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[The Economics of Greenhouse Gas Emissions Abatement in China, A Preliminary Analysis]
[Binder] [1]

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9/7/99 Preliminary Draft; For Use in International Negotiations; Do Not Cite; Close Hold

The Economics of Greenhouse Gas Emissions Abatement in China, A Preliminary Analysis
U.S. Council of Economic Advisers
September 1999

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The Economics of Greenhouse Gas Emissions Abatement in China, A Preliminary Analysis Executive Summary

An international greenhouse gas emissions market would offer substantial economic opportunities for China. Under an efficient international market, low-cost opportunities to reduce greenhouse gases in China would attract foreign direct investment for energy and industrial abatement technologies, allowing China to generate billions of dollars in revenues annually through the sale of emissions credits or allowances to countries with higher abatement costs. Results from a range of economic models indicate that by taking on an emissions target and actively participating in international emissions trading, China would be able to sell emissions allowances valued at \$4 to \$14 billion annually.

Participating in an international greenhouse gas emissions market would also help China gain new technology transfer and investment resources to reduce the high levels of local air pollution, resulting in substantial public health benefits. Efforts to abate carbon dioxide emissions will likely result in significant reductions in emissions of local air pollutants, such as sulfur dioxide and particulate matter, since both kinds of emissions are by-products of fossil fuel combustion. Local air pollution levels are a significant threat both to China's economy (especially the agriculture and forestry sectors) and to its citizens. As epidemiological research has shown, current pollution levels increase mortality rates, the incidence of chronic illness, and the number of hospital and emergency room visits. One study, for example, estimates that the mortality rate in Shenyang increases by 2 percent for every 100 micrograms per cubic meter more sulfur dioxide in the air. China's position as a low-cost producer in a global greenhouse gas emissions market offers a promising avenue for attracting investment in the energy and industrial technologies necessary to significantly address the high levels of local air pollution.

The Kyoto Protocol's market-based provisions include the Clean Development Mechanism (CDM) and international emissions trading. These provisions allow countries with low emissions abatement costs to take advantage of the opportunity to abate emissions and to sell certified emissions reductions or tradable allowances to higher-cost countries. Just as in the production of commodities or the sale of financial assets, low-cost producers could attract foreign direct investment to finance their emissions abatement industry.

Through the CDM, a country with a greenhouse gas emissions target under the Protocol can invest in projects that abate emissions in countries without targets, thereby generating emissions credits or allowances that can be transferred to the first country and used to help meet its target. The additional economic value of the emissions allowances that a project generates provides an incentive for investment, meaning that the CDM can leverage investment in clean energy and other similar projects that would not likely happen otherwise.

International emissions trading holds even greater promise as a vehicle for transferring capital and

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technology and for stimulating cost-effective emissions abatement. Under the Kyoto Protocol, each country with an emissions target has, in effect, an emissions “budget” – a total amount of greenhouse gases that it is allowed to emit into the atmosphere over a given period of time. A country with an emissions target can transfer a portion of its emissions budget to another such country. The incentive to trade these emission allowances stems from the large differences in the marginal costs of emissions abatement across countries. Countries that have relatively inexpensive ways to control greenhouse gases have incentives to reduce emissions by more than their targets require, because they can sell tradable allowances that they will not need. Countries facing the most expensive emissions abatement measures have the incentive to buy less costly allowances from others. Thus, trading allows the international community to achieve the same overall reduction in emissions at significantly lower cost. At the same time, both buyers and sellers stand to reap significant gains. Countries buying allowances save in abatement costs while countries selling allowances receive additional financial inflows and increased technology transfer.

The Kyoto Protocol stipulates that a country must have a greenhouse gas emissions target in order to participate in trading. Since the Kyoto Conference, several developing countries have expressed an interest in emissions targets. At the same time, it is broadly recognized that any such targets must be made compatible with developing countries’ legitimate needs and objectives for sustainable development. One way to do so would be for a country to set its target above current emissions levels, but below what emissions are forecast to be without additional abatement policies during the Protocol’s first commitment period (2008 to 2012). Such an “emissions growth target” could provide for continued economic development, but with a lower emissions growth rate. To mitigate the risk that a target could end up being too stringent (or too lax), a target could be indexed to a country’s economic performance between now and the 2008-2012 commitment period.

China stands to reap substantial benefits by participating in an international emissions market. Over the past two decades, China’s economy has grown at an impressive rate and it is now the world’s 7th largest. At the same time, its energy consumption has more than doubled and its greenhouse gas emissions have grown substantially. While China is making impressive strides towards lowering its greenhouse gas emissions intensity (emissions per unit of output), a variety of economic analyses and modeling efforts indicate that there are still many low-cost emissions abatement opportunities in China. Some analyses suggest that China has lower abatement costs than virtually any other country in the world.

By participating in a global emissions market, China would greatly benefit both its economy and its environment. Results from a range of economic models indicate that by taking on an emissions target and actively participating in international emissions trading, China would find it economic to reduce emissions 14 percent to 24 percent below projected 2010 emissions levels and would be able to sell emissions allowances valued at \$4 to \$14 billion annually. Gains from trade would vary greatly depending on the extent to which China’s growth target varied from the business as usual projection.

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Divider Title: _____

The Economics of Greenhouse Gas Emissions Abatement in China, A Preliminary Analysis

Over the past two decades, China has experienced an impressive rate of economic growth. Between 1978 and 1997, the size of the economy increased from the 18th largest to the 7th largest in the world (in market exchange rate terms), per capita incomes increased by nearly 450%, and energy consumption more than doubled. Like virtually all countries in the world, economic growth was accompanied by the growth of greenhouse gas emissions, especially carbon dioxide. ① 1A
③ 1A
④ 1A

Emissions of greenhouse gases from all countries pose a risk to the global climate. International efforts to address these risks in Rio de Janeiro in 1992 and Kyoto in 1997 recognize the need to abate greenhouse gas emissions while sustaining economic development. Specifically, the Kyoto Protocol calls for the design of mechanisms that will facilitate the transfer of capital and technology to the countries where emissions can be abated at least cost. A country that can abate greenhouse gas emissions at lower cost than others has the opportunity to attract investment for climate-friendly technology that abates emissions and can then sell emissions credits or allowances to countries with higher abatement costs. Effectively, the Kyoto Protocol provides the potential for low-cost abating countries to create an export industry – whose export products are emissions abatement – that could be financed through foreign direct investment. ⑤ 1A
⑥ 1A
⑦ 1A
⑧ 1A

What is the potential for a fast-growing economy such as China's to create and benefit from the export of emissions allowances? The economic literature indicates that China has the opportunity to abate more greenhouse gas emissions at a lower cost than any other country. Selling these abated emissions through the Kyoto mechanisms could attract billions of dollars of investment per year that could finance technology leap-frogging in the energy generation and industrial production sectors. In addition, abating carbon dioxide, for example by improving combustion efficiency of coal power plants, would reduce emissions of local air pollutants that carry significant economic costs through lost worker days, additional health care expenses, and premature mortality. The potential is clearly available for China to be better off economically through the development of an emissions abatement export industry.

This paper provides an overview of this potential drawing from economic research on China conducted by academic, industry, and government analysts from around the world. First, the paper presents a description of the trade-oriented mechanisms in the Kyoto Protocol that will promote capital and technology flows to support emissions abatement. Second, it reviews the extensive literature on the potential economic gains associated with participation in the Kyoto mechanisms. Finally, it describes the potential improvement in public health associated with abating emissions of local air pollutants that usually accompany carbon dioxide abatement.



Joseph E. Aldy
08/31/99 08:57:14 AM

Record Type: Record

To: Leigh L. Linden/CEA/EOP@EOP

cc:

Subject: fact-checking China

Leigh,

Could you look into, or ask John G. to look into the numbers in the paragraph below for the China paper? We ought to confirm these with the World Bank, and it may be useful for ask for these in terms of both market exchange rates and PPP. Thanks,

Joe

Over the past two decades, China has experienced an impressive rate of economic growth. Between 1978 and 1997, the size of the economy increased from the 16th largest to the 7th largest in the world, per capita incomes increased by nearly 400%, and energy consumption grew 112%.

18th

7th

444%

Series Name		1978	1997		
GNP per capita (constant 1995 US\$)	China	150.1077	667.8576		4.449191

(2)

①

Series Name		1978	1997
GDP at market prices (constant 1995 US\$)	United States	4.81E+12	7.79E+12
GDP at market prices (constant 1995 US\$)	Japan	2.98E+12	5.38E+12
GDP at market prices (constant 1995 US\$)	France	1.1E+12	1.59E+12
GDP at market prices (constant 1995 US\$)	United Kingdom	7.92E+11	1.17E+12
GDP at market prices (constant 1995 US\$)	Italy	7.54E+11	1.11E+12
GDP at market prices (constant 1995 US\$)	Brazil	4.44E+11	7.47E+11
GDP at market prices (constant 1995 US\$)	Spain	3.84E+11	5.93E+11
GDP at market prices (constant 1995 US\$)	Canada	3.83E+11	6.12E+11
GDP at market prices (constant 1995 US\$)	Netherlands	2.79E+11	4.24E+11
GDP at market prices (constant 1995 US\$)	Switzerland	2.35E+11	3.13E+11
GDP at market prices (constant 1995 US\$)	Australia	2.17E+11	3.82E+11
GDP at market prices (constant 1995 US\$)	Argentina	2.1E+11	3.2E+11
GDP at market prices (constant 1995 US\$)	Belgium	2.01E+11	2.85E+11
GDP at market prices (constant 1995 US\$)	Mexico	1.92E+11	3.22E+11
GDP at market prices (constant 1995 US\$)	Sweden	1.75E+11	2.37E+11
GDP at market prices (constant 1995 US\$)	Austria	1.55E+11	2.45E+11
GDP at market prices (constant 1995 US\$)	India	1.45E+11	3.78E+11
GDP at market prices (constant 1995 US\$)	China	1.44E+11	8.35E+11

Series Name		1978	1997
GDP at market prices (constant 1995 US\$)	United States	4.81E+12	7.79E+12
GDP at market prices (constant 1995 US\$)	Japan	2.98E+12	5.38E+12
GDP at market prices (constant 1995 US\$)	Germany	..	2.49E+12
GDP at market prices (constant 1995 US\$)	France	1.1E+12	1.59E+12
GDP at market prices (constant 1995 US\$)	United Kingdom	7.92E+11	1.17E+12
GDP at market prices (constant 1995 US\$)	Italy	7.54E+11	1.11E+12
GDP at market prices (constant 1995 US\$)	China	1.44E+11	8.35E+11

(2)

THE KYOTO PROTOCOL
AND THE
PRESIDENT'S POLICIES TO
ADDRESS
CLIMATE CHANGE:

ADMINISTRATION
ECONOMIC ANALYSIS

July 1998

INTRODUCTION

The earth's surface appears to be warming as a result of the accumulation of greenhouse gases from myriad sources worldwide. None of the emitters of these gases currently pays the cost to others of the adverse effects of warming. No individual firm, nor any single country, has an incentive to reduce emissions sufficiently to protect the global environment against climate change. Each has an economic incentive to "free ride" on the efforts of others. Without an international agreement limiting emissions abroad, even if one country sharply reduces its emissions unilaterally, greenhouse gas emissions from all other countries would continue to grow, and the risks posed by climate change would not be significantly reduced. The complex nature of the climate change problem requires global cooperation and a long-term solution.

In June of 1992, the Framework Convention on Climate Change, the first international agreement to address the risks of climate change, was signed during the Earth Summit in Rio de Janeiro. This treaty, ratified by the United States with the advice and consent of the Senate in October 1992, established the following ultimate objective:

"[To achieve] stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner" (Framework Convention on Climate Change, Article 2).

The Framework Convention laid the foundation for international cooperation to reduce emissions of greenhouse gases. The treaty encouraged industrial countries to return their greenhouse gas emissions to their 1990 levels by 2000.

Since the Framework Convention entered into force, the world's scientists have continued to warn of the potential negative environmental and economic effects of climate change. In 1995, the Intergovernmental Panel on Climate Change (IPCC), jointly established by the World Meteorological Organization and the United Nations Environment Programme, and representing the work of more than 2,000 scientists, concluded that "the balance of evidence suggests that there is a discernible human influence on global climate" (Houghton et al. 1996, p. 5). Without measures to abate the expected increase in greenhouse gas emissions over the next century, the IPCC

projected that average global temperatures would increase by 1.8 to 6.3° F (1 to 3.5° C), resulting in coastal damage from rising sea levels, greater frequency of severe weather events, shifts in agricultural growing conditions from changing weather patterns, threats to human health from increased range and incidence of diseases, changes in availability of freshwater supplies, and damage to ecosystems and biodiversity.

To address these climate change risks better and to build on the existing treaty, approximately 160 countries met in ~~Kyoto, Japan in December of 1997~~ and agreed to take substantial steps toward meeting the Convention's ultimate objective. The Kyoto Protocol, which requires the advice and consent of the Senate, would place binding limits on industrial countries' emissions of the six principal types of greenhouse gases: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), sulfur hexafluoride (SF₆), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs). The Protocol embraces several flexible, market-based approaches to allow for the emissions targets to be achieved at least cost. While the Protocol includes some participation by developing countries -- for example, through the Clean Development Mechanism¹ -- it does not currently include adequate participation by key developing countries, and the Administration is working to promote such participation.

7

The Administration will continue its efforts to promote meaningful participation by key developing countries and will work for effective implementation rules for international trading, the Clean Development Mechanism, and joint implementation. The risks of climate change are global and thus they require a global effort. The President will not submit the Kyoto Protocol to the Senate for advice and consent until key developing countries agree to participate meaningfully.

Independent of the agreement reached in Japan, the Administration has proposed a suite of measures to reduce emissions domestically.

- Corresponding to the first stage of the three stage domestic strategy that the President announced in October 1997, the Administration has proposed a five-year, \$6.3 billion package of tax incentives and R&D investments to improve energy efficiency and spur the development of renewable energy; commenced a set of consultations with our energy-intensive sectors aimed at achieving voluntary agreements on reducing greenhouse gas emissions; submitted a proposal for electricity restructuring that will reduce greenhouse gas emissions; and commenced an intensive review of how to improve the Federal government's own energy use and procurement.

¹ For a discussion of the Clean Development Mechanism, see p. 35.

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FULL TEXT OF THE CONVENTION

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The Parties to this Convention,

Acknowledging that change in the Earth's climate and its adverse effects are a common concern of humankind,

Concerned that human activities have been substantially increasing the atmospheric concentrations of greenhouse gases, that these increases enhance the natural greenhouse effect, and that this will result on average in an additional warming of the Earth's surface and atmosphere and may adversely affect natural ecosystems and humankind,

Noting that the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs,

Aware of the role and importance in terrestrial and marine ecosystems of sinks and reservoirs of greenhouse gases,

Noting that there are many uncertainties in predictions of climate change, particularly with regard to the timing, magnitude and regional patterns thereof,

Acknowledging that the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions,

Recalling the pertinent provisions of the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972,

Recalling also that States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction,

Reaffirming the principle of sovereignty of States in international cooperation to address climate change,

Recognizing that States should enact effective environmental legislation, that environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply, and that standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries,

Affirming that responses to climate change should be coordinated with social and economic development in an integrated manner with a view to avoiding adverse impacts on the latter, taking into full account the legitimate priority needs of developing countries for the achievement of sustained economic growth and the eradication of poverty,

(7)

Recognizing that all countries, especially developing countries, need access to resources required to achieve sustainable social and economic development and that, in order for developing countries to progress towards that goal, their energy consumption will need to grow taking into account the possibilities for achieving greater energy efficiency and for controlling greenhouse gas emissions in general, including through the application of new technologies on terms which make such an application economically and socially beneficial,

Determined to protect the climate system for present and future generations,

Have agreed as follows:

ARTICLE 1 DEFINITIONS*

For the purposes of this Convention:

1...."Adverse effects of climate change" means changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare.

2...."Climate change" means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

3...."Climate system" means the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions.

4...."Emissions" means the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time.

5...."Greenhouse gases" means those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation.

6...."Regional economic integration organization" means an organization constituted by sovereign States of a given region which has competence in respect of matters governed by this Convention or its protocols and has been duly authorized, in accordance with its internal procedures, to sign, ratify, accept, approve or accede to the instruments concerned.

7...."Reservoir" means a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored.

8...."Sink" means any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.

9...."Source" means any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere.

* Titles of articles are included solely to assist the reader.

ARTICLE 2 OBJECTIVE

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

ARTICLE 3 PRINCIPLES

In their actions to achieve the objective of the Convention and to implement its provisions, the Parties shall be guided, INTER ALIA, by the following:

1....The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.

2....The specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, and of those Parties, especially developing country Parties, that would have to bear a disproportionate or abnormal burden under the Convention, should be given full consideration.

3....The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into account different socio-economic

(7) (8)

**KYOTO PROTOCOL TO THE
UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE**

The Parties to this Protocol,

*Being Parties to the United Nations Framework Convention on Climate Change,
hereinafter referred to as "the Convention",*

In pursuit of the ultimate objective of the Convention as stated in its Article 2, (7)

Recalling the provisions of the Convention, (7)

Being guided by Article 3 of the Convention,

*Pursuant to the Berlin Mandate adopted by decision 1/CP.1 of the
Conference of the Parties to the Convention at its first session,*

Have agreed as follows:

Article 1

For the purposes of this Protocol, the definitions contained in Article 1 of the Convention shall apply. In addition:

1. "Conference of the Parties" means the Conference of the Parties to the Convention.
2. "Convention" means the United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992.
3. "Intergovernmental Panel on Climate Change" means the Intergovernmental Panel on Climate Change established in 1988 jointly by the World Meteorological Organization and the United Nations Environment Programme.
4. "Montreal Protocol" means the Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in Montreal on 16 September 1987 and as subsequently adjusted and amended.
5. "Parties present and voting" means Parties present and casting an affirmative or negative vote.
6. "Party" means, unless the context otherwise indicates, a Party to this Protocol.
7. "Party included in Annex I" means a Party included in Annex I to the Convention, as may be amended, or a Party which has made a notification under Article 4, paragraph 2(g), of the Convention.

alia, the Intergovernmental Panel on Climate Change and advice provided by the Subsidiary Body for Scientific and Technological Advice, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall regularly review and, as appropriate, revise the global warming potential of each such greenhouse gas, taking fully into account any relevant decisions by the Conference of the Parties. Any revision to a global warming potential shall apply only to commitments under Article 3 in respect of any commitment period adopted subsequent to that revision.

Article 6

8

1. For the purpose of meeting its commitments under Article 3, any Party included in Annex I may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy, provided that:

- (a) Any such project has the approval of the Parties involved;
- (b) Any such project provides a reduction in emissions by sources, or an enhancement of removals by sinks, that is additional to any that would otherwise occur;
- (c) It does not acquire any emission reduction units if it is not in compliance with its obligations under Articles 5 and 7; and
- (d) The acquisition of emission reduction units shall be supplemental to domestic actions for the purposes of meeting commitments under Article 3.

2. The Conference of the Parties serving as the meeting of the Parties to this Protocol may, at its first session or as soon as practicable thereafter, further elaborate guidelines for the implementation of this Article, including for verification and reporting.

3. A Party included in Annex I may authorize legal entities to participate, under its responsibility, in actions leading to the generation, transfer or acquisition under this Article of emission reduction units.

4. If a question of implementation by a Party included in Annex I of the requirements referred to in this Article is identified in accordance with the relevant provisions of Article 8, transfers and acquisitions of emission reduction units may continue to be made after the question has been identified, provided that any such units may not be used by a Party to meet its commitments under Article 3 until any issue of compliance is resolved.

Article 7

1. Each Party included in Annex I shall incorporate in its annual inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol, submitted in accordance with the relevant decisions of the Conference of the Parties, the necessary supplementary information for the purposes of

3. The developed country Parties and other developed Parties in Annex II to the Convention may also provide, and developing country Parties avail themselves of, financial resources for the implementation of Article 10, through bilateral, regional and other multilateral channels.

Article 12

(8)

1. A clean development mechanism is hereby defined.

2. The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.

3. Under the clean development mechanism:

(a) Parties not included in Annex I will benefit from project activities resulting in certified emission reductions; and

(b) Parties included in Annex I may use the certified emission reductions accruing from such project activities to contribute to compliance with part of their quantified emission limitation and reduction commitments under Article 3, as determined by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

4. The clean development mechanism shall be subject to the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to this Protocol and be supervised by an executive board of the clean development mechanism.

5. Emission reductions resulting from each project activity shall be certified by operational entities to be designated by the Conference of the Parties serving as the meeting of the Parties to this Protocol, on the basis of:

(a) Voluntary participation approved by each Party involved;

(b) Real, measurable, and long-term benefits related to the mitigation of climate change; and

(c) Reductions in emissions that are additional to any that would occur in the absence of the certified project activity.

6. The clean development mechanism shall assist in arranging funding of certified project activities as necessary.

7. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, elaborate modalities and procedures with the objective of ensuring transparency, efficiency and accountability through independent auditing and verification of project activities.

8. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall ensure that a share of the proceeds from certified project activities is used to cover administrative expenses as well as to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation.

9. Participation under the clean development mechanism, including in activities mentioned in paragraph 3(a) above and in the acquisition of certified emission reductions, may involve private and/or public entities, and is to be subject to whatever guidance may be provided by the executive board of the clean development mechanism.

10. Certified emission reductions obtained during the period from the year 2000 up to the beginning of the first commitment period can be used to assist in achieving compliance in the first commitment period.

Article 13

1. The Conference of the Parties, the supreme body of the Convention, shall serve as the meeting of the Parties to this Protocol.

2. Parties to the Convention that are not Parties to this Protocol may participate as observers in the proceedings of any session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. When the Conference of the Parties serves as the meeting of the Parties to this Protocol, decisions under this Protocol shall be taken only by those that are Parties to this Protocol.

3. When the Conference of the Parties serves as the meeting of the Parties to this Protocol, any member of the Bureau of the Conference of the Parties representing a Party to the Convention but, at that time, not a Party to this Protocol, shall be replaced by an additional member to be elected by and from amongst the Parties to this Protocol.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall keep under regular review the implementation of this Protocol and shall make, within its mandate, the decisions necessary to promote its effective implementation. It shall perform the functions assigned to it by this Protocol and shall:

(a) Assess, on the basis of all information made available to it in accordance with the provisions of this Protocol, the implementation of this Protocol by the Parties, the overall effects of the measures taken pursuant to this Protocol, in particular environmental, economic and social effects as well as their cumulative impacts and the extent to which progress towards the objective of the Convention is being achieved;

bodies serve as the subsidiary bodies of this Protocol, decisions under this Protocol shall be taken only by those that are Parties to this Protocol.

3. When the subsidiary bodies established by Articles 9 and 10 of the Convention exercise their functions with regard to matters concerning this Protocol, any member of the Bureaux of those subsidiary bodies representing a Party to the Convention but, at that time, not a party to this Protocol, shall be replaced by an additional member to be elected by and from amongst the Parties to this Protocol.

Article 16

The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, as soon as practicable, consider the application to this Protocol of, and modify as appropriate, the multilateral consultative process referred to in Article 13 of the Convention, in the light of any relevant decisions that may be taken by the Conference of the Parties. Any multilateral consultative process that may be applied to this Protocol shall operate without prejudice to the procedures and mechanisms established in accordance with Article 18.

Article 17

The Conference of the Parties shall define the relevant principles, modalities, rules and guidelines, in particular for verification, reporting and accountability for emissions trading. The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article.

Article 18

The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, approve appropriate and effective procedures and mechanisms to determine and to address cases of non-compliance with the provisions of this Protocol, including through the development of an indicative list of consequences, taking into account the cause, type, degree and frequency of non-compliance. Any procedures and mechanisms under this Article entailing binding consequences shall be adopted by means of an amendment to this Protocol.

Article 19

The provisions of Article 14 of the Convention on settlement of disputes shall apply *mutatis mutandis* to this Protocol.

Article 20

1. Any Party may propose amendments to this Protocol.
2. Amendments to this Protocol shall be adopted at an ordinary session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. The text of

IA spreadsheet

Table E1 World Primary Energy Consumption (Btu), 1980-1996
(Quadrillion Btu)

	Country		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	96/80
r7	China	CH	17.215324	16.920433	18.033815	19.506908	21.184943	22.148517	23.240786	24.742171	26.454689	28.936009	28.993609	28.236225	29.304614	31.340961	33.971569	36.345854	37.040317	2.1515899

3

EIA Spreadsheet

Table H1 World Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels, 1980-1996																			
(Million Metric Tons of Carbon)																			
Region	Country	FIPS CODE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Far East and	China	CH	393.0354	399.4443	407.3988	431.5835	467.0873	506.1547	538.1918	573.7599	612.7978	620.3403	619.8883	649.0188	671.7873	709.9303	759.1854	792.3176	804.818

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I. Opportunities to Participate in Kyoto Flexibility Mechanisms

The Kyoto Protocol establishes three mechanisms that, if designed and implemented efficiently, could provide the foundation for a global emissions market. Through international emissions trading (Article 17), joint implementation (Article 6), and the Clean Development Mechanism (Article 12), an emissions reduction would generate emissions credits that have economic value in the international emissions market. ^{① See previous page} Since greenhouse gas emissions have the same climatic consequences regardless of where they occur, the least-cost approach to addressing the risks of climate change would be to reduce emissions wherever such reductions are cheapest. This implies that emissions abatement has the economic property of a commodity, which facilitates the evolution of a market where entities that demand emissions abatement (e.g., those with relatively high abatement costs) can funnel capital and/or technology to suppliers of emissions abatement. In such a market, countries with low emissions abatement costs could take advantage of the opportunity to "produce" emissions abatement and to "export" certified emissions reductions or tradable allowances to other higher-cost countries. Just as in the production of commodities or the sale of financial assets, low-cost producers could attract foreign direct investment to finance their emissions abatement industry. ^{② 1A}

This potential evolution of an international emissions market reflects some of the experiences and lessons learned from the international trade in a variety of financial assets, goods, and services. The concept of gains from trade is basically the same as it is for trade in goods and services. For example, Frankel (1999) notes that developing countries could "specialize in installing clean new-technology power-generation capacity, while industrialized countries specialize in producing the capital goods that go into those plants" (p. 4). ^{③ 1A} Toman et al (1998) also note that "[t]hose countries which find themselves with lower abatement costs and more generous emission ceilings can generate a valuable commodity to export" (p. 3). ^{④ 1A} Thus, developing countries would export emissions abatement, and use their export revenues to import, among other things, these new energy technologies.

The gains from trade in emissions allowances occur as a result of the large differences in marginal abatement costs across countries. ^{⑤ 1A} Weyant and Hill (1999) note that "if the marginal cost in any country participating in a trading regime is higher than in any other participating country, it is advantageous to both countries for the higher cost country to buy emissions rights at a price that is between the two marginal costs" (p. xvii). ^{⑥ 1A} However, before reviewing the estimated marginal costs across countries, it is important to understand how the Kyoto Mechanisms, specifically the Clean Development Mechanism and international emissions trading, could serve as the necessary foundation of an international emissions market.

A. The Clean Development Mechanism

The Clean Development Mechanism (CDM) was incorporated in the Kyoto Protocol to 1) promote sustainable development; 2) contribute to the Framework Convention's climate objective of stabilizing greenhouse gas concentrations at a safe level; and 3) assist the industrialized countries with Kyoto Protocol emissions targets in complying with their commitments (Toman et al 1998). ^{⑦ 1A}

② ③

THE KYOTO PROTOCOL
AND THE
PRESIDENT'S POLICIES TO
ADDRESS
CLIMATE CHANGE:

ADMINISTRATION
ECONOMIC ANALYSIS

July 1998

"Where" Flexibility (International)

Greenhouse gas emissions have the same environmental consequences regardless of where in the world they occur. Therefore, the least-cost approach to controlling climate change is to reduce emissions wherever such reductions are cheapest. The Kyoto Protocol includes three important cost-saving provisions of this nature. (2)

- First, it provides for countries that take on binding targets -- at present the industrial countries -- to trade greenhouse gas emissions allowances with each other (Kyoto Protocol, Article 17, initially referred to as Article 16bis). This market in emissions allowances could ensure that emissions reductions occur where they are least expensive within the industrial countries. In particular, U.S. companies could purchase emissions reductions in other participating countries when doing so would reduce their costs -- thus lowering costs without diminishing the level of environmental protection. It is worth noting that regardless of where the reductions take place, countries and their people will bear the cost of ensuring reductions sufficient to meet their specific Kyoto targets, while everyone will enjoy the environmental benefits.
- Second, the agreement provides for joint implementation by Annex I countries (Kyoto Protocol, Article 6). Thus if some industrial countries do not develop programs to trade allowances internationally, U.S. firms could nonetheless implement projects in those countries for which they could receive emissions reduction credits in the United States.
- Third, the agreement allows industrial countries or firms in those countries, through the Clean Development Mechanism, to invest in "clean development" projects in the developing world and use certified emissions reductions from these projects toward meeting their targets (Kyoto Protocol, Article 12). Investment in these kinds of projects would promote sustainable development in developing countries. Many such clean development projects may be quite inexpensive, measured in terms of the cost per ton of emissions avoided, as has been illustrated by the U.S. joint implementation pilot program. The low cost implies that both developing countries and industrial countries could benefit through these clean development efforts.

Opportunities for Cost-Savings through International Trade in Emissions Allowances

One of the primary principles of classical and neoclassical economics is that trade can make the participating parties better off. In the case of reducing greenhouse gas emissions, trade in emissions allowances could reduce the costs of firms and/or countries with higher abatement costs because they can choose to pay low-cost abaters to further reduce their emissions. Similarly, countries with lower abatement costs are better off by participating in international emissions markets because of the net income they can earn by selling emissions allowances abroad. This is no different from high-cost producers of any good wanting to buy at lower world market prices from willing exporters. If a firm finds it relatively costly to "produce" an emissions reduction, it may find it economically advantageous to purchase emissions from low-cost "producers". An international market for emissions also would create incentives for high-cost producers to innovate and find ways to become low-cost producers, and thus sellers of emissions. A wide range of both formal and anecdotal evidence shows that the flexibility mechanisms, particularly trade in emissions, would allow the world to achieve global emissions reductions at substantially reduced cost. Given the magnitude of the reductions necessary, an effective trading system would be needed to achieve our environmental goals while minimizing the cost and disruption to our people and firms.

The benefits of achieving emissions reductions targets through international trading have been evaluated by numerous economists in the energy modeling community. Barrett (1992), for example, found that stabilizing emissions country-by-country could cost the European Union (E.U.) 50 times as much as stabilizing emissions for the E.U. as a whole. OECD's GREEN model shows that the costs of abatement vary among regions of the globe with comparable emissions targets by a factor of 10 (Burniaux et al. 1992). GREEN also indicates that allowing trade among regions would lower worldwide compliance costs by a factor of two.

The Stanford Energy Modeling Forum (EMF) conducts exercises with a set of energy-economic models to assess hypothetical energy policy scenarios. In the EMF-14 exercise, six models assessed two emissions pathways over the next 100+ years to achieve a 550 ppm carbon dioxide concentration target. For these two emissions pathways, the models calculated the economic costs of reducing emissions with and without international trading. While the magnitude of the cost-savings varied across models, the finding that trading reduces costs among the group of trading partners was very robust. In the six models included in the EMF exercise, international trading reduced the cost of meeting the global emissions targets by nearly 60% (Weyant 1997).



- Office of Communications
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Policy Brief #52 -- June 1999

Greenhouse Gas Emissions

Governments and scholars in developed nations (G7-8) by developing countries should be part of the effort to reduce global climate change. The policy must advance an approach that is binding, measurable, and verifiable. That should be neither so tight as to retard economic development nor so generous as to confer enormous windfall gains. But where in this range should these targets be set? A fair allocation for potential emissions would be the present pattern of emissions reduced by agreed amounts. However, as outlined in the Kyoto Protocol in December 1997, richer countries in effect agreed to make bigger sacrifices (on average) than did poorer ones. Clearly, uncertainties about the future, however, using the agreed quantitative emission targets, would create great risks regarding the ultimate benignity of the target. It would raise concerns that a target could, without other uncertainty, and only unintentionally, retard economic development or, in a worst case, result in emissions greater than in the absence of an agreement. Emissions targets set as a percent of gross domestic product (GDP) might avoid this problem, but would still be subject to the same risks.

By Jeffrey A. Frankel

Many difficulties plague the effort to implement the Kyoto Protocol negotiated in November 1997, and the other steps necessary to reduce global emissions of greenhouse gases in an effort to check global climate change. Probably the most difficult chasm that needs to be bridged is between the United States and developing countries regarding the necessity of participation by the latter in any worldwide global climate change plan.

The Viewpoint from the North

We cannot solve the climate change problem without participation by developing countries. For starters, the U.S. Senate strongly opposes any agreement that omits targets for them. The Senate passed by a vote of 95-0 the Byrd-Hagel resolution, which made commitment by developing countries to emission targets a prerequisite for ratifying the Kyoto treaty.

Meaningful participation by developing countries is essential for several reasons:

- First, a global problem requires a global solution. The problem is inherently one on which an individual country can make little progress on its own. An effective solution requires that all countries agree to participate together.
- Emissions in developing countries are increasing the most rapidly,

Compiled from the Brookings Institution

sacrifices.

It is hard to disagree with these arguments. But I do not believe that the Clinton administration is asking poor countries to forego their economic development. *Meaningful participation during the period 2008-2012 need not entail economic sacrifice by developing countries.*

The Gains from Trade

Industrial countries should pay developing countries for emissions reductions. Under such a system--called targets-with-trading--the developing countries would commit to binding targets for greenhouse gas emissions and then participate in an international system in which permits for emissions are bought and sold. A country or corporation would be able to pay for a permit to exceed its target while other countries receive payment for emissions that fall below their targets. If developing countries were to join a system such as targets-with-trading, it would not only have environmental and economic advantages for the rest of the world; it would also have important environmental and economic benefits for the developing countries themselves. Let us consider a plan under which developing countries do no more than commit to their business-as-usual emission paths in the 2008-2012 budget period and join the trading system.

The first thing to notice is that this system is not going to hurt the developing countries. They have the right in this budget period to emit whatever amount they would have emitted anyway. They need not undertake emission reductions unless a developed-country government or corporation offers to pay them enough to persuade them voluntarily to do so. (The Clinton administration proposes that U.S. participation in international trading of emission permits be undertaken solely by private entities acting voluntarily, not by the government with taxpayer money.)

One anticipates that the governments and corporations of developed countries would indeed offer to pay participating countries enough in the budget period to persuade them voluntarily to reduce emissions below their BAU levels. Otherwise, it could get expensive for the United States, Europe, and Japan to reduce domestic emissions to less than the 1990 levels over the next ten to fourteen years, because it would require major structural changes in these economies in a short span. But the cost of reductions is far lower in developing countries. Thus governments and corporations in industrialized countries will be able to offer terms that make emission reductions economically attractive to developing countries. The economic theory behind the gains from trading emission rights is analogous to the economic theory behind the gains from trading commodities. By doing what they each do most cheaply, both developing and industrialized countries win. In British Economist David Ricardo's classic trade example, Portugal specialized in producing wine and England in producing textiles. In the current context, developing countries specialize, for example, in installing clean new-technology power-generation capacity, while industrialized countries specialize in

③

producing the capital goods that go into those plants.

Why are emissions reductions so much cheaper in developing countries than in rich countries? One major reason is that, in industrialized countries, one would have to scrap coal-fired power plants far in advance of the end of their forty-year useful life, in order to replace them with natural-gas facilities or other cleaner technologies. This would be very expensive to do, because it would mean wasting a huge existing capital stock. In rapidly growing developing countries, on the other hand, it is more a matter of choosing to build cleaner power-generating plants to begin with, instead of building coal-fired plants. In general, when contemplating large increases in future demand for energy, it is good to be able to plan ahead. This includes learning from the mistakes of others that have gone before and taking advantage of their technological advances.

Fossil-Fuel Subsidies

An extreme example of how measures to reduce carbon emissions cost less in developing countries is the case of existing subsidies to fossil fuels, especially coal, which is the most carbon-emitting form of fuel. Eliminating such subsidies would create substantial immediate benefits--fiscal, economic, and environmental--even before counting any benefits under a global climate change agreement. Coal provides the majority of energy in China, for example. A major reason for the heavy use of coal is that it has historically been heavily subsidized. Estimates are that coal subsidies outside the Organization for Economic Cooperation and Development (OECD) totaled from \$37 to \$51 billion from 1991 to 1992. Total fossil fuel subsidies have been much greater--well over \$200 billion in the early 1990s, though smaller now. A 1994 study estimated that removing them would reduce global emissions by 7 percent. A 1995 study estimated that energy subsidies currently act as a negative carbon tax of about \$40 per ton and that global carbon dioxide emissions would be reduced by 4 to 5 percent if all energy subsidies were removed.

China and other Asian countries, Argentina, Brazil, South Africa, and some oil-producing countries reportedly already have reduced the dollar value of such subsidies substantially in recent years. Non-OECD countries cut fossil-fuel subsidies by half from the period 1990-91 to 1995-96. But more progress is needed. Subsidy cuts within a target-and-trade system would pay developing-country governments twice over--once in the form of the money that is saved by eliminating wasteful expenditure and then again in the form of the money that is paid by a developed country for the resulting emission reductions.

Summary of Arguments for Target-and-Trade

It would be useful to get developing countries to agree to binding limits on emissions, even if the targets involved only small (or no) cuts below the level expected were countries to continue with business as usual in the first budget period. Such targets, with trading, imply gains for developed economies, gains for the United States, and gains for the

INTERNATIONAL EMISSIONS TRADING AND THE CLEAN DEVELOPMENT MECHANISM

**Michael Toman, Raymond Kopp
and Marina Cazorla**

Climate Issues Brief No. 13

October 1998

**Resources for the Future
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II. What's So Great About International Emission Trading?

Since emission trading lowers the cost of attaining environmental targets like the Kyoto GHG limits, it avoids the waste of resources. From a political perspective, lower compliance cost makes it politically less difficult to agree to targets.

The cost savings from international GHG trading may be considerable, depending on the amount of gains from trade that the international community allows countries to reap and the organization of the emission reduction markets. Computerized simulation analyses of trading among Annex B countries indicate that under ideal circumstances – no limits on trading volumes and very well-organized markets for emission reductions – the cost savings for the US could be on the order of 50 percent or more. Actual savings are likely to be lower, but the potential still is significant.

A second benefit associated with global emission trading benefit derives from the fact that it separates who pays for emission reductions from who undertakes the reductions. Those countries which find themselves with lower abatement costs and more generous emission ceilings can generate a valuable commodity to export. Emission trading thus can be used to provide financial inducements for participation to those countries that because of lower incomes or other reasons are less eager to join in meeting numerical emission targets. This kind of differentiation was built into the Kyoto Protocol, with Russia and Ukraine even receiving targets in excess of what projected emissions over 2008-2012. In the future, this same approach may lead developing countries to find it advantageous assume national emission limits which provide room for future emissions growth and nearer-term opportunities for emission permit sales to developed countries that generate badly needed investment capital. (4)

III. What's the Downside?

Many criticisms of emission trading are based on philosophical aversion, misunderstanding of the system, or a confusion of means and ends. Some critics believe that it is improper for a rich country to "buy its way" out of its commitments to reduce GHG emissions by purchasing permits from other countries. Some of the debate over supplementarity seems to be based not on the economics of trading, but rather on these philosophical foundations.

A related concern is that if the richer industrialized countries can "get by" through international permits, they will act too slowly to make the long-term changes in their energy and economic systems necessary for sharper future GHG reductions, such as greater energy conservation and more rapid development and spread of new technologies. Whatever the merits of this view (and the thesis is open to debate), it is ultimately a criticism of the emissions targets set for the Annex B countries rather than a criticism of trading per se.

INTRODUCTION AND OVERVIEW

*John P. Weyant and Jennifer N. Hill**

This Special Issue of *The Energy Journal* represents the first comprehensive report on a comparative set of analyses of the economic and energy sector impacts of the Kyoto Protocol on Climate Change. Organized by the Stanford Energy Modeling Forum (EMF), the objectives of this study were the same as for previous EMF studies: (1) identifying policy-relevant insights and analyses that are robust across wide ranges of models, (2) providing explanations for differences in results from different models, and (3) identifying high priority areas for future research. This study has produced a particularly rich set of results in all three areas, which is a tribute to the active participation of the modeling teams and the care each team took in preparing a paper for this volume.

The volume consists of a paper prepared by each modeling team on what it did and what it concluded from the model runs that were undertaken, proceeded by this introduction and summary paper. This summary focuses on the motivation for the study, the design of the study scenarios, and the interpretation of results for the four core scenarios, which all the teams ran. Each succeeding chapter contains ideas and insights drawn by the modeling teams from applying their models to issues they were able to address selected from a small set of important areas on which the group had mutually agreed to focus.

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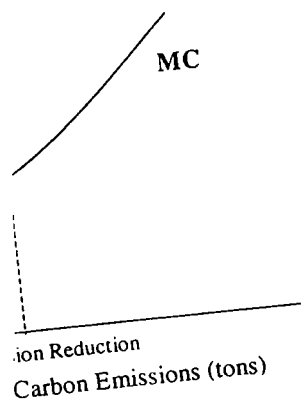
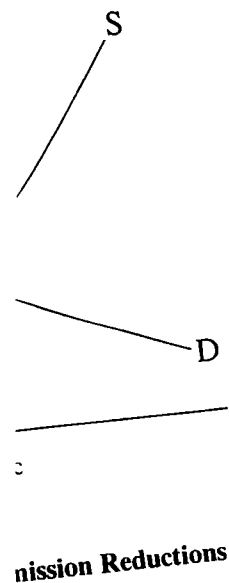
The studies of the Energy Modeling Forum are sponsored by the U.S. Department of Energy, the U.S. Environmental Protection Agency, the Electric Power Research Institute, Mitsubishi Corporation, the New Energy and Industrial Technology Development Organization of Japan, and about 20 corporate affiliates. Besides the authors of the other papers in this volume, we would especially like to thank Campbell Watkins for his enthusiasm about the idea of doing this special issue and his insightful advice at each step in the production process. In addition, we would like to thank Geoff Pearce of the Energy Journal and Dave Williams of the IAEE for going above and beyond the call of duty in making this special issue a reality.

G. Campbell Watkins
Joint Editor
The Energy Journal

The carbon tax resulting from any particular policy is an imperfect measure of the welfare costs (or even the total economic costs) of a particular policy. By integrating under the marginal cost curve we can compute a total resource cost estimate that includes the loss of surplus by consumers who are no longer willing to buy the carbon intensive goods at the new price and producers who no longer find it profitable to produce them. To this we would need to add payments for carbon emission rights or receipts from the sale of them to form a simple cost measure that can be easily understood and compared across models. However, this simple cost measure will generally be different from a more comprehensive measure such as the change in welfare derived from changes in consumers' utility. Divergence between these two cost measures can be attributed to changes in other components that are explicitly included in some models, but not in others, yet contribute to overall changes in economic welfare. Examples of such components include changes in the world price of crude oil, the effect of pre-existing energy taxes, and the manner in which carbon tax revenues are recycled. In addition, some representation of consumers' utilities of consumption and leisure would need to be added to get a consistent and meaningful welfare measure. The size of the carbon tax required is, however, a good indicator of the size of the economic adjustments required to satisfy the requirements of the Protocol under the alternative international emissions trading regimes.

The benefits from international emissions trading result from differences in the marginal cost of reducing emissions between countries. ⁽⁶⁾ If the marginal cost in any country participating in the trading regime is higher than in any other participating country, it is advantageous to both countries for the higher cost country to buy emissions rights from the lower cost country at a price that is between the two marginal costs.⁵ The resulting equilibrium for a simple two country example is shown in Figure 3. Country "a" initially has an emissions reduction obligation of R_a and country "b" an emissions reduction obligation of R_b . Without trading, the carbon tax required to meet the obligations would be T_a in country a and T_b in country b, and the total cost of the emissions reductions would be $A_1 + A_2$ in country a, and B_1 in country b. Since the tax required to meet country b's obligation is lower than that for country a, if trading is allowed it will be possible for country b to sell emission rights to country a at a price of $T_{b,1} = T_{a,1}$, making both countries better off than without trading. The total amount of emissions reductions must be the same with and without trading, so $R_{a,1} + R_{b,1} = R_a + R_b$. Country a's marginal cost curve is now capped at $T_{a,1}$, and country b receives $T_{b,1} \times (R_{b,1} - R_b)$ for emission reductions that cost it $(T_{b,1} - T_b)/2 \times (R_{b,1} - R_b) = B_2$. So the global cost of reducing emissions is reduced from $A_1 + A_2 + B_1$ to $A_1 + B_1 + B_2$ for a reduction of $A_2 - B_2$.

⁵ This is just another example of the gains from trade (c.f., Bhagwati and Scriven, 1983), albeit for a good that is not now traded.



INTERNATIONAL EMISSIONS TRADING AND THE CLEAN DEVELOPMENT MECHANISM

**Michael Toman, Raymond Kopp
and Marina Cazorla**

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THE CLEAN DEVELOPMENT MECHANISM: A PRIMER

Mike Toman and Marina Cazorla, Resources for the Future

I. Introduction

The Clean Development Mechanism (CDM) is one of several "flexibility mechanisms" authorized in the December 1997 Kyoto Protocol to the 1992 United Nations Framework Convention on Climate Change (signed at the Rio de Janeiro "Earth Summit"). The Kyoto Protocol specified legally binding commitments by most industrialized countries to reduce their collective greenhouse gas (GHG) emissions by at least 5% compared to 1990 levels by the period 2008-2012. With the goal of reaching these targets at the lowest possible cost for countries that committed to reductions, the Protocol created two flexibility mechanisms, GHG emissions trading and CDM. The CDM is also intended to be an opportunity for developing countries that did not accept binding emissions reductions at Kyoto to be involved in GHG mitigation.

The second section of this paper introduces the CDM's purpose, mandate and institutional structure as authorized in the Kyoto Protocol. The third section focuses on the principal technical and administrative issues that will arise as the CDM is designed and implemented. The last section discusses some of the main unresolved issues with the CDM that confront the Conference of Parties to the Framework Convention.

II. The Kyoto Protocol and Article 12: Organization and Purpose of the CDM

The CDM was created as a successor to "Joint Implementation" (JI). JI consists of a bilateral agreement between two entities to complete a GHG mitigation project. The investor is from an "Annex B" industrialized country that must reduce its emissions under the Framework Convention. JI potentially can provide credit for emissions abatement to the investor at a lower cost than domestic abatement. In other words, JI is a form of "emissions trading." At the same time, a developing country host can benefit from new investment that increases economic productivity and may reduce local environmental problems. Under the Kyoto Protocol, JI projects still can be undertaken between entities in Annex B industrialized countries (as specified in Articles 3 and 4). However, collaborative projects to reduce emissions or sequester carbon in developing countries are now to occur through the CDM.

Article 12 of the Kyoto Protocol identifies three specific goals for the CDM: (1) to assist in the achievement of sustainable development, (2) to contribute to the attainment of the environmental goals of the Framework Convention, and (3) to assist Annex B parties in complying with their emissions reduction commitments. In particular, Article 12 specifies that developing countries are to benefit from CDM projects resulting in "certified emission reductions" (CERs) and that industrialized countries may use CERs to comply with their quantified emissions reduction commitments under the Kyoto Protocol. Essentially, this allows for voluntary projects similar to previous JI projects between Annex B and non-Annex B countries. The difference is that unlike previous JI projects, CERs are specifically authorized to apply to Annex B emissions reduction targets.

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Developing countries participating in CDM projects do not have their own quantitative emissions targets like developed countries. The CDM allows developed and developing countries to work together to design and implement projects in developing countries that abate greenhouse gas emissions. These projects must undergo a review process to certify that the emissions reductions are real in that total emissions are below what they would have been otherwise. In addition, a portion of the emissions credits generated by the project would support an adaptation fund for low-income countries especially vulnerable to climate change and for administrative costs of the CDM. Under the Buenos Aires Plan of Action, the rules for the Clean Development Mechanism are scheduled to be developed by the sixth Conference of the Parties. (1) 1A (2) 1A (3) 1A (4) 1A (5) 1A

The Clean Development Mechanism effectively incorporates a new factor – the economic value of abating greenhouse gas emissions – for project finance consideration by investors. The emissions abatement certified through the CDM would have economic value because developed countries will demand emissions abatement under the Kyoto Protocol. For example, a U.S. firm may evaluate the opportunity to invest in an energy production project such as an advanced technology coal plant in China. In evaluating this project, one of the critical determinants in the decision to invest in the project is the rate of return to the investor. Without the CDM, the investing firm would assess the traditional financial characteristics associated with the project to calculate the rate of return. With the CDM, the investing firm would also account for the economic value associated with the certified emissions reductions that would accrue from the project going forward. Without CDM, the project may not have a sufficient rate of return to justify investment. However, with the CDM, the project may generate enough economic benefits to justify investment. By including the additional stream of economic benefits associated with abating greenhouse gas emissions, the CDM can leverage investment in clean energy and other greenhouse gas abating projects that would not likely happen otherwise.

However, efforts to promote sustainable development through CDM projects probably would result in a likely volume of capital and technology flows much smaller than that expected for a country with an emissions target that is participating actively in international emissions trading. The CDM carries with it several transaction costs, such as project approval and certification, the adaptation charge, and a charge to cover administrative expenses that together reduce the potential cost-effectiveness of this approach relative to a less-burdened emissions trading system. It should also be noted that developing countries that adopt emissions targets could be able to participate as a host to CDM projects until the beginning of the commitment period, at which time, it would begin to participate in international trading. (6) 1A

In addition to firms in developed and developing countries working together to design and implement specific projects, some have suggested that governments could cooperate to design project “fast-track” processes (Chayes 1998). To reduce some of the transaction costs associated with participating in the CDM, two countries could design a fast-track process that makes the project approval process more transparent to the private sector and simplifies the rules for approval. Others have suggested that smaller CDM projects might be bundled, or that a standard for calculating (7) 1A

**KYOTO PROTOCOL TO THE
UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE**

The Parties to this Protocol,

Being Parties to the United Nations Framework Convention on Climate Change, hereinafter referred to as “the Convention”,

In pursuit of the ultimate objective of the Convention as stated in its Article 2,

Recalling the provisions of the Convention,

Being guided by Article 3 of the Convention,

Pursuant to the Berlin Mandate adopted by decision 1/CP.1 of the Conference of the Parties to the Convention at its first session,

Have agreed as follows:

Article 1

For the purposes of this Protocol, the definitions contained in Article 1 of the Convention shall apply. In addition:

1. “Conference of the Parties” means the Conference of the Parties to the Convention.
2. “Convention” means the United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992.
3. “Intergovernmental Panel on Climate Change” means the Intergovernmental Panel on Climate Change established in 1988 jointly by the World Meteorological Organization and the United Nations Environment Programme.
4. “Montreal Protocol” means the Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in Montreal on 16 September 1987 and as subsequently adjusted and amended.
5. “Parties present and voting” means Parties present and casting an affirmative or negative vote.
6. “Party” means, unless the context otherwise indicates, a Party to this Protocol.
7. “Party included in Annex I” means a Party included in Annex I to the Convention, as may be amended, or a Party which has made a notification under Article 4, paragraph 2(g), of the Convention.

3. The developed country Parties and other developed Parties in Annex II to the Convention may also provide, and developing country Parties avail themselves of, financial resources for the implementation of Article 10, through bilateral, regional and other multilateral channels.

Article 12

1. A clean development mechanism is hereby defined.

2. The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3. (2)

3. Under the clean development mechanism:

(a) Parties not included in Annex I will benefit from project activities resulting in certified emission reductions; and (1)

(b) Parties included in Annex I may use the certified emission reductions accruing from such project activities to contribute to compliance with part of their quantified emission limitation and reduction commitments under Article 3, as determined by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

4. The clean development mechanism shall be subject to the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to this Protocol and be supervised by an executive board of the clean development mechanism.

5. Emission reductions resulting from each project activity shall be certified by operational entities to be designated by the Conference of the Parties serving as the meeting of the Parties to this Protocol, on the basis of: (3) (6)

(a) Voluntary participation approved by each Party involved;

(b) Real, measurable, and long-term benefits related to the mitigation of climate change; and

(c) Reductions in emissions that are additional to any that would occur in the absence of the certified project activity. (5)

6. The clean development mechanism shall assist in arranging funding of certified project activities as necessary.

7. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, elaborate modalities and procedures with the objective of ensuring transparency, efficiency and accountability through independent auditing and verification of project activities.

8. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall ensure that a share of the proceeds from certified project activities is used to cover administrative expenses as well as to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation. ✓

④ ⑥

9. Participation under the clean development mechanism, including in activities mentioned in paragraph 3(a) above and in the acquisition of certified emission reductions, may involve private and/or public entities, and is to be subject to whatever guidance may be provided by the executive board of the clean development mechanism.

10. Certified emission reductions obtained during the period from the year 2000 up to the beginning of the first commitment period can be used to assist in achieving compliance in the first commitment period.

Article 13

1. The Conference of the Parties, the supreme body of the Convention, shall serve as the meeting of the Parties to this Protocol.

2. Parties to the Convention that are not Parties to this Protocol may participate as observers in the proceedings of any session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. When the Conference of the Parties serves as the meeting of the Parties to this Protocol, decisions under this Protocol shall be taken only by those that are Parties to this Protocol.

3. When the Conference of the Parties serves as the meeting of the Parties to this Protocol, any member of the Bureau of the Conference of the Parties representing a Party to the Convention but, at that time, not a Party to this Protocol, shall be replaced by an additional member to be elected by and from amongst the Parties to this Protocol.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall keep under regular review the implementation of this Protocol and shall make, within its mandate, the decisions necessary to promote its effective implementation. It shall perform the functions assigned to it by this Protocol and shall:

(a) Assess, on the basis of all information made available to it in accordance with the provisions of this Protocol, the implementation of this Protocol by the Parties, the overall effects of the measures taken pursuant to this Protocol, in particular environmental, economic and social effects as well as their cumulative impacts and the extent to which progress towards the objective of the Convention is being achieved;

**THE BUENOS AIRES CLIMATE CHANGE CONFERENCE
STATE DEPARTMENT FACT SHEET
DECEMBER 1998**

OVERVIEW

- At a conference held November 2-13, 1998, in Buenos Aires, Argentina, the Parties to the UN Framework Convention on Climate Change agreed to a two-year action plan for advancing the ambitious agenda outlined in the historic Kyoto Protocol. The Protocol commits developed countries to reduce emissions of the greenhouse gases most scientists believe are causing global warming, and provides innovative, market-based tools for achieving those reductions. [See box].
- The Buenos Aires conference (known also as the "Fourth Session of the Conference of the Parties" or "CoP-4") also saw a significant breakthrough on the issue of developing country participation in international efforts to address climate change. Argentina became the first developing country to announce its intention to take on a binding emissions target for the 2008-2012 time period. Kazakhstan announced that it intended to do so as well.
- During the Buenos Aires conference, on November 12, 1998, the United States signed the Kyoto Protocol at the United Nations in New York. Signing reaffirms the United States' commitment to work with other nations to meet the Protocol's ambitious environmental goals and ensures a continued strong U.S. role in settling issues left unresolved at Kyoto. Signing does *not* impose an obligation on the United States to implement the Kyoto Protocol. (The Protocol cannot become binding on the United States without the approval of the United States Senate.) The President will not submit the Protocol to the U.S. Senate for approval without the meaningful participation of key developing countries in efforts to address climate change.

SUMMARY OF ACCOMPLISHMENTS

BUENOS AIRES ACTION PLAN

- By securing a plan of action with a deadline for developing key aspects of the operational framework of the Kyoto Protocol, the United States achieved one of its primary diplomatic objectives in Buenos Aires.
- In the Buenos Aires action plan, the Parties resolved to reach decisions by the end of 2000 on a number of key issues, including:
 - Rules and guidelines for Kyoto's market-based mechanisms (e.g., emissions trading, joint implementation, and the Clean Development Mechanism);
 - Compliance rules and procedures, including consequences for non-compliance;
 - Development and transfer of cleaner, climate-friendly technologies; and
 - Consideration of the adverse impacts of climate change and response measures.

5

**A SUGGESTED MODEL FOR IMPLEMENTING THE
CLEAN DEVELOPMENT MECHANISM**

**ABRAM CHAYES
(ASSISTED BY AMANDA COHEN, KAREN FILIPOVICH
AND ALASTAIR ILES)**

E-98-07

JULY 1998

Board, where parties would have the opportunity to challenge the findings of the auditors. When its review is completed, the Executive Board would forward the project report, auditor's report and its own recommendations to the COP for final action. Funding for the audit process would be a project expense.

6. Granting of GHG abatement credits

Based on the project report, the auditor's report and the Executive Board recommendations, the COP would certify the emissions reductions eligible for use by the investing Annex I country in accordance with Article 12. There would be no need to allocate credits among private investors within the investor countries. This distribution process would instead be handled individually by participating countries through a domestic emissions trading system or other incentive devices as discussed in section C(1) below. In order to attract private investors to back clean development projects, however, it is clearly necessary that participating countries have functioning domestic incentive systems based on the value of the credits the country has received from the CDM project.

B. The Umbrella Agreement

We conceive that the U.S.-China Clean Development Program and other future CDM efforts would be initiated by an umbrella agreement, concluded by the participating countries at the highest levels and outlining the scope, objectives and basic principles and practices of the program. These agreements would streamline the identification, planning and approval process for potential CDM projects, significantly reducing transaction costs and lowering bureaucratic hurdles. For the U.S.-China program proposed here, the umbrella agreement would state that the object of the program is to promote U.S. private investment in China's power industry, on mutually agreeable and beneficial terms, in order to reduce the industry's GHG emissions below those projected on the basis of existing Chinese technology.

7

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7

Divider Title: _____

emission reductions might be employed to further reduce transaction costs.

B. International Emissions Trading

Articles 3 and 17 of the Kyoto Protocol allow countries with binding targets to meet their targets by participating in international emissions trading.¹ These binding targets take the form of an "assigned amount" – the number of metric tons of greenhouse gases that may be emitted by sources within the country during the five-year commitment period running from 2008 through 2012. In emissions trading, one country transfers part of its assigned amount to another. This transfer of assigned amount lowers the number of tons of greenhouse gases that the first country may emit between 2008 and 2012, and raises the number of tons that the second country may emit by an equal amount. It is useful to think of each one-ton unit of assigned amount as a tradable allowance for one ton of emissions that may be transferred between countries.

Because the cost of controlling greenhouse gases differs by large amounts from country to country, emissions trading will allow substantial gains from trade in meeting the Kyoto targets. Countries that have relatively inexpensive ways to control greenhouse gases have incentives to reduce emissions by more than their targets require, because they can sell tradable allowances that they will not need. Countries facing the most expensive emissions abatement measures have incentives to buy less costly allowances from others. Since greenhouse gases are global pollutants, the environmental impact of reducing them is the same no matter where the reductions take place. The same overall reduction is achieved, total costs are reduced, and both buyers and sellers gain from the savings allowed by trading. As a result, the international community will be able to afford greater emissions reductions over the longer term while countries selling allowances will receive additional financial in-flows to assist in their economic development.

A country that wants to increase the number of tons of greenhouse gases that it is allowed to emit would seek out other countries that are willing to sell some of their tradable allowances. Buying and selling countries could arrange their transactions directly or use brokers or exchanges. Because of the voluntary nature of trading, a selling country would engage in a trading transaction only if it makes that country better off.

In addition to trading at the governmental level, some countries (including the United States) plan to use both domestic and international emissions trading at the company level as part of their program to meet their Kyoto Protocol commitments. Companies and other legal entities subject to these domestic trading programs (integrated with the international trading system) would have strong incentives to look constantly for innovative ways to abate their greenhouse gas emissions. Those who found inexpensive opportunities to abate their emissions could sell the allowances they do not need

¹ These countries with binding targets include most OECD countries, several eastern European countries, and some former Soviet Union countries. This set of countries is often referred to as Annex I countries. All other countries in the world are often referred to as Non-Annex I countries in the climate policy context.

**KYOTO PROTOCOL TO THE
UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE**

The Parties to this Protocol,

*Being Parties to the United Nations Framework Convention on Climate Change,
hereinafter referred to as “the Convention”,*

In pursuit of the ultimate objective of the Convention as stated in its Article 2,

Recalling the provisions of the Convention,

Being guided by Article 3 of the Convention,

*Pursuant to the Berlin Mandate adopted by decision 1/CP.1 of the
Conference of the Parties to the Convention at its first session,*

Have agreed as follows:

Article 1

For the purposes of this Protocol, the definitions contained in Article 1 of the Convention shall apply. In addition:

1. “Conference of the Parties” means the Conference of the Parties to the Convention.
2. “Convention” means the United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992.
3. “Intergovernmental Panel on Climate Change” means the Intergovernmental Panel on Climate Change established in 1988 jointly by the World Meteorological Organization and the United Nations Environment Programme.
4. “Montreal Protocol” means the Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in Montreal on 16 September 1987 and as subsequently adjusted and amended.
5. “Parties present and voting” means Parties present and casting an affirmative or negative vote.
6. “Party” means, unless the context otherwise indicates, a Party to this Protocol.
7. “Party included in Annex I” means a Party included in Annex I to the Convention, as may be amended, or a Party which has made a notification under Article 4, paragraph 2(g), of the Convention.

Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, consider ways to facilitate such cooperation, taking into account all relevant information.

2. The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively.

3. The Parties included in Annex I shall strive to implement policies and measures under this Article in such a way as to minimize adverse effects, including the adverse effects of climate change, effects on international trade, and social, environmental and economic impacts on other Parties, especially developing country Parties and in particular those identified in Article 4, paragraphs 8 and 9, of the Convention, taking into account Article 3 of the Convention. The Conference of the Parties serving as the meeting of the Parties to this Protocol may take further action, as appropriate, to promote the implementation of the provisions of this paragraph.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol, if it decides that it would be beneficial to coordinate any of the policies and measures in paragraph 1(a) above, taking into account different national circumstances and potential effects, shall consider ways and means to elaborate the coordination of such policies and measures.

Article 3

1. The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.

2. Each Party included in Annex I shall, by 2005, have made demonstrable progress in achieving its commitments under this Protocol.

3. The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I. The greenhouse gas emissions by sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 and 8.

4. Prior to the first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol, each Party included in Annex I shall provide, for consideration by the Subsidiary Body for Scientific and Technological Advice, data to establish its level of carbon

stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how, and which, additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories shall be added to, or subtracted from, the assigned amounts for Parties included in Annex I, taking into account uncertainties, transparency in reporting, verifiability, the methodological work of the Intergovernmental Panel on Climate Change, the advice provided by the Subsidiary Body for Scientific and Technological Advice in accordance with Article 5 and the decisions of the Conference of the Parties. Such a decision shall apply in the second and subsequent commitment periods. A Party may choose to apply such a decision on these additional human-induced activities for its first commitment period, provided that these activities have taken place since 1990.

5. The Parties included in Annex I undergoing the process of transition to a market economy whose base year or period was established pursuant to decision 9/CP.2 of the Conference of the Parties at its second session shall use that base year or period for the implementation of their commitments under this Article. Any other Party included in Annex I undergoing the process of transition to a market economy which has not yet submitted its first national communication under Article 12 of the Convention may also notify the Conference of the Parties serving as the meeting of the Parties to this Protocol that it intends to use an historical base year or period other than 1990 for the implementation of its commitments under this Article. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall decide on the acceptance of such notification.

6. Taking into account Article 4, paragraph 6, of the Convention, in the implementation of their commitments under this Protocol other than those under this Article, a certain degree of flexibility shall be allowed by the Conference of the Parties serving as the meeting of the Parties to this Protocol to the Parties included in Annex I undergoing the process of transition to a market economy.

7. In the first quantified emission limitation and reduction commitment period, from 2008 to 2012, the assigned amount for each Party included in Annex I shall be equal to the percentage inscribed for it in Annex B of its aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A in 1990, or the base year or period determined in accordance with paragraph 5 above, multiplied by five. Those Parties included in Annex I for whom land-use change and forestry constituted a net source of greenhouse gas emissions in 1990 shall include in their 1990 emissions base year or period the aggregate anthropogenic carbon dioxide equivalent emissions by sources minus removals by sinks in 1990 from land-use change for the purposes of calculating their assigned amount.

8. Any Party included in Annex I may use 1995 as its base year for hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, for the purposes of the calculation referred to in paragraph 7 above.

9. Commitments for subsequent periods for Parties included in Annex I shall be established in amendments to Annex B to this Protocol, which shall be adopted in accordance

with the provisions of Article 21, paragraph 7. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall initiate the consideration of such commitments at least seven years before the end of the first commitment period referred to in paragraph 1 above.

10. ~~Any emission reduction units, or any part of an assigned amount, which a Party acquires from another Party in accordance with the provisions of Article 6 or of Article 17, shall be added to the assigned amount for the acquiring Party.~~

(1) (3)

11. Any emission reduction units, or any part of an assigned amount, which a Party transfers to another Party in accordance with the provisions of Article 6 or of Article 17 shall be subtracted from the assigned amount for the transferring Party.

12. Any certified emission reductions which a Party acquires from another Party in accordance with the provisions of Article 12 shall be added to the assigned amount for the acquiring Party.

13. If the emissions of a Party included in Annex I in a commitment period are less than its assigned amount under this Article, this difference shall, on request of that Party, be added to the assigned amount for that Party for subsequent commitment periods.

14. Each Party included in Annex I shall strive to implement the commitments mentioned in paragraph 1 above in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention. In line with relevant decisions of the Conference of the Parties on the implementation of those paragraphs, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, consider what actions are necessary to minimize the adverse effects of climate change and/or the impacts of response measures on Parties referred to in those paragraphs. Among the issues to be considered shall be the establishment of funding, insurance and transfer of technology.

Article 4

1. Any Parties included in Annex I that have reached an agreement to fulfil their commitments under Article 3 jointly, shall be deemed to have met those commitments provided that their total combined aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of Article 3. The respective emission level allocated to each of the Parties to the agreement shall be set out in that agreement.

2. The Parties to any such agreement shall notify the secretariat of the terms of the agreement on the date of deposit of their instruments of ratification, acceptance or approval of this Protocol, or accession thereto. The secretariat shall in turn inform the Parties and signatories to the Convention of the terms of the agreement.

bodies serve as the subsidiary bodies of this Protocol, decisions under this Protocol shall be taken only by those that are Parties to this Protocol.

3. When the subsidiary bodies established by Articles 9 and 10 of the Convention exercise their functions with regard to matters concerning this Protocol, any member of the Bureaux of those subsidiary bodies representing a Party to the Convention but, at that time, not a party to this Protocol, shall be replaced by an additional member to be elected by and from amongst the Parties to this Protocol.

Article 16

The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, as soon as practicable, consider the application to this Protocol of, and modify as appropriate, the multilateral consultative process referred to in Article 13 of the Convention, in the light of any relevant decisions that may be taken by the Conference of the Parties. Any multilateral consultative process that may be applied to this Protocol shall operate without prejudice to the procedures and mechanisms established in accordance with Article 18.

Article 17

The Conference of the Parties shall define the relevant principles, modalities, rules and guidelines, in particular for verification, reporting and accountability for emissions trading. The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article.

Article 18

The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, approve appropriate and effective procedures and mechanisms to determine and to address cases of non-compliance with the provisions of this Protocol, including through the development of an indicative list of consequences, taking into account the cause, type, degree and frequency of non-compliance. Any procedures and mechanisms under this Article entailing binding consequences shall be adopted by means of an amendment to this Protocol.

Article 19

The provisions of Article 14 of the Convention on settlement of disputes shall apply *mutatis mutandis* to this Protocol.

Article 20

1. Any Party may propose amendments to this Protocol.
2. Amendments to this Protocol shall be adopted at an ordinary session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. The text of

(4)

**KYOTO PROTOCOL TO THE
UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE**

The Parties to this Protocol,

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6. "Party" means, unless the context otherwise indicates, a Party to this Protocol.
7. "Party included in Annex I" means a Party included in Annex I to the Convention, as may be amended, or a Party which has made a notification under Article 4, paragraph 2(g), of the Convention.

Party	<u>Quantified emission limitation or reduction commitment</u> (percentage of base year or period)
Australia	108
Austria	92
Belgium	92
Bulgaria*	92
Canada	94
Croatia*	95
Czech Republic*	92
Denmark	92
Estonia*	92
European Community	92
Finland	92
France	92
Germany	92
Greece	92
Hungary*	94
Iceland	110
Ireland	92
Italy	92
Japan	94
Latvia*	92
Liechtenstein	92
Lithuania*	92
Luxembourg	92
Monaco	92
Netherlands	92
New Zealand	100
Norway	101
Poland*	94
Portugal	92
Romania*	92
Russian Federation*	100
Slovakia*	92
Slovenia*	92
Spain	92
Sweden	92
Switzerland	92
Ukraine*	100
United Kingdom of Great Britain and Northern Ireland	92
United States of America	93

* Countries that are undergoing the process of transition to a market economy.

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**WHAT'S NEW?
THE SECRETARIAT
PROGRAMMES**

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SITE INFO
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ADVANCED SEARCH**

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FULL TEXT OF THE CONVENTION

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The Parties to this Convention,

Acknowledging that change in the Earth's climate and its adverse effects are a common concern of humankind,

Concerned that human activities have been substantially increasing the atmospheric concentrations of greenhouse gases, that these increases enhance the natural greenhouse effect, and that this will result on average in an additional warming of the Earth's surface and atmosphere and may adversely affect natural ecosystems and humankind,

Noting that the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs,

Aware of the role and importance in terrestrial and marine ecosystems of sinks and reservoirs of greenhouse gases,

Noting that there are many uncertainties in predictions of climate change, particularly with regard to the timing, magnitude and regional patterns thereof,

Acknowledging that the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions,

Recalling the pertinent provisions of the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972,

Recalling also that States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction,

Reaffirming the principle of sovereignty of States in international cooperation to address climate change,

Recognizing that States should enact effective environmental legislation, that environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply, and that standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries,

1....At any time after three years from the date on which the Convention has entered into force for a Party, that Party may withdraw from the Convention by giving written notification to the Depositary.

2....Any such withdrawal shall take effect upon expiry of one year from the date of receipt by the Depositary of the notification of withdrawal, or on such later date as may be specified in the notification of withdrawal.

3....Any Party that withdraws from the Convention shall be considered as also having withdrawn from any protocol to which it is a Party.

ARTICLE 26 AUTHENTIC TEXTS

The original of this Convention, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary- General of the United Nations.

IN WITNESS WHEREOF the undersigned, being duly authorized to that effect, have signed this Convention.

DONE at New York this ninth day of May one thousand nine hundred and ninety- two.

ANNEX I AND ANNEX II COUNTRIES

Annex I

Annex I

Australia
Austria
Belarus a/
Belgium
Bulgaria a/
Canada
Czechoslovakia a/
Denmark
European Economic Community
Estonia a/
Finland
France
Germany
Greece
Hungary a/
Iceland
Ireland
Italy
Japan
Latvia a/

(4)

Lithuania a/
Luxembourg
Netherlands
New Zealand
Norway
Poland a/
Portugal
Romania a/
Russian Federation a/
Spain
Sweden
Switzerland
Turkey
Ukraine a/
United Kingdom of Great Britain and Northern Ireland
United States of America

a/ Countries that are undergoing the process of transition to a market economy.

Annex II

Australia
Austria
Belgium
Canada
Denmark
European Economic Community
Finland
France
Germany
Greece
Iceland
Ireland
Italy
Japan
Luxembourg
Netherlands
New Zealand
Norway
Portugal
Spain
Sweden
Switzerland
Turkey
United Kingdom of Great Britain and Northern Ireland
United States of America

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U.S. Views

Greenhouse Gas Emissions Trading: A Country's- and Company's-Eye View

The Kyoto Protocol combines ambitious greenhouse gas reduction targets with innovative market-based mechanisms to help country Parties achieve those targets at the lowest possible cost. Recognizing that reducing greenhouse gas emissions is many times more expensive in some countries than in others, the Protocol allows the Parties to use "emissions trading" and other flexibility mechanisms to meet their commitments at much reduced cost. This paper describes how emissions trading would work, from the perspective of a country, and from the perspective of companies and other legal entities.

How Will Emissions Trading Work?

The Kyoto Protocol establishes binding greenhouse gas emissions targets for 38 countries. These targets take the form of an "assigned amount" — the number of metric tons of greenhouse gases (counted as carbon dioxide equivalent) that may be emitted by sources within the country during the five-year commitment period running from 2008 through 2012. Each country must make sure that its emissions during the five-year period do not exceed its assigned amount.

Articles 3 and 17 of the Kyoto Protocol allow countries with binding targets to lower the cost of meeting their targets by participating in international emissions trading. In emissions trading, one country transfers part of its assigned amount to another. This transfer of assigned amount lowers the number of tons of greenhouse gases that the first country may emit between 2008 and 2012, and raises the number of tons that the second country may emit by an equal amount. It is useful to think of each one-ton unit of assigned amount as a *tradeable allowance* for one ton of emissions that may be transferred between countries.

Because the cost of controlling greenhouse gases differs by many times from country to country, emissions trading will allow enormous savings in meeting the Kyoto targets. Countries that have relatively inexpensive ways to control greenhouse gases have incentives to reduce emissions by more than their targets

require, because they can sell tradeable allowances that they will not need to others. Countries facing the most expensive control measures have incentives to buy less costly allowances from others, and thereby increase the amount they may emit. Since greenhouse gases are global pollutants, the environmental impact of reducing them is the same no matter where the reductions take place. The same overall reduction is achieved, total costs are reduced, and both buyers and sellers gain from the savings allowed by trading.

While countries can benefit by engaging in emissions trading at the government-to-government level, far more savings are possible if countries also authorize their legal entities (companies, individuals, NGOs, etc.) to trade. The cost of controlling greenhouse gas emissions varies dramatically between companies both within the same country, and across borders. The private sector can be much more effective than governments in finding the lowest cost emission reduction opportunities. The greatest savings can come if private sector companies with the ability to reduce emissions are allowed to buy and sell allowances with other companies in the same country and with companies in other countries.

How Would a Country Engage in Emissions Trading?

Trading rules should require a country that wants to trade to have the necessary capacity and infrastructure to *measure and report* on its

emissions of greenhouse gases, according to the requirements of Articles 5 and 7 of the Protocol. In addition, the rules should require the country to establish a *national registry* — a computerized system to record who holds tradeable allowances; to keep track of changes in allowance holdings due to emissions trading; and to show which allowances have already been used to cover past emissions (these would be permanently retired) and which remain available to be used against future emissions.¹

A country that wants to increase the number of tons of greenhouse gases that it is allowed to emit could seek out other countries that are willing to sell some of their tradeable allowances. Buying and selling countries could arrange their transactions directly or use brokers or exchanges. Trades would be accomplished by removing allowances from the national registry of the selling country and adding them to the national registry of the buying country.

Trading rules should require each country to report to the Secretariat for the Framework Convention on Climate Change in Bonn at least once each year on the trades it has conducted and the appropriate increases or decreases in its assigned amount. These reports would be in addition to the annual reports countries must make to the Secretariat on their greenhouse gas emissions. Together, this information would serve as the starting point for determining whether a country had met its commitment to keep emissions within its assigned amount, as adjusted up or down by trading.

The emissions trading rules could be structured to give countries strong incentives to comply with basic requirements of the Protocol.

¹ Allowances would be identified by serial numbers and country of origin. Those that have been used to cover emissions would be marked in the user country's registry as permanently retired. Those not yet used could be kept for use later in the five-year period, traded to other countries, or "banked" for the country's use in the next commitment period.

For example, a country that came out of compliance with the Article 5 and 7 measurement and reporting rules, or that failed to maintain its national registry, could lose its eligibility to trade. The prospect of losing the savings available from trading could be a strong inducement to keep buyer countries in compliance. Likewise, the prospect of losing investment revenue could be a strong encouragement for seller countries to remain in compliance.

How Would a Private Company Engage in Emissions Trading?

In addition to trading at the governmental level, some countries plan to use both domestic and international emissions trading at the company level as part of their program to meet their Kyoto commitments. The highly successful U.S. acid rain program, established in 1990, is a model for how a domestic greenhouse gas trading program could work. The acid rain program sets a strict limit on the total national emissions of sulfur dioxide allowed from electric power plants. There is a fixed number of emission allowances available each year, each one permitting the emission of one ton of sulfur dioxide. These allowances were allocated to power plant owners.² Emissions are rigorously monitored, and at the end of each year each plant owner must turn back to the government enough allowances to cover its emissions during the year.

The sulfur dioxide allowances can be bought and sold. Companies facing high emission control costs have the flexibility to choose their own compliance strategies. They can reduce their emissions by enough to match their allowance allocation (e.g., by installing

² A country can distribute allowances in several ways: They can be auctioned to the highest bidders, or they can be allocated (given out) by a variety of formulas to the companies that the country makes responsible for emissions, to consumers, or to others.

pollution controls, switching to cleaner fuels, or improving efficiency). They can also choose to purchase more allowances. Companies with inexpensive opportunities to reduce emissions below their allocations can sell allowances they do not need. A national registry records all allowance holdings and trades, and shows which allowances have been used and which remain available for future use. Electric utilities, brokers, and private individuals, have accounts in the registry recording their allowance holdings, purchases, and sales. Some allowances have even been purchased by school children and environmentalists, who have taken them "off the market" to further reduce emissions.

The results speak for themselves. Sulfur dioxide emissions are being cut about 30 percent more rapidly than expected, bringing cleaner air to millions of Americans. And the total costs of the acid rain program are now projected to be well under half of original expectations.

Countries could establish similar domestic emissions trading programs for greenhouse gases. While private companies and other legal entities would be able to hold and trade allowances, the country would remain fully responsible for compliance with Kyoto commitments. All legal entity holdings would be recorded in the country's national registry. In setting up their domestic programs, countries would have to address many issues, including which sectors to include in the emissions trading system and which to address through other policies. Other issues include how to distribute allowances (allocation or auction?), and how frequently to require emitters to turn them in (every year, or only at the end of the five-year period?). But the potential savings would make the effort well worthwhile.

Companies and other legal entities subject to these programs would have strong incentives to look constantly for innovative ways to control their greenhouse gas emissions. Those who found inexpensive opportunities to reduce their emissions could sell the allowances they do not need to other companies who face higher

costs. These tangible rewards for innovation should result in a steady stream of cost-saving breakthroughs and new technologies.

A country's domestic emissions trading program would also connect seamlessly with the international emissions trading system, using the same system of national registries to keep track of every allowance traded. An international trade between legal entities of different countries would be carried out by moving the traded allowances from the account of the selling entity in the registry of one country, to the account of the buying entity in the registry of the other country. By buying and selling allowances not only within the same country, but also across borders, companies and other legal entities would dramatically reduce the overall cost of meeting the agreed Kyoto targets.

And that is the key to success in meeting the ambitious commitments made in Kyoto, and sustaining and strengthening our efforts to protect the global climate over the coming decades.

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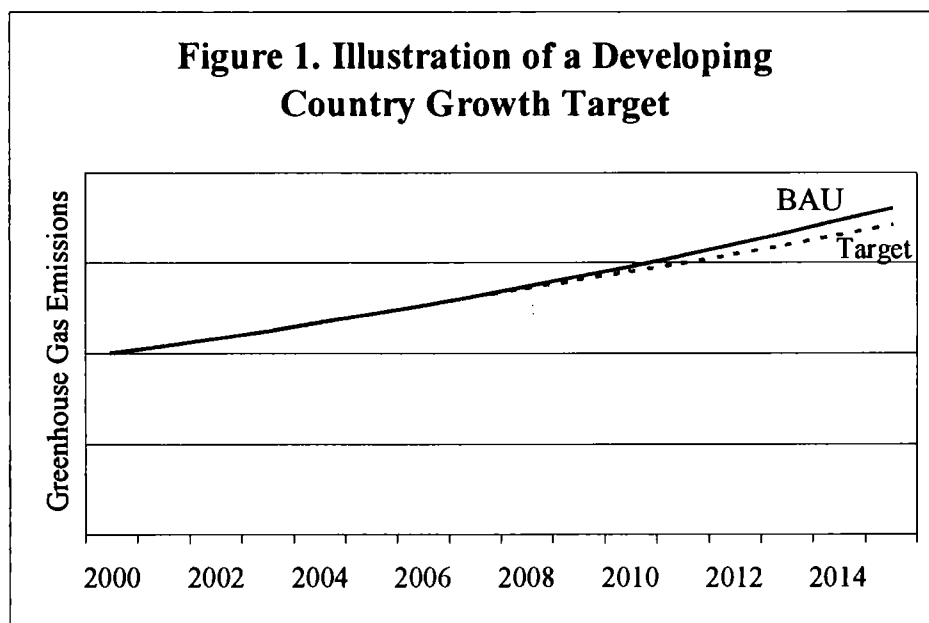
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to other companies or countries who face higher costs. Further, some companies that have climate-friendly technology may find it cost-effective to transfer this technology to facilities in a low-cost abatement country in return for tradable allowances. Countries selling emissions allowances will, therefore, not only benefit from new financial flows but also from increased technology transfer. These tangible rewards for innovation should provide the incentive for research and development and subsequent technological breakthroughs (Petsonk et al 1998).

As stated above, the Kyoto Protocol stipulates that countries must have an emissions target to engage in international emissions trading. Since the Kyoto Conference, several developing countries have expressed an interest in emissions targets. Consistent with the Framework Convention on Climate Change, targets for developing countries should help promote their sustainable development. To do so, such targets should accommodate emissions growth. Unlike targets currently set in the Kyoto Protocol, which were set below most countries' current emissions levels, such a target for developing countries could be set above current emissions levels. To contribute to the international effort to address climate change risks, such targets must result in real abatement of emissions below levels that would otherwise occur during the commitment period – that is, below the projected business as usual (BAU) emissions level.² This kind of target, often referred to as an emissions growth target, could provide for continued economic development but with a lower emissions growth rate.

If developing countries were to agree to binding limits, even if they involved only small cuts below BAU in the first budget period, then such targets, with trading, would imply gains for their economies



² The term "business as usual emissions level" as used in this paper is synonymous with the term "reference emissions level."

Joe

Market **mechanisms**

& Global **climate change**

An Analysis of Policy Instruments

Annie Petsonk

Daniel J. Dudek

Joseph Goffman

ENVIRONMENTAL
DEFENSE FUND

IN COOPERATION
WITH THE PEW
CENTER ON GLOBAL
CLIMATE CHANGE



PEW CENTER
ON
Global CLIMATE
CHANGE

Trading, in contrast, provides direct feedback to firms about their compliance with environmental performance targets at the same time that it requires sources to internalize pollution costs. Trading thus creates competitive demand for cost-effective compliance.

Properly designed emissions trading markets can capitalize on the common interests of nations, emissions sources, and the public to provide incentives to meet and exceed environmental and economic performance goals. Properly designed emissions trading programs can:

- increase environmental effectiveness,
- reduce compliance costs,
- create financial rewards for environmental performance,
- tap existing expertise in the search for new solutions, and
- create incentives for new technologies, processes, and environmental management.

A few straightforward steps can achieve these results. First, a limit must be placed on total emissions from each major source over a specified period of time. Second, sources must report their overall emissions. Third, any source that reduces its emissions below its limit may transfer or assign the unused increment of allowable emissions to another source; the other source may emit above its limit by that same amount, using the transferor's extra allowable emissions. The result is that the total emissions from the two sources remains constant.

By giving sources the flexibility, and the incentive, to produce emissions reductions cost-effectively, emissions trading harnesses entrepreneurial energy and deploys it to solve pollution problems. In most industrialized nations, the vast bulk of the money spent ameliorating environmental problems comes from the private sector, or from government corporations operating in market conditions. Emissions trading programs aim to ensure that when environmental expenditures are made, markets apply the forces of competition and innovation to grind down costs.

B. Five Essential Elements for Environmental and Economic Integrity

The key to the success of trading programs is defining and quantifying, in a transparent, consistent manner, what constitutes an extra, transactable reduction. Five elements are essential for emissions trading markets to operate with environmental and economic integrity.

THE FIVE KEY ELEMENTS FOR MARKET INSTRUMENTS

1. **Measurement.** Quantify emissions—including "extra" allowable emissions—accurately.
2. **Transparency.** Make reporting and program operation publicly available.
3. **Accountability.** Hold participants accountable for meeting their goals.
4. **Fungibility.** Minimize constraints on transactions.
5. **Consistency.** Apply fixed rules objectively and automatically.

THE BUENOS AIRES CLIMATE CHANGE CONFERENCE
STATE DEPARTMENT FACT SHEET
DECEMBER 1998

OVERVIEW

- At a conference held November 2-13, 1998, in Buenos Aires, Argentina, the Parties to the UN Framework Convention on Climate Change agreed to a two-year action plan for advancing the ambitious agenda outlined in the historic Kyoto Protocol. The Protocol commits developed countries to reduce emissions of the greenhouse gases most scientists believe are causing global warming, and provides innovative, market-based tools for achieving those reductions. [See box].
- The Buenos Aires conference (known also as the "Fourth Session of the Conference of the Parties" or "CoP-4") also saw a significant breakthrough on the issue of developing country participation in international efforts to address climate change. Argentina became the first developing country to announce its intention to take on a binding emissions target for the 2008-2012 time period. Kazakhstan announced that it intended to do so as well. (2)
- During the Buenos Aires conference, on November 12, 1998, the United States signed the Kyoto Protocol at the United Nations in New York. Signing reaffirms the United States' commitment to work with other nations to meet the Protocol's ambitious environmental goals and ensures a continued strong U.S. role in settling issues left unresolved at Kyoto. Signing does *not* impose an obligation on the United States to implement the Kyoto Protocol. (The Protocol cannot become binding on the United States without the approval of the United States Senate.) The President will not submit the Protocol to the U.S. Senate for approval without the meaningful participation of key developing countries in efforts to address climate change.

SUMMARY OF ACCOMPLISHMENTS

BUENOS AIRES ACTION PLAN

- By securing a plan of action with a deadline for developing key aspects of the operational framework of the Kyoto Protocol, the United States achieved one of its primary diplomatic objectives in Buenos Aires.
- In the Buenos Aires action plan, the Parties resolved to reach decisions by the end of 2000 on a number of key issues, including:
 - Rules and guidelines for Kyoto's market-based mechanisms (e.g., emissions trading, joint implementation, and the Clean Development Mechanism);
 - Compliance rules and procedures, including consequences for non-compliance;
 - Development and transfer of cleaner, climate-friendly technologies; and
 - Consideration of the adverse impacts of climate change and response measures.

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FULL TEXT OF THE CONVENTION

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The Parties to this Convention,

Acknowledging that change in the Earth's climate and its adverse effects are a common concern of humankind,

Concerned that human activities have been substantially increasing the atmospheric concentrations of greenhouse gases, that these increases enhance the natural greenhouse effect, and that this will result on average in an additional warming of the Earth's surface and atmosphere and may adversely affect natural ecosystems and humankind,

Noting that the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs,

Aware of the role and importance in terrestrial and marine ecosystems of sinks and reservoirs of greenhouse gases,

Noting that there are many uncertainties in predictions of climate change, particularly with regard to the timing, magnitude and regional patterns thereof,

Acknowledging that the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions,

Recalling the pertinent provisions of the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972,

Recalling also that States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction,

Reaffirming the principle of sovereignty of States in international cooperation to address climate change,

Recognizing that States should enact effective environmental legislation, that environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply, and that standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries,

Affirming that responses to climate change should be coordinated with social and economic development in an integrated manner with a view to avoiding adverse impacts on the latter, taking into full account the legitimate priority needs of developing countries for the achievement of sustained economic growth and the eradication of poverty,

Recognizing that all countries, especially developing countries, need access to resources required to achieve sustainable social and economic development and that, in order for developing countries to progress towards that goal, their energy consumption will need to grow taking into account the possibilities for achieving greater energy efficiency and for controlling greenhouse gas emissions in general, including through the application of new technologies on terms which make such an application economically and socially beneficial,

Determined to protect the climate system for present and future generations,

Have agreed as follows:

ARTICLE 1 DEFINITIONS*

For the purposes of this Convention:

1...."Adverse effects of climate change" means changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare.

2...."Climate change" means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

3...."Climate system" means the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions.

4...."Emissions" means the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time.

5...."Greenhouse gases" means those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation.

6...."Regional economic integration organization" means an organization constituted by sovereign States of a given region which has competence in respect of matters governed by this Convention or its protocols and has been duly authorized, in accordance with its internal procedures, to sign, ratify, accept, approve or accede to the instruments concerned.

7...."Reservoir" means a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored.



Framework Convention
on Climate Change

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Third session
Kyoto, 1-10 December 1997
Agenda item 5

**KYOTO PROTOCOL TO THE
UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE**

The Parties to this Protocol,

*Being Parties to the United Nations Framework Convention on Climate Change,
hereinafter referred to as "the Convention",*

In pursuit of the ultimate objective of the Convention as stated in its Article 2,

Recalling the provisions of the Convention,

Being guided by Article 3 of the Convention,

*Pursuant to the Berlin Mandate adopted by decision 1/CP.1 of the
Conference of the Parties to the Convention at its first session,*

Have agreed as follows:

Article 1

For the purposes of this Protocol, the definitions contained in Article 1 of the Convention shall apply. In addition:

1. "Conference of the Parties" means the Conference of the Parties to the Convention.

UKY.97-

Article 3

1. The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012. (4)
2. Each Party included in Annex I shall, by 2005, have made demonstrable progress in achieving its commitments under this Protocol.
3. The net changes in greenhouse gas emissions from sources and removals by sinks resulting from direct human-induced land use change and forestry activities, limited to afforestation, reforestation, and deforestation since 1990, measured as verifiable changes in stocks in each commitment period shall be used to meet the commitments in this Article of each Party included in Annex I. The greenhouse gas emissions from sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 and 8.
4. Prior to the first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol, each Party included in Annex I shall provide for consideration by the Subsidiary Body for Scientific and Technological Advice data to establish its level of carbon stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how and which additional human-induced activities related to changes in greenhouse gas emissions and removals in the agricultural soil and land use change and forestry categories, shall be added to, or subtracted from, the assigned amount for Parties included in Annex I, taking into account uncertainties, transparency in reporting, verifiability, the methodological work of the Intergovernmental Panel on Climate Change, the advice provided by the Subsidiary Body for Scientific and Technological Advice in accordance with Article 5 and the decisions of the Conference of the Parties. Such a decision shall apply in the second and subsequent commitment periods. A Party may choose to apply such a decision on these additional human-induced activities for its first commitment period, provided that these activities have taken place since 1990.
5. The Parties included in Annex I undergoing the process of transition to a market economy whose base year or period was established pursuant to decision 9/CP.2 of the Conference of the Parties at its second session, shall use that base year or period for the implementation of their commitments under this Article. Any other Party included in Annex I undergoing the process of transition to a market economy which has not yet submitted its first national communication under Article 12 of the Convention may also notify the

Annex B

<u>Party</u>	<u>Quantified emission limitation or reduction commitment</u> (percentage of base year or period)
Australia	108
Austria	92
Belgium	92
Bulgaria*	92
Canada	94
Croatia*	95
Czech Republic*	92
Denmark	92
Estonia*	92
European Community	92
Finland	92
France	92
Germany	92
Greece	92
Hungary*	94
Iceland	110
Ireland	92
Italy	92
Japan	94
Latvia*	92
Liechtenstein	92
Lithuania*	92
Luxembourg	92
Monaco	92
Netherlands	92
New Zealand	100
Norway	101
Poland*	94
Portugal	92
Romania*	92
Russian Federation*	100
Slovakia*	92
Slovenia*	92
Spain	92
Sweden	92
Switzerland	92
Ukraine*	100
United Kingdom of Great Britain and Northern Ireland	92
United States of America	93

* Countries that are undergoing the process of transition to a market economy.

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and gains for the environment. Figure 1 provides an illustration of an emissions growth target. Such a target could be expressed as some percentage of a base year, in a similar fashion to current Kyoto Protocol targets, but perhaps with a different base year and/or a percentage greater than 100% to account for emissions growth.

An emissions target could also take alternative forms. Some have expressed concerns about the uncertainty associated with BAU emissions projections (Baumert et al 1999). A country that takes on a commitment for the 2008-2012 period that is fixed *now*, faces the risk, for example, that its economy will grow more rapidly than expected, resulting in an inadvertently stringent target. Alternatively, a country's economy could grow less rapidly than expected, resulting in an inadvertently lax target. There are, however, ways of designing targets to reduce uncertainty and mitigate these risks. In particular, targets could be indexed to future values of economic and other, possibly demographic, variables.

A target could, for example, be indexed to a country's economic performance between now and the start of the 2008-2012 commitment period (Frankel 1999). This approach is used in the private sector, where contracts are frequently indexed to various economic variables. This approach is also used in the public sector (e.g., the U.S. government provides cost-of-living adjustments for social security recipients). A target could then be specified in a way that depends on the future values of economic variables, such as GDP. For example, Baumert et al (1999) have argued for a carbon-to-GDP intensity measure as an appropriate form of developing country commitment. Zhang (1999) also discussed a greenhouse gas emissions per unit GDP measure as the basis for a voluntary commitment by China around 2020.

Such targets would avoid the risk of inadvertent stringency associated with higher than projected economic growth between now and the beginning of the commitment period in 2008. Developing countries would face only the much smaller risk that emissions would be higher than expected, *given* the economic conditions realized in 2007. Similarly, such targets would also avoid the risk of inadvertent laxness associated with lower than expected economic growth between now and the start of the commitment period.



WHAT MIGHT A DEVELOPING COUNTRY CLIMATE COMMITMENT LOOK LIKE?

BY KEVIN A. BAUMERT, RUCHI BHANDARI, AND NANCY KETE

International climate change negotiations have stalemated over the timing and nature of developing country commitments. This is both unfortunate and unnecessary. The Climate Convention itself makes clear that developing and industrialized countries have "common but differentiated" responsibilities to meet the Convention's goals. While the North has focused on common responsibilities, the South has focused on differentiated responsibilities. The purpose of this Climate Note is to examine voluntary participation by developing countries under an approach that reintegrates the two facets of the common but differentiated principle.¹

Most developing countries argue that making commitments now to reduce or limit greenhouse gas (GHG) emissions is incompatible with existing national priorities, such as economic development or improving living standards. Many believe that industrialized countries (Annex I) should make and keep the first round of commitments

under the Framework Convention on Climate Change (FCCC) and the Kyoto Protocol before asking developing countries (non-Annex I) to do more. Industrialized countries must act first, they argue, because they are more responsible for the historical buildup of GHGs in the atmosphere and have per capita emissions many times higher than those of developing countries.² Furthermore, contrary to popular perceptions, even without formal commitments, developing countries are already taking significant steps to rein in GHG emissions.³ The policies and measures behind these largely unrecognized improvements have required leadership and entailed political cost for which these countries deserve recognition.

In pressing for voluntary commitments from developing countries, the United States and other industrialized countries frequently invoke the fact that Annex I countries alone cannot achieve the ultimate objective of the climate convention—preventing dangerous interference with the cli-

KEY FINDINGS

- Modeling developing country climate commitments after industrialized country commitments poses environmental dangers, given the uncertainty of future emission levels and the international emissions trading provisions in the Kyoto Protocol.
- A greenhouse gas intensity indicator is a measure of sustainable development that addresses the real climate challenge in developing countries—decoupling economic growth and emissions growth. The Clean Development Mechanism can also help address this challenge.
- If a developing country is contemplating a voluntary commitment under the climate treaty, other measures such as greenhouse gas intensity could provide a better standard.
- The lack of accurate and comprehensive data on greenhouse gas emissions (including emissions from land-use change) impairs any discussion of developing country commitments.



mate system. Indeed, effectively addressing a global problem like climate change does require a global solution. However, neither the United States, nor any other country, has yet offered a policy approach for treaty participation that effectively accommodates the development priorities of non-Annex I countries.

The stalemate stems, at least in part, from a default assumption evident in the current political debate that a developing country commitment would take the same basic form as an Annex I commitment—a limitation on the *absolute level* of GHG emissions. Of course, one key difference is assumed—a developing country commitment would likely be expressed as a growth cap set at some level *above* the country's current emission level, while Annex I commitments collectively cap emissions at 5.2 percent *below* historical levels, with some variations among countries. This is problematic for several reasons.

For a developing country that is not yet ready to implement the set of measurement, reporting, and verification requirements of industrialized countries, a quantitative binding commitment is not likely to be appropriate or desirable. In fact, for a developing country experiencing high or volatile rates of economic growth, binding growth caps may be highly inappropriate. Yet, developing countries are being urged to make voluntary commitments expressed as growth caps so that they can

participate in international emissions trading under the Kyoto Protocol. Given the inherent uncertainty of estimating future emissions, growth caps for developing countries raise serious environmental concerns over how many emissions might be added to the collective Annex I cap, and whether significant GHG reductions will ever actually take place in industrialized countries.

Fortunately, developing country participation under the Protocol or Convention can take a different approach. Because most developing countries are not currently in a position to make *absolute* emission reductions, the most immediate and realistic challenge is lowering the *greenhouse gas intensity* of their economies. Thus, rather than measuring the absolute amount of a country's emissions, the GHG intensity indicator provides a more realistic and practical framework for participation by expressing the emissions that an economy generates *per unit of output*. This can be expressed as:

$$\text{GHG intensity indicator} = \frac{\text{GHG emissions}}{\text{gross domestic product}}$$

Given the *voluntary* character of new commitments, developing countries could choose the form of commitment that is most environmentally sound and compatible with domestic priorities. For countries that wish to make “soft,”

nonbinding commitments, a GHG intensity indicator is an effective way to benchmark national progress on climate change. This measure might even help shape their priorities for the Clean

The challenge for most developing countries is not to reduce absolute emission levels but to lower the greenhouse gas intensity of their economies.

Development Mechanism. For countries that wish to make binding commitments—already agreed to in principle by Argentina and Kazakhstan—commitments could still take the form of an intensity-based measure, such as a carbon intensity indicator, without losing the ability to engage in emissions trading. This would entail voluntarily accepting a set of binding obligations, including some limit on the future GHG intensity of the economy. In either case—binding or nonbinding—a GHG intensity indicator may be a useful approach for many developing countries in furthering both sustainable development and Climate Convention objectives.

LESSONS FROM THE KYOTO PROTOCOL: WHAT DO WE ALREADY KNOW?

Country experiences, in relation to formulations already agreed to under the Kyoto Protocol, can help shape our preliminary thoughts on whether An-





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Policy Brief #52 -- June 1999

Greenhouse Gas Emissions

Greenhouse gas emissions are increasing at a rapid pace, and the world is facing a serious threat to the environment. The Kyoto Protocol, signed in November 1997, is the first international agreement to set targets for reducing greenhouse gas emissions. However, the United States and other developed countries have not ratified the protocol, and many developing countries are not participating in the effort to reduce emissions. This is a serious problem because greenhouse gas emissions are a major cause of global warming, which is expected to have significant impacts on the environment and human health. The United States and other developed countries have a responsibility to lead by example and to encourage other countries to participate in the effort to reduce emissions. The Kyoto Protocol is a first step, but it is not enough. We need a global agreement that sets targets for all countries and that includes mechanisms for enforcing the targets. The United States and other developed countries should work to ratify the Kyoto Protocol and to encourage other countries to do the same. We should also work to develop a global agreement that sets targets for all countries and that includes mechanisms for enforcing the targets.

Many difficulties plague the effort to implement the Kyoto Protocol negotiated in November 1997, and the other steps necessary to reduce global emissions of greenhouse gases in an effort to check global climate change. Probably the most difficult chasm that needs to be bridged is between the United States and developing countries regarding the necessity of participation by the latter in any worldwide global climate change plan.

The Viewpoint from the North

We cannot solve the climate change problem without participation by developing countries. For starters, the U.S. Senate strongly opposes any agreement that omits targets for them. The Senate passed by a vote of 95-0 the Byrd-Hagel resolution, which made commitment by developing countries to emission targets a prerequisite for ratifying the Kyoto treaty.

Meaningful participation by developing countries is essential for several reasons:

- First, a global problem requires a global solution. The problem is inherently one on which an individual country can make little progress on its own. An effective solution requires that all countries agree to participate together.
- Emissions in developing countries are increasing the most rapidly,

Common and Consistent Sense from the Brookings Institution

Resolving Concerns about Target Stringency

Governments of developing countries worry that the uncertainty surrounding their forecasted economic performance is so great that they cannot risk adopting an emissions target in 1999 that would be binding in 2008. Even if a particular numerical target appears beneficial now, after a decade it might turn out to be something different. A response to this concern would be to structure international agreements on developing-country targets to reduce the risk of being inadvertently restrictive. Agreements should be designed to reduce the possibility of a target so stringent as to cause large economic losses to the developing countries or as to constrain economic development.

Environmentalists have also expressed a counter concern, that a target may be too lax. They fear that such a target might fail to result in actual emissions reductions relative to what would have happened in the absence of a treaty. Thus, it is desirable to mitigate the risk of inadvertent stringency while also mitigating the risk of inadvertent laxity--to narrow the variability of the effective restrictions without relaxing or tightening the intended target.

My proposal would be to index targets for developing countries. The international agreement would look like a contract under which the numerical emission target depends, in a defined manner, on future variables whose values are as yet undetermined. (An example is the cost-of-living adjustment agreements in a labor contract. It specifies certain wage increases for each increase in the Consumer Price Index, thus reducing uncertainty over *real* wages.) Future economic growth rates are probably the biggest source of uncertainty. Forecasts of GDP among East Asian countries, for example, are already very different now from what they were in 1997, and will again look different in 2007. A simple format would index a country's aggregate emissions to future income alone. (Other possible proposals include in the formula other variables like population or temperature.)

More specifically, for every percentage point in GDP growth that is higher or lower than forecast, the emissions target is raised or lowered by a corresponding amount. The specified adjustment in emissions could be a bit less than proportionate. This proposal would require countries that are doing a bit better than expected to contribute more than those that are not, again maintaining the principle of progressivity, without penalizing them unduly for their success.

Indexation is one possible approach to removing some of the economic uncertainty that holds back commitment to a quantitative emission target. Another possible idea, suitable for any country that is willing to implement its program for meeting its targets via a carbon tax or tradeable permit system, is an *escape clause* or *safety valve*, which eases the quantitative limit when the price of carbon threatens to rise above a pre-agreed threshold. These solutions to the uncertainty problem would

Is China Taking Actions to Limit its Greenhouse Gas Emissions?

Past Evidence and Future Prospect¹

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Summary: As the world's second largest carbon emitter, China has long been criticised as a "free-rider" enjoying benefits from other country's efforts towards abating greenhouse gas emissions but without taking due responsibilities of its own. It has been singled out as the major target at the subsequent negotiations after the Kyoto curtain had fallen. By analyzing the historical contributions of inter-fuel switching, energy conservation, economic growth and population expansion to China's CO₂ emissions during the period 1980-97, this article first indicates that the above criticism cannot hold its ground. Then the article envisions some efforts and commitments that could be expected from China until its per capita income catches up with the level of middle-developed countries. With their focus on the win-win strategies, these efforts and commitments could be unlikely to severely jeopardize the Chinese economic development and, at the same time, give China more leverage at the post-Kyoto climate change negotiations.

1. Introduction

In December 1997, 160 countries reached a historical agreement on limiting greenhouse gas emissions in Kyoto. In comparison with the United Nations Framework Convention on Climate Change (UNFCCC) at the Earth Summit in June 1992 that only committed Annex I countries to "aim" to stabilize emissions of carbon dioxide (CO₂) and other greenhouse gases at their 1990 levels by 2000, the so-called Kyoto Protocol sets legally binding emissions targets and timetables for these countries. Together, they must reduce their emissions of six greenhouse gases by at least 5% below 1990 levels over the commitment period 2008-2012, with the European Union (EU), the United States (US) and Japan required to reduce their emissions of such gases by 8%, 7% and 6% respectively (UNFCCC, 1997). This Protocol will become effective once it is ratified by at least 55 parties representing at least 55% of the total CO₂ emissions of Annex I Parties in the year 1990.

The binding emissions targets set at Kyoto for Annex I countries, although far short of what developing countries called for, may give them some "moral" right to persuade developing countries to take meaningful mitigation action. There is no doubt that securing meaningful participation from key developing countries will

¹ This article will appear in J. Goldemberg and W. Reid (editors), Promoting Development while Limiting Greenhouse Gas Emissions, United Nations Development Programme, New York.

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environment, it is not unwise to propose an explicit value for energy or carbon intensity of the economy as a starting point for negotiations. In this regard, there is a pressing need for comprehensive analysis of quantifying the economic implications of climate change for China. For a long time, the Chinese government has claimed and continues to claim that asking for China to take actions would seriously harm China's economic development. But, until now, there has been no one comprehensive study indicating what the economic effects of possible future carbon limits are for China, for example, in terms of foregone national income. By providing the convincing findings that China would be the region hardest hit by carbon limits, such a study not only helps to convince the world of the Chinese government's claim, but also is to China's advantage in bargaining a possible targeted energy or carbon intensity with other countries.

The fourth option would be that China would voluntarily commit itself to an emissions cap on a particular sector at some point around or beyond 2020. Taking on such a commitment, although already burdensome for China, raises the US concern about the carbon leakage from the sector to those sectors whose emissions are not capped.

~~The leads to the final option that China could offer. It is a combination of the targeted energy or carbon intensity with an emissions cap on a particular sector at some point around or beyond 2020. This is the bottom line, and China can not afford to go beyond that until its per capita income catches up with the level of middle-developed countries..~~

3.4 Combating global climate change is in China's interest

Because economic development still remains the priority for China, its climate policy would focus on the so-called win-win strategies. With this in mind, the above efforts and commitments proposed for China do not go beyond the scope of taking no-cost or low-cost "no-regrets" actions. Although the last three commitments are more stringent than the first two ones, none of them could be likely to severely jeopardize the Chinese economic development. Indeed, taking due responsibilities in combating global climate change should be in China's interest on the following grounds.

First, because climate-sensitive sectors such as agriculture still account for a much larger proportion of GDP in China than in the developed countries (see Table 5), China is even more vulnerable to climate change than the developed countries. Therefore, a broad commitment to global efforts towards limiting GHG emissions would reduce the potential damage from climate change in China itself, since after all it is not only the developed countries whose climate will change if GHG emissions are not reduced.

Second, China is scarce in energy, with per capital energy endowments far below the world average (see Table 11). Although energy consumption per unit of output in China has been cut in half since 1980, its major industries continue to use energy far more intensively than in industrialized countries (see Table 12). By making the above commitments, China will be pushed for a more efficient use of its scarce energy resources.

Third, driven by the threat of further degradation of the environment¹⁸ and the harmful economic effects of energy shortages, China is already determined to push energy conservation and enhanced energy efficiency in general and more efficient coal usage in particular. While taking such drastic domestic efforts, China badly needs assistance and economic and technical cooperation with the developed countries, because of very large amounts of capital and technical expertise required. In this regard, the CDM, if designed appropriately, could provide an opportunity for China to get increased access to more advanced energy efficiency and pollution control technologies and additional funding.

Table 11 Proved reserves and utilization rates of fossil fuels in China in 1997

¹⁸ Existing estimates for the economic costs of China's environmental degradation vary, depending on the comprehensiveness of the estimates. For example, using the measure of willingness to pay, the World Bank (1997b) has estimated that air and water pollution cost China about 8% of its GDP, around \$ 54 billion annually, while Smil (1996) puts China's environmental damages between 5.5% and 9.8% of its GNP.

Therefore, efforts towards effectively communicating what have been achieved in China to the outside world will help to correct a much distorted picture that had been painted for China.

On the other hand, while insisting on its legitimate demand for industrialized countries to provide adequate technology transfer and financing, and demanding that emissions targets beyond the first commitment period be set for Annex I countries in the subsequent negotiations over new additional developing country's commitments, China could propose and direct negotiations, rather than just react and respond. In proposing its voluntary efforts and commitments, China should bear in mind that demanding for the "equal per capita entitlements" is politically unrealistic at the time span we are considering, although it is perfectly justified on grounds that all human beings are born equal and that the atmosphere is the global common. On the other hand, the US demand for imposing a cap on China's future emissions is absolutely not acceptable for China either until its per capita income catches up with the level of middle-developed countries. For the reasons, we consider neither "equal per capita entitlements" or an absolute cap on national emissions is realistic. We envision the following five proposals could be put on the table as China's plausible negotiation position, which are each described in the order of their stringency.

First, just as Article 3.2 requires Annex I countries to "have made demonstrable progress" in achieving their commitments by 2005, China could commit itself to demonstrate efforts towards slowing its GHG emissions growth at some point between the first commitment period and 2020. Securing the undefined "demonstrable progress" regarding China's efforts is the best option that China should fight for at and beyond the fourth COP in Buenos Aires.

Second, if China could not resist the US demand that the above commitment is not really "meaningful", it could give in a little by making voluntary commitments to specific policies and measures to limit GHG emissions at some point between the first commitment period and 2020. Policies and measures might need to be developed to explicitly demonstrate whether or not China has made adequate efforts. Such policies and measures might include abolishing energy subsidies, improving the efficiency of energy use, promoting renewable energies, and increasing the R&D spending on developing environmentally sound coal technologies.

China should resort to all means of securing either of the above deals. It could even lobby for support from the EU and therefore put collective pressure on the US.¹⁶ If all the attempts were unsuccessful, China might resort to the last three options.

Third, China could make an voluntary commitment to total energy consumption or total GHG emissions per unit of GDP at some point around or beyond 2020.¹⁷ Such commitment will still allow China to grow economically while improving the environment. It is in line with the UNFCCC which has included the developing country's need for further development and economic growth as a basic element. The industrialized countries, particularly the US, have no reasons or rights to argue against it. Otherwise this will conflict with their claim that asking China's involvement in combating global climate change is not to limit its capacity to industrialize, reduce poverty and raise the standards of living rather wants China to grow in a more environmentally sound way. Even if the Chinese government has claimed that China will in any event continue its efforts towards improving energy efficiency and minimizing further degradation of the

¹⁶ In the run up to Kyoto, the following two points distinguish the EU from the US. In comparison with the US demand for developing countries to agree to cuts in GHG emissions in the same timeframe as industrialized countries, the EU has made clear that developing countries need not to promise at Kyoto to make cuts, although they should be persuaded to do so at a later date. Moreover, by permitting a 30-40% increase in emissions to Greece and Portugal, the EU proposal for international community burden-sharing accepts that poorer countries should be treated more leniently, whereas the US has been opposed to differentiated emissions targets until it has to give up its opposition at Kyoto. If Greece and Portugal can have this sort of rise, it would be very difficult for the EU to reject the demand from the really poor, that is, developing countries, for a not unreasonable leeway in emissions.

¹⁷ Carbon intensity of the economy is preferred to energy intensity of the economy because all the efforts towards shifting away from high-carbon energy are awarded by the former.

Calculation of the Cost-of-Living Adjustment



The Social Security Act specifies a formula for determining the amount of the automatic cost-of-living adjustment or COLA. For December 1998, the percentage benefit increase is equal to the percentage increase in the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) since the most recent "cost-of-living computation quarter." (4)

By law, the third calendar quarter of 1997 was a cost-of-living computation quarter. The average CPI-W for this quarter (the most recent such quarter) was 157.9. The average CPI-W for the new cost-of-living computation quarter (the third calendar quarter of 1998) is 160.0. The computation of these averages from the monthly CPI-W is shown below:

Month	1997 CPI-W	1998 CPI-W
July	157.5	159.8
August	157.8	160.0
September	158.3	160.2
Total	473.6	480.0
Average (rounded to the nearest 0.1)	157.9	160.0

The percentage increase in the CPI-W from the third quarter of 1997 through the third quarter of 1998 is 1.3 percent. The calculation of this percentage increase is as follows (rounded to the nearest one-tenth of one percent): $(160.0 - 157.9)/157.9 \times 100 = 1.3$. Thus the COLA for December 1998 is 1.3 percent.

Legislation enacted in 1983 may limit the COLA if the combined assets of the Social Security trust funds are below 20 percent of annual expenditures. Such limitation has not occurred in the past, nor does it affect the current COLA determination. The combined trust fund assets at the beginning of 1998 are estimated to be 171.2 percent of 1998 expenditures.

Effect of COLA on Social Security Benefits

The automatic cost-of-living adjustment (COLA) for December 1998 is 1.3 percent. The COLA is first payable in January 1999. The table below shows the impact of the 1.3-percent increase on the average benefits payable to selected types of Social Security beneficiaries or families for December 1998:

Type of benefit or family	Before COLA	After 1.3% COLA	Increase
All retired workers	\$769.68	\$779.69	\$10.01
Aged couple	1,293.55	1,310.37	16.82
Widowed mother and 2 children	1,536.30	1,556.27	19.97
Aged widow(er) alone	739.38	748.99	9.61
Disabled worker, spouse, and one or more children	1,202.92	1,218.56	15.64
All disabled workers	723.67	733.08	9.41

Benefits payable to a person who retires in 1999, based on hypothetical, steady earnings at low, average, high, or maximum levels are also available.

History of Automatic Cost-Of-Living Adjustments

Automatic benefit increases, also known as cost-of-living adjustments or **COLAs**, have been in effect since 1975. The 1975-82 **COLAs** were effective with Social Security benefits payable for June in each of those years; thereafter **COLAs** have been effective with benefits payable for December. **COLAs** for 1975-1998 are shown below.

Year	COLA	Year	COLA	Year	COLA
1975	8.0%	1985	3.1%	1995	2.6%
1976	6.4%	1986	1.3%	1996	2.9%
1977	5.9%	1987	4.2%	1997	2.1%
1978	6.5%	1988	4.0%	1998	1.3%
1979	9.9%	1989	4.7%		
1980	14.3%	1990	5.4%		
1981	11.2%	1991	3.7%		
1982	7.4%	1992	3.0%		
1983	3.5%	1993	2.6%		
1984	3.5%	1994	2.8%		

The first automatic **COLA**, for June 1975, was based on the increase in the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) from the second quarter of 1974 to the first quarter of 1975. The 1976-82 **COLAs** were based on increases in the CPI-W from the first quarter of the prior year to the corresponding quarter of the current year in which the **COLA** became effective. After 1982, **COLAs** have been based on increases in the CPI-W from the third quarter of the prior year to the corresponding quarter of the current year in which the **COLA** became effective.

Return links:

Introductory page on [automatic increases](#)
Office of the Chief Actuary [Home Page](#).

*Office of the Chief Actuary
Social Security Administration
December 15, 1998*

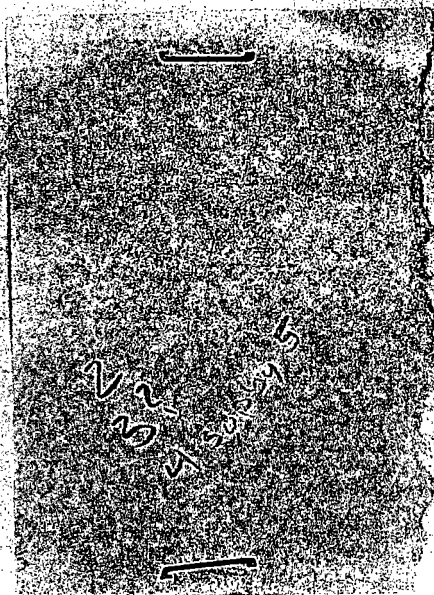
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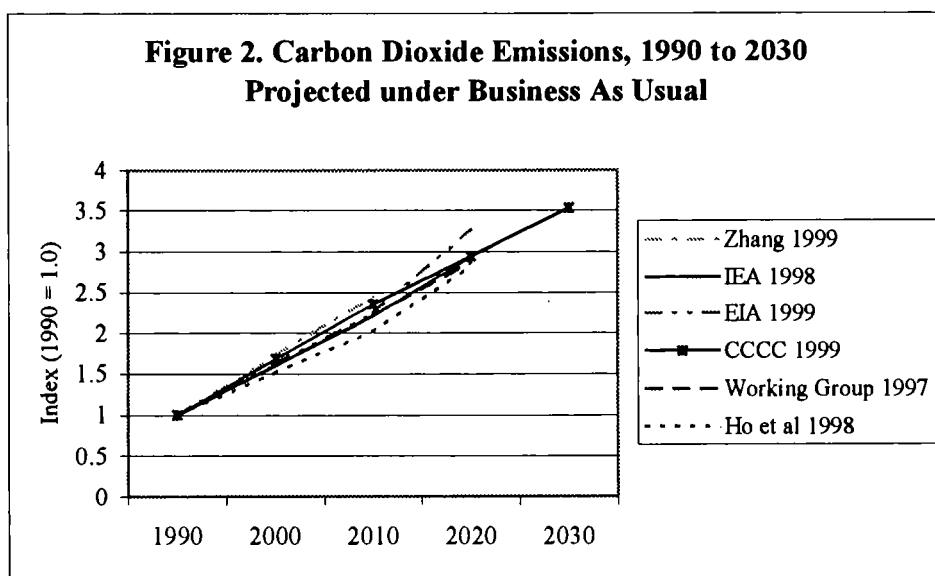


II. Economic Gains from the Clean Development Mechanism and Emissions Trading

A variety of economic models have been developed throughout the world that can evaluate the potential economic gains from trade in emissions allowances. These economic tools effectively model trade in emissions as if they were any other internationally tradable commodity where both production costs and demand vary across countries. However, before reviewing the summary of model results for China, it may be useful to consider some relevant statistics regarding China's projected energy trends. These data will facilitate an understanding of and provide some context for the model results presented below.

A. Illustrative Energy and Economic Statistics

China's economy is expected to continue growing at a strong pace. The International Energy Agency (1998) projects China's economy will grow 5.5% for the 1995-2020 period, while IEA projects OECD countries' GDP to grow on average about 2% over this time period. The higher economic growth rate will likely result in a higher emissions growth rate. However, projected emissions in China are estimated to grow at a slower rate than GDP growth, consistent with the declining energy-to-GDP ratio trend of the past twenty years (IEA 1998, CCCC 1999).



Forecasts of emissions growth through 2010 across six different business as usual projections appear to be fairly similar (figure 2). The small differences in projections appear to be influenced by different economic growth rate assumptions. Indeed, energy-to-GDP projections by many of these analysts follow very similar trends of continued improvement. These forecasts illustrate that the recent decoupling of greenhouse gas emissions and economic growth will likely continue into the future.

Because of the higher growth rate, China has more opportunities than many OECD countries to

Introduction

This chapter provides a summary of China's energy situation and examines likely energy developments over the period to 2020. The objective is to increase the understanding of China's energy system and its driving forces as well as to present the underlying uncertainties, rather than to forecast energy developments over the next 25 years. It is important to emphasise that the projections included in this chapter are based on a wide range of assumptions, some of which are made on relatively scarce information. Data on much of the Chinese energy system, and on important energy demand drivers, are rather poor or are available for a very limited period of time, making standard econometric analysis difficult. Problems also exist for the main macroeconomic indicators, especially GDP and its components.

Even without data problems, the dramatic changes in the Chinese economy and energy system over the past 15 years would make any standard econometric techniques inappropriate for deriving projections. In the past, energy consumption was allocated rather than individually chosen. Policy mechanisms and the behaviour of economic agents are in the process of substantial change. The model underlying the projections presented here is primarily an accounting framework. The main drivers are assumed activity levels. Deregulation introduces elements of market economies, like price signals. It is assumed that market reforms in China will continue. Price elasticities for different fuels/sectors are imposed throughout the Outlook period.

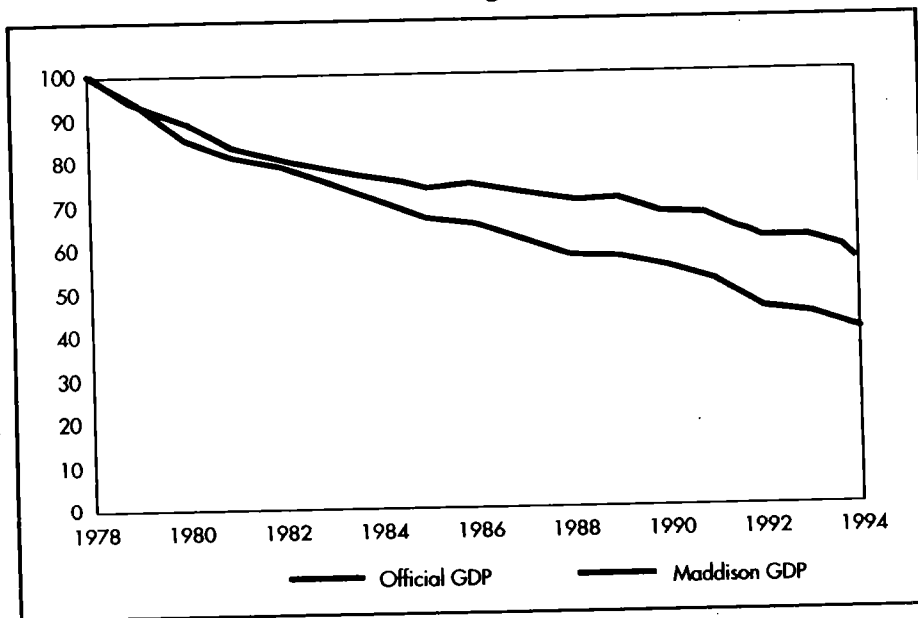
There are many reasons for China's growing importance in economic, energy and environmental terms. With a population of over 1.2 billion, China is the most populous country in the world. If the size of its economy is measured using purchasing power parities, it is the second largest economy in the world², after the United States.

1. In this Outlook, Hong Kong is included in China. Hong Kong became a Special Administrative Region of China in 1997.

2. The use of market exchange rates to make the comparison provides a significantly different picture. GDP calculated on a purchasing power parity approach is six times as large as that based on market exchange rates.

The same issue arises in the calculation of the income elasticity of energy demand, the main parameter determining long-term energy demand projections. Official statistics show an income elasticity of roughly 0.5, while for a developing country one would expect a value of around 1. (3)

Figure 15.2: Comparison of Energy Intensities Based on Official and Maddison GDP Figures (1978 = 100)



Although official GDP statistics are used for the projections presented here, the issue of the reliability of these figures represents a key uncertainty for this analysis.

In the business as usual case assumptions, the economy is projected to grow at 5.5% per annum from 1995 to 2020. The assumed GDP growth rates for China are consistent with official data and are higher than those assumed for any other region in this Outlook. If realised over the next 15 to 20 years, China would become the largest economy of the world in purchasing power parity terms. It is assumed here that policy reform will continue in China. As state-owned enterprises still dominate the Chinese economy, problems involved in transforming these enterprises and transferring them successfully to the private sector, as well as bottlenecks in many critical sectors of the economy, may dampen this assumed growth. It is (1)

assumed that China will be successful in limiting growth in population to an average of 0.8% per annum over the Outlook period.

Table 15.3: Assumptions for China Region

	1971	1995	2010	2020	1995-2020 Annual Growth Rate
Coal price (\$1990 per metric ton)	44	40	42	46	0.5%
Oil price (\$1990 per barrel)	6	15	17	25	2.1%
LNG price (\$1990 per toe)	n.a.	126	141	210	2.1%
GDP (\$Billion 1990 and PPP)	484	3404	8426	13123	5.5%
Population (millions)	845	1206	1372	1469	0.8%
GDP per capita (\$1000 1990 and PPP per person)	0.57	2.82	6.14	8.93	4.7%

Energy Demand

Overview

Using the same methodology (i.e. extrapolating past GDP and related energy growth), primary energy demand in China is expected to grow at 3.6% per annum over the Outlook period. This increase is lower than historical growth rates (5.5% in the period 1971 to 1995). The difference can be attributed largely to slower economic growth. It is assumed that, as a result of increased liberalisation in many sectors, fuel prices will begin gradually to play a role in energy consumption decisions and slow energy demand growth. These assumptions lead to a further decline of energy intensity by 1.8% per annum on average.

In terms of total primary energy demand, solid fuels are expected to grow the slowest, at 3.1% per annum. As a result, the current 77% market share of solid fuels declines by about 10 percentage points by 2020, but solid fuels remain dominant. The main driver of solid fuel demand is power generation. Oil demand is projected to grow by 4.6% per annum, resulting in a significant market share increase by 2020. Gas is expected to grow very strongly, at 6.5% per annum, but its share of total primary energy demand remains limited. As discussed in the power generation section, in order to meet the high electricity demand growth, both nuclear and hydro power plants are expected to increase their shares in the primary energy mix. Over the

Energy to GDP Ratios Indexed to 1990

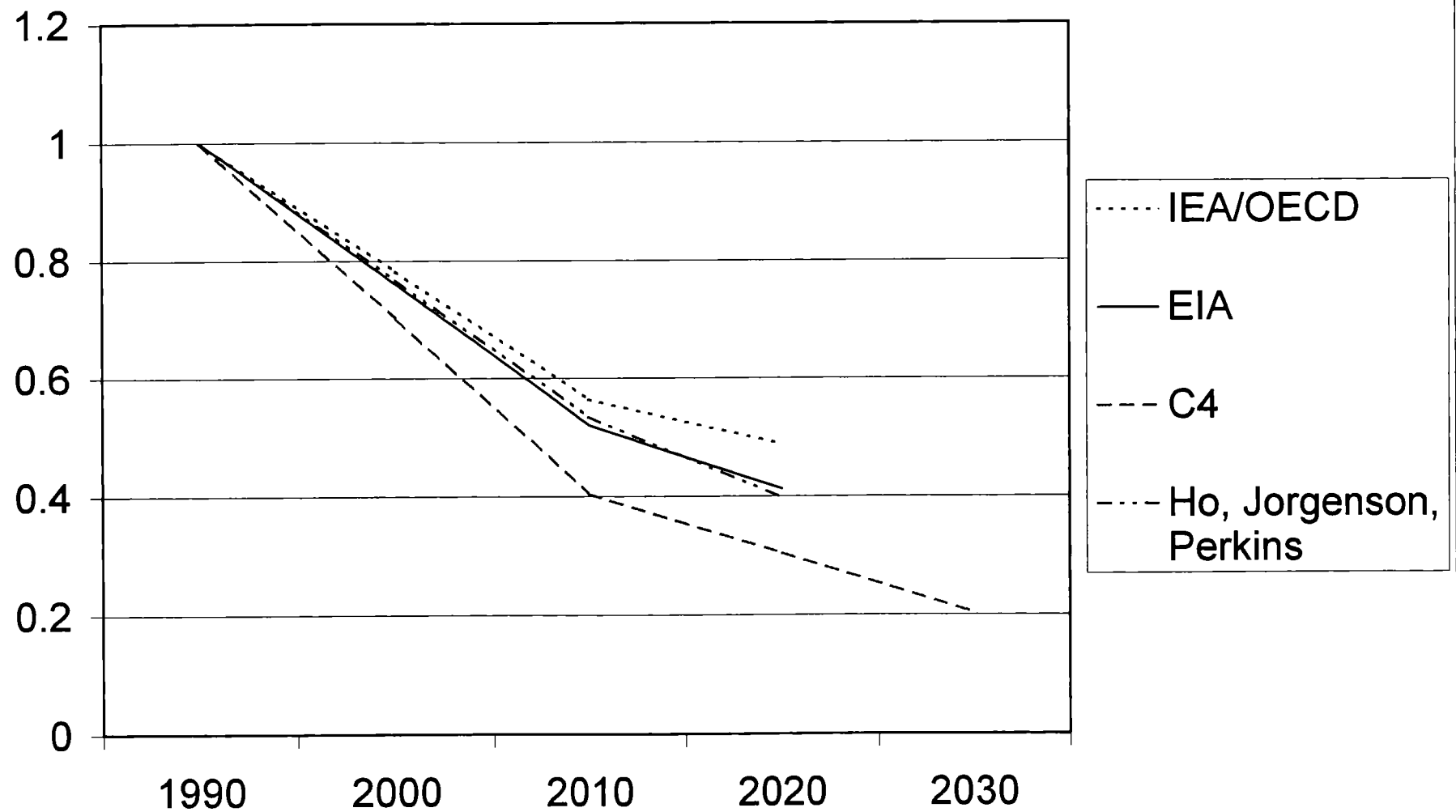
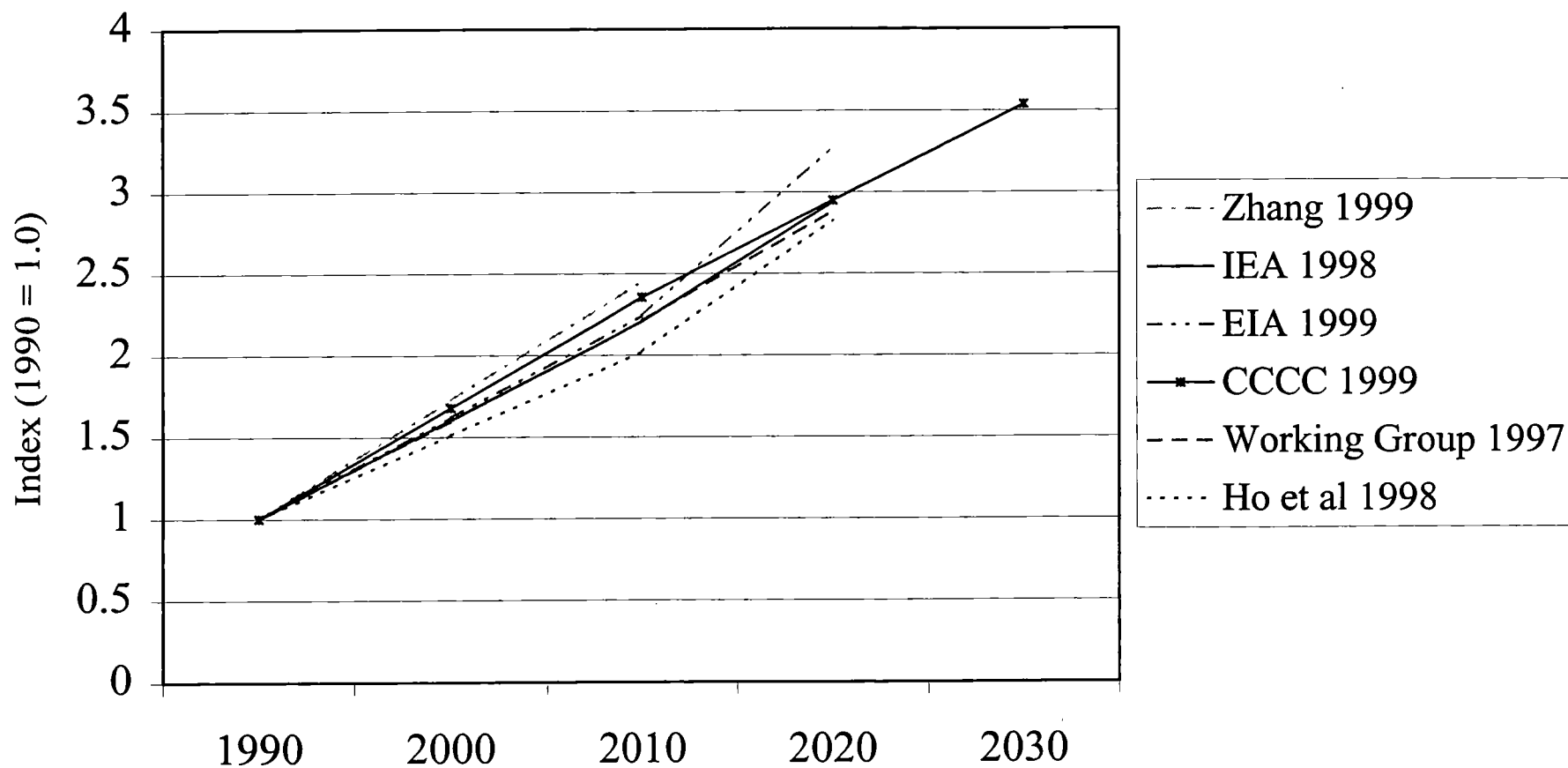


**Figure 2. Carbon Dioxide Emissions, 1990 to 2030
Projected under Business As Usual**



Carbon Emissions (measured in MMTCE)

	IEA/OEC D	EIA	C4	Ho, Jorgenson	Working Group	Zhang 1999
1990	657.5 ¹	620 ⁴	560 ⁷	638.9206 ¹⁰	812 ¹³	586.9 ¹⁷
2000	1054.5	1005.5	939.85	965.7847	1298 ¹⁴	
2010	1451.5 ²	1391 ⁵	1319.7 ⁸	1292.649 ¹¹	1796 ¹⁵	1441.3 ¹⁸
2020	1931.2 ³	2031 ⁶	1650.25	1807.615 ¹²	2342 ¹⁶	
2030			1980.8 ⁹			

Non-fact checked
values are
interpolated

Carbon Emission Indexed to 1990

	IEA 1998	EIA 1999	CCCC 1999	Zhang 1999	Ho et al 1998	Working Group 1997
1990	1	1	1	1	1	1
2000	1.603802	1.621774	1.678304	1.727892	1.511588	1.598522
2010	2.207605	2.243548	2.356607	2.455785	2.023176	2.211823
2020	2.937186	3.275806	2.946875		2.82917	2.884236
2030			3.537143			

values are
interpolated.

Facts 10, 11 & 12 are derived from 1993 level of ^{carbon} 604.05
731 MMTCE and using the avg growth rate
of 3.41 % from 1993-2023.

Ho et al do not give a carbon level or growth rate
during 1990-1992. The 1990 emissions value (Fact 10)
was derived using the 1993 level and assuming
carbon growth matched energy growth from
1990-1993 at 4.59 %.

Business as Usual Projection: China

CARBON DIOXIDE EMISSIONS	1971	1990	1995	2010	2020	1971	1990	1995	2010	2020	1971-1995	1995-2010	1995-2020	1990-2010
	million tonnes CO ₂					percentage shares					average annual growth rate			total growth
Mobility	16	142	180	389	564						10.5%	5.3%	4.7%	174%
Fossil fuel in Stationary Uses (Industry, Services, Agriculture, Households)	675	1506	1893	2955	3682	100	100	100	100	100	4.4%	3.0%	2.7%	96%
Solid Fuels	578	1318	1682	2508	3072	86	88	89	85	83	4.5%	2.7%	2.4%	90%
Oil	93	168	190	391	538	14	11	10	13	15	3.0%	4.9%	4.2%	133%
Gas	3	20	21	56	72	0	1	1	2	2	7.9%	6.9%	5.1%	180%
Total Final Consumption	692	1648	2073	3344	4246	100	100	100	100	100	4.7%	3.2%	2.9%	103%
Solid Fuels	578	1359	1709	2536	3099	84	82	82	76	73	4.6%	2.7%	2.4%	87%
Oil	110	268	344	752	1074	16	16	17	22	25	4.9%	5.4%	4.7%	181%
Gas	3	20	21	56	72	0	1	1	2	2	8.0%	6.8%	5.1%	176%
Electricity Generation (incl. CHP Plants)	132	607	982	1930	2753	100	100	100	100	100	8.7%	4.6%	4.2%	218%
Solid Fuels	118	556	938	1787	2523	90	92	95	93	92	9.0%	4.4%	4.0%	221%
Oil	13	49	43	114	175	10	8	4	6	6	4.9%	6.8%	5.8%	135%
Gas	0	2	2	29	55	0	0	0	1	2	-	20.7%	14.9%	1395%
Other Transformation	52	156	-4	48	83						-	-	-	-70%
Solid Fuels	42	106	-75	-111	-136									
Oil	5	43	57	120	169									
Gas	4	8	14	38	50									
Total Emissions	875	2411	3051	5322	7081	100	100	100	100	100	5.3%	3.8%	3.4%	121%
Solid Fuels	739	2021	2572	4212	5486	84	84	84	79	77	5.3%	3.3%	3.1%	108%
Oil	128	360	443	987	1418	15	15	15	19	20	5.3%	5.5%	4.8%	174%
Gas	7	30	36	123	177	1	1	1	2	3	6.9%	8.5%	6.5%	312%

Numbers must be divided by ~~32/3~~ to convert to CE.

32/3 (44/12 - CO₂ molecular ratio)

Table A10. World Carbon Emissions by Region, Reference Case, 1990-2020
(Million Metric Tons)

Region/Country	History			Projections					Average Annual Percent Change, 1996-2020
	1990	1995	1996	2000	2005	2010	2015	2020	
Industrialized Countries									
North America	1,550	1,629	1,687	1,833	1,946	2,079	2,202	2,314	1.3
United States ^a	1,346	1,411	1,463	1,585	1,678	1,790	1,890	1,975	1.3
Canada	126	135	140	151	156	162	171	182	1.1
Mexico	78	82	84	97	113	127	141	158	2.7
Western Europe	936	885	904	947	983	1,021	1,066	1,114	0.9
United Kingdom	187	145	153	156	165	170	176	181	0.7
France	103	97	101	103	106	109	115	124	0.8
Germany	267	235	238	244	254	265	277	286	0.8
Italy	113	116	116	122	131	138	146	153	1.2
Netherlands	59	57	58	62	65	67	69	71	0.8
Other Western Europe	226	234	237	260	262	271	284	298	1.0
Industrialized Asia	364	379	389	377	423	435	458	479	0.9
Japan	274	281	291	273	314	322	341	358	0.9
Australasia	90	99	99	103	109	113	117	122	0.9
Total Industrialized	2,850	2,893	2,980	3,157	3,353	3,535	3,726	3,907	1.1
EE/FSU									
Former Soviet Union	991	636	613	583	627	666	702	746	0.8
Eastern Europe	299	230	228	243	262	270	274	277	0.8
Total EE/FSU	1,290	866	842	827	889	935	976	1,024	0.8
Developing Countries									
Developing Asia	1,065	1,427	1,474	1,659	2,028	2,426	2,849	3,377	3.5
China	620	792	805	930	1,143	1,391	1,670	2,031	3.9
India	153	222	230	273	331	386	436	494	3.2
South Korea	61	102	113	112	140	168	199	230	3.0
Other Asia	232	311	326	344	414	480	545	622	2.7
Middle East	229	269	283	323	379	434	490	555	2.8
Turkey	35	40	43	46	58	65	72	81	2.7
Africa	178	192	198	214	241	270	296	325	2.1
Central and South America	174	194	206	251	330	418	513	629	4.8
Brazil	57	64	71	73	95	121	151	187	4.1
Other Central/South America	117	130	135	178	236	297	362	442	5.1
Total Developing	1,646	2,083	2,161	2,447	2,978	3,547	4,148	4,886	3.5
Total World	5,786	5,841	5,983	6,430	7,220	8,018	8,850	9,817	2.1

^aIncludes the 50 States and the District of Columbia. U.S. Territories are included in Australasia.

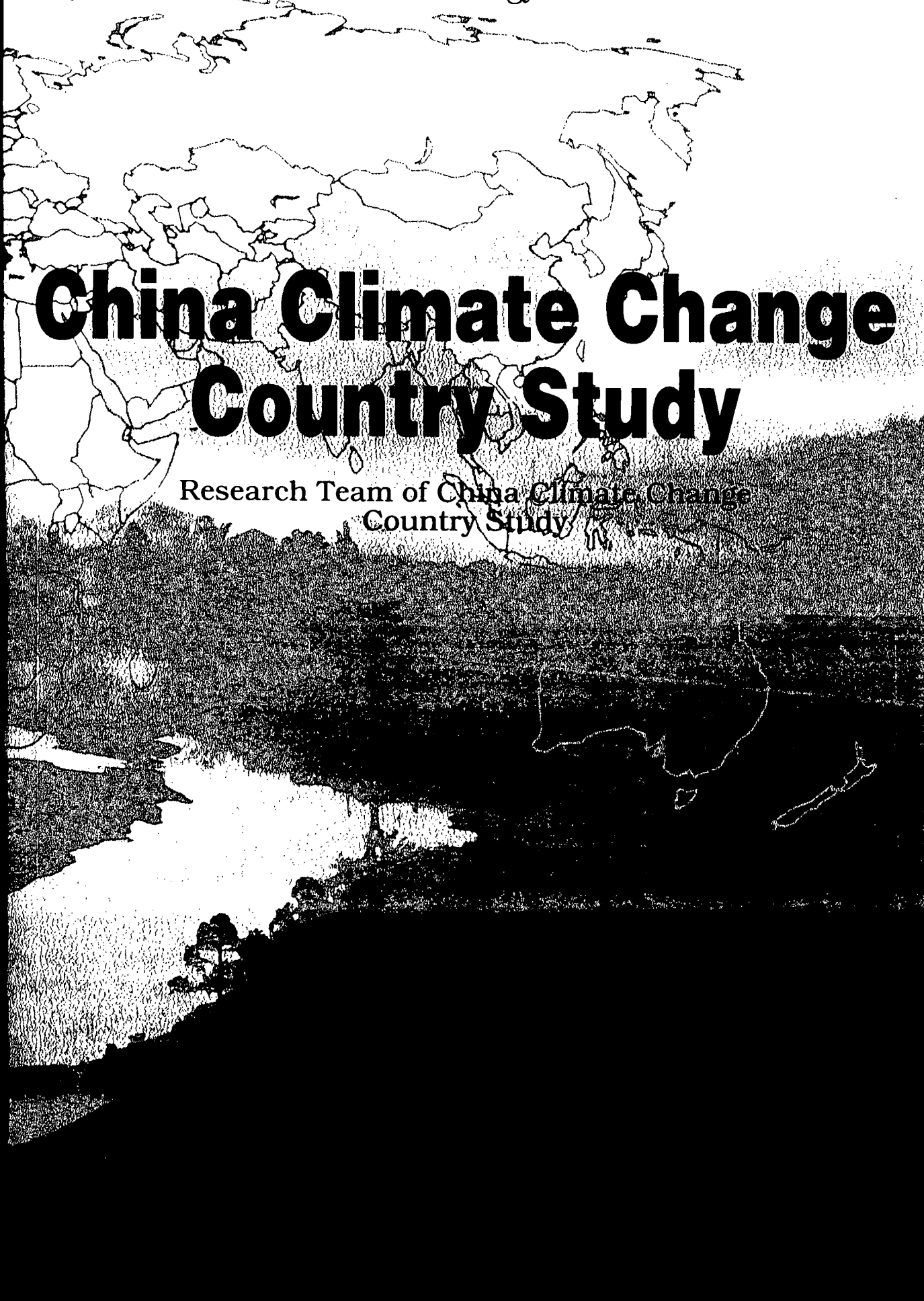
Notes: EE/FSU = Eastern Europe/Former Soviet Union. The U.S. numbers include carbon emissions attributable to renewable energy sources.

Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1996*, DOE/EIA-0219(96) (Washington, DC, February 1998). **Projections:** EIA, *Annual Energy Outlook 1999*, DOE/EIA-0383(99) (Washington, DC, December 1998), Table A19; and World Energy Projection System (1999).

Supported by the Department of Energy of the United States and
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China Climate Change Country Study

Research Team of China Climate Change
Country Study



6.7 Macro-economic analysis of GHG emissions

6.7.1 Macro-economic analysis of CO₂ emissions in energy systems

CO₂ emissions from energy consumption are the main anthropogenic GHG emission source, therefore energy conservation and substitution are considered priorities for abatement of GHG emissions in China. There is no doubt that economic development in China will cause an increase in energy consumption and CO₂ emissions. Meanwhile, technical options for improving energy efficiency and fuel substitution to mitigate CO₂ emissions will be an important part of a long-term strategy for energy development.

6.7.1.1 Evaluation of the Baseline Scenario

Some indicators relevant to future economic growth, energy consumption, and CO₂ emissions are shown in Table 6.31.

Table 6.31 Indicators for CO₂ emissions of energy consumption in the Baseline Scenario

	1990	2000	2010	2030
population (billion)	1.143	1.294	1.386	1.560
GDP (billion Yuan)	1,768	4,586	9,901	31,750
primary energy consumption (Mtce)	987.0	1,562	2,235	3,592
total power consumption (TWh)	623.0	1,506.7	2,714	4,937
CO ₂ emissions (Mt-C)	560.0	915	1,319.7	1,980.8 ^a
GDP energy intensity (kgce/Yuan)	0.558	0.341	0.226	0.113
GDP power-consumption intensity(kWh/Yuan)	0.352	0.328	0.274	0.155
CO ₂ emission intensity in energy consumption (kg-C/kgce)	0.575	0.586	0.590	0.551
CO ₂ emission intensity of GDP(kg-C/Yuan)	0.321	0.200	0.133	0.062
energy consumption per capita (kgce)	864	1,207	1,613	2,303
power consumption per capita (kWh)	545	1,164	1,958	3,164
CO ₂ emission per capita (kg-C)	496	707	952	1,270

The current energy consumption intensity in China is higher than that of industrialized countries. The reasons can be explained as follows: first, the GDP per capita is calculated in terms of the exchange rate, which is generally lower than the real domestic purchasing power in developing countries. Second, the high level is also attributed to the national economy industry structure. The industry sectors in China constitute a very large share (44.3%) of the GDP. It is not only higher than the low-income countries, but higher than the industrialized countries as well. Moreover, the proportion of manufacturing industry with high energy consumption intensity is also higher than the normal level of other countries. However, the share of service industry is lower than the developed countries and many low-income countries. Third, technologies of energy conversion and utilization are also important factors. The specific energy consumption of major industrial products in terms of physical units in China is 30% to 100% higher than that of developed

ENERGIZING CHINA

*Reconciling Environmental Protection
and Economic Growth*

EDITED BY
Michael B. McElroy, Chris P. Nielsen, and Peter Lydon

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CHINA'S ECONOMIC GROWTH AND CARBON EMISSIONS

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INTRODUCTION

WHEN CHINA'S ECONOMY WAS GROWING at under 5% a year, as was the case before 1979, China's impact on the environment was largely a domestic concern. When the growth rate doubled this figure, as occurred for sixteen years beginning in 1979, China's impact on the environment became a global concern. Figure 1 shows the regional contributors to global carbon dioxide (CO_2) in the three most recent decades. If this reform-generated high growth rate continues for another two decades or more, both domestic Chinese and global concern for China's influence on the environment will grow with the expansion of the economy.

But will high growth rates of Gross Domestic Product (GDP) be maintained over two or more decades into the future? And how will that growth actually affect the generation of CO_2 and other environmentally damaging emissions? There is no automatic relationship between a particular rate of growth in GDP and the emission of greenhouse gases or other pollutants. Alternative growth strategies, alternative technologies, and differing policies can all affect this relationship. Is it

TABLE 1

Growth Rate of GDP, Inputs, and Productivity (% per Year)

	1953-68	1969-77	1978-92
GDP per capita	1.94	4.75	7.93
GDP	3.88	6.79	9.43
Capital	10.96	8.35	9.65
Labor	2.70	2.45	3.00
Energy (sce)	8.55	11.15	4.59
Productivity	-2.81	0.87	3.07

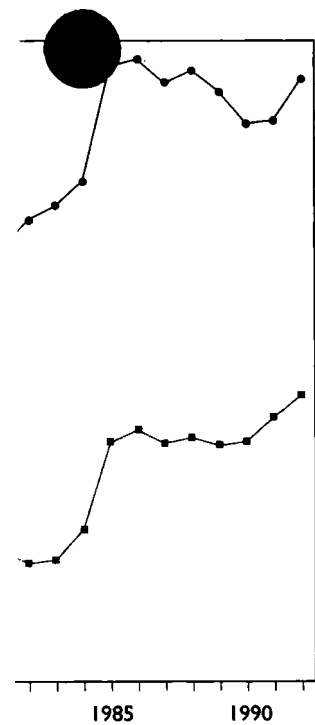
Note: sce = standard coal equivalent. For all major sources except nuclear.
Source: Author's calculations (see Appendix A).

that productivity grew by 2.7 percent per year after 1978 through 1990 (Li et al. 1992, 344), and Perkins, who estimates that productivity grew by 3.79 percent per year through 1985 (Perkins 1988, 628). These differences result from different end year dates (Li's figures end in the years 1989-1990 whereas Perkins' data began in 1977 and end in 1985). Also contributing to the disparity are some differences in the growth rate of capital stock due in part to different assumptions about capital and labor. In Li's case these were estimated econometrically, and in Perkins' case were assumed to be similar to estimates for other countries for which we have a more reliable data set from which to make estimates. Both estimates, however, show a marked rise in productivity growth, from negative rates up through 1978 to positive rates thereafter.

The other estimates of productivity growth in China deal mainly or exclusively with the reform period and with the industrial sector alone. The capital stock series on which these are based has been carefully estimated for the whole economy, but no comparable effort has gone into estimating the pre-1979 capital stock of industry. The productivity estimates of Jefferson, Rawski, and Zheng (1992) indicate the productivity growth in the nonstate industrial sector after 1979 through 1988 was 4.6% per year. Surprisingly, even in the state-owned industrial enterprises there was significant productivity growth of 2.4% per year.

Capital contributed even more to growth in the reform period than did productivity, but how much more depends on whose estimate one uses. Li's estimates for the reform period hold that capital contributed 50% more to growth than did productivity, whereas Perkins' suggests that the contribution of the two sources was about the same.

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of the eighteen industries.⁷
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t-output table we can esti-
y sources of energy. Using

the information in Table 3 we can then estimate the energy equivalent of the fossil fuels and carbon emissions. One can also estimate the output of cement, the production of which is a large generator of CO₂.

CHINA'S ECONOMIC GROWTH AND CARBON EMISSIONS

China's economic growth is projected by simulating the above model with the initial capital stock K_1 set equal to the actual stock at the end of 1992. We shall present three growth scenarios using various assumptions about the evolution of the exogenous variables—a base case, a high growth case and a slow growth case. The base case is calculated using the assumptions given at the beginning of the section above.

The Base Case Scenario

Base Case A. The Base Case scenario is summarized in Table 4 and illustrated in Figures 9 and 10. GDP growth averages some 6.5% in the first thirty years, slowing down beyond that. Recall that we assumed a high rate of savings/investment of about 40%, which is reasonable given the high rate of return in this capital-poor economy. This high savings is reflected in the rapid growth of the per capita capital stock as shown in

TABLE 4
Base Case Projections

	Annual Growth Rates (%)			Level (1993 Yuan)	
	1993– 2000	1993– 2023	1993– 2043	1993	2023
GDP	8.35	6.53	5.14	3195	21288 bn Y
Capital	10.46	7.97	6.27	5607	55878 bn Y
Population	1.16	0.88	0.67	1166	1514 mil
Work force	1.01	0.80	0.45	743	944 mil
Effective labor	2.27	1.83	1.23		
GDP per capita	7.11	5.60	4.44	2741	14057 Y
Consum. per cap	4.43	4.41	3.62	900	3282 Y
Coal use				1211	2719 mil ton
Oil use				158	786 mil ton
Energy	5.06	3.41	2.75	1079	2951 mil ton sce
C emissions	5.06	3.41	2.75	731	1858 mil ton C

Note: Values are based on model's price normalizations.

Articles

Short-term improvements in public health from global-climate policies on fossil-fuel combustion: an interim report

*Working Group on Public Health and Fossil-Fuel Combustion**

Summary

Background Most public-health assessments of climate-control policies have focused on long-term impacts of global change. Our interdisciplinary working group assesses likely short-term impacts on public health.

Methods We combined models of energy consumption, carbon emissions, and associated atmospheric particulate-matter (PM) concentration under two different forecasts: business-as-usual (BAU); and a hypothetical climate-policy scenario, where developed and developing countries undertake significant reductions in carbon emissions.

Findings We predict that by 2020, 700 000 avoidable deaths (90% CI 385 000–1 034 000) will occur annually as a result of additional PM exposure under the BAU forecasts when compared with the climate-policy scenario. From 2000 to 2020, the cumulative impact on public health related to the difference in PM exposure could total 8 million deaths globally (90% CI 4.4–11.9 million). In the USA alone, the avoidable number of annual deaths from PM exposure in 2020 (without climate-change-control policy) would equal in magnitude deaths associated with human immunodeficiency diseases or all liver diseases in 1995.

Interpretation The mortality estimates are indicative of the magnitude of the likely health benefits of the climate-policy scenario examined and are not precise predictions of avoidable deaths. While characterised by considerable uncertainty, the short-term public-health impacts of reduced PM exposures associated with greenhouse-gas reductions are likely to be substantial even under the most conservative set of assumptions.

Lancet 1997; 350: 1341–49

- Log Structure
- Statistical Life years

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Introduction

Since the industrial revolution, the contribution of anthropogenic sources of greenhouse gases to the global environment has increased significantly.¹ Atmospheric concentrations of greenhouse gases, including carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), are of greater importance today than at any other time in human history. These trends can be largely attributed to human activities, primarily fossil-fuel combustion, and change in land use and agricultural practices. In the absence of efforts to reduce greenhouse gases, the concentrations of these gases are expected to grow significantly throughout the next century. The mid-range estimate from the Intergovernmental Panel on Climate Change (IPCC) is that human-induced climate-change will increase surface temperatures by about 2°C by the year 2100;² many uncertainties exist about this projection.

In an effort to protect the global-climate system for future generations, over 150 nations signed the UN Framework Convention on Climate Change (UNFCCC) in June, 1992.³ The UNFCCC established the objective of stabilising atmospheric greenhouse-gas concentrations at levels that would avoid dangerous anthropogenic interference with the global-climate system. Signatory countries will be considering options to control greenhouse gases at the third conference of parties in Kyoto, Japan, in December, 1997.

Short-term public-health impacts have generally not been considered in assessments of global-climate change. Two studies,^{4,5} for example, have projected that well into the next century, weather patterns resulting from climate change are expected to affect the health of future generations. Heat-related mortalities and illnesses, physical and psychological traumas, and changes in vector-borne and infectious diseases, food supplies, and coastal sea-levels are expected to become evident. With various models, we estimate likely public-health benefits of current and future global-climate-change mitigation policies in the first two decades of the 21st century in developed and developing countries.

Many of the fossil-fuel combustion processes that produce CO₂ and other greenhouse gases also produce a host of air pollutants such as particulate matter (PM), sulphate, ozone, and other pollutants, all of which have short-term adverse effects on public health. We use PM as a sentinel air pollutant because it is commonly associated with fossil-fuel combustion. Extensive public-health literature in several countries has shown that both mortality and morbidity are significantly associated with exposure to PM.^{6,7} Most air pollutants from fossil fuels have local impacts but some airborne pollutants (eg, fine particulates) can be transported thousands of miles and have global impacts.⁸

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Centrally Planned Asia¹ Energy Consumption (eJ) and Carbon Emissions (MMTC)

BAU

		1990	1995	2000	2005	2010	2015	2020
Electric Utility	Coal	8.1	10.6	13.1	14.5	16.4	18.1	20.1
	Oil	0.3	0.5	0.8	1.5	2.5	3.6	4.9
	nat. gas	1.8	2.9	4.2	5	5.6	6.2	6.6
Industry	Coal	8.5	10.8	12.9	15.3	18	20.4	22.7
	Oil	0.2	0.3	0.5	0.8	1.3	1.9	2.8
	nat. gas	0.6	1	1.5	2.1	2.8	3.6	4.4
Residential/Comm.	Coal	9.1	10.9	12.1	13.4	14.5	14.8	14.1
	Oil	0.3	0.6	1.1	1.6	2.4	3.5	5.1
	nat. gas	0.9	1.3	1.9	2.6	3.3	4.3	5.6
Transportation	Oil	1.9	2.8	4.1	5.1	6.9	9.2	12.2
Total		31.7	41.7	52.2	61.9	73.7	85.6	98.5
Carbon		812	1054	1298	1523	1796	2061	2342
Climate Policy		13	14	15	16			
		1990	1995	2000	2005	2010	2015	2020
Electric Utility	Coal	8.1	10.6	13.1	13.2	13.8	14.6	16.1
	Oil	0.3	0.5	0.8	1.4	2.5	3.6	5
	nat. gas	1.8	2.9	4.2	5.2	5.9	6.5	6.9
Industry	Coal	8.5	10.8	12.9	14.6	16.5	18.4	20.3
	Oil	0.2	0.3	0.5	0.8	1.4	2.1	3
	nat. gas	0.6	1	1.5	2.2	3.1	4	4.9
Residential/Comm.	Coal	9.1	10.9	12.1	12.4	12.7	12.5	11.8
	Oil	0.3	0.6	1.1	1.6	2.4	3.5	5
	nat. gas	0.9	1.3	1.9	2.6	3.4	4.4	5.6
Transportation	oil	1.9	2.8	4.1	5.1	6.9	9.2	12.3
total		31.7	41.7	52.2	59.1	68.6	78.8	90.9
carbon		812	1054	1298	1443	1647	1864	2122

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Centrally Planned Asia Region Mortality Estimates from Lancet Article

Year	Lower bound	Central Bound	Upper Bound
2005	21,399	39,024	57,610
2010	39,717	72,342	106,602
2015	68,528	124,635	183,257
2020	71,570	130,155	191,307
Total (2000-2020)	862,932	1,570,469	2,311,268

Pope et al. (1995) reported three coefficients: a central value, and lower (5% confidence level estimate) and upper (95% confidence level estimate) bounds. The upper and lower bounds therefore yield the 90% confidence interval estimate.

¹ Includes China, Hong Kong, Laos, North Korea and Vietnam

Supported by the Department of Energy of the United States and
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3

China Climate Change Country Study

Research Team of China Climate Change
Country Study

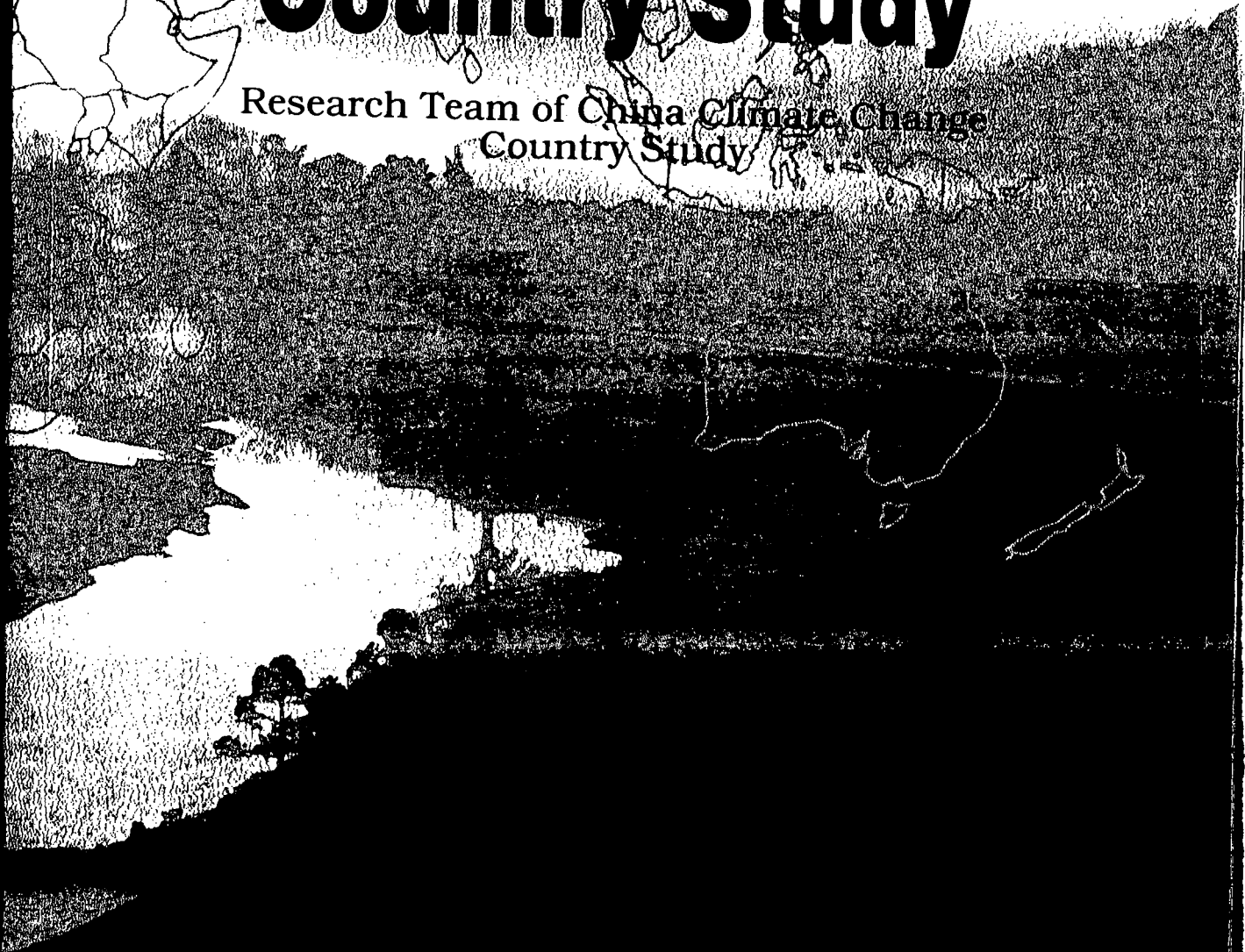


Table 1.16 Composition of end energy consumption by Sector ^[2,5,6,7]

sector	1985	1990	1994
primary industry	5.3	4.1	4.2
secondary industry	67.1	69.7	72.7
subset: manufacturing	65.4	68.5	71.6
Tertiary industry	9.0	9.4	10.6
Personal or private	17.4	16.0	12.6

1.5.3 Energy consumption and economy growth

In recent years China's economy has maintained a high growth rate. The average annual growth rate of GDP was about 10%. However, the average annual growth rate of energy consumption was only about 5% (that of electricity consumption is very high), and the elasticity of energy consumption was approximately equal to 0.5. The relation between energy consumption and economy growth is shown in Table 1.17.

Table 1.17 Energy consumption and economy growth^[4]

Period	AAGR of energy consumption (%)	AAGR of electricity consumption	AAGR of GDP (%)	elasticity of energy consumption	elasticity of electricity consumption
1981-85	4.93	6.44	10.71	0.46	0.60
1986-90	5.18	8.63	7.87	0.66	0.97
1991-95	5.50	10.00	11.93	0.45	0.84
1981-90	5.06	7.53	9.28	0.55	0.81
1981-95	5.20	8.34	10.16	0.51	0.82

1.5.4 Per capita energy consumption

Although the energy production and consumption of China ranks third in the world, its per capita energy consumption is much lower than the world average. China's recent history of per capita energy consumption is shown in Table 1.18. It can be seen from Table 1.18 that with the growing economy and increasing living standard, per capita energy consumption is continuously rising.

Table 1.18 Per capita energy consumption

Year	per capita energy consumption (tce)	AAGR of per capita energy consumption (%)
1980	0.61	3.4
1985	0.72	3.6
1990	0.86	4.7
1991	0.90	4.7
1992	0.93	3.3
1993	0.98	5.4
1994	1.02	4.1
1995	1.07	4.9

Reference

1. State Statistical House, Beijing, 1991
2. State Statistical House, Beijing, 1991
3. Ye Du zhi Publishing, Beijing, 1991
4. State Statistical House, Beijing, 1991
5. Department of Energy Resources, Beijing, 1991
6. Department of Energy Resources, Beijing, 1991
7. State Statistical House, Beijing, 1991

Is China Taking Actions to Limit its Greenhouse Gas Emissions?

Past Evidence and Future Prospect¹

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Summary: As the world's second largest carbon emitter, China has long been criticised as a "free-rider" enjoying benefits from other country's efforts towards abating greenhouse gas emissions but without taking due responsibilities of its own. It has been singled out as the major target at the subsequent negotiations after the Kyoto curtain had fallen. By analyzing the historical contributions of inter-fuel switching, energy conservation, economic growth and population expansion to China's CO₂ emissions during the period 1980-97, this article first indicates that the above criticism cannot hold its ground. Then the article envisions some efforts and commitments that could be expected from China until its per capita income catches up with the level of middle-developed countries. With their focus on the win-win strategies, these efforts and commitments could be unlikely to severely jeopardize the Chinese economic development and, at the same time, give China more leverage at the post-Kyoto climate change negotiations.

1. Introduction

In December 1997, 160 countries reached a historical agreement on limiting greenhouse gas emissions in Kyoto. In comparison with the United Nations Framework Convention on Climate Change (UNFCCC) at the Earth Summit in June 1992 that only committed Annex I countries to "aim" to stabilize emissions of carbon dioxide (CO₂) and other greenhouse gases at their 1990 levels by 2000, the so-called Kyoto Protocol sets legally binding emissions targets and timetables for these countries. Together, they must reduce their emissions of six greenhouse gases by at least 5% below 1990 levels over the commitment period 2008-2012, with the European Union (EU), the United States (US) and Japan required to reduce their emissions of such gases by 8%, 7% and 6% respectively (UNFCCC, 1997). This Protocol will become effective once it is ratified by at least 55 parties representing at least 55% of the total CO₂ emissions of Annex I Parties in the year 1990.

The binding emissions targets set at Kyoto for Annex I countries, although far short of what developing countries called for, may give them some "moral" right to persuade developing countries to take meaningful mitigation action. There is no doubt that securing meaningful participation from key developing countries will

¹ This article will appear in J. Goldemberg and W. Reid (editors), Promoting Development while Limiting Greenhouse Gas Emissions, United Nations Development Programme, New York.

² ZhongXiang Zhang has jointly appointed at Faculty of Economics and Faculty of Law, University of Groningen, The Netherlands. He also holds a part-time professor of economics at the Chinese Academy of Social Sciences, Beijing. He has published a large number of articles in the field of energy and environmental economics, trade and the environment, public finance and economic modelling. He has served as an expert/consultant to many national and international organizations. As a member of the expert team appointed by the UNCTAD Secretariat, he has co-authored the document on *Greenhouse Gas Emissions Trading: Defining the Principles, Modalities, Rules and Guidelines for Verification, Reporting and Accountability* for the Fourth Conference of Parties to the UNFCCC (UNCTAD, 1998).

emissions in China are increasing in line with its rapid economic development, its carbon emissions per unit of output are expected to be cut about in half during the period 1990-2010.

On a per capita basis, China's energy consumption of 0.86 tce in 1990 is expected to rise to 1.80 tce in 2010, while the corresponding CO₂ emissions of 0.51 tC in 1990 are expected to rise to 1.01 tC in 2010. Although the figures are doubled over twenty years, they are still well below the corresponding current world average levels, which were equal to 2.12 tce and 1.14 tC respectively in 1990 (Zhang, 1997a).

Table 8 Energy-related results for the baseline scenario of the Chinese economy

	1990	1997	2010
Energy consumption (million tce)	987.0	1440.0	2560.4
Coal's share in total energy consumption (%)	76.2	73.5	67.5
Energy consumption per capita (tce)	0.86	1.16	1.80
CO ₂ emissions (million tons of carbon)	586.9 ¹⁷	847.3	1441.3 ¹⁸
Carbon intensity of GDP (GNP) ^a	0.802	0.551	0.427
CO ₂ emissions per capita (tons of carbon)	0.51	0.69	1.01

^a Measured in tC per thousand US\$ at 1980 prices.

Sources: Zhang (1997a, 1998a). Own calculations.

Using the CGE model, we have then analysed the implications of two scenarios under which China's CO₂ emissions in 2010 will be cut by 20% and 30% respectively relative to the baseline (see Figure 4). The two emission targets are less restrictive in that they are not compared with the level of emissions in a single base year, but with the baseline CO₂ emissions in 2010, the latter being 2.46 times that in 1990. The carbon tax required to achieve a 20% cut in CO₂ emissions in 2010 relative to the baseline is estimated to be US\$ 18 at 1987 prices, while the corresponding figure necessary to achieve a 30% cut in CO₂ emissions in 2010 is estimated to be US\$ 35 at 1987 prices.¹¹ This means that a larger absolute cut in CO₂ emissions will require a higher carbon tax. Higher tax also implies higher fuel-specific tax rates and hence higher prices of fossil fuels.

¹¹ Although a carbon tax is incorporated as a means in this modeling exercise, it is not first order in considering China's response strategies for climate change. The main concern is whether China can afford or were determined to commit to an emissions cap. If there were an emissions cap for China, using a carbon tax is not impossible, given that a carbon tax is a cost-effective means of limiting carbon emissions and that China has used emissions charges to control emissions of a number of pollutants, including SO₂ emissions in the acid rain control area.

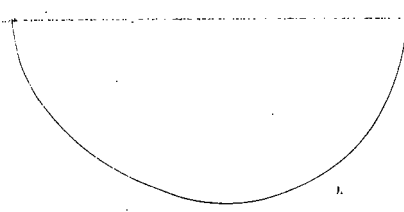
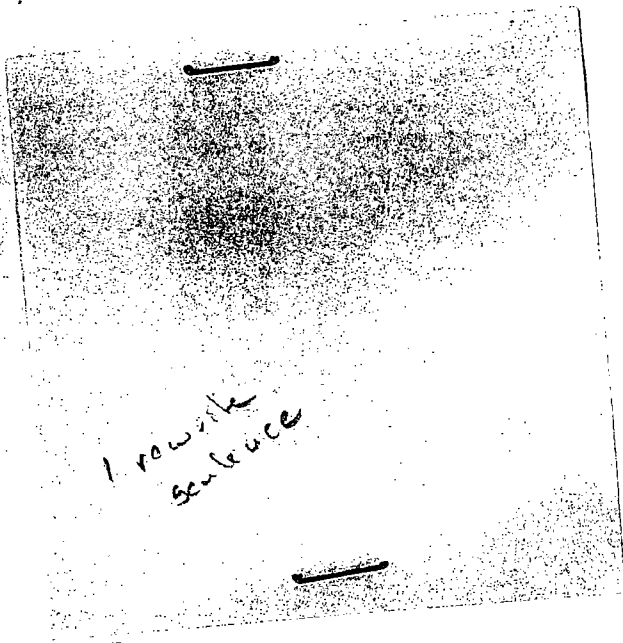
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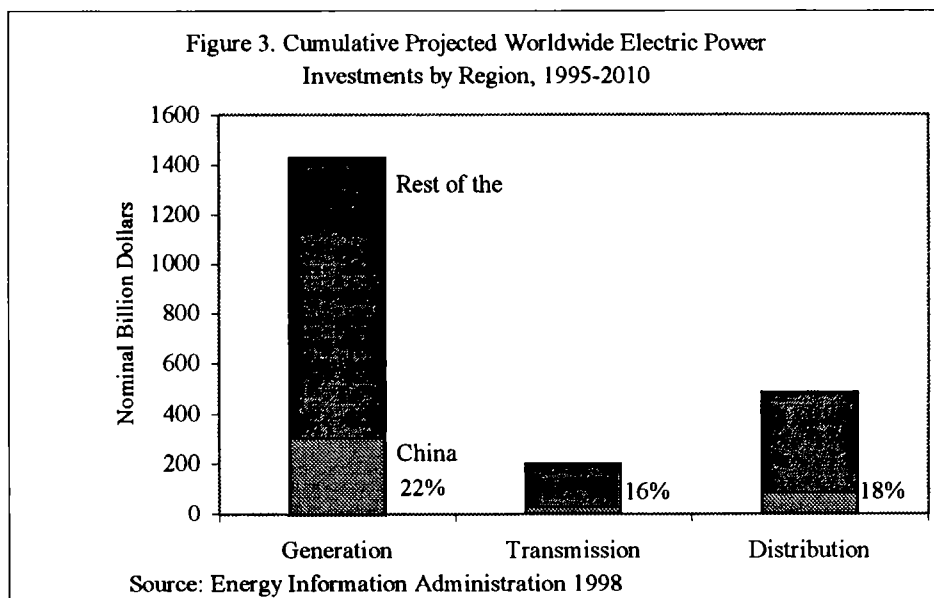


reduce emissions relative to baseline projections by installing new greenhouse gas-efficient plants and adopting other new technologies. In contrast to retrofitting existing plants, new investment in greenhouse gas-efficient plants is a less costly approach to abate emissions.

The faster economic growth expected in China implies a higher rate of investment than most OECD countries. For example, investments in electric power generation in China are projected to comprise nearly ¼ of total world generation investment between 1995 and 2010 (figure 3). Many of these Chinese investment projects are likely to increase total generation, while a larger share of OECD investments will likely replace existing power plants. Current Chinese coal plants are about 25 to 33% less efficient than developed countries' coal plants (Fang et al 1998). Investing in power technologies with comparable efficiencies to developed countries' plants could significantly reduce Chinese emissions per unit of electricity generated. Further, one out of every six dollars expected to be invested in transmission systems around the world will be spent in China through 2010. Improving transmission efficiency in China – where transmission losses are twice those found in developed countries and can range up to 30% (Ni and Nien 1998) – through these investments can further reduce emissions per unit of energy consumed.

①

②
1A



Differences in energy efficiency between China and developed countries also exist in various industrial sectors. Table 1 illustrates some of these differences in industrial production activities. As these industrial sectors in China evolve, new investment could be leveraged by the value derived from generating emissions abatement to install more advanced, more energy-efficient production technologies.

ENERGIZING CHINA

Reconciling Environmental Protection and Economic Growth

Edited by

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Harvard University Committee on Environment.

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2

ENERGY SUPPLY AND DEVELOPMENT IN CHINA

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INTRODUCTION AND OVERVIEW

LARGE PRODUCTION AND USE OF ENERGY has become synonymous with membership in the industrial world. Nearly every sector of advanced economies relies upon a plentiful and dependable energy supply. The economic production—whether in manufacturing, transportation, or services—that supports the enviable living standards enjoyed in developed nations requires enormous amounts of energy.

Energy use in developing nations, almost by definition, has not yet reached the level of developed nations. Although all people desire a better standard of living, those of the developing nations strive with a special urgency for economic, social, and national advancement. Furthermore, as the world becomes smaller and people become more aware of other cultures through progress in telecommunications, the huge gaps in living standards among nations become ever more obvious and measurable. Developing nations seek to expand their energy supply, requiring a substantial investment of human and financial resources. In the coming decades, the energy demand of developing countries is expected to exceed that of the now-developed countries, bringing a new host of

TABLE 12

Electricity Generation in Recent Years

	1990	1991	1992	1993	1994	Avg.
Total power generation						
TWh	614.6	671.6	744.6	815.8	909	-
Annual rate of increase %	-	9.3	10.9	9.6	11.4	10.3
Thermal power						
TWh	490	548.4	613.7	666.8	724	-
Share %	79.4	81.7	82.4	81.7	79.6	81.0
Annual rate of increase %	-	11.9	11.9	8.7	8.6	10.3
Hydropower						
TWh	124.5	123	130	146	170.3	-
Share %	20.3	18.3	17.5	17.9	18.7	18.5
Annual rate of increase %	-	1	5.7	12.3	16.6	8.4

Source: SSB 1990-1994.

this period were 81% and 10%, respectively, illustrating the continuing importance of coal-fired power generation technology in the national economy. The technical level as compared to that of developed countries is summarized as follows:

- Coal consumption per kWh in 1991 and 1993 were 427 and 417 grams of coal equivalent (gce) respectively, nearly 90 to 100 gce more than the level in developed countries.
- Almost all of the coal-fired power plants operate without scrubbers (only the Luohuang power plant in Sichuan Province has desulfurization devices).
- Low voltage power transmission lines caused a transmission loss of about 9%. In some rural areas, this loss is closer to 30%! The normal transmission loss in developed countries is 5-6%.
- Power plants maintain a high auxiliary power ratio, consuming about 8% of the generated electricity for themselves. The level in advanced countries is 4%.
- Automation remains at a low level.

As explored in more detail in the chapter by Murray and Rogers in this volume, the reasons for such continued inefficiencies include:

- A major fraction (more than 40%) of the thermal power installed capacity consists of small and medium-size units, from 6 MW to 200 MW, whose efficiency is very low.

- Though large units under license from manufacturing and relative units are higher than

- Poor operation and

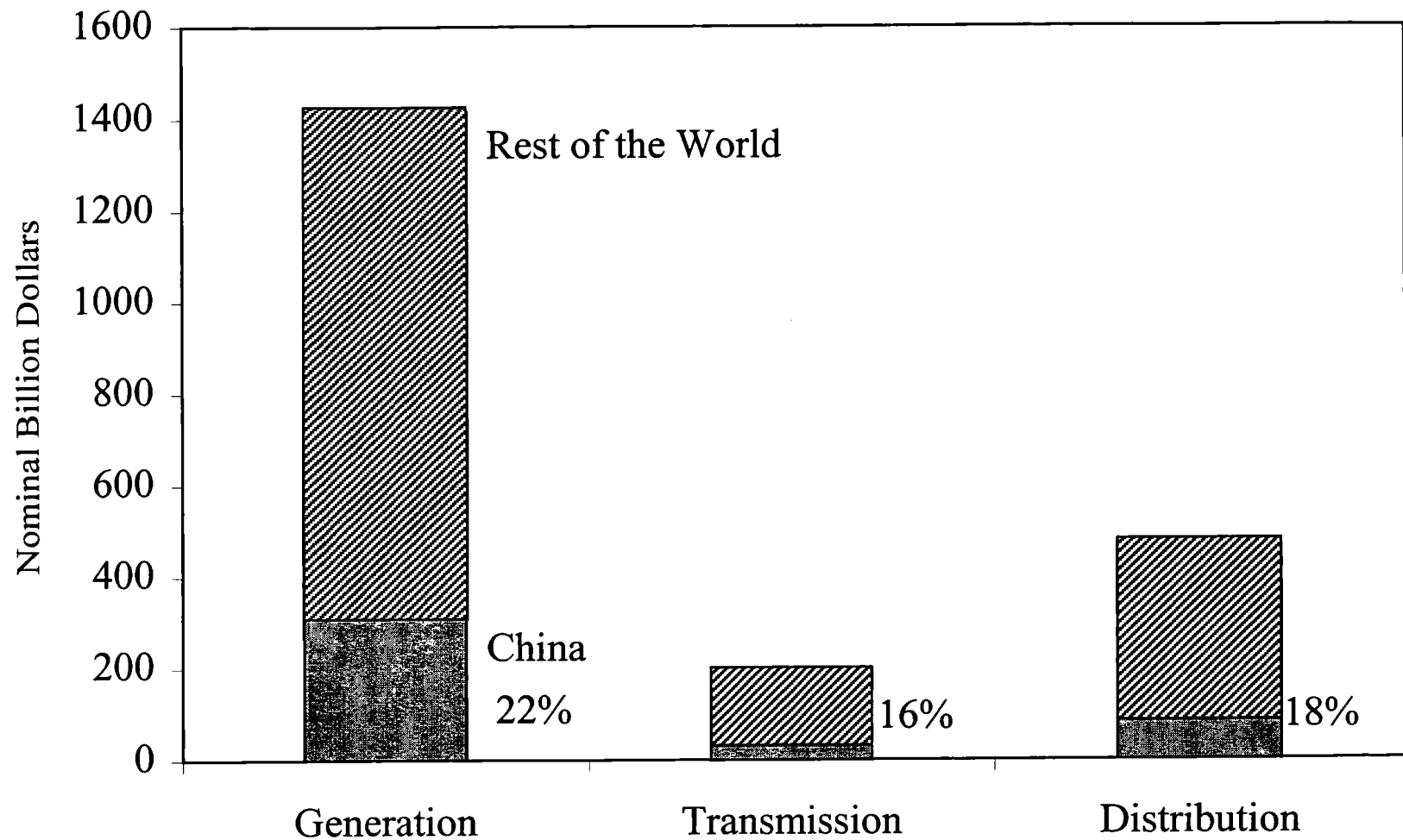
According to estimates, power, hydropower, nuclear be approximately 73%, and then, the rate of increase in electricity will be at a level industry faces opportunities the years from 1995 to investment, uncertainty in generation equipment, and firm of fossil fuel dependence. yuan/kWh), the electric significant investment by generation was 280 billion years 1996-2000 it shows channels, only one third of 240 billion yuan to be tion of this capital may the paper by Murray, Rogers.

By the end of this century 0.5-0.6 billion tons of coal production. Nearly 70% power generation. Address the problem of transportation.

Thermal efficiency (larger) coal-fired power ever, in China, the most efficiency. This must be creased.

The technology of liquiders (CFBC) has matured remove SO₂ during the generation is expected to as well as worldwide, since environmental protection

Figure 3. Cumulative Projected Worldwide Electric Power
Investments by Region, 1995-2010



Source: Energy Information Administration 1998



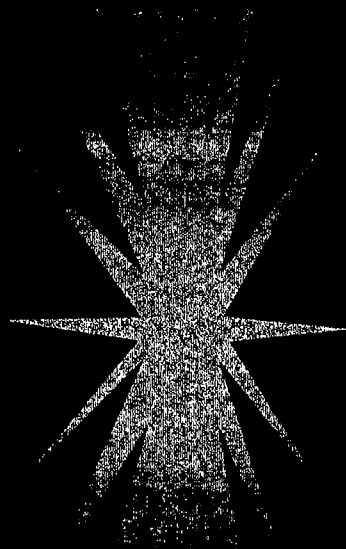
	China	Rest of World
Generation	308 ¹	1118 ⁴
Transmissi	31 ²	169 ⁵
Distribution	84 ³	396 ⁶



April 1998

International Energy Outlook 1998

*With Projections
Through 2020*



Energy Information Administration

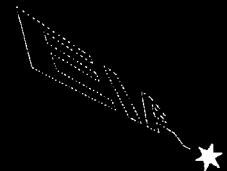


Table 27. Cumulative Projected Worldwide Electric Power Investments by Region, 1995-2010
(Billion Nominal Dollars)

(Billion Nominal Dollars)												
Investment Type	North America	Latin America	Western Europe	China	OECD Pacific Rim	East Asia	South Asia	Central and Eastern Europe	FSU	Middle East	Africa	World Total
Generation												
Solid Fuel	94	22	102	222	51	100	71	19	24	2	27	734
Natural Gas	32	23	89	1	14	41	13	10	33	27	16	298
Oil	1	8	1	0	0	1	1	7	2	2	6	29
Nuclear	6	3	8	18	39	21	6	3	26	0	0	129
Renewable	17	52	15	67	5	6	48	5	13	3	5	235
Subtotal	149	108	215	308 ¹	108	169	139	44	98	34	54	1,426 ⁴
Other Investments												
Transmission . . .	14	42	20	31 ²	10	28	23	3	14	4	12	200 ⁵
Distribution	54	36	78	84 ³	39	61	60	11	30	10	19	480 ⁶
General	14	17	20	43	10	17	21	6	14	5	7	173
Subtotal	82	94	118	156	59	105	103	19	58	18	38	854
Total	231	202	333	467	167	275	242	63	156	52	91	2,279
Annual Average . .	15	13	25	31	11	18	16	4	10	3	6	152

Note: North America includes Canada and the United States; Western Europe includes European Union countries, Finland, Switzerland, Iceland, Norway, and Turkey. OECD Pacific Rim includes Australia, Japan, and New Zealand. Central and Eastern Europe includes Albania, Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, former Yugoslavia. East Asia includes Brunei, Hong Kong, Indonesia, Kampuchea, Laos, Malaysia, North Korea, Papua New Guinea, Philippines, Singapore, Republic of Korea, Taiwan, Thailand, Vietnam, Pacific Islands, Afghanistan, Mongolia. South Asia includes Pakistan, India, Bangladesh, Nepal, Sri Lanka. Latin America includes Mexico and all South and Central American nations, as well as the nations of the Caribbean. Middle East includes Israel, Jordan, Iran, Iraq, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, and Yemen.

Source: Estimates by Resource Dynamics, based on International Energy Agency, *World Energy Outlook 1995* (Paris, France, 1995), Capacity Constraints Scenario, base case.

barriers for domestic or foreign investors has spawned the development of independent power producers that significantly augment power generation capacity.

Although global capital markets and the global pool of savings are considered adequate to the task of funding future electricity investments, for several nations investment funds may not be forthcoming unless difficult electricity policy reforms are adopted. These reforms are necessary in order to provide investors (both foreign and domestic) with expectations of achieving adequate rates of return at acceptable levels of risk. The state and methodology of policy reform varies widely among developing nations. Clearly, however, there is strong pressure toward reform. Significant policy reforms are underway in developed countries as well, where the pressure for reform stems from an expectation that increased competition will reduce the cost of electricity. The precise character of reform varies widely among countries, and in most areas it is still evolving.

Regional Highlights

Developing Asia

Of all the regions, Asia is expected to show the most rapid increase in economic growth and electricity con-

sumption over the next few decades. Whereas developing Asia accounted for only 16 percent of total world electricity consumption in 1995, it is expected to account for 42 percent of demand growth between now and 2020.

China

In part, China's vast size will drive the growth of electricity demand. China, with 1.2 billion people, is the world's most populous nation. It also has had one of the fastest growing economies in recent years, a trend that is projected to continue, although at a reduced rate.

Electricity consumption in China is expected to grow at a 5.8-percent annual rate over the forecast period. The high level of coal use in China's electricity industry reflects the country's ample coal reserves. China accounts for nearly one-third of all world coal production [4, p. 73] and has about 11 percent of the world's coal reserves [2, p. 30]. As a consequence, coal accounted for 76 percent of China's electricity fuel in 1995 (Figure 76). That share is expected to fall slightly by 2020, even while overall coal consumption increases threefold. Renewables (largely hydropower), which accounted for 19 percent of China's electricity consumption in 1995, are expected to have a 14-percent share of the power

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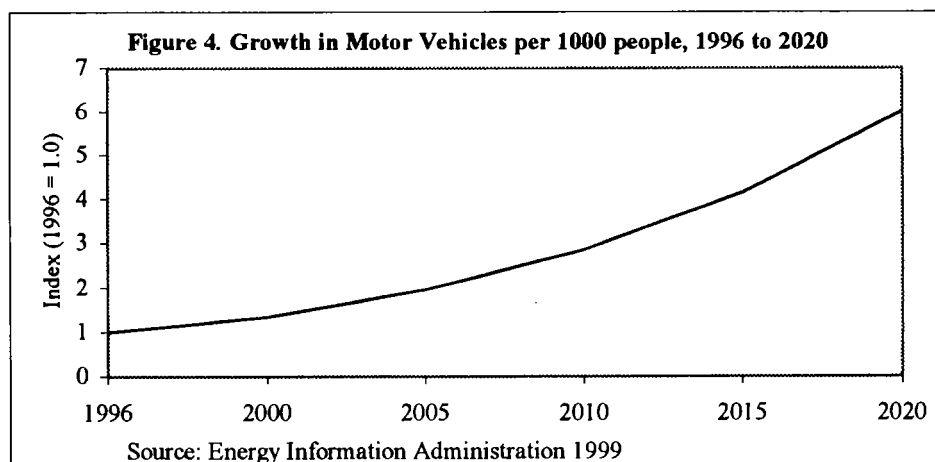
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Table 1. Comparison of Physical Energy Efficiency in Industrial Production between China and Western Countries

Production Activity	China	Western Countries
Industrial Boiler	55-60%	75-80%
Industrial Furnaces	20-30%	50-60%
Thermal Electrical Power	25-30%	35-40%
Steel Industry	1.0 tce/ton of output	0.7 tce/ton of output
Synthetic Ammonia	2.1 tce/ton of output	1.15 tce/ton of output
Cement	0.2 tce/ton of output	0.13 tce/ton of output

Source: Fang et al 1998, p. 125.

As per capita incomes continue to rise in China, the number of motor vehicles per capita is projected to increase much faster (figure 4). Between 1996 and 2010, motor vehicles per capita is projected to triple, and then double again by 2020 (EIA-1999). Since Chinese fuel intensity in highway transport is 25% higher than in developed countries, and domestic-made vehicles consume 30-40% more fuel than comparable import vehicles (Lin and Polenske 1998), this growth in vehicle usage could significantly increase emissions. However, this differential in fuel economy also illustrates another potential opportunity to improve energy efficiency as the transportation sector continues to expand, in part by improving the technologies incorporated in vehicles made in China.



B. Clean Development Mechanism

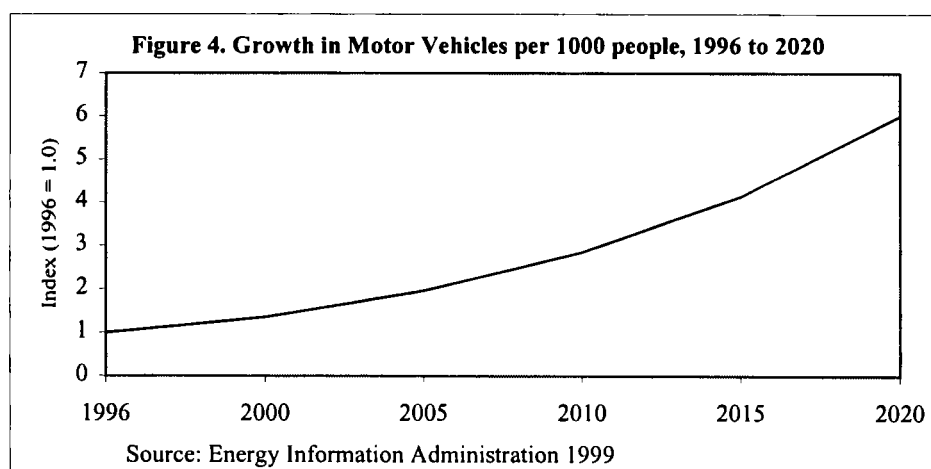
The Clean Development Mechanism can serve as a vehicle for transferring technology from developed countries to developing countries. In addition, CDM projects can provide investment opportunities for clean energy technologies developed within developing countries. CDM projects will attract investment from firms in developed countries if they generate a sufficient economic return, which includes the value of the certified emissions reductions. The technologies to be diffused through the CDM most likely will be focused in the energy sector.

Table 1. Comparison of Physical Energy Efficiency in Industrial Production between China and Western Countries

Production Activity	China	Western Countries
Industrial Boiler	55-60% ¹	75-80% ⁷
Industrial Furnaces	20-30% ²	50-60% ⁸
Thermal Electrical Power	25-30% ³	35-40% ⁹
Steel Industry	1.0 tce/ton of output ⁴	0.7 tce/ton of output ¹⁰
Synthetic Ammonia	2.1 tce/ton of output ⁵	1.15 tce/ton of output ¹¹
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ENERGIZING CHINA

*Reconciling Environmental Protection
and Economic Growth*

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3

STRATEGIC OPTIONS FOR REDUCING CO₂ IN CHINA: IMPROVING ENERGY EFFICIENCY AND USING ALTERNATIVES TO FOSSIL FUELS

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Tsinghua University

Debra Lew
*International Institute for
Energy Conservation*

Li Ping 1800 777 6804
DSC Communications Corp.

Daniel M. Kammen
Princeton University

Richard Wilson
Harvard University

INTRODUCTION

CHINA'S ECONOMIC GROWTH OVER the past fifteen years has been dramatic, with average annual increases in gross national product (GNP) of over 7%. In the next ten years, average annual growth is expected to remain at least at this level (Ho, Jorgenson, and Perkins, this volume). Associated with this economic expansion will be increased energy use. Table 1 lists the overall energy consumption in China by resource in 1993. We would expect that electricity use would rise faster than total energy use in China, as it has in other countries in comparable phases of their development (Bodansky 1991; Starr 1990; Wilson 1989), and in fact, Chinese leaders have decided to expand electricity production as fast as they can (11% per year in recent years).

In a perspective of concern about CO₂ emissions, it is equally or more important that it has been decided that the expansion of electricity production will be predominantly based on coal. The rapid increase in de-

TABLE 3

Use of Fuel in Major Chinese Industrial Sectors from 1985 to 1990,
Showing the Decrease of Energy Intensity (in kgce/yuan) with Time

Manufacturing Sector	Unit	1985	1986	1987	1988	1989	1990
Ferrous metal							
Energy use	Mtce	73	84	88	94	99	103
Output	billion yuan	44	50	56	61	65	69
Energy intensity	kgce/yuan	1.67	1.67	1.59	1.53	1.51	1.51
Non-ferrous metal							
Energy use	Mtce	14	15	15	17	18	19
Output	billion yuan	19	21	24	26	29	30
Energy intensity	kgce/yuan	0.71	0.69	0.65	0.64	0.63	0.64
Chemicals							
Energy use	Mtce	79	85	96	101	107	107
Output	billion yuan	57	62	74	89	98	107
Energy intensity	kgce /yuan	1.40	1.37	1.29	1.13	1.10	1.00
Building materials							
Energy use	Mtce	77	85	92	98	100	94
Output	billion yuan	49	85	92	98	100	94
Energy intensity	kgce /yuan	1.57	1.45	1.33	1.17	1.06	1.04

Note: 1 Mtce = 1,000,000,000 kgce.

Source: Liu et al. 1994, Table 4.

TABLE 4

Comparison of (Physical) Energy Efficiency in Industrial Production
Between China and Western Countries

	China	Western Countries
Industrial Boiler	55–60% ¹	75–30% ⁷
Industrial Furnaces	20–30% ²	50–60% ⁸
Thermal Electrical Power	25–30% ³	35–40% ⁹
Steel Industry	1.0 tce/t ⁴	0.70 tce/t ¹⁰
Synthetic Ammonia	2.1 tce/t ⁵	1.15 tce/t ¹¹
Cement	0.2 tce/t ⁶	0.13 tce/t ¹²

Notes:

1. 100% efficiency corresponds to all internal heat of the fuel being tuned into process heat or electrical energy.
2. tce/t = tons of standard coal equivalent per ton of output.

Sources: SETC 1994; Lu 1993.

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ing Biomass (1985–1992)

1991	1992	1993	1994
714	763	812	879
142	n/a	n/a	n/a
573	n/a	n/a	n/a
51	50	48	51
13	14	13	13
48	51	56	56
13	14	19	18
160	158	157	154
40	44	54	55
1038	1094	1160	1227

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tained in the ingot was lost,
g pit. After a "hot discharge"
27% of the ingot heat was
ons of heavy oil, worth 1.64
t paid for itself within six
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tion.



Daniel Kammen <dkammen@socrates.berkeley.edu>

09/06/99 03:23:16 PM

Record Type: Record

To: Leigh L. Linden/CEA/EOP

cc:

Subject: Re: Fact in 1998 Paper

Hi Leigh,

Yes, in the copy-setting the '8' became a '3'.

It should be 75 - 80%

Regards,
Dan Kammen

>Prof Kammen,

>

>In your joint article "Strategic Options for Reducing CO2 in China" in the

>book Energizing China (1998), Table 4 (p125) lists the efficiency of an

>industrial boiler in Western Countries as 75-30%. Should the 30% have been
>80% or another number entirely?

>

>Thanks in advance for your help,

>Leigh L. Linden

>Council of Economic Advisers

Daniel M. Kammen

Associate Professor of Energy and Society

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ENERGIZING CHINA

Reconciling Environmental Protection and Economic Growth

Edited by

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and Peter Lydon

Studies of Phase I of the
Harvard University Committee on Environment
China Project (1995–1998)



Harvard University Committee on Environment.

Distributed by Harvard University Press.

5

ENERGY USE AND AIR- POLLUTION IMPACTS OF CHINA'S TRANSPORTATION GROWTH

Xiannuan James Lin
Standard & Poor's DRI

Karen R. Polenske
Massachusetts Institute of Technology

TRANSPORTATION ACTIVITY IN CHINA has grown dramatically since the beginning of the economic reform in the late 1970s.¹ Between 1978 and 1993, the total volume of passenger movements more than quadrupled, while that of freight transportation tripled (SSB 1994). Transportation capacity provides accessibility, which is essential to economic development. It supplies materials to factories, distributes products to markets, reduces the time and cost required to move people and goods, thus in effect "bringing places closer" to each other. This enhances specialization, notably spatial specialization. As part of the basic infrastructure in modern societies, the passenger transportation system carries people to and from work and leisure, expands personal freedom, enlarges horizons of awareness, and improves the quality of life. China's demand for transportation is expected to continue to grow for the foreseeable future as the economy rapidly expands.

The benefits of transportation, however, may come at a high cost. Transportation requires a large quantity of gasoline and diesel, both of which are in short supply in China (SSB 1994). The growth in transportation fuel consumption was a primary reason why China, the world's sixth largest oil producer, became a net oil importer by the end of 1993

TABLE 5 (CONTINUED)

Growth Factor Analysis, 1978–1993 (continued)

6. Total Traffic Turnover Volume = freight traffic volume + 0.07 × passenger traffic volume.
7. GDP per capita = GDP / population.
8. Total Traffic Volume per Unit Product = Total traffic volume / GDP.
9. Passenger Traffic Volume per Unit Product = passenger traffic volume / GDP.
10. Freight Traffic Volume per Unit Product = freight traffic volume / GDP.
11. Energy Use per Unit Transportation = Total energy consumption / total traffic volume.
12. Average annual growth rate = arithmetic mean of annual growth rates.

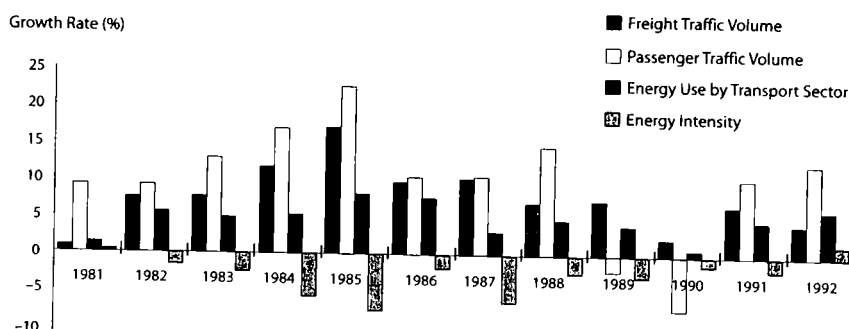
Sources: SSB (1993, Tables 2–10, 12–6, and 12–8; 1994, Tables 2–10, 3–1, 6–3, 14–6, and 14–8; 1991b, 205–206).

for the traffic-turnover volumes for passenger and freight (Table 5). The energy intensity of the transport sector, measured in terms of kilograms standard coal equivalent (kgce) per ton-km of transport volume, declined at an average annual rate of 2.7% from 23.8 kgce in 1980 to 17.1 kgce in 1990 (Table 5 and Figure 3). We believe that three factors are primarily responsible for the energy-intensity decline: (1) replacement of inefficient steam locomotives with more efficient diesel and electric ones, (2) improvements in the average fuel efficiency of motor vehicles due to the addition of a large number of new, more-efficient vehicles, especially imported ones, and (3) the increase in the load factor for all transport modes, which tends to reduce fuel consumption per unit of transport volume.

② Even so, the transport-fuel efficiency is still very low in China. The fuel intensity of the highway transport sector, for example, is 15–25%

FIGURE 3

Decline in Fuel Intensity in the Transport Sector, 1981–1992



Sources: SSB (1993, Tables 12–6 and 12–8; 1994, Tables 14–6 and 14–8; 1991b, 205–206).

higher than in developed countries for this:

1. Less fuel-efficient engines
2. A high percentage of heavy-duty and light-duty trucks
3. A relatively low share of energy efficiency is higher
4. Scarcity of paved highways
5. A poor highway transport capacity ratio in trucks

There are large potential for improvements. We will discuss them below.

Air-Pollutant Emissions

Transportation's use of fossil fuels has a major impact on the environment. Hydrocarbons (HCs), carbon monoxide (CO), nitrogen oxides (NO_x), and ozone pollution. Transportation's use of fossil fuels has a major impact on the environment. Hydrocarbons (HCs), carbon monoxide (CO) and particulate compounds, and various other pollutants from vehicles are far higher than those produced in Beijing or Shanghai per kilometer (g/km) compared to the United States (Zhang et al., 1994). An automobile emits an average of 1.5 g/km of NO_x compared to 0.65 g/km in the United States. A single motor vehicle emits 1.5 g/km of NO_x equivalent to that of 100 motor vehicles in Tokyo, but the total number of motor vehicles in all three cities (Zhang et al., 1994).

Motor vehicles are the largest source of air pollution in large metropolitan areas. The concentration in the urban

(continued)

ight traffic volume + 0.07 × passenger traffic volume.

duct = Total traffic volume / GDP.

duct = passenger traffic volume / GDP.

duct = freight traffic volume / GDP.

= Total energy consumption / total traffic volume.

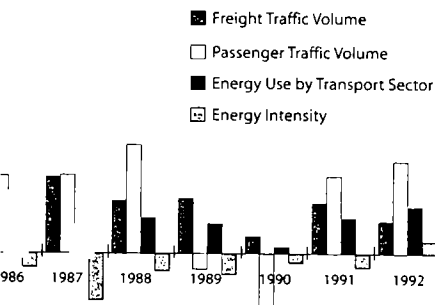
netic mean of annual growth rates.

12–8; 1994, Tables 2–10, 3–1, 6–3, 14–6, and 14–8;

or passenger and freight (Table 5). The sector, measured in terms of kilograms per ton-km of transport volume, declined 2.7% from 23.8 kgce in 1980 to 17.1 kgce in 1992. We believe that three factors are responsible for this energy-intensity decline: (1) replacement of older vehicles with more efficient diesel and electric vehicles; (2) the average fuel efficiency of motor vehicles has improved; (3) the number of new, more-efficient vehicles, and (4) the increase in the load factor for all vehicles. These factors will continue to reduce fuel consumption per unit of transport volume.

Energy efficiency is still very low in China. The energy intensity in the transport sector, for example, is 15–25%

Transport Sector, 1981–1992



1994, Tables 14–6 and 14–8; 1991b, 205–206).

higher than in developed countries. He et al. (1994) cite five major reasons for this:

1. Less fuel-efficient engines in trucks and buses;
2. A high percentage of medium-sized trucks in use and insufficient heavy-duty and light-duty ones;
3. A relatively low share in trucks and buses of diesel use, whose fuel efficiency is higher than that of gasoline fuel;
4. Scarcity of paved highways in China, which increases fuel use; and
5. A poor highway transport management system and low load-to-capacity ratio in trucks.

There are large potentials, therefore, for further energy-intensity reductions. We will discuss fuel-efficiency policy options later.

Air-Pollutant Emissions

Transportation's use of energy contributes its share of serious damage to the environment. Hydrocarbon (HC) emissions from the tailpipe and from the evaporation of fuels, together with exhaust emissions of nitrogen oxides (NO_x), are principal causes of urban smog and low-level ozone pollution. Transportation is also a major source of carbon monoxide (CO) and particulate matters (PMs), including lead and sulfur compounds, and various toxic substances. China does not have national vehicle-emission standards, and the tailpipe emissions of its vehicles are far higher than those in the Western countries. A car produced in Beijing or Shanghai, for example, emits 60–80 grams of CO per kilometer (g/km) of vehicle travel, 10–15 g/km of HC, and 5–10 g/km of NO_x , compared with values of about 2.1 g/km CO, 0.25 g/km HCs, and 0.65 g/km NO_x emissions for a typical automobile in the United States (Zhang et al. 1994, 34). In other words, one Chinese-made automobile emits an amount of CO equivalent to that from 30–40 U.S. automobiles, HCs equivalent to that from 40–60 U.S. automobiles, and NO_x equivalent to that from 8–15 U.S. automobiles. In Beijing, the number of motor vehicles is only about one-tenth that in Los Angeles and Tokyo, but the total amount of vehicle emissions is about the same for all three cities (Zhang et al. 1994, 34).

Motor vehicles are becoming a major source of air pollution in many large metropolitan areas of China because of their rapid growth, high concentration in the urban center, and traffic congestion. Researchers

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ments may be achieved by many measures, which could include an increase in fuel prices, imposition of congestion charges, establishment of fuel-economy standards, implementation of transportation-system management, and provision of incentives to retire old vehicles.

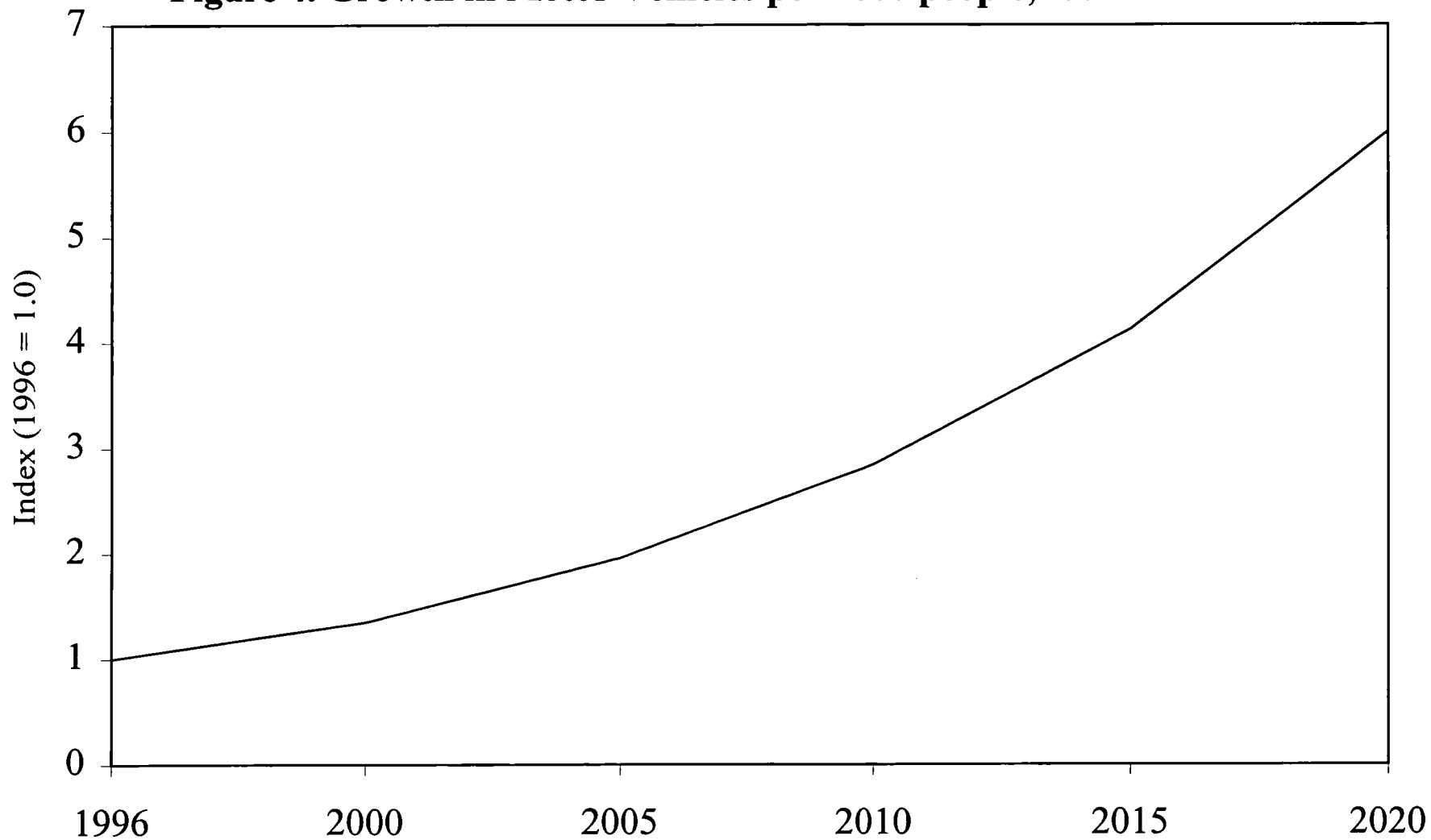
Despite recent improvements, the fuel intensity of China's transportation sector is still much higher than that in developed countries. The fuel consumption rate of the domestic-made motor vehicles, for example, is about 30–40% higher than that of comparable import models (Zhang et al. 1994, 52). There are a number of ways in which the government can encourage fuel-efficiency improvements. First, it could establish fuel-economy standards, requiring automakers to increase the fuel economy of new cars over time, and provide research and development support to help the industry meet these standards. Second, the prices of fuels could be increased to provide an economic incentive for vehicle owners/operators to reduce fuel consumption. Third, policy measures could be taken to improve road conditions (e.g., better pavement and signal controls), to reduce congestion, to increase the occupancy rate of vehicles, and to match the actual load with vehicle capacity, all of which help to increase fuel efficiency. ③

To increase the impact of reducing new vehicle emissions and imposing fuel-economy standards, the Chinese government could develop a program to encourage old-vehicle retirement. Due to the slow turnover of motor vehicles in China, many trucks, jeeps, and cars made in the 1960s, and even the 1950s, are still operating on the road. They have fuel consumption and emission rates that are several times greater than the comparable new models. The government could allow new automobile buyers to trade-in their old vehicles, with the state purchasing the old vehicles and supplying them for scrap to steel manufacturers who use electric-arc furnaces.

Improving Accessibility to Reduce Transport Growth

More fundamentally, we believe that China needs to find a new way to provide transportation services and to slow traffic growth, that is, control the transportation intensity, TKM/GDP, in Equation (2). This is important because emission regulations and fuel efficiency alone may not be sufficient to control negative energy and environmental impacts of motorization. Cars can get cleaner and more fuel efficient, but if more people are buying cars and they are driving more, energy use and air-pollutant emissions can still rise rapidly.

Figure 4. Growth in Motor Vehicles per 1000 people, 1996 to 2020



Source: Energy Information Administration 1999

①

Motor Vehicles per 1000 people

1996	9 ¹	1
2000	12.13	1.347778
2005	17.62	1.957778
2010	25.59	2.843333
2015	37.17	4.13
2020	54 ²	6

interpolated using

7.5^{7.6} avg annual growth rate

The avg annual growth estimate of 7.6

has to be wrong w/ end points of 9 & 54.

The authors may have use more accurate

numbers than 9 & 54 when calculating

the avg growth rates.

Transportation Energy Use

Transportation energy use is projected to constitute more than half of the world's oil consumption in 2020. Developing nations account for more than half the expected growth in transportation energy use in the IEO99 forecast.

The *International Energy Outlook 1999 (IEO99)* presents a more detailed analysis than in previous years of the underlying factors conditioning long-term growth prospects for worldwide transportation energy demand. A nation's transportation system is generally an excellent indicator of its level of economic development. In many countries, personal travel still means walking or bicycling, and freight movement often involves domesticated animals. High rates of growth from current levels in developing countries such as China and India still leave their populations with very limited transportation services in 2020 by industrialized standards.

Currently, transportation energy accounts for 48 percent of world oil demand (Table 19). Since 1970 transportation energy demand has grown by 110 percent or 18 million barrels of oil per day. The *IEO99* reference case projection indicates growth in transportation fuel use of 77 percent or 27 million barrels per day by 2020. Virtually all demand growth involves increased use of oil products, and transportation accounts for 69 percent of the projected growth in oil demand over the next two decades. On a percentage basis, the increase in transportation energy consumption more than doubles the projected rise in world population. Developing countries account for 55 percent of the expected growth in transportation energy demand.

Growth in transportation sector energy demand within the industrialized countries, where modern transportation systems have been in place for many decades, is expected to average only 1.6 percent per year; but even in the most economically advanced countries, transportation energy use per capita continues to increase as people opt to drive larger and larger cars and as higher per capita incomes allow people to travel increasingly by air for long-distance vacations (Figure 73). Aggregate demand for transportation fuels in the industrialized countries in 2020 is projected to be about 10 million barrels per day higher than it was in 1996, reaching 34 million barrels per day (Figure 74). In many countries of the industrialized world, road congestion and vehicle ownership saturation may ultimately limit expansion of transportation sector energy demand [1, pp. 181, 210]. Car ownership in the United States and Canada is the highest in the world, and in these countries it is expected to reach saturation by the end of the projection period.

Energy use for transportation has increased sharply in industrialized Asia in recent years, in part as the result of a shift to larger cars in Japan [1, p. 234], where the share of passenger cars with an engine capacity of more than 119 cubic inches increased from about 4 percent in 1989 to more than 21 percent in 1996. Although the Japanese economy has expanded more slowly in this decade than

Table 19. World Oil Consumption Trends, 1980-2020

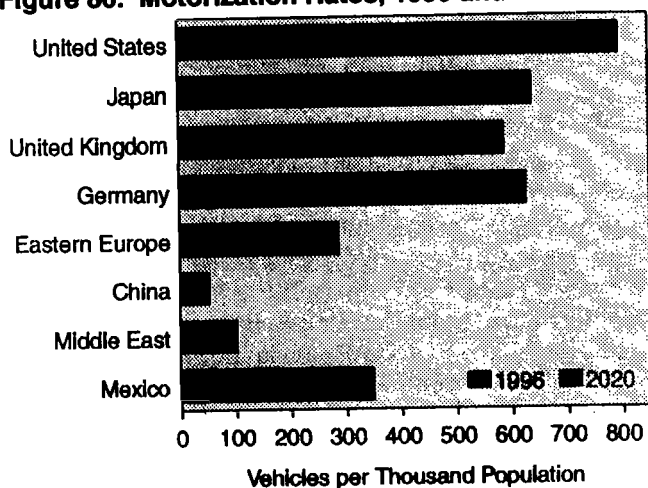
Year	Developing Countries		Industrialized Countries		World Total	
	Transportation	Total	Transportation	Total	Transportation	Total
Oil Consumption (Million Barrels per Day)						
1980	4.5	12.2	16.5	39.9	23.5	63.1
1990	6.8	17.0	20.9	39.0	31.0	66.0
1996	9.6	23.1	23.3	42.7	34.6	71.5
2010	17.0	37.0	29.9	50.1	49.9	93.5
2020	24.2	48.7	33.7	54.5	61.3	110.1
Annual Growth in Oil Consumption (Percent per Year)						
1980-1996 . . .	5.1	4.1	1.7	0.4	2.1	0.8
1996-2020 . . .	3.9	3.2	1.6	1.0	2.4	1.8

Note: World totals include Eastern Europe and the former Soviet Union (EE/FSU).

Sources: **1980-1996:** Derived from Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1996*, DOE/EIA-0219(96) (Washington, DC, February 1998). **1996-2020:** EIA, World Energy Projection System (1999).

vehicles per thousand people in 1996 to 438 vehicles per thousand people in 2020 (Figure 86). The Latin American countries, in general, have higher vehicle ownership rates than many other developing countries, based on their higher per capita incomes, high levels of urbanization, historically low subsidized prices for transportation fuels throughout the region, and the large distances separating cities [1, p. 354].

Figure 86. Motorization Rates, 1996 and 2020



Sources: 1996: American Automobile Manufacturers Association, *World Motor Vehicle Data* (Detroit, MI, 1997). 2020: EIA, *World Energy Projection System* (1999).

Several developing Asian countries have also achieved fairly high motorization levels. South Korea is projected to reach a motorization level of 450 vehicles per thousand people by 2020, up from 207 in 1996. There has been substantial growth in motorization in South Korea over the past decades. Since 1980—when there were an estimated 14 vehicles per thousand people—motorization has grown by an average of 18.4 percent per year. This trend is expected to continue through the projection period as the motorization level approaches that of the industrialized countries of Western Europe.

For those developing Asian countries that had barely begun providing wide-scale road transportation services by 1996 (China, India, and other developing Asia), motorization levels are expected to remain low throughout the projection period, despite robust projected growth. In China, the number of motor vehicles per thousand people is projected to increase by 7.6³ percent annually between 1996 and 2020, but motorization increases only from 9¹ to 54² vehicles per thousand people—less than one-fourteenth the current U.S. level.

In the Middle East, vehicle ownership is expected to grow by 2.7 percent per year over the projection period, rising from 55 to 103 vehicles per thousand people between 1996 and 2020. Motorization levels in the Middle East are not expected to approach those of industrialized countries, such as France, Germany, or Japan. One

reason for the slow projected growth in car ownership in the Middle East is that in some of the countries women are actively discouraged from driving, ultimately limiting the fraction of the population that will own cars [2, p. 399]. Another reason for the lower motorization rates in this region is the age distribution of the population in some countries. In Saudi Arabia, for example, Standard & Poor's DRI has estimated that there are currently about 90 vehicles per thousand people [15, p. 240], despite the fact that 60 percent of the population is under the age of 20.

Vehicle Energy Intensity

Energy projections for a road vehicle that is a composite representation of all road vehicles implicitly include assumptions about the future mix of vehicles and their individual usage and efficiency characteristics. Because a freight truck's annual fuel consumption may easily equal that of 30 passenger cars, these assumptions are critical to the energy forecast. For developing countries, major changes in average vehicle characteristics mark the transformation of a nation's road system from one dominated by inefficient trucks driving long hours on poor roads to one increasingly focused on personal passenger vehicles. Not surprisingly, the assumptions made about vehicle energy intensity for developing nations differ from those for industrialized nations. In each case, however, projected trends follow smoothly from historical data.

Projections of vehicle energy intensity (energy use per vehicle per year) are based on an analysis of historical trends in both industrialized and developing countries. Three observations from the analysis shaped the methodology used to project changes in energy intensity for each country's average road vehicle:

- Annual fuel use per vehicle is consistently higher in developing regions than in the industrialized nations.
- Among developing nations vehicle energy intensity has declined as economic development has progressed.
- Among industrialized countries remarkably little change in energy intensity has taken place over the past decade.

Among the industrialized nations, data categorized by vehicle type (freight truck, passenger car, and commercial size van) commonly include vehicle registrations and travel as well as fuel consumption. Average energy intensity is generally a derived estimate calculated as the quotient of fuel use per vehicle per year and miles traveled per vehicle per year. Where available, such data are the foundation for energy projections by vehicle use category. They define a starting point for analysis and a benchmark against which projections can be measured.