electricity accounts for about one-half of emissions from the sectors analyzed in India in 2010, but only about two-fifths in 2020, while the share of transportation emissions is projected to increase from 14% in 2000 to more than one-quarter in 2020. The Indian iron and steel and cement sectors will also increase significantly over the period, and combined will account for the same share of emissions (28%) as transportation in 2020.

In Brazil, the projected increases are significant as well, with transportation emissions rising by 130%—largely driven by an increase in emissions from freight trucks. In Brazil, transportation accounts for about one-half of total emissions throughout the period.

Taken together, sector emissions from these countries would increase by 150% – almost 5,000 $MMTCO_2$. From the pre-2000 perspective, the outlook from these countries is therefore one of rapidly increasing fuel consumption and GHG emissions in all sectors, and a corresponding increase in their contribution to global greenhouse gas emissions.

I.C “Unilateral” Efforts Will Slow This Trend and Reduce Emissions

While emissions will likely continue to expand in many sectors in the near term, **fully implemented government policies and programs adopted since 2000 in these countries will slow this projected growth in GHG emissions and reduce emissions below projected levels.** It is important to note that these emissions reductions are not necessarily guaranteed as achieving these levels of reduction will require full enforcement of existing policies and programs. For this reason, the teams and the in-country reviewers felt it was more appropriate to use the pre-2000 scenario (which does not include policies adopted since 2000) as the basis of the “business as

[12] The growth rates assumed were based on government plans detailed in the Tenth Five Year Plan prepared by the Planning Commission, Government of India. Other studies, however, have projected lower rates of growth for the Indian economy, some on the order of 5% or less.

usual" case. These efforts have been undertaken for reasons other than climate change mitigation, such as energy security, air quality, competitiveness, and sustainable development. Figure 2 shows the impact of these policies and programs.

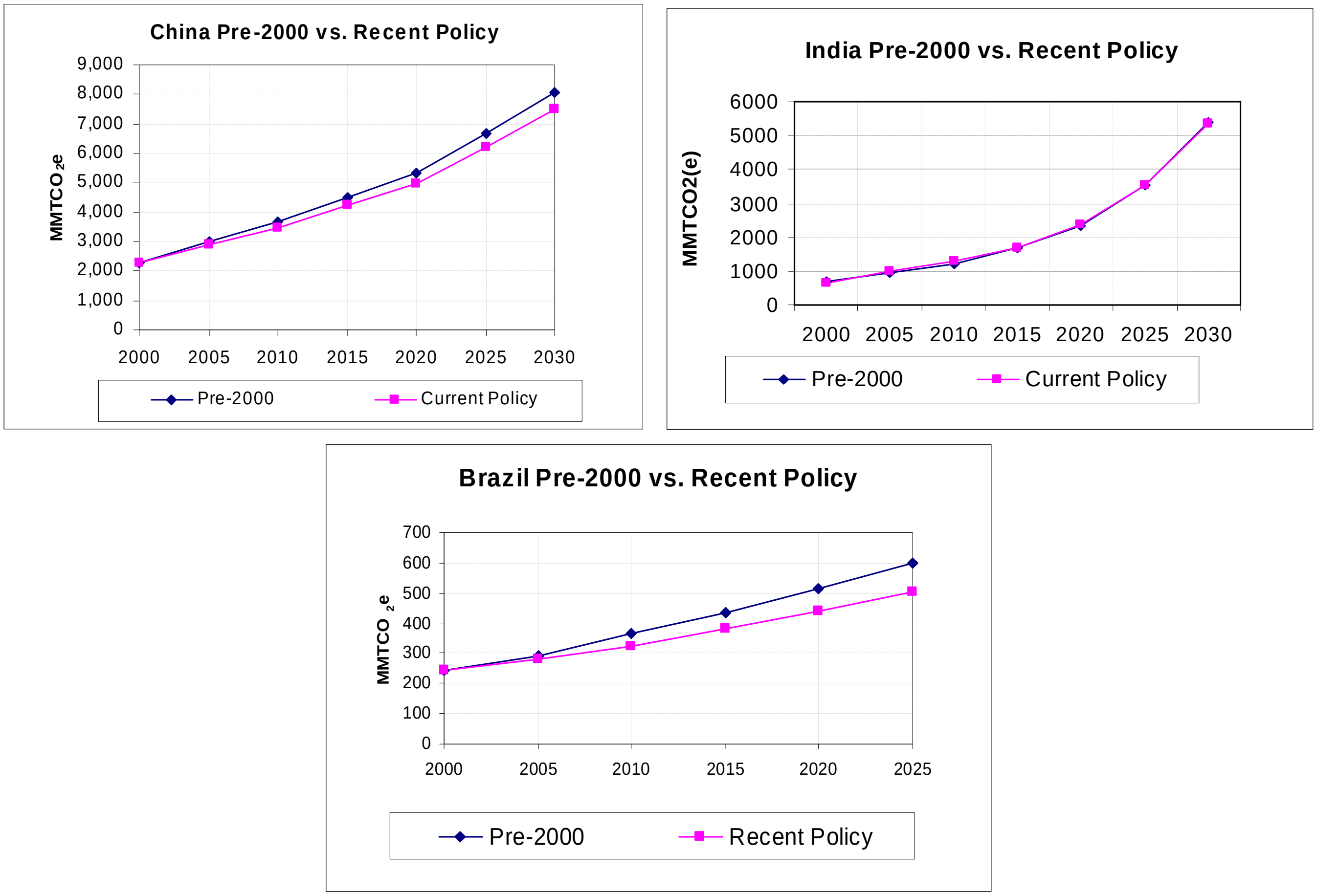

Figure 2. GHG Emissions Under Pre-2000 Policy and Recent Policy Scenarios

Overall, the policies and actions already undertaken and underway in these three countries, if full implemented, are estimated to lower GHG emissions by about 460 MMTCO$_2$ below BAU levels in 2020, a fall of 6%—equivalent to offsetting the emissions of over 120 coal-fired power plants[13]. In China and Brazil, these measures are estimated to reduce emissions by 7 and 14 percent below projected levels, respectively, while in India overall emissions are expected to increase slightly on a net basis as a result of new policies. Thus, while the current outlook in China, India and Brazil is for a significant growth in emissions, unilateral actions already undertaken through government policies and programs in these three countries driven primarily for non-climate change reasons will have a positive impact in lowering this trend. This development represents an important "first step" for developing countries, as they have already begun to make important contributions to the global effort to reduce GHG emissions and combat climate change.

[13] Assumes a new 600 MW facility with 85% capacity factor and 9,000 Btu/kWh heat rate using sub-bituminous coal, which equals 3.74 MMTCO$_2$ per year in emissions. This value is used in the conclusions for the "rule of thumb" comparisons.

These actions have in some cases been taken at real net economic cost and principally for reasons other than climate-related considerations, including: energy security with growing demand and limited domestic supply, reliability of the power network, enhanced economic productivity and competitiveness, and improved air and water quality.

Many of the emissions reductions achieved through these policies are not being developed as Clean Development Mechanism (CDM) projects and thus represent these countries' "contribution to protection of the atmosphere." Overall, these countries have over 823, with average annual reductions of 144 $MMTCO_2$, in the CDM pipeline.[14] The majority of these reductions in China and Brazil are in sectors not covered by this analysis (e.g., landfill gas or HFCs) or in sectors where these "unilateral actions" are being undertaken: over 70% of the average annual reductions in China and Brazil are in sectors not covered by this analysis.[15] The opposite is true in India where the majority of average annual emissions reductions in the CDM pipeline—69%—are in sectors covered by this analysis.[16]

The level of reduction achieved in China and Brazil through these actions is equal to or better than the level of reduction projected to be achieved by the U.S. under its voluntary emissions intensity target and around 30% of the level of reduction estimated for the EU-15 to meet its Kyoto target. Accounting for only the domestic reductions in the EU-15 to meet the Kyoto target (excluding the expected use of the Kyoto Mechanisms for compliance) would increase the value to 37%. This study estimates that Brazil and China are projected to achieve more than 210 million tons of CO_2 reduction in 2010 from existing unilateral policies, while the U.S. voluntary target is slated to achieve 183 million tons of CO_2e reduction per year on average over the life of the voluntary program according US Administration[17]. Brazil and China were responsible for 17% of global anthropogenic CO_2 emissions in 1990 while the U.S. was responsible for 25% in 1990.[18] To meet the EU-15 emissions target under the Kyoto Protocol requires an estimated emissions reduction from the business as usual level of around 682 $MMTCO_2e$ in 2010. Taking out the use of Kyoto Mechanisms would mean that EU domestic emissions reductions below the BAU would be 573 $MMTCO_2e$.[19] It is important to note that the stated U.S. reductions and the EU's Kyoto targets are economy-wide, while those in Brazil and China cover a segment of the economy (See Figure 3).

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[14] UNEP Riso, CDM Pipeline, October 2006.

[15] In the China, these reductions are in agriculture, coal bed/mine methane, HFCs, landfill gas, N_2O, and reforestation projects. In Brazil, these reductions are in agriculture, fugitive, landfill gas, and N_2O projects.

[16] Not all these projects in the CDM pipeline will necessarily qualify as CDM projects and others may be developed.

[17] As noted in: U.S. Administration (2002), February. Value is noted online in State Department Fact Sheet, available at: www.state.gov/g/oes/rls/fs/2004/38641.htm

[18] WRI, Climate Analysis Indicators Tool. 2006.

[19] Values for the base year (4269 $MMTCO_2e$) and the expected use of Kyoto Mechanisms (110.5 $MMTCO_2e$) are from the European Environment Agency (2006), *Greenhouse gas emission trends and projections in Europe 2006*. Business as usual values in 2010 (4611 $MMTCO_2e$) based upon values presented in: European Commission: Fourth National Communication from the European Community Under the UN Framework Convention on Climate Change.

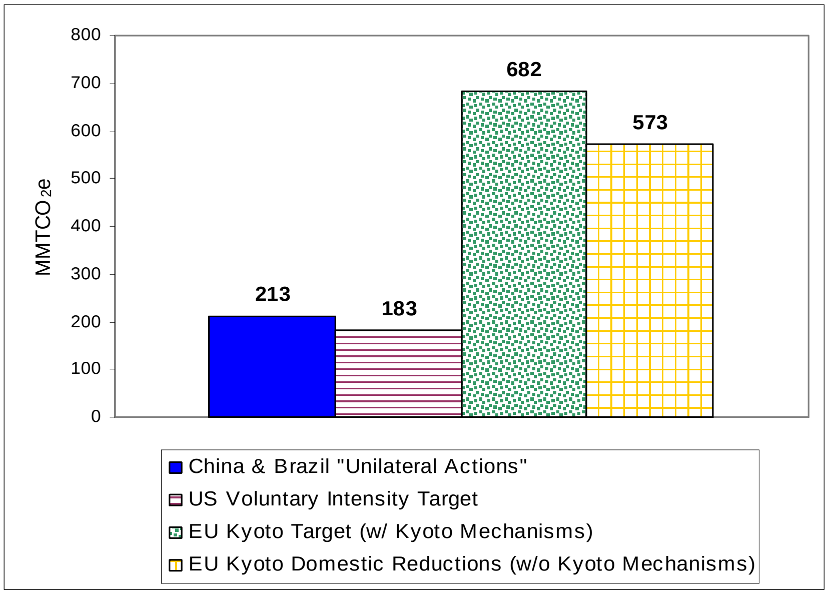

Figure 3. Brazil and China "Unilateral" Emissions Reductions Below Business as Usual Compared with Estimates for U.S. and EU Efforts (in 2010)

I.C.1 *Recent Chinese Policies and Programs*

In China, policies adopted between 2000 and 2005 will reduce GHG emissions in all sectors below their BAU levels—by almost 400 $MMTCO_2$ in 2020—with the combined emissions from these sectors expected to fall by 7%. This is equivalent to shutting down approximately one-third of China's existing coal-fired power plants. Emissions will fall most dramatically in pulp and paper, where emissions will fall by one-fifth in 2020. The largest reductions in absolute terms will occur in cement, where year 2020 emissions are projected to decrease by 162 MMT (15%), and in electricity, where they will decline by 142 MMT (5%). While these emissions reductions from "unilateral actions" are large, the growth in emissions in these sectors are so fast that emissions in 2020 still increase by 115% over 2000 levels. Table 1 shows the emissions reductions achieved in each sector from these policies and programs.

Table 1. Change in China's Emissions Due to Recent Policies

Sector	BAU Scenario		Recent Policies Scenario		
	2000 Emissions ($MMTCO_2$)	2020 Emissions ($MMTCO_2$)	2020 Emissions ($MMTCO_2$)	Emissions Change from BAU ($MMTCO_2$)	% Change from BAU
Electricity	1,199	3,102	2960	(142)	-5%
Cement	643	1,098	937	(162)	-15%
Iron/Steel	200	323	294	(29)	-9%
Pulp/Paper	63	141	111	(30)	-21%
Transport	195	676	643	(34)	-5%
TOTAL	2,299	5,340	4,945	(395)	-7%

These actions have been taken for reasons other than climate-related considerations. For instance, actions taken in electricity, iron & steel sector were aimed to increase reliability of the power network, enhance economic productivity and competitiveness, and improve air and water quality. Enhancing energy security and independence is another motivation behind these actions. In particular, China's growing demand for oil and limited domestic supply has led China to import nearly half (an estimated 3.6 million barrels of oil per day) of its total demand in 2006 – a key factor motivating China's recent vehicle efficiency standards. Considering its reliance on imported oil, China is keen on improving energy-intensity of its economy through various actions such as these discussed here.

Some of these actions have been undertaken at a positive economic cost. While precise cost estimates for these unilateral actions are not available, the government's development of renewables (under the Renewable Energy Law and other recent programs) is a large source of the electricity sector reductions, and many of the renewable opportunities in China are estimated to cost greater than $10 per ton. A similar result is evident in the cement and iron and steel sectors, where a number of the mitigation options needed to meet the level of reductions achieved in the recent policies case cost in the $5 to $10 per ton range.

Many of the emissions reductions achieved through these policies are not being developed as CDM projects and are thus becoming China's "contribution to protection of the atmosphere". China has a total of 177 projects in the CDM pipeline with average total reductions of 82 $MMTCO_2$ per year.[20] Of this total, 123 are electricity generation projects—accounting for an average reduction of around 17 $MMTCO_2$ per year—far less reductions than the 142 $MMTCO_2$ estimated in the electricity sector through "unilateral actions". In addition, there are 17 industrial energy efficiency projects—accounting for 5 $MMTCO_2$ per year—significantly lower than the 220 $MMTCO_2$ reductions in 2010 from unilateral actions in the industry sectors. Lastly, the improvements achieved from the vehicle efficiency standard have not been developed into a CDM project—so the estimated reductions of 34 $MMTCO_2$ are not being captured by CDM projects.

Specifically, **Chinese policies and programs adopted between 2000 and 2005, including the following, have led to these reductions.**

<u>Electricity</u> (in 2020: 5% CO_2 reduction from BAU; 142 $MMTCO_2$; equivalent to offsetting emissions from more than 37 new coal-fired power plants; average projected growth in capacity between 2000 and 2020 is equivalent to adding over one 600 MW power plant per week)

- The *Renewable Energy Law* encourages the construction of renewable energy (RE) facilities, requires power grid operators to purchase resources from registered renewable energy producers, offers financial incentives for renewable energy projects, and stipulates penalties for non-compliance. The law also requires that the National Development and Reform Commission (NDRC) develop specific targets be set for RE development.[21] The most recent goals announced by China are 16% of primary energy from renewables in 2020, including large hydroelectric facilities—this includes RE capacity targets of 300 GW from hydropower, 30 GW from wind, 30 GW from biomass, 1.8 GW from solar photovoltaics, as well as targets for solar thermal, geothermal and solar hot water.[22] In addition, the government has developed a *renewables feed-in program* which provides direct incentives

[20] UNEP RISOE, CDM Pipeline, 20 October 2006.
[21] See http://www.renewableenergyaccess.com/assets/download/China_RE_Law_05.doc for an unofficial copy of the text of China's Renewable Energy Law.
[22] REN21, Renewables Global Status Report: 2006 Update, available at: www.ren21.net/globalstatusreport/download/RE_GSR_2006_Update.pdf

for renewable programs.[23] As a result, even though China is already the world leader in RE capacity (with 42 GW in 2005, excluding large hydro projects), China tied with Germany in 2005 for the largest national investment in renewable energy, excluding large hydropower—$7 billion. This was primarily directed to small hydro and solar hot water projects, and an additional $10 billion was invested in large hydro facilities. Wind generation also expanded significantly in China, with 500 MW of new wind capacity installed in 2005—the fifth largest amount among any country.[24]

- The *Tenth Five-Year Plan* includes several objectives for the electricity sector, including improving operations, shutting down inefficient power plants, developing nuclear power and renewables, etc. For example, as a result the government adopted a policy that requires that new coal facilities be greater than 300 MW and has shut down around 14 GW of small thermal units.[25]

<u>Cement</u> (in 2020: 15% CO_2 reduction from BAU; 162 $MMTCO_2$ in 2020; equivalent to shutting down half of the shaft kiln cement facilities in China in 2000[26]; projected growth in cement production between 2000 and 2020 is equivalent to adding about one of China's largest-capacity cement plants per week)

- *Policy Outlines of Energy Conservation Technologies* (rev. 1996) in the cement sector proposed to close small, illegal plants, promote retrofitting of inefficient operations (wet to dry process), and recover waste heat for re-use. More recent the National Development and Reform Commission's (NDRC's) 2004 China *Medium and Long Term Energy Conservation Plan* sets out a goals for the improvement of energy intensity to 148 kilogram of coal equivalent per ton (kgce/t) cement in 2010 and 129 kgce/t cement in 2020.[27]

<u>Iron and Steel</u> (in 2020: 9% CO_2 reduction from BAU; 29 $MMTCO_2$ in 2020; roughly equivalent to shutting down around 750 iron and steel facilities; projected growth in iron and steel production between 2000 and 2020 is equivalent to adding about one 100-ton electric arc steel furnace or one 1000-m^3 iron-making blast furnace per month)

- China *Medium and Long Term Energy Conservation Plan* (2005) in iron and steel sector, proposed to improve its energy intensity. Specific goals included: (1) industry-wide energy intensity to achieve the level of advanced world in the 1990's by 2010; (2) medium and large entities to achieve the level of advanced world levels in the 2000's by 2010; and (3) industry-wide energy intensity to achieve the level of advanced countries by 2020.[28]

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[23] "The China Sustainable Energy Program: China Program Update and Clippings." *The Energy Foundation.* Issue 19. February 2006. p2 &15. Available at: http://www.efchina.org/documents/CSEP_Clippings_Feb_2006.pdf

[24] REN21, Renewables Global Status Report: 2006 Update, available at: www.ren21.net/globalstatusreport/download/RE_GSR_2006_Update.pdf

[25] China September 2006 CCAP GHG Report Final. p37. Also available at: "Laws & Regulations – The 10th Five-Year Plan for Energy Conservation and Resources Comprehensive Utilization." Available at: http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=5389. http://www.ccchina.gov.cn/en/Public_Right.asp?class=17

[26] China's shaft kiln cement facilities are estimated to have emitted 340.5 $MMTCO_2$ in 2000 (Tsinghua University of China, 2006).

[27] Price, L. and C. Galitsky (2006), Opportunities for Improving Energy and Environmental Performance of China's Cement Kilns, August, Lawrence Berkeley National Laboratory.

[28] "China Medium and Long-Term Energy Conservation Plan." National Development and Reform Commission (NDRC). People's Republic of China. January 2005. http://www.sdpc.gov.cn/ [in Chinese].

- The NDRC's 2005 *"China iron and steel industry development policy"* sets guidelines for the long-term development of this industry in China, including requirements for the production efficiency, energy consumption and environmental performance of steel companies in China. The policy also calls for the use of fiscal measures, such as tax rebates, to promote the production of high value-added steel.

Pulp and Paper (in 2020: 21% CO_2 reduction from BAU; 30 $MMTCO_2$ in 2020; equivalent to around half of the sector's emissions in 2000; projected growth in pulp and paper production between 2000 and 2020 is about 150%)

- Measures in the pulp and paper industry—composed mostly of state-owned enterprises—are modernizing facilities and operations that were significantly outdated compared to world standards. China's government is currently attempting to modernize its pulp and paper industry through restructuring – encouraging state-owned plants to automate their operations, promoting mergers (the largest manufacturing facilities are also the most efficient), facilitating foreign investment, and closing down smaller, older facilities.

Transportation (in 2020: 5% CO_2 reduction from BAU; 34 $MMTCO_2$; equivalent to 75% of car emissions in 2000)

- *"Maximum Limits of Fuel Consumption (L/100-km) for Passenger Cars"* establishes fuel efficiency standards for passenger vehicles – passenger cars, SUVs and multi-purpose vans. The requirements are divided into 16 weight classes, with each class having a designated maximum fuel consumption rate.[29] These standards are implemented in two phases with an estimated equivalent vehicle efficiency of 34 miles per gallon (MPG) in 2005 and 37 MPG in 2008 (An and Sauer, 2004).[30] Phase I of this program is consistent with the goal of the 10th Five-Year Plan to reduce oil consumption from current levels by 5-10%; it went into effect on July 1, 2005, for new models of vehicles and on July 1, 2006, for existing models. Phase II will take effect on January 1, 2008, for new models and on January 1, 2009, for existing models; this phase is expected to allow achievement of the 11th Five-Year Plan's goal of reducing oil consumption by 15% from current levels.

In 2006, China has adopted a number of additional efforts (not analyzed in this project as they were outside the scope) that could have a significant impact on overall emissions.

- The recently adopted *Eleventh Five Year Plan* sets a goal to reduce energy use per unit of GDP by 20% between 2005 and 2010. This is no small undertaking given that China has already improved energy intensity by 77% between 1990 and 2003, but has become a major focus of a number of initiatives.
- In the *"1000 highest energy-consuming enterprises"*[31] program the 1000 facilities accounting for the greatest energy use are to benchmark their energy performance, install efficient equipment, and attain a 20% efficiency improvement by 2010.

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[29] Stricter standards apply for passenger cars with manual transmissions in each weight class; SUVs and multi-purpose vans must meet the same standards as passenger cars with automatic transmissions. The stringency of the maximum fuel efficiency standards also increases with weight, so lighter vehicles can meet their respective standards more easily than heavier vehicles.

[30] This standard was modeled in this analysis based upon the rates in the "Mid- and Long-Term Specific Plan on Energy Conservation" level of 6.7-8.2 L/100-km by 2010 (13.4 km/L, 31.5 mpg), so the level of reduction could be even greater depending on the fleet mix.

[31] These facilities account for an estimated 30% of China's energy consumption.

- *Vehicle excise taxes* are now based on the vehicle engine size—ranging from 1-20% of the vehicle purchase price—with the tax on four-liter engines (e.g., SUVs) quadrupling from 5% to 20% (to about $8,000 per vehicle).[32]
- The NDRC outlined goals for structural adjustment of the cement industry between 2005 and 2010, including: increasing the share of new dry process cement kiln production from 40 to 70%, closure of 250 million tons of inefficient production capacity, reducing the total number of facilities to 3500, and reducing energy intensity of production from 130 kgce/t clinker to 110 kgce/t of clinker.[33]

I.C.2 *Recent Brazilian Policies and Programs*

A similar trend is expected in Brazil, where recent policies will lower emissions in all sectors analyzed except cement (where the impact of recent policies will be negligible). **These policies will reduce the combined seven-sector CO_2 emissions in Brazil by a dramatic 14% in 2020—a total cut of 73 $MMTCO_2$—in 2020**. This is approximately equivalent to the total current emissions of all Brazilian light-duty vehicles, its seven coal-fired power plants, and cement facilities combined. The largest proportional reductions will occur in the residential and commercial sectors, where the combined emissions are expected to decline by over one-third. Emissions in the transportation sector will fall by almost one-fifth due to increased ethanol consumption from flex-fuel vehicles, and the development of renewables in electricity will lower emissions in that sector by 14%. Emissions are projected to be slightly higher than BAU levels in the cement sector, mostly due to the projected increased use of fuel oil in place of pet coke. While these emissions reductions from "unilateral actions" are large, emissions in these sectors grow at such a fast pace that emissions in 2020 still increase by over 80% over 2000 levels.[34] Table 2 shows the emissions reductions achieved in each sector from these policies and programs.

Table 2. Change in Brazil's Emissions Due to Recent Policies

Sector	BAU Scenario		Recent Policies Scenario		
	2000 Emissions ($MMTCO_2$)	2020 Emissions ($MMTCO_2$)	2020 Emissions ($MMTCO_2$)	Emissions Change from BAU ($MMTCO_2$)	% Change from BAU
Electricity	23	38	33	(5)	-14%
Cement	26	40	41	0.2	0.5%
Iron/Steel	46	82	76	(5)	-6.5%
Pulp/Paper	25	59	57	(2)	-3%
Transport	106	245	202	(44)	-18%
Residential	NA	36	23	(13)	-37%
Commercial	NA	12	8	(4)	-32%
TOTAL	227	512	439	(73)	-14%

Similar to China, **these Brazilian efforts have largely been undertaken for reasons other than climate change.** For example, the ethanol program was largely driven in response to

[32] China Program Update & Clippings, 2006, newsletter of The China Sustainable Energy Program, Issue 19, February, p. 3-4.
[33] CementChina.net, 2006, China Cement Industry Developing Goal till 2010, available at: www.cementchina.net/news/shownews.asp?id=1549.
[34] Excludes emissions in the residential and commercial sectors.

energy security concerns in response to the oil crisis in the mid-1970s and the energy efficiency programs were driven out of a variety of concerns including energy shortages, local air quality, sustainable development, and competitiveness.

Also significant is that **some of the recent measures have been high cost measures, highlighting that other positive benefits have driven these efforts**. For example, Brazil's flex fuel vehicle program, begun in 2003, is estimated to achieve about 20 MMT reductions in 2020 (about 1.7 tonne CO_2 per new vehicle) at a cost greater than $30 per ton.

Some of the emissions reductions achieved through these policies are not being developed as CDM projects and are thus becoming Brazil's "contribution to protection of the atmosphere." Brazil has a total of 190 projects in the CDM pipeline with average total reduction of over 21 $MMTCO_2$ per year.[35] The introduction of Brazilian flex fuel vehicles and the concurrent emissions reductions have not been registered as a CDM project, so the total estimated reductions in the transportation sector from "unilateral actions" of 20 $MMTCO_2$ estimated to be achieve in 2010 are not being scored as CDM projects. However, some of the ensuing reductions from these policies are likely being captured as CDM projects. For example, a large number of wind, hydro, and biomass projects have been proposed in Brazil as CDM projects. These projects are estimated to reduce emissions by around 5 $MMTCO_2$ per year[36] — roughly the same level of reduction estimated in the electricity sector from recent policies.

In particular, **Brazilian policies and programs implemented between 2000 and 2005, including the following, have led to these reductions.**

<u>Electricity</u> (in 2020: 14% CO_2 reduction from BAU; 5 $MMTCO_2$; equivalent to closing 42% of Brazil's current oil-fired electricity generation)[37]

- The *Program for Incentive of Alternative Electric Energy Sources (PROINFA)* launched in 2002 sets an overall goal to produce 10% of the total electricity from renewable sources by 2022 in two phases. The first phase is to achieve 3,300 MW of renewables—split equally among biomass, small hydro and wind—through long-term power purchasing agreements between Eletrobrás and independent power producers (IPPs) and fiscal incentives for each type of renewable energy (e.g., wind energy subsidy of $86.32 – 97.90/MWh).

<u>Transportation</u> (in 2020: 18% CO_2 reduction from BAU; 44 $MMTCO_2$; equivalent almost 1.5 times the total emissions from light-duty vehicles in 2000[38])

- The *National Program of fuel alcohol (PROALCOOL)* aimed to promote ethanol use in transportation in response to oil crisis of the 1970s. Although it was discontinued in the late 1980s, PROALCOOL transformed 85% of the vehicle fleet into ethanol vehicles. More recently, this program has laid an important groundwork for the introduction of flex fuel vehicles (which can use either gasoline or ethanol) into the market. As a result, these vehicles accounted for 50% of sales of new LDVs in 2005 and 77% in February 2006. This

[35] UNEP RISOE, CDM Pipeline, 20 October 2006.
[36] To be conservative, we have included all projects listed in the CDM pipeline classified as biomass, wind, and hydro.
[37] In 2000, oil-fired generation was estimated to emit 11.8 $MMTCO_2$ (Centro Clima, 2006).
[38] Light-duty vehicles in Brazil are estimated to emit a total of 31.9 $MMTC0_2$ in 2000.

is estimated to grow to the point where in 2020 all light-duty vehicles sold in Brazil are flex-fuel and 70% of the fuel used in these vehicles is ethanol.

- The *Program to Promote Efficient Use of Non-renewable Resources (CONPET)* has used a free testing and inspection program for tanker trucks that transport Petrobras fuel to reduce their diesel fuel use by 15% and their associated CO_2 emissions by 38,000 metric tons annually (through mid-2004).

Residential (in 2020: 37% reduction from BAU; 13 $MMTCO_2$; equivalent to 86% of the Brazilian iron and steel emissions in 2000)

- The *Brazilian Stove and Heater Compulsory Labeling Program*, which came into effect in March 2003, requires labeling of energy efficiency for all stove and heaters. As a result, the new models manufactured in Brazil consume on average 13% less liquefied petroleum gas (LPG) than the old models, which implies a saving of two gas canisters per household per year and an approximate annual reduction of 300,000 tons of imported LPG.[39]

I.C.3 *Recent Indian Policies and Programs*

India is projected to achieve emissions reductions by 2020 in the transportation and iron and steel sectors below "business as usual" (BAU) levels, but these reductions are projected to be offset principally by emissions increases in the electricity sector. In 2020, recent efforts are expected to reduce emissions in the Indian transportation and iron and steel sectors by 15% below BAU levels in transportation—97 $MMTCO_2$—and by 5% in iron and steel—17 $MMTCO_2$. Emissions increase due primarily to the implementation of the National Electricity Policy, which causes emissions to rise in that sector by 12% above the BAU levels. The net impact of these efforts is projected to increase emissions by 6 $MMTCO_2$ in 2020—a total increase for all sectors of less than 0.3%. While emissions reductions from "unilateral actions" decrease emissions in two of the sectors, emissions for the evaluated sectors grow at such a fast pace that emissions in 2020 from these sectors still increase by 230% above 2000 levels. Table 3 shows the emissions impacts in each sector from these policies and programs.

Table 3. Change in India's Emissions Due to Recent Policies

Sector	BAU Scenario		Recent Policies Scenario		
	2000 Emissions ($MMTCO_2$)	2020 Emissions ($MMTCO_2$)	2020 Emissions ($MMTCO_2$)	Emissions Change from BAU ($MMTCO_2$)	% Change from BAU
Electricity	427	952	1,062	110	12%
Cement	67	334	339	5	1%
Iron/Steel	66	317	300	(17)	-5%
Pulp/Paper	6	12	13	0	1%
Transport	97	644	547	(97)	-15%
Residential	47	76	80	4	6%
Commercial	7	18	18	-	0%
TOTAL	717	2,352	2,358	6	0%

Indian policies and programs implemented between 2000 and 2005 have led to these reductions, including the following.

[39] PETROBRAS/CONPET, 2004.

Iron and Steel (In 2020: 5% CO_2 reduction from BAU; 17 $MMTCO_2$; equivalent to one-third of the sector's total emissions in 2000)

- The *National Steel Policy 2005* seeks to increase the capacity and efficiency of steel production in India and is expected to spur the iron and steel industry to retrofit inefficient plants and build more efficient facilities. The minimum production in the most efficient BF-BOF facilities is thus estimated to increase from 20% of total production in 2036 (under BAU) to 60%.

Transportation (in 2020: 15% CO_2 reduction from BAU; 97 $MMTCO_2$; equivalent to the total Indian transportation emissions in 2000)

- Under the *Indian Integrated Transport Policy 2002*, the government seeks to meet the transport demand generated by higher rate of growth of GDP, realize the optimal inter-modal mix as well as freight-passenger mix in the railways through appropriate pricing and user charges, and promote sustainable transport system with increased emphasis on energy efficiency and environmental conservation. As a result of this and other policies (*Vision 2020 Transport* and a *draft national urban transport policy*), it is estimated that fuel economy will improve and the rail shares for both passengers and freight will increase.

Some recent policies are expected to increase emissions. For example, the Electricity Act 2003 is expected to expand electricity generation, largely driven by increased electricity access. The National Electricity Policy includes the following objectives: access to electricity available for all households in next five years; electricity demand to be fully met by 2012; supply of reliable and quality power in an efficient manner and at reasonable rates; and per capita availability of electricity to be increased to over 1000 kWh by 2012. To meet these objectives electricity production is estimated to expand by more than 110 TWh in 2020 due to increased demand for electric lighting and appliances—6% above the level without recent policies. The analysis assumes that demand for electricity will increase (e.g., for lighting, home appliances, and other services) as a result of access to the electricity grid. It also makes the conservative assumption that traditional fuels such as wood for cooking which are replaced by electricity generation are carbon-neutral as they are "sustainably" harvested. This does not account for some of the other climate change impacts from biomass combustion (e.g., black carbon, CH_4, etc.). On net, accounting for these factors could make the emissions implications of this policy neutral or lead to net emissions reductions, but the methodology employed here does not necessarily capture these factors. Based upon this, electricity sector emissions are estimated to increase by 110 $MMTCO_2$—a 12% increase above BAU—due to the introduction of recent policies.

Indian actions that occurred prior to 2000 (and therefore included in the baseline[40]) have been undertaken which have led to reduced or avoided emissions. India has long supported efforts for expanding renewable generation, particularly wind generation. For example, India has worked to develop a domestic manufacturing industry[41] and has provided incentives such as five-year tax holidays on income from sales of electricity, accelerated depreciation of 100 percent on investment in capital equipment in the first year, excise duty and sales tax exemptions

[40] This means that it isn't possible to pull out the impact of this policy since it is captured in the pre-2000 baseline.
[41] This has been done with the assistance of overseas companies such as Denmark, Germany, and the Netherlands.

for wind turbines, waiver of import duties on a variety of components, and moving toward a production tax incentive to encourage performance.[42] In addition, the India Renewable Energy Development Agency (IREDA) was formed to provide assistance in obtaining loans from the World Bank, the Asian Development Bank, and the Danish International Development Agency (DANIDA). As a result, India has the fourth largest amount of installed wind capacity—4,430 MW—and added almost 1,500 MW in 2005 alone.[43]

Some of the emissions reductions achieved through these policies are not being developed as CDM projects and are thus becoming India's "contribution to protection of the atmosphere". India has a total of 456 projects in the CDM baseline, with total average reductions of 38 $MMTCO_2$ per year.[44] Only one transportation CDM projects is in the CDM pipeline for India and it is expected to result in a small emissions reductions—estimated at 7 kt CO_2 per year—far lower than the 14 $MMTCO_2$ estimated to be achieved in 2010 in the transportation sector from recent policies. In contrast, India has a large number of industrial-based CDM projects, some of which are in the iron and steel sector which is estimated to generate emissions reductions of 17 $MMTCO_2$ through "unilateral actions".[45]

I.D Opportunities for achieving significant additional emission reductions at reasonable cost are also available

Additional emissions reduction opportunities are also available in each country, some are available at low cost while others require larger incremental investment. **A total emissions reduction of 1,534 $MMTCO_2$—a reduction of 19% below BAU levels—can be achieved in these three countries through implementation of "unilateral actions" and additional mitigation measures.** This is roughly equivalent to offsetting emissions from 410 new coal-fired power plants. In this analysis, estimates of the reductions from unilateral efforts (also referred to as Recent Policies) undertaken prior to 2006 were developed separately from the analysis of potential reductions that could be achieved through additional new mitigation ("Advanced Scenarios"). It should be noted that the Advanced Options scenarios assume implementation of both the unilateral actions and the select additional mitigation options. Therefore, a portion of the additional reductions claimed for the Advanced Options scenarios in some sectors will be the result of unilateral actions already undertaken. When comparing and interpreting the unilateral/Recent Policies reductions to the reductions obtained through additional mitigation measures (Advanced Options), it should therefore be kept in mind that the reductions are not additive. On an aggregate basis, the study projects cost-effective reductions (below $10/ton CO_2) of four percent in India, four percent in Brazil and 10 percent in China below BAU levels in 2020 totaling more than 625 million tons of CO_2 per year – the equivalent of avoiding the construction of more than 150 coal-fired power plants.

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[42] EIA, Wind Energy Developments: Incentives in Selected Countries, available at: www.eia.doe.gov/cneaf/solar.renewables/rea_issues/windart.html

[43] REN21, Renewables Global Status Report: 2006 Update, available at: www.ren21.net/globalstatusreport/download/RE_GSR_2006_Update.pdfENEWABLES

[44] UNEP Risoe, CDM pipeline, October 2006.

[45] It was impossible, without going through each project design document, to assess how many of the industrial CDM projects were in the iron and steel sector.

If China, Brazil and India chose to make the reductions outlined in this study by 2020, their efforts, coupled with other countries' efforts, could be sufficient to stay on track to stabilize global atmospheric CO_2 concentrations at 450 ppm.[46] To meet this concentration goal, other nations would need to make significant reductions along the lines of the: EU and other developed nations cutting their emissions to 30 percent below 1990 levels by 2020, U.S. cutting its emissions to 1990 levels by 2020, and other major developing countries making efforts similar to China, India and Brazil.[47] This proposed combination of emission reductions is simply illustrative. Any combination of reductions from developed and developing nations that achieves the same aggregate reduction can keep the achievement of a 450 ppm global atmospheric CO_2 concentration in play. Even given the huge projected growth in emissions in these three developing countries through 2020, the key point here is that the potential, largely cost-effective reductions identified in this study are significant – their achievement would mark important progress toward achieving the goal of limiting global increases in temperature to 2 degrees Centigrade.

Below we summarize the emissions reduction potential identified in this analysis for each sector in each country.

I.D.1 *China*

In China, an emission reduction of nearly 20% from these sectors[48] could be achieved with implementation of all feasible mitigation measures analyzed in 2020—equivalent to nearly a billion ton emissions reduction from 2020 BAU levels. This is equivalent to 83% of China's electricity sector emissions in 2000. Almost half (45%) of these reductions are available in the electricity sector, with over one-fifth available in both cement and transportation. Figure 4 shows the projected emissions trajectory in China from 2000 to 2020 under each mitigation scenario, for all five sectors combined.

[46] Stabilizing emissions at 450ppm CO_2 is roughly equivalent to stabilizing emissions at 500 ppm CO_2 equivalent. Source: den Elzen and Meinshausen (2005), Meeting the EU 2°C climate target: global and regional emission implications.

[47] Based upon analysis conducted by Ecofys Consulting for CCAP. Available at: www.ccap.org/international/Sector%20Straw%20Proposal%20-%20FINAL%20for%20FAD%20Working%20Paper%20%7E%208%2025%2006.pdf and www.ccap.org/FADforum/Hoehne%7ESector-Based%20Program%20GHG%20Implications.pdf

[48] The China analysis only included electricity, iron and steel, cement, pulp and paper, and on-road vehicles.

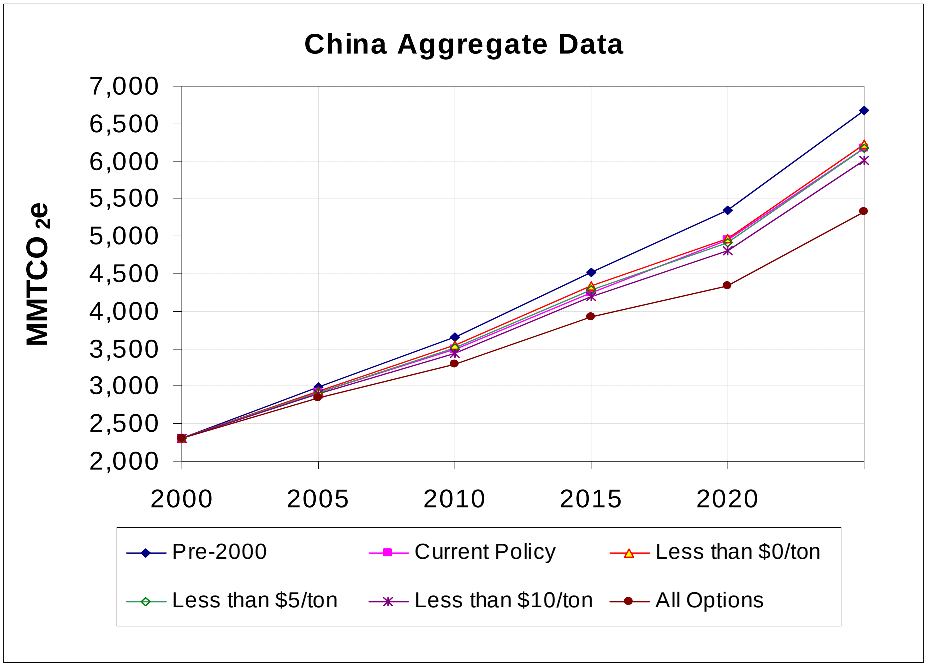

Figure 4. CO_2 Emissions in China Under Various Scenarios

Implementation of only the lower cost measures (with net savings or less than $5 per ton) in China would reduce GHG emissions from the five sectors by 7% below the BAU level in 2020—a 397 MMTCO$_2$ emissions reduction. This is roughly equivalent to offsetting the annual emissions of over 100 new coal-fired power plants. The majority of these reductions are available in the transportation sector (52% of the reductions), followed by cement (32%) and electricity (11%).

At higher cost of less than $10 per ton, emissions could be cut by 10% below BAU levels in 2020 for these sectors—a total reduction of over 510 MMTCO$_2$. This is equivalent to 44% of China's emissions from coal-fired electricity in 2000. These more expensive reductions are largely available in the cement sector (70 MMTCO$_2$ above the amount achievable at less than $5 per ton), followed by electricity (25 MMTCO$_2$) and iron and steel (19 MMTCO$_2$).

The table below (Table 4) shows the individual options for emissions mitigation in the sectors analyzed for China, and the associated costs and emissions reductions available in each sector in 2020.

Table 4. Chinese Emissions Reduction Options in 2020

Marginal Abatement Cost ($/tonne CO_2e)	Total Emission Reduction ($MMTCO_2$e)	Cumulative Reduction ($MMTCO_2$e)	Mitigation Options	Sector
-18.4	19.1	19.1	Transmission Technologies	Transportation
-12.0	43.8	62.9	Vehicle Technologies	Transportation
-11.9	136.0	198.9	Engine Technologies	Transportation
-11.1	3.8	202.7	Engine-Transmission-Vehicle Technologies	Transportation
-4.5	23.5	226.2	Preventative Maintenance	Cement
-3.8	21.5	247.7	Use of Waste Derived Fuels	Cement
-3.6	5.7	253.4	CFBC (Circulating Fluidized Bed Combustion)	Electricity
-3.6	3.6	257.0	Establish energy management center	Iron and Steel
-3.0	38.0	295.0	Demand side management	Electricity
-2.4	19.5	314.5	Process management and Control	Cement
-1.9	11.3	325.8	Kiln Shell Heat Loss Reduction	Cement
0.2	8.2	334.0	High-Efficiency Motors and Drives	Cement
0.9	10.2	344.2	Active Additives	Cement
1.5	14.3	358.5	Composite Cement	Cement
2.6	2.8	361.3	BRT	Transportation
3.0	9.1	370.4	Advanced coke oven	Iron and Steel
3.8	49.1	419.5	Conversion to Multi-stage pre-heater kiln	Cement
4.1	34.8	454.3	Combustion System Improvement	Cement
5.4	24.6	478.9	Advanced blast furnace technology	Iron and Steel
5.7	25.1	504.0	Reconstruction of conventional thermal power	Electricity
6.0	29.7	533.7	Supercritical/Ultra supercritical plant	Electricity
6.6	28.6	562.3	High-efficiency roller mills	Cement
8.2	43.6	605.9	Adjust ratio of iron/steel	Iron and Steel
9.7	10.2	616.1	High-efficiency Powder Classifiers	Cement
12.7	3.7	619.7	Efficient transport systems	Cement
19.2	136.9	756.6	Nuclear power	Electricity
21.5	10.3	766.9	Fuel Switch	Transportation
30.4	3.5	770.5	Dry coke quenching	Iron and Steel
31.0	171.2	941.7	Hydropower	Electricity
31.6	10.8	952.4	Advanced sinter machine	Iron and Steel
32.7	4.2	956.6	Natural gas	Electricity
34.9	4.4	961.1	Advanced direct steel rolling machine	Iron and Steel
38.0	7.6	968.7	Wind power	Electricity
38.8	14.1	982.8	IGCC (Integrated Gasification Combined-Cycle) & PFBC (Pressurized Fluidized Bed Combustion)	Electricity
52.7	25.6	1008.4	Smelt reduction technology	Iron and Steel
53.3	5.0	1013.4	CCS (Carbon Capture and Storage)	Electricity
61.0	7.6	1021.0	Advanced converter	Iron and Steel
131.4	5.7	1026.7	Advanced EAF	Iron and Steel
133.7	11.4	1038.1	Solar thermal	Electricity

Electricity

The analysis conducted for this sector indicates that **future GHG emission reduction potential in electricity is large in absolute terms, but may be achieved at relatively higher cost.** The electricity sector in China has the highest potential level of absolute reductions of all sectors analyzed, and accounts for 45% (444 $MMTCO_2$) of the total reductions analyzed. It is also the largest sector in terms of aggregate emissions in the Chinese economy. Implementing these measures would reduce electricity emissions by 14% in 2020, but 85% of these reductions would cost more than $10 per ton (see Figure 5).

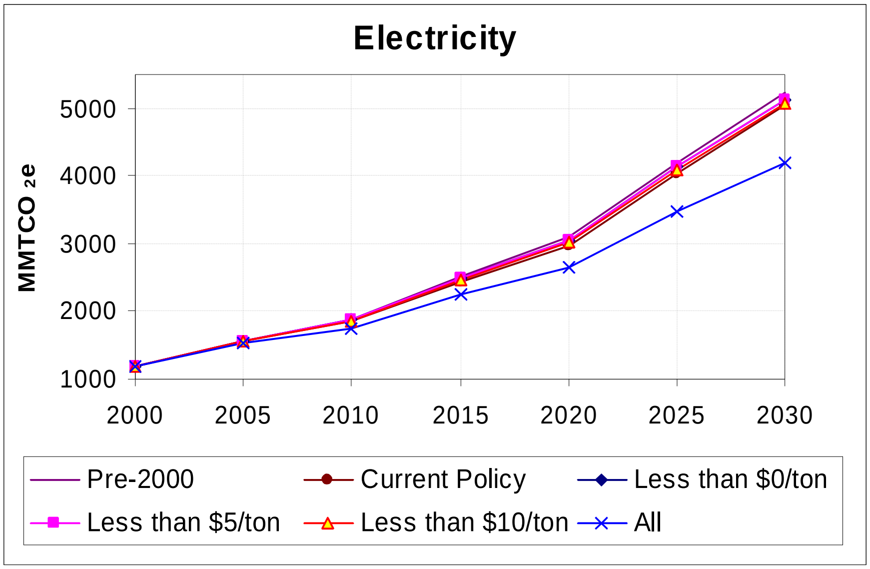

Figure 5 Electricity-Sector CO_2 Emissions in China Under the Various Scenarios

While policies already underway are expected to reduce emissions significantly and the availability of further low-cost reductions is uncertain, **some low cost emissions reductions remain in this sector**, including:

- demand side management in all sectors (38 $MMTCO_2$ reduction in 2020 at a savings of $3 per ton)—it is important to note that demand-side management assumed in this analysis is a first order estimate as detailed bottom-up data was not available for all sectors to make a more accurate assessment.[49]
- more efficient new coal facilities (35 $MMTCO_2$ in 2020 at a cost less than $6 per ton); and
- efficiency improvements at existing coal-fired units (25 $MMTCO_2$ at a cost of $5.7 per ton)

Co-benefits could also make some of the higher cost options more promising. For example, although replacing new coal plants with nuclear power, hydro, and natural gas all cost in the range of $20 to $30 per ton, these measures would produce significant benefits in the form of reduced coal consumption and a corresponding drop in SO_2, particulate and NO_x emissions, improved water quality, increased economic productivity, and enhanced power reliability and grid stability (in the case of nuclear power). More expensive options which have been pursued in China to date for a variety of reasons include:

- Nuclear power (137 $MMTCO_2$ at a cost of $19 per ton)
- Wind generation (8 $MMTCO_2$ at a cost of $38 per ton)
- Integrated gasification combined cycle with carbon capture and sequestration (5 $MMTCO_2$ at a cost of $53 per ton). It is important to note that this assumes the building of only one such plant as the Tsinghua team felt that the cost was too high and the technology development in China too low prior to 2020 for further plants to be likely to be deployed pre-2020. Technological development in China and further cost reductions through demonstration plants in China and elsewhere were considered pivotal in whether greater penetration of this technology can be expected post 2020 in China. Other analysis (Larsen

[49] Other analysis has found that 5.1 EJ of energy could be saved in the buildings sector alone through more building energy efficiency efforts (ERI and LBNL, 2003).

et al., 2003) found that 132-363 MMTCO_2 could be sequestered in China under a scenario with carbon constraints.

Table 5. Electricity Sector Mitigation Options for China

Sector	Electricity			
Advanced Options Scenario	BAU Baseline Emissions in 2020 (MMTCO_2)	Emissions under Scenarios in 2020 (MMTCO_2)	Emissions Reduction from Baseline in 2020 (MMTCO_2)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	3,102	3058	44	1%
#2 (options < $5/ton CO2)	3,102	-	n/a	n/a
#3 (options < $10/ton CO2)	3,102	3033	69	2%
#4 (all options)	3,102	2658	444	14%

Domestic policy options that might be considered by China to achieve these reductions include: fuel pricing programs or energy taxes to promote conservation, as well as capacity building efforts to increase public awareness and encourage energy efficiency activities. Other approaches that could allow China to achieve significant additional emission reductions could include promotion of renewable sources through measures such as subsidies, production tax credits, expansion of the current Renewable Energy Law, carbon portfolio standards, caps, and other regulatory approaches.

Under all scenarios analyzed for the electricity sector, China's GDP is barely affected, and decreases by no more than 0.02%.[50] Implementation of all measures that cost less than $5 per ton, does not impact GDP at all. Undertaking actions that increase the production cost of electricity or implementing mitigation options less $10/ per MMT$CO_2$ therefore does not negatively impact China's GDP significantly. Analysis of the changes of Chinese industrial production prices further suggests that an increased electricity production cost would raise electricity prices by 2 to 3%, while causing only very minimal changes in the costs of most industrial products (less than ± 0.1%). Slightly greater changes in production prices of fossil fuels, especially coal and natural gas, were expected. Increased electricity production costs and implementing electricity mitigation options would lead other industrial production output to generally decrease slightly, although manufacturing increases only slightly. Coal and natural gas output and electricity generation decrease at a greater but still relatively small amount, ranging from 0.5 to 2%.

Lower cost mitigation actions (less than $10 per ton) could be undertaken in China's electricity sector with a minimal impact on the performance of other sectors. Electricity demand falls as electricity prices increase—by 0.2 to 0.4% on average. In the chemical, metal and metallurgy, water, and electricity sectors where prices increase slightly as electricity production costs increase, exports decrease as well. Some sectors see their exports increase, including textile, manufacturing and coal.

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[50] Scenarios were analyzed for each sector considered in China, but only results of electricity sector are presented in the China report. More elaboration on all sectors and the results of analysis implementing costs across the entire economy will be discussed in Phase II of this project.

Cement

The cement sector in China is a promising source of low-cost emissions reductions. **Options analyzed in the cement sector are estimated to reduce emissions by one-fifth in 2020—233 $MMTCO_2$ below BAU** (see Figure 6)**.**

Most of these reductions are available at low cost—implementing only the less than $0 per ton measures would achieve an 8% reduction in 2020—93 $MMTCO_2$. Measures available at a net cost saving include:

- preventive maintenance (24 $MMTCO_2$ at a savings of $5 per ton)
- use of waste fuels (22 $MMTCO_2$ at a savings of $4 per ton)
- process control and management (20 $MMTCO_2$ at a savings of $2 per ton), and
- kiln shell heat loss reduction (11 $MMTCO_2$ at a savings of $2 per ton).

Table 6. Cement Sector Mitigation Options for China

Sector	Cement			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	1098	1005	93	8%
#2 (options < $5/ton CO2)	1098	970	128	12%
#3 (options < $10/ton CO2)	1098	900	198	18%
#4 (all options)	1098	866	233	21%

Implementation of the less than $5 and $10 per ton options would achieve reductions of 12% and 18%, respectively. Many of the low-cost options are also expected to produce significant economic co-benefits through increased productivity; air and water quality would also improve from a major drop in the use of coal, which provides nearly all of China's direct fuel needs for cement production. For example, the cement sector accounts for 40% of industrial particulate emissions in the country. The ongoing effort by the government to retrofit old plants and improve energy efficiency indicates an awareness of the potential in these areas.

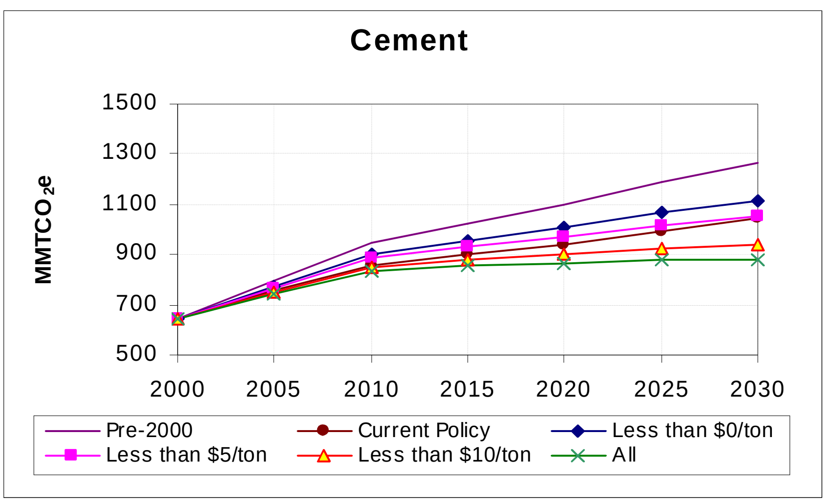

Figure 6. Cement-Sector CO_2 Emissions in China Under the Various Scenarios

Iron and Steel

Implementation of all measures costing less than \$5 per ton are projected to achieve a 6% reduction in iron and steel emissions—a 19 MMTCO$_2$ reduction below BAU in 2020.

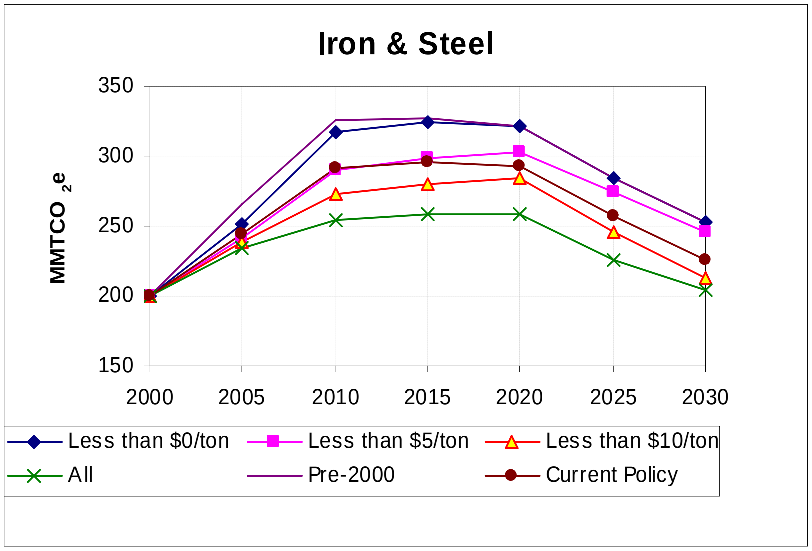

Figure 7. Iron&Steel-Sector CO_2 Emissions in China Under the Various Scenarios

Available options in this regard include:

- establishment of an energy management center (4 MMTCO$_2$ at a savings of \$4 per ton) and
- advanced coke ovens (9 MMTCO$_2$ at a cost of \$3 per ton)

Implementation of all measures less costing than \$10 per ton would reduce emissions by 12% below BAU in 2020—a reduction of 38 MMTCO$_2$. Two additional measures are available at this cost level:

- advanced blast furnace technology (25 MMTCO$_2$ at a cost of \$5 per ton)
- adjusting the ratio of iron/steel (44 MMTCO$_2$ at a cost of \$8 per ton)

Table 7. Iron & Steel Sector Mitigation Options for China

Sector	Iron & Steel			
Advanced Options Scenario	BAU Baseline Emissions in 2020 (MMTCO$_2$)	Emissions under Scenarios in 2020 (MMTCO$_2$)	Emissions Reduction from Baseline in 2020 (MMTCO$_2$)	Percentage Reduction from Baseline in 2020
#1 (options < \$0/ton CO2)	323	321	1.6	0.5%
#2 (options < \$5/ton CO2)	323	303	19	6%
#3 (options < \$10/ton CO2)	323	284	38	12%
#4 (all options)	323	257	65	20%

These efforts could be supported through government-run voluntary assistance programs where officials share knowledge and training with plant managers, as well as direct incentives (subsidies, tax credits, etc.) for capital investments in modern plants or advanced technologies and research and development. Since the Chinese iron and steel sector currently is a major producer of global steel, measures that improve efficiency and competitiveness might be ideal for consideration.

Pulp and Paper

In the pulp and paper sector, emissions mitigation could reduce emissions by 25% in 2020, the second-largest proportional reduction after transportation. With respect to measures already underway, efforts to improve technology and energy efficiency undertaken in the industry since 2000 are expected to reduce emissions by 21% in 2020, the largest sectoral proportional reduction from recent measures of all five sectors analyzed. Specific mitigation options and costs were not evaluated for this sector. Instead, the mitigation scenario considered an industry-wide effort to increase the share of production with larger, more efficient plants. A detailed evaluation of the prospects for unilateral action in this sector would require a more in-depth analysis; however, one factor in favor of domestic GHG mitigation efforts in pulp and paper is the important co-benefits such actions would deliver. In addition to enhanced industrial productivity, increased efficiency would also improve local environmental quality, since the industry's fuel needs are met almost entirely with coal, and pulp and paper production typically produces significant amounts of organic and liquid waste. In fact, the desire to reduce such pollution has been a key driver in China's ongoing restructuring of the industry. Further unilateral action thus appears promising.

Table 8. Pulp & Paper Sector Mitigation Options for China

Sector	Pulp & Paper			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	141	-	n/a	n/a
#2 (options < $5/ton CO2)	141	-	n/a	n/a
#3 (options < $10/ton CO2)	141	-	n/a	n/a
#4 (all options)	141	105	36	25%

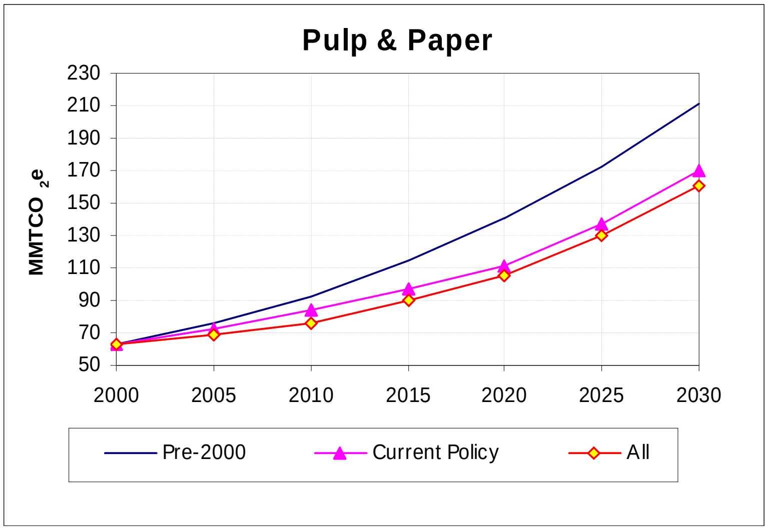

Figure 8. Pulp & Paper-Sector CO_2 Emissions in China Under the Various Scenarios

Transportation

Vehicle ownership in China is still low, so the passenger vehicle portion of the transportation sector[51], contributed less than 10% of the total emissions in 2000 from all sectors included in this analysis—an estimated 6% of China's total CO_2 emissions. However, emissions in this sector are growing rapidly, and a substantial opportunity for emissions reductions exists in China's transportation sector. **The emissions from passenger vehicles in China could be reduced by nearly one-third in 2020 through adoption of the mitigation measures evaluated here. A 30% reduction from BAU is achievable through fuel economy improvements in passenger cars alone, and the technologies required to achieve these gains are estimated to be cost-effective to consumers:**[52]

- transmission technologies (19 $MMTCO_2$ at cost saving of $18 per ton)
- vehicle technologies (44 $MMTCO_2$ at cost saving of $12 per ton)
- combined engine, vehicle, and transmission technologies (4 MMTCO2 at cost saving of $11 per ton)

Table 9 Transportation Sector Mitigation Options for China

Sector	Transportation			
Advanced Options Scenario	BAU Policy Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	676	473	203	30%
#2 (options < $5/ton CO2)	676	470	206	30%
#3 (options < $10/ton CO2)	676	-	n/a	n/a
#4 (all options)	676	460	216	32%

In addition, bus rapid transit is being pursued in a number of regions in China for a variety of non-climate change reasons and has an estimated potential to reduce emissions by 3 $MMTCO_2$ at a cost of $3 per ton.

[51] The transportation analysis for China includes only specific types of passenger vehicles – buses, trucks, cars and motorcycles – but omits trains, ships, airplanes and all freight vehicles. Thus, the emissions discussed here do not represent the comprehensive emissions budget of the entire sector.

[52] The cost estimates only account for costs associated with deployment of specific vehicle technologies but do not include costs associated with retooling of manufacturing facilities, training, technology transfer, and similar activities that could constitute barriers to full deployment of advanced vehicle technologies.

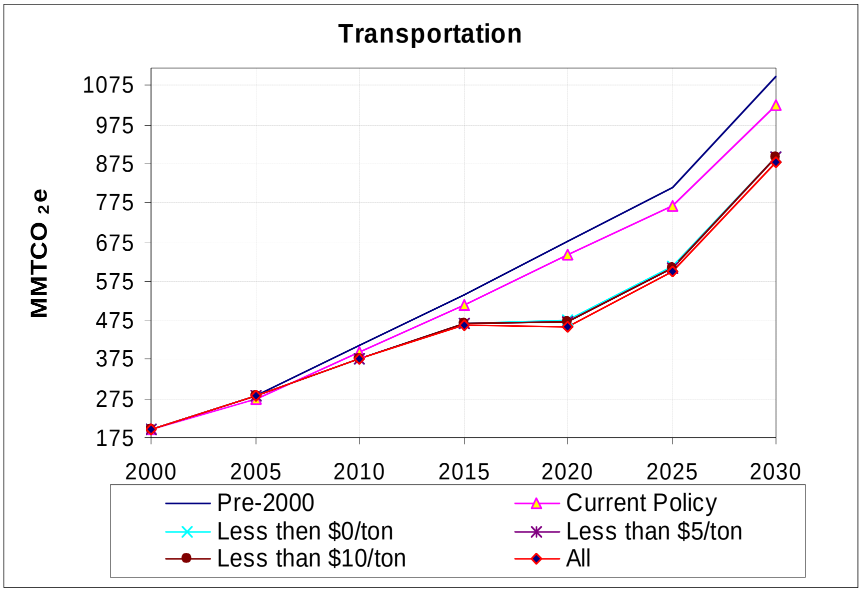

Figure 9. Transportation-Sector CO_2 Emissions in China Under the Various Scenarios

The China analysis proposes a number of policy options that could be implemented to attain the emissions reductions identified. These include some domestic measures – fuel taxes; financial incentives; criteria pollutant emissions standards; financial, technical, or training assistance provided by the government; urban planning – as well as some that are international – e.g., assistance with financing and technology transfer.

Table 10 All Sector Mitigation Options for China

Sector	TOTAL			
Advanced Options Scenario	BAU Policy Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	5340	4998	342	6%
#2 (options < $5/ton CO2)	5340	4943	397	7%
#3 (options < $10/ton CO2)	5340	4829	511	10%
#4 (all options)	5340	4346	994	19%

I.D.2 *Brazil*

Implementation of all measures evaluated for Brazil in 2020 would reduce emissions from the seven sectors evaluated by nearly 30% below BAU—a reduction of 147 $MMTCO_2$—which is more than the total emissions in 2000 from electricity, cement, iron and steel, pulp and paper, and light-duty vehicles combined.[53]

[53] It is important to note that a large share of this reduction is through the introduction of flex-fuel vehicles. This is considered as a new option for this analysis since the emissions baseline for comparison was the pre-2000 scenario, under which flex-fuel vehicles weren't envisioned since they were only introduced after that date.

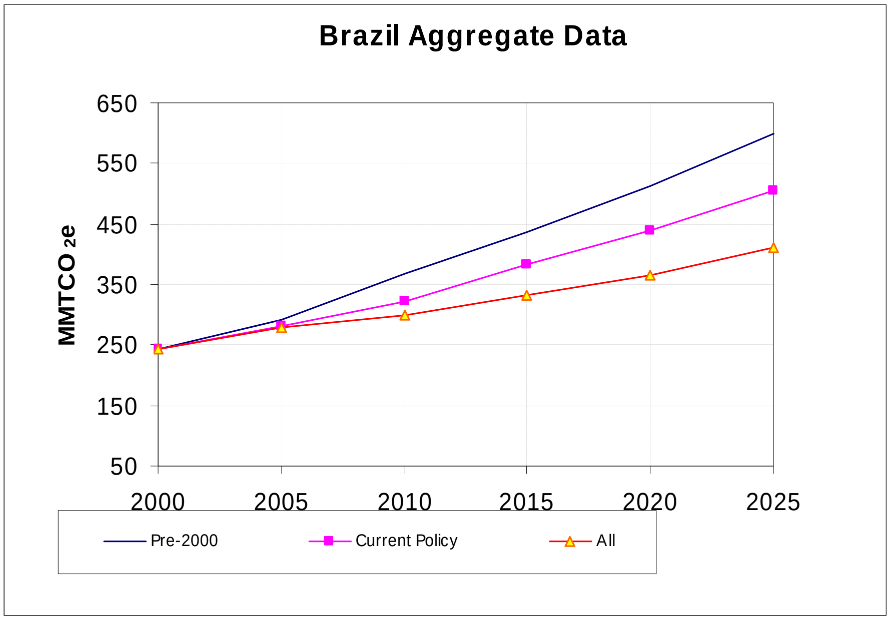

Figure 10. CO_2 Emissions in Brazil Under Various Scenarios

It was not possible to analyze the cost of all mitigation options considered viable in Brazil; however, **implementation of only the Brazilian measures which have no net cost would reduce emissions by 4% in 2020—a 22 MMTCO$_2$ reduction—which is roughly equivalent to the total electricity sector emissions in 2000.** [54] The following tables show the total and sector emissions reductions that can be achieved below each dollar per ton cost threshold in Brazil.

Table 11 shows the Brazilian emissions reductions available in each sector in 2020.

Marginal Abatement Cost ($/tonne CO_2e)	Total Emission Reduction (MMTCO$_2$e)	Cumulative Reduction (MMTCO$_2$e)	Mitigation Options	Sector
-182.5	6.21	6.21	Efficiency gains	Transportation
-115.7	15.2	21.4	Small Hydro	Electricity
-12.9 to -15.1	39.2*	n/a	Increasing Thermal Efficiency	Cement
-9.7	19.5*	n/a	Reducing Clinker ratio	Cement
30.1	21.2	42.6	Flex fuel vehicles	Transportation
30.9	19.6	62.2	Sugar-cane bagasse	Electricity
51.1	19.8	82.0	Wind power	Electricity
107.6	10.0	92.0	Biodiesel	Transportation

* Emission reductions given for multiyear period, so not included in totals

Electricity

The Brazilian energy sector is notable for its abundance of water resources and its lack of high-quality coal. As a result, hydro power accounts for about two-thirds of Brazil's electricity generation, and the sector has a very low average emissions rate. The generation share of fossil fuels is expected to increase, but will still account for only about 5 to 10% of total generation over the next two decades. The sector still offers **potential opportunities to cut electricity**

[54] In this analysis cost data was only available for electricity, cement and iron and transportation. Other cost-effective measures are likely to exist in other sectors, so the actual level of potential negative and low-cost reductions would most likely be higher.

sector emissions in 2020 by more than half (56%) below BAU—a reduction of 21 $MMTCO_2$ (see Figure 11)**.**

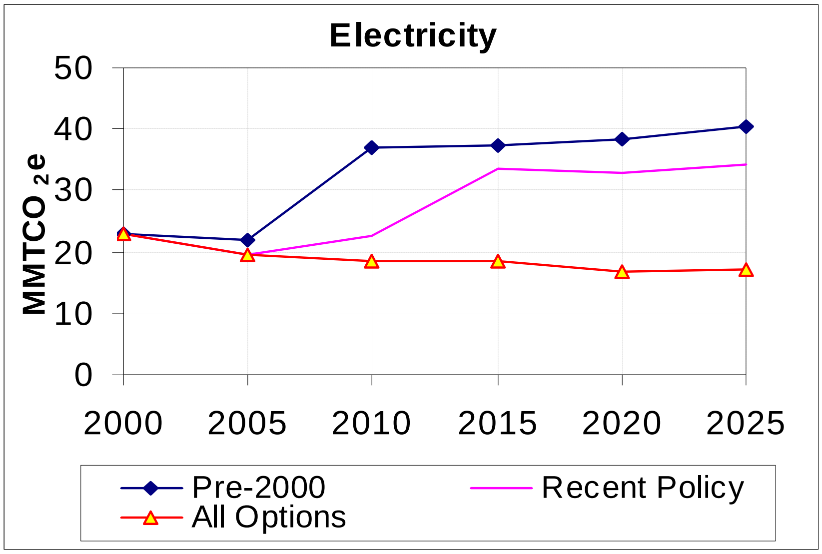

Figure 11. Electricity-Sector CO_2 Emissions in Brazil Under the Various Scenarios

Brazil's electricity sector has only one low cost emissions reduction option—small hydro (15 $MMTCO_2$ at a savings of $116 per ton), while the other renewable options are more costly:

- sugar-cane bagasse (20 $MMTCO_2$ at a cost of $31 per ton)
- wind power (20 $MMTCO_2$ at a cost of $51 per ton)

Table 12. Electricity Sector Mitigation Options for Brazil

Sector	Electricity			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	38	23	15	40%
#2 (options < $5/ton CO2)	38	-	n/a	n/a
#3 (options < $10/ton CO2)	38	-	n/a	n/a
#4 (all options)	38	17	21	56%

To help achieve these reductions the PROINFA program could be expanded to include a higher level of renewables, and also to provide incentives for the development of some resources such as biomass, for which the tariffs in the initial phase of the program were too low to encourage a major expansion. In addition, with only one wind equipment manufacturer currently in business in Brazil, it would also be helpful to develop policies that encourage the opening of one or more additional domestic companies. This could be done with international financing, or by reforming PROINFA to expand the time of the program to accommodate lead-times of investors. An expansion of CDM projects in Brazil is another good prospect for emissions mitigation, particularly with respect to small hydro development, which is currently only partially tapped in the CDM.

Cement

The Brazilian cement industry is already quite efficient but still presents some opportunity for inexpensive emissions reductions. **The mitigation options examined in the cement sector in Brazil indicate that the cement industry can reduce its emissions by at least 17% below BAU in 2020—a 7 MMTCO_2 reduction** (see Figure 12).[55] Two options, both of which produce cost savings, yield these reductions:

- increasing thermal efficiency (39 MMTCO_2 at a savings of $13 to $15 per ton)
- reducing the ratio of clinker through increased cement blending (20 MMTCO_2 at a savings of $10 per ton)

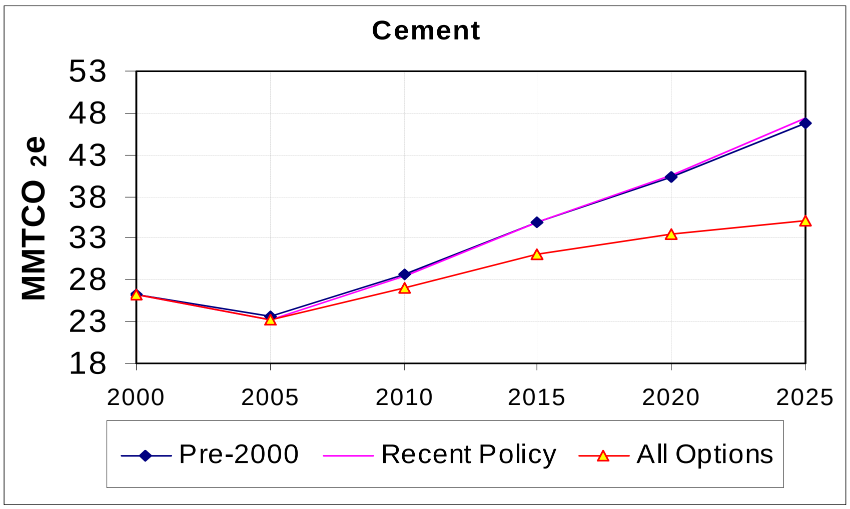

Figure 12. Cement-Sector CO_2 Emissions in Brazil Under the Various Scenarios

Table 13. Cement Sector Mitigation Options for Brazil

Sector	Cement			
Advanced Options Scenario	BAU Baseline Emissions in 2020 (MMTCO_2)	Emissions under Scenarios in 2020 (MMTCO_2)	Emissions Reduction from Baseline in 2020 (MMTCO_2)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	40	33	7	17%
#2 (options < $5/ton CO2)	40	-	n/a	n/a
#3 (options < $10/ton CO2)	40	-	n/a	n/a
#4 (all options)	40	33	7	17%

Because cement blending is cost-effective and does not require any special technologies, Brazil could likely achieve significant reductions in its cement industry operations through domestic actions, but may require some capacity building or technical assistance. For example, the demand for blended cement in Brazil has been inhibited by public opinion – blended cement

[55] Lack of cost information prevented an analysis of many cement-sector mitigation options in Brazil. An evaluation of more advanced technologies for cement production (such as exclusive use of 6-stage pre-heaters with pre-calciners), use of alternative fuels, or other mitigation options may identify further opportunities for emissions reductions. For example, CHP was not seen as a viable alternative in cement facilities because it is more expensive in cement plants than in many other industrial applications due to the high content of clinker dust in the exhaust gas.

often has a darker color than typical cement, so in some cases the Brazilian public has not found it to be as attractive.

Iron & Steel

In Brazil, **the potential reductions identified in iron and steel production could reduce emissions by 16% below BAU levels in 2020—a reduction of 13 MMTCO$_2$ (see Figure 13).**[56]

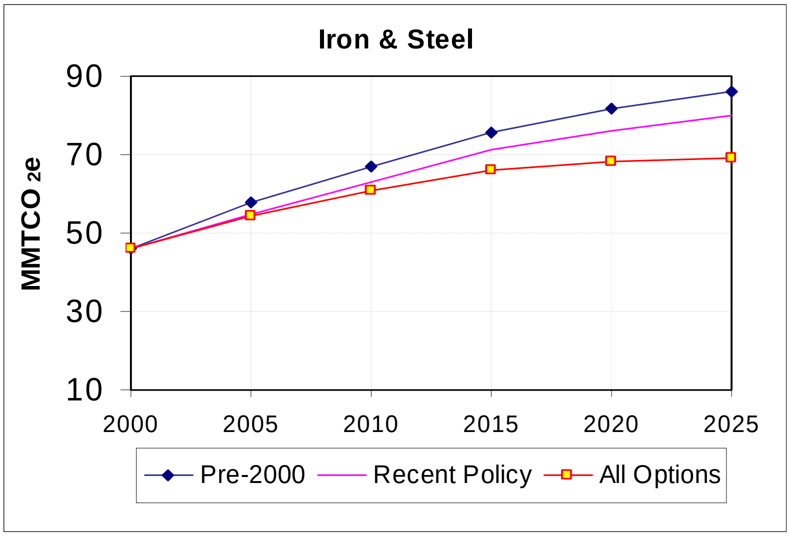

Figure 13. Iron and Steel-Sector CO_2 Emissions in Brazil Under the Various Scenarios

Table 14. Iron & Steel Sector Mitigation Options for Brazil

Sector	Iron & Steel			
Advanced Options Scenario	BAU Baseline Emissions in 2020 (MMTCO$_2$)	Emissions under Scenarios in 2020 (MMTCO$_2$)	Emissions Reduction from Baseline in 2020 (MMTCO$_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	82	-	n/a	n/a
#2 (options < $5/ton CO2)	82	-	n/a	n/a
#3 (options < $10/ton CO2)	82	-	n/a	n/a
#4 (all options)	82	69	13	16%

The total potential for emissions reduction in 2020 is achieved through a mix of mitigation measures – greater market penetration of some advanced technologies (such as electric arc furnaces), a 20% increase in the share of charcoal in the fuel mix (replacing coal coke), a 3% improvement in the efficiency of electric motors, and greater use of scrap in iron and steel production. The most significant of these options is likely to be fuel-switching of coal for charcoal.

[56] Due to a lack of cost information, the cost-effectiveness of mitigation options could not be evaluated for Brazil's iron and steel sector. Some preliminary data indicate that their may be some mitigation measures that were not examined in this study – such as programmed heating, blast stove automation and improved blast furnace control systems – that may be able to moderately reduce emissions cost-effectively, while others (e.g., BOF gas and sensible heat recovery) could significantly reduce emissions at relatively low cost.

Pulp & Paper
Due to Brazil's large share of zero-emission electricity generation, the pulp and paper industry actually emits more CO_2 than the electricity sector. In this analysis, **emissions reductions of 6% below BAU levels in 2020—a reduction of 4 MMTCO₂—were identified** (see Figure 14)**.**

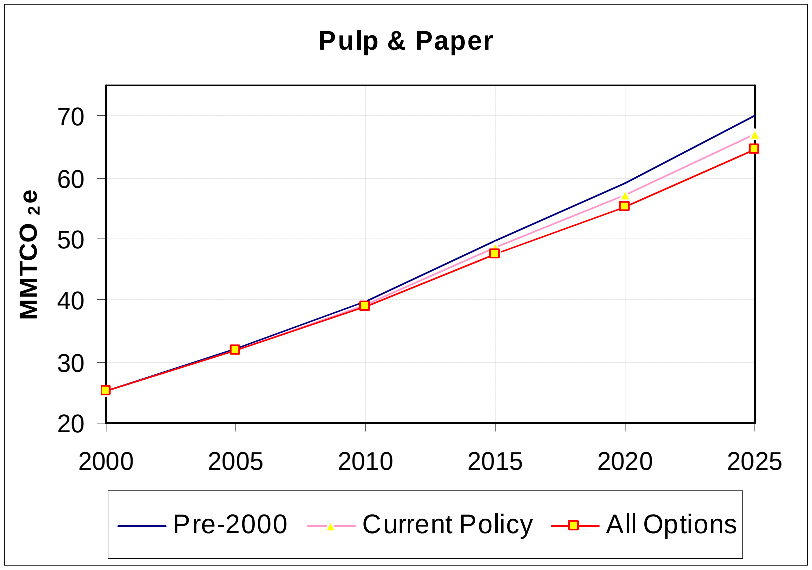

Figure 14. Pulp and Paper-Sector CO_2 Emissions in Brazil Under the Various Scenarios

Table 15. Pulp & Paper Sector Mitigation Options for Brazil

Sector	Pulp & Paper			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	59	-	n/a	n/a
#2 (options < $5/ton CO2)	59	-	n/a	n/a
#3 (options < $10/ton CO2)	59	-	n/a	n/a
#4 (all options)	59	55	4	6%

The primary mitigation options analyzed for Brazil's pulp and paper industry are increased use of natural gas as a fuel source and improved thermal efficiency of plant operations.[57] The analysis indicates that fuel-switching from fuel oil to natural gas is the most promising option to pursue in this sector, although the extent to which this can be achieved is dependent on Brazil's future supply of natural gas.

Transportation

[57] As in the iron and steel industry, cost information was not available to assess the cost effectiveness of the CO_2 emissions mitigation options analyzed for the pulp and paper sector.

The Brazilian transportation sector is already among the lowest-emitting globally because of their extensive use of ethanol in light-duty vehicles. Nevertheless, because Brazil's electricity sector is also extremely clean, transportation-related emissions account for more than half of Brazil's total CO_2 emissions in the sectors included in this analysis. Adopting the suite of **mitigation options examined for the transportation sector would reduce emissions in this sector below BAU by 36% in 2020—a reduction of 87 MMTCO$_2$** (see Figure 15).

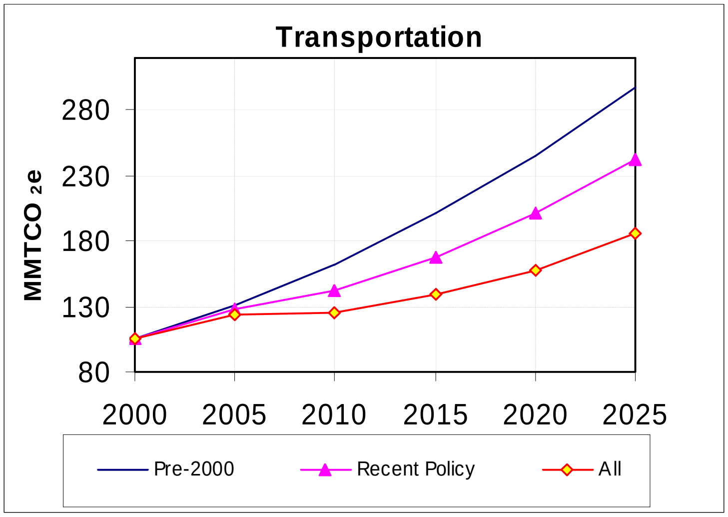

Figure 15. Transportation-Sector CO_2 Emissions in Brazil Under the Various Scenarios

Table 16. Transportation Sector Mitigation Options for Brazil

Sector	Transportation			
Advanced Options Scenario	BAU Baseline Emissions in 2020 (MMTCO$_2$)	Emissions under Scenarios in 2020 (MMTCO$_2$)	Emissions Reduction from Baseline in 2020 (MMTCO$_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	245	-	n/a	n/a
#2 (options < $5/ton CO2)	245	-	n/a	n/a
#3 (options < $10/ton CO2)	245	-	n/a	n/a
#4 (all options)	245	158	87	36%

An important GHG mitigation option in Brazil—in addition to the continued expansion of flex-fuel vehicle—is improving the average fuel efficiency of the LDV fleet through a vehicle labeling program.[58] Such a program, currently under development by CONPET, is estimated to improve the fuel economy of the LDV fleet by 15% between 2005 and 2008, in addition to the 10% improvement due to natural technological progress in the automotive industry. As current trends indicate that the ethanol supply will not grow as quickly as transportation demand, one mitigation option requiring further domestic support is expansion of the ethanol supply.

[58] Numerous mitigation options were analyzed for reducing GHG emissions in the Brazilian transportation sector, although cost information was again unavailable for many of these. For this reason, only three mitigation options were evaluated in terms of cost-effectiveness, and in each case, only the difference in fuel costs was included in the mitigation cost estimates.

For heavy-duty vehicles (HDVs) – trains, ships, airplanes and trucks transporting both freight and passengers – a wide variety of GHG mitigation activities are assumed to result from current industry trends and recent government programs, each of which is believed to be deployable to an even greater extent in the future. These include measures related to the fuel mix, the mode splits of freight and passenger transport, the occupancy of passenger vehicles and the load of freight vehicles, and the fuel efficiency of diesel trucks, diesel buses and natural gas buses. Some of these reductions are likely to be cost-effective, particularly those that are occurring as part of current market trends, rather than being spurred by any specific government policy. The only HDV mitigation option for which costs were estimated in the Brazil analysis is the use of 20% biodiesel blends (B20) in the place of diesel fuel. Such a goal could be attained through expansion of the current PROBIODIESEL program, which aims to achieve 5% biodiesel fuel (B5) use by 2010. However, this mitigation measure is estimated to cost more than $100 per tonne CO_2 in 2020.

Table 17. All Sector Mitigation Options for Brazil

Sector	TOTAL			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	512	490	22	4%
#2 (options < $5/ton CO2)	512	490	22	4%
#3 (options < $10/ton CO2)	512	490	22	4%
#4 (all options)	512	365	147	29%

I.D.3 *India*

In 2020, the analyzed measures could reduce emissions in India by 17% below BAU—394 $MMTCO_2$—which is equivalent to 93% of the electricity sector's emissions in 2000 (see Figure 16)**.** It should be noted, however, that this includes increases in emissions in the Indian residential and commercial sectors; excluding these increases, the other sectors would together achieve reductions of 402 $MMTCO_2$.

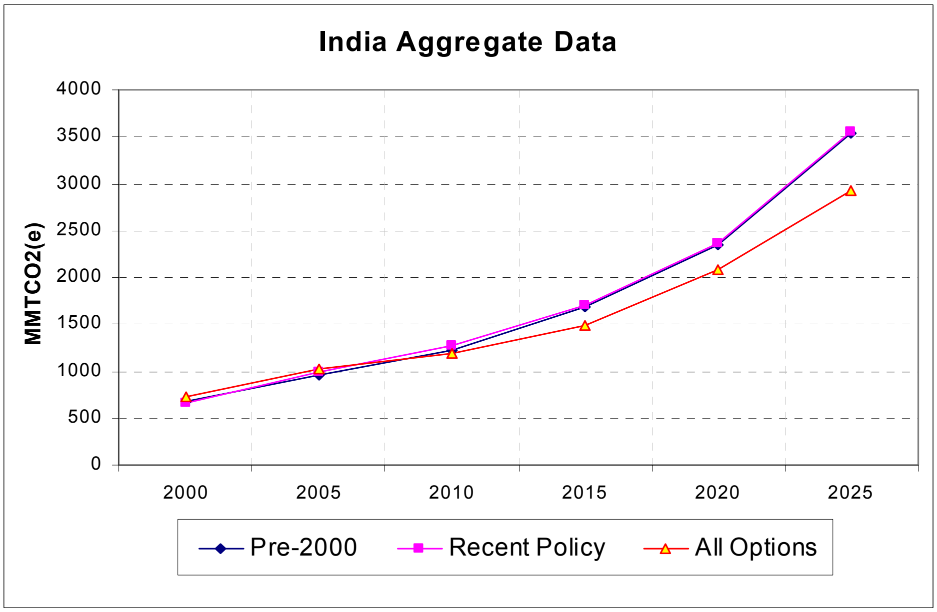

Figure 16. CO_2 Emissions in India Under Various Scenarios

The vast majority of these potential reductions occur in the electricity (178 $MMTCO_2$) and transportation (179 $MMTCO_2$) sectors. Of the identified reductions, only a small fraction—12%—have been identified as available at a net cost savings, and one-fourth of the reductions are known to cost less than $10/ton.

Implementation of only the measures that cost less than $5 per ton could reduce emissions by 3% below BAU—72 $MMTCO_2$—in 2020, which is equivalent to approximately the cement sector emissions in 2000. At higher cost (less than $10 per ton) a total reduction of 4% below BAU in 2020 could be achieved—95 $MMTCO_2$—in 2020, which is nearly equivalent to the total transportation emissions in 2000.

Table 18 shows the Indian emissions reductions available in each sector in 2020.

Marginal Abatement Cost ($/tonne CO_2e)	Total Emission Reduction ($MMTCO_2e$)	Cumulative Emission Reduction ($MMTCO_2e$)	Mitigation Options	Sector
-2081	37.0	37.0	Higher share of rail in freight movement + electrification	Transportation
-20.5	3.2	40.2	H -Frame Combined Cycle Gas Based Plant (60% Efficiency)	Electricity
-16.3	0.8	40.9	Wood based efficient -2	Pulp and Paper
-14.7	0.2	41.2	Retrofit- waste paper based	Pulp and Paper
-14.7	0.2	41.4	Retrofit agro based	Pulp and Paper
-7.5	6.8	48.2	6 Stage producing PPC cement	Cement
-7	36.0	84.2	Enhanced share of public-transport	Transportation
-6.7	3.8	88.0	6 Stage producing PSC cement	Cement
-6.2	23.4	111.4	Wind Power Plant	Electricity
-5	8.0	132.4	Switch towards CNG from conventional fuel based vehicles	Transportation
-4	13.0	124.4	Higher share of rail in passenger movement	Transportation
-3.8	0.3	132.7	Waste paper based efficient	Pulp and Paper
-3.6	145.9	278.6	Nuclear Power Plant	Electricity
0	119.0	397.6	Efficiency improvements	Transportation
6.1	29.1	426.7	Small Hydro Plant	Electricity
6.7	0.3	427.0	Agro based - efficient	Pulp and Paper
83.1	19.4	446.3	BF-BOF -Efficient	Iron and Steel
130	108.0	554.3	Replacing diesel by bio-diesel	Transportation

Electricity

The analysis for electricity generation in India finds that the GHG reduction potential in this sector is very large. In addition, compared to the likely baseline technology that would be installed under BAU conditions,[59] many of these reductions could be achieved in a highly cost-effective manner. **Implementing all measures considered would reduce annual emissions in 2020 by almost one-fifth below BAU levels—a 178 MMTCO$_2$ reduction** (see Figure 17)**.**

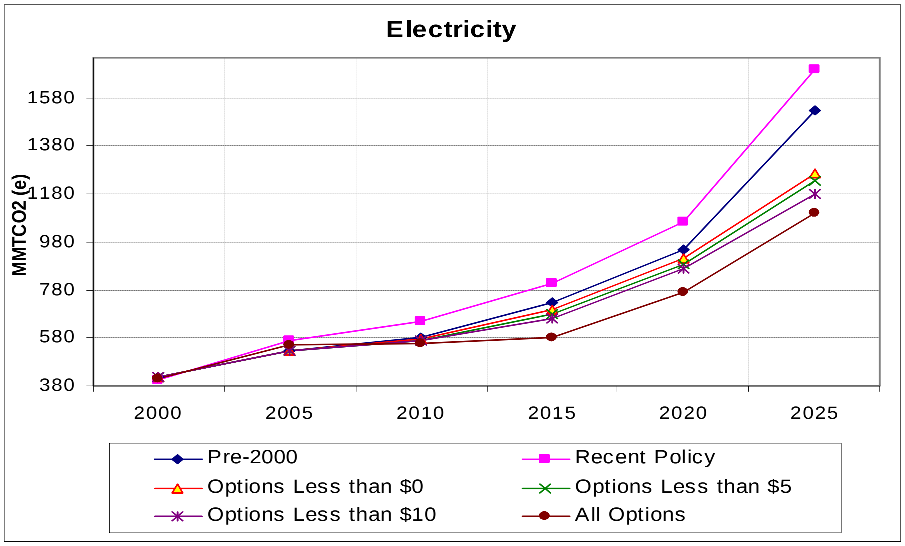

Figure 17. Electricity Sector CO_2 Emissions in India Under Various Scenarios

Introduction of only measures costing less than $0 per ton would reduce emissions in 2020 by 4% below BAU levels—a cut of 38 MMTCO$_2$. Promising options with cost savings include:

- More efficient natural gas combined cycle facilities (a reduction of 3 MMTCO$_2$ at a savings of $20 per ton)
- Wind power plants (a reduction of 23 MMTCO$_2$ at a savings of $6 per ton)
- Nuclear power plants (a reduction of 146 MMTCO$_2$ at a savings of $4 per ton)
- Demand-side management reductions from end-use energy efficiency measures (an approximate reduction of 80 MMTCO$_2$ and decrease in total generation needs of 7%)
- Advanced coal technologies such as coal fluidized bed combustion (CFBC), supercritical and others would also be available at cost savings, although this analysis concludes that their penetration would only be marginal compared to the other options considered.

Implementing measures that cost less than $10 per ton would achieve a 9% reduction in 2020 below BAU levels—a reduction of 81 MMTCO$_2$. Promising additional options in this regard include:

- Small hydro (a reduction of 29 MMTCO$_2$ at a cost of $6 per ton)
- IGCC based on imported coal

[59] Costs for coal, nuclear and renewable options are estimated by comparing to those of a new subcritical coal unit. Costs for the H-Frame combined cycle option are compared to those of a new combined cycle unit.

Table 19. Electricity Sector Mitigation Options for India

Sector	Electricity			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenario in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	952	914	38	4%
#2 (options < $5/ton CO2)	952	891	61	6%
#3 (options < $10/ton CO2)	952	871	81	9%
#4 (all options)	952	774	178	19%

Mitigation in this sector will also produce significant co-benefits, particularly in the case of renewable energy. The development of renewable energy technologies will create numerous new jobs in rural areas, which can in turn help to reduce India's rural poverty and also decrease migration of rural populations to urban areas. It will also reduce emissions of NO_x and other air pollutants considerably. In addition, the accelerated diffusion of these technologies will improve the general knowledge and experience with them in the country, and may thus reduce their future costs and enhance their performance.

Domestic policy options that might encourage the introduction of these measures, include: subsidies, tax credits, or development of renewable portfolio standards. The government's ongoing efforts to expand rural generation and electrification could also be coupled with an increased emphasis on wind and small hydro power for off-renewable power generation. Expanded demand-side management and energy efficiency programs in end-use sectors could be encouraged through government-industry partnerships to share knowledge and experience, as well as public capacity building efforts. IGCC based on imported coal is a promising option for 2020 and beyond. While its potential is uncertain, it could be explored as an option along with carbon capture and sequestration (CCS) through a domestic pilot program to study and test the technologies and their applicability in India.

Cement

The cement industry in India is modern, with nearly 99% of cement produced in plants that are only about 10 years old on average. In addition, the most inefficient plants are expected to be retired in the next few years, while the middle-aged plants are being upgraded to incorporate the latest technologies. Therefore, **the cement sector in India presents only a modest potential for emissions reductions—increased production of blended cements can reduce CO_2 emissions by approximately 3% below BAU (10 $MMTCO_2$ reduction) in 2020—but the reductions are available at a net cost savings** (see Figure 18)

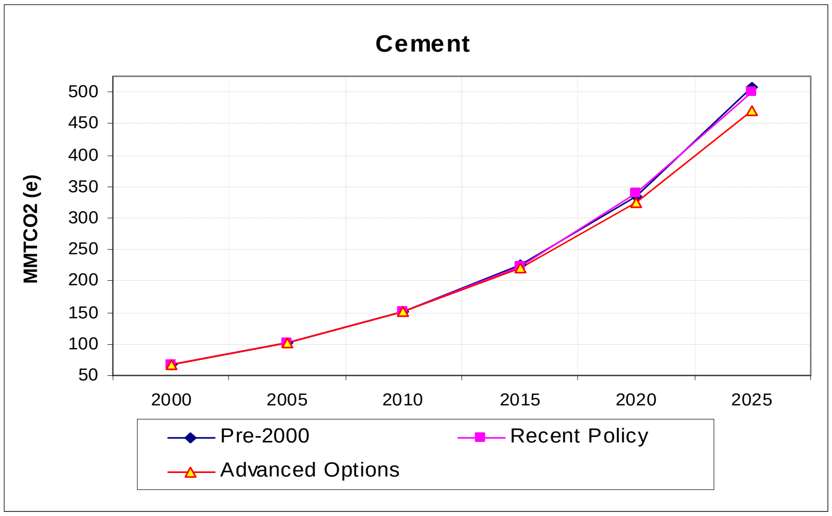

Figure 18. Cement Sector CO_2 Emissions in India Under Various Scenarios

Table 20. Cement Sector Mitigation Options for India

Sector	Cement			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	334	324	10	3%
#2 (options < $5/ton CO2)	334	-	n/a	n/a
#3 (options < $10/ton CO2)	334	-	n/a	n/a
#4 (all options)	334	324	10	3%

Potential additional emissions reductions in the sector, not analyzed, could be achieved through fuel-switching measures. Improvements in the emissions intensity of cement manufacturing are limited by the insufficient supply of domestic coal. In the analysis, it is assumed that higher-emitting imported coal will be used to supplement domestic coal as its supply dwindles, but if an alternative fuel (and perhaps some financial assistance) could be found, greater emissions reductions may be possible from this sector. Implementing co-generation technologies is another option that could reduce emissions but would likely require financial and technical assistance.

Iron and Steel

The single mitigation option considered for the iron and steel industry in India – building new Blast Furnace – Basic Oxygen Furnace (BF-BOF) plants instead of Direct Reduced Iron – Electric Arc Furnace (DRI-EAF) plants – has the potential to reduce emissions in this sector by 10% (32 MMT) in 2020 (see Figure 19)**.**

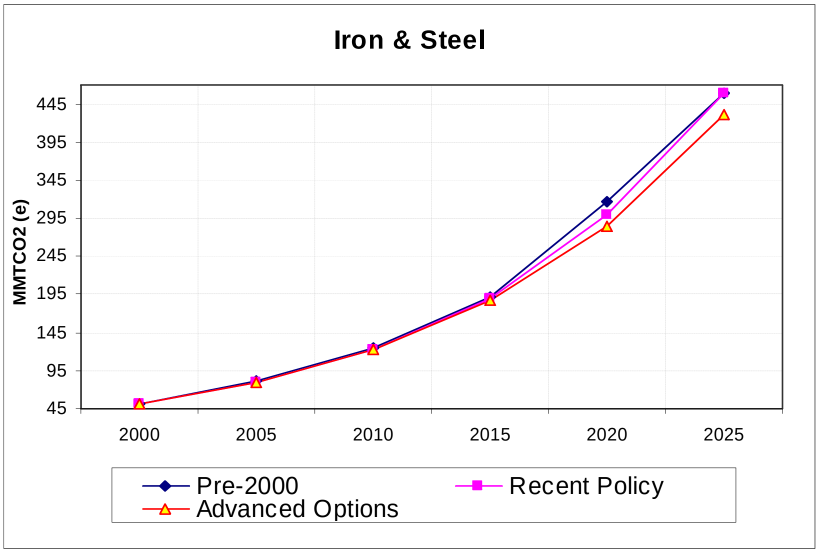

Figure 19. Iron and Steel Sector CO_2 Emissions in India Under Various Scenarios

The potential may exist for even further emissions reductions from this sector because limited supplies of fuel and scrap iron are predicted to increase the emissions intensity of steel production in the next few decades, after an initial decline. Future steel production is assumed to continue to be fueled by coal because demand in the power sector is expected to have priority for the available supply of natural gas. Because domestic coal supplies are limited, as steel production rises, imported coal, which is higher emitting than domestic coal, makes a greater fraction of the industry's fuel use. In addition, India does not have large supplies of scrap iron, so the percentage of iron and steel produced in Scrap-EAF facilities is expected to drop from current levels (~24%) to 10% in 2036. If policies or measures could be put in place to promote fuel-switching or increase scrap supplies, emissions could be reduced even further in this sector, but the costs of such reductions remains to be evaluated. Tax incentives or subsidies may help entities to pursue such mitigation actions.

Table 21. Iron & Steel Sector Mitigation Options for India

Sector	Iron & Steel			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	317	-	n/a	n/a
#2 (options < $5/ton CO2)	317	-	n/a	n/a
#3 (options < $10/ton CO2)	317	-	n/a	n/a
#4 (all options)	317	285	32	10%

While the *National Steel Policy 2005* is expected to support some of these reductions, the remainder could be attained through expansion of this policy but may instead require some type of financial or other incentive to the industry, as the reductions from this measure are not cost-effective (estimated at $83 per ton CO_2). This may include broadening the scope of the Steel Development Fund: Consolidated Fund of India which currently funds options such as improving blast furnace productivity and automation of production processes.

Pulp and Paper

Although the pulp and paper industry only accounts for about 1% of the CO_2 emissions in the seven sectors examined in India, there is a large potential for emissions reductions. Unlike the cement industry, many facilities in this sector are old. In addition, the pulp and paper industry was long protected by the government, so there was no incentive for technological advancement, and the energy efficiency and technological sophistication of the average and best paper plants in India fall below those of the international community.

The mitigation options evaluated for the pulp and paper industry in India can reduce CO_2 emissions by 25% below BAU in 2020—a reduction of 3 $MMTCO_2$—and all of these reductions can be attained at less than $10 per ton (see Figure 20)**.**

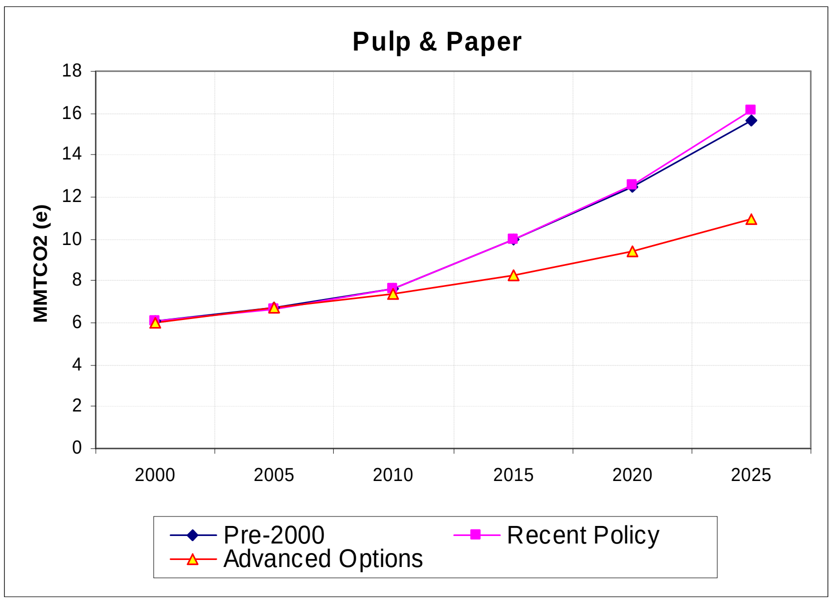

Figure 20. Pulp and Paper Sector CO_2 Emissions in India Under Various Scenarios

These mitigation options involve efficiency improvements – either retrofitting existing paper plants or constructing new plants that are more efficient than typical new facilities – and halting the expected decline in the percentage of waste-based paper production. The latter is expected to fall because significant amounts of waste paper is imported, and these imports are predicted to be phased out completely by 2036 due to concerns regarding their hazardous waste content.

Table 22. Pulp & Paper Sector Mitigation Options for India

Sector	Pulp & Paper			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	12	-	n/a	n/a
#2 (options < $5/ton CO2)	12	-	n/a	n/a
#3 (options < $10/ton CO2)	12	9	3	25%
#4 (all options)	12	9	3	25%

Four of the five efficiency-based mitigation options in the pulp and paper sector are cost-effective; only the construction of more efficient agri-based paper plants has a positive cost, and thus may require subsidies or other fiscal measures to achieve, but it nonetheless remains less than $10 per ton of CO_2 reductions.[60] The waste paper supply could be augmented by a program to increase domestic recycling (India's waste paper collection rate is low from an international standpoint) or through regulation and monitoring of imported waste paper quality.

Transportation

CO_2 emissions from the transportation sector are the fastest growing of the seven sectors analyzed in India, rising from 14% of the nation's total from these sectors in 2000 to 27% of the total in 2020. **The transportation sector offers significant opportunity for emissions reductions, as mitigation options have been identified that will reduce emissions in 2020 by 28% below BAU—a reduction of 179 MMTCO₂, many of which are cost-effective.**

Existing government efforts to improve fuel-efficiency by 25% between 2001 and 2036 are expected to provide significant reductions, while **the remaining reductions can be obtained by a package of measures – further fuel economy improvements, electrification of rail systems, increasing the shares of freight and passengers transported by rail, increasing the share of passenger road travel by public transport, and fuel switching to CNG and biodiesel** (see Figure 21)**.**

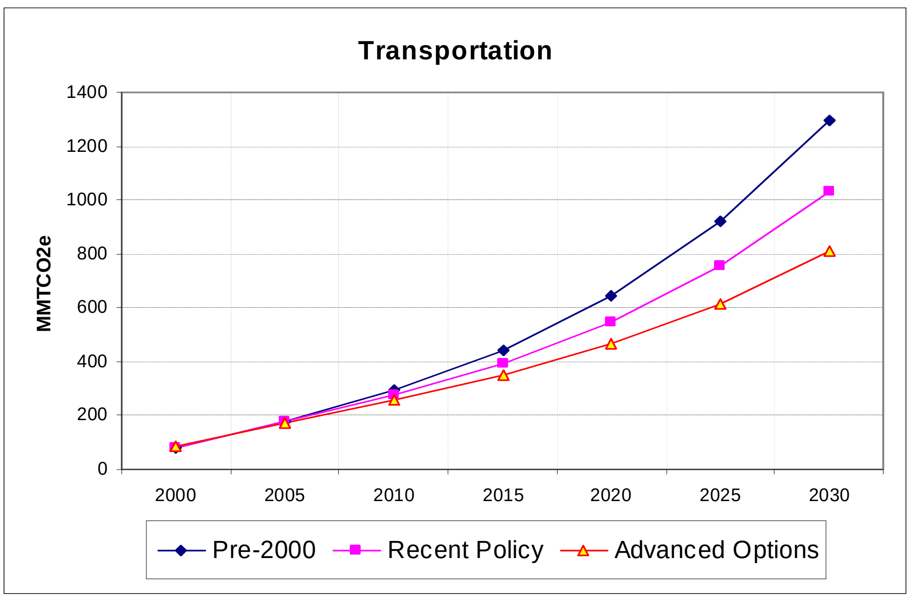

Figure 21. Transportation Sector CO_2 Emissions in India Under Various Scenarios

All measures, except for biodiesel, are estimated to be achieved at cost savings.

However, the transportation sector is unique in that it is influenced to a large degree by public perception and consumer attitudes. In many countries, for example, the personal prestige of car

[60] A cost analysis was not performed for the waste paper production option.

ownership has been identified as a key barrier to any attempts to increase the use of public transport. Some mitigation options may therefore need some type of regulatory push or incentive to reach their full potential, even if they are cost-effective. The Integrated Transport Policy 2001, Vision 2020 Transport, and a draft national urban transport policy have begun to address these issues, and each could be expanded or otherwise revised to include more concrete goals and mechanisms for their achievement. Government-funded research and development would likely be needed to implement a biofuels program, as well as either international or domestic financial or technical assistance.

Table 23. Transportation Sector Mitigation Options for India

Sector	Transportation			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	644	-	n/a	n/a
#2 (options < $5/ton CO2)	644	-	n/a	n/a
#3 (options < $10/ton CO2)	644	-	n/a	n/a
#4 (all options)	644	465	179	28%

The mitigation options explored for India would provide benefits in addition to a reduction in GHG emissions. Increasing the public transit and rail mode shares can reduce congestion, noise, and road wear, while improving safety. Reduced use of motor fuels will also improve the country's energy security, by reducing its dependence on imported oil, and lower the emissions of pollutants, such as nitrous oxides. Decreased particulate emissions from diesel fuel, which accounts for about 80% of the motor fuel used in India today, would be a significant co-benefit of many of the CO_2 mitigation options.

Table 24. All Sector Mitigation Options for India

Sector	TOTAL			
Advanced Options Scenario	BAU Baseline Emissions in 2020 ($MMTCO_2$)	Emissions under Scenarios in 2020 ($MMTCO_2$)	Emissions Reduction from Baseline in 2020 ($MMTCO_2$)	Percentage Reduction from Baseline in 2020
#1 (options < $0/ton CO2)	2352	2304	49	2%
#2 (options < $5/ton CO2)	2352	2281	72	3%
#3 (options < $10/ton CO2)	2352	2258	95	4%
#4 (all options)	2352	1959	394	17%

I.E Role of International Policy in Domestic Implementation

As discussed above, these countries are undertaking domestic "unilateral actions" which if fully implemented will contribute sizeable emissions reductions. These reductions will make progress towards putting global emissions on a path towards lower stabilization levels, but further global reductions will be needed than achieved from these policies and programs alone. The analysis in this project identified a range of mitigation options which can produce emissions reductions of the magnitude necessary to put global emissions on a lower stabilization level path. These options are available at a range of costs, some of which are available at net savings while others suggest cost levels that without significant co-benefits may not seem attractive to these countries. In some cases, even options which are estimated to produce cost savings could benefit from further policy support as there can be non-economic barriers to their introduction. Each of these elements suggests the need for a future international structure to climate change that:

- Recognizes and encourages "unilateral actions" and
- Provides incentives for more expensive actions.

A future international policy which recognizes and encourages "unilateral actions" is needed. "Unilateral policies and programs" already pursued in these countries if fully implemented could yield significant reductions in GHG emissions. In the current debate around the future of the international response to climate change, these "unilateral actions" by developing countries are often not fully recognized and could benefit from further support. In some cases, these reductions have greater certainty as they are supported by policies and programs with more likelihood of full enforcement. In other cases, further support for achieving these reductions may be needed through domestic or international policies and programs. This suggests that a future international effort to address climate change needs to establish mechanisms to recognize and encourage these and other "unilateral actions", which could be supported through international efforts including the following:

- *Establishment of "pledge and review" process for "unilateral actions".* A reporting system could be established to recognize the "unilateral actions" taken by these countries. This could serve as a means to "pledge" the unilateral actions that countries will undertake and serve as a mechanism to track progress against those actions.
- *Provide "positive incentives" for the successful implementation of these and further "unilateral actions".* Supporting these countries in their unilateral actions could potentially benefit from "positive incentives" such as capacity building to understand the options that are attractive for non-climate change reasons, assistance with full implementation and enforcement, technology support, help in overcoming non-economic barriers, among others.

The future international policy also needs to provide incentives for the more expensive emissions reductions options available in these countries. A range of mitigation options are available in these countries which can keep emissions on path for lower stabilization levels. While some of these could potentially be implemented "unilaterally" due to their cost savings, relatively low cost, or significant co-benefits, some of these options are available at relatively higher cost. This suggests the need for a future international structure which can provide assistance for these more expensive options, including through: financial support, technology development and transfer assistance, and capacity building. **These efforts could be supported through a variety of international options under discussion, including (among others):**

- ***Sustainable Development Policies and Measures (SD-PAMs)*** where developing countries undertake actions primarily focused on their sustainable development and where climate change is considered a "co-benefit"(Winkler et al., 2002; Winkler et al., 2005; Bradley et al., 2005).[61] Countries begin by examining their development priorities and identify how these could be achieved in a more sustainable manner, either by tightening existing policy or by implementing new measures. In practice, a country might undertake a number of concrete steps under SD-PAMs (Winkler et al., 2005): identify policies and measures that would make the development path more sustainable; register nationally selected SD-PAMs in a registry maintained by the UNFCCC secretariat; mobilize investment and implement SD-PAMs; and review the implementation of specific SD-PAMs and quantify the changes in GHG emissions.

- ***Sector-Based "No-Lose" Target*** where key developing countries would pledge to achieve a voluntary, sector-wide "no lose" GHG intensity target (e.g., GHG / ton of steel) in major energy and heavy industry sectors (Schmidt et al., 2006a[62]). If a participating country does not meet the voluntary target, no sanctions are accrued. Emissions reductions achieved beyond the pledged target would be eligible for sale as emissions reductions credits (ERCs) to developed countries. Emissions reductions to meet the country's pledge would be permanently "retired from the atmosphere" and thus would not be eligible for sale. To encourage developing countries to pledge to meet more aggressive sectoral intensity targets, industrialized countries and international financial institutions (IFIs) would provide assistance through a *Technology Finance and Assistance Package*, aimed to support deployment of advanced technologies, development of small and medium-sized enterprises to assist in technology implementation, capacity-building activities, and pilot and demonstration projects.

- ***Sectoral Approaches to the CDM*** where sector-wide policies are adopted and net emissions reductions achieved in all facilities—not just the ones reducing emissions—in a single sector (e.g., electricity) or sub-sector (e.g., grid connected electricity) below the level that would have occurred without the project are eligible to generate emissions reduction credits for sale (Schmidt et al., 2006b[63]; Figueres, 2006[64]). This approach would require a baseline into the future—which could be a business as usual projection or an intensity level—that took account of the emissions for the entire sector without the project. Emissions reduction credits could be generated for the entire reduction below the baseline or could be discounted—with only a portion available for sale—and the remainder representing the developing country's "contribution to protection of the atmosphere".

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Center for Clean Air Policy
750 First Street, NE • Suite 940
Washington, DC 20002

Tel: 202.408.9260 • Fax: 202.408.8896