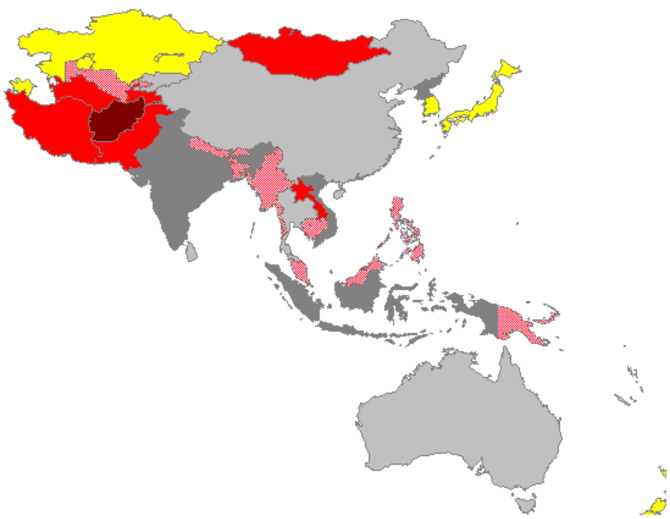
THE ECONOMICS OF CLIMATE CHAGE IN ASIA: FROM AN ENERGY PERSPECTIVE



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*ABSTRACT **:** The Asian region comprises many of the fastest growing economies in the world accompanied by substantial increases in energy use, primarily in the form of fossil fuels. Although Asian countries have contributed very little to the present high levels of greenhouse gases (GHGs) in the atmosphere, the current growth rates of their emissions extrapolate to dangerous levels in the future.*

This paper presents a review of some of the economic issues involved in deciding how to react to the threat of climate change. The paper also attempts to present the summaries of the scientific background and uncertainties, survey the results of existing studies of the impacts of climate change and a study of efficient policies to slow global warming.

I. INTRODUCTION

Since the Industrial Revolution, increased use of fossil fuels has been strongly linked with the economic growth. In recent years, there has been a growing level of concern that anthropogenic (i.e., caused by human activities) emissions of carbon dioxide and other[1] "greenhouse gases" from burning fossil fuels are contributing to global warming. As a result of this concern, interest has risen regarding possible cost-effective options to help reduce GHG emissions. Interest has focused primarily on limiting the burning of fossil fuels, which releases carbon (mainly in the form of carbon dioxide) into the atmosphere. One of the most frequently mentioned options in this regard has been reducing the amount of energy needed to produce a given unit of economic output. This option is seen by many as offering the potential for stabilizing (or even reducing) carbon emissions without sacrificing economic growth. A similar consequence could be achieved by substituting low carbon fuels (such as natural gas) for high carbon fuels (coal, for example), or non carbon-emitting fuels (such as hydroelectric, nuclear, or solar) for fossil fuels. In order to implement these measures, a bundle of various policy instruments is discussed reaching from command and control policies over information programs to the use of fiscal instruments such as subsidies or introduction of a carbon tax (*OECD, 1993 and 1994; GOTO, 1995; EPRI, 1994; POTERBA, 1993; RAJAH and SMITH, 1994).*

The purpose of this paper is to discuss and highlight some of the important aspects of the interaction between GHG limitation and economic development in developing Asian countries. Also, this paper discusses the ways of assessing costs related to GHG limitation in developing Asian countries.

II. ECONOMICS OF CLIMATE CHANGE IN ASIA : A BIBLIOGRAPHY SURVEY

In the last few years some comprehensive attempts have been made to estimate the potential effects of the economy as a result of global warming in developed countries. However, there has been a limited study in the context of Asian countries. As much of the data required for estimating the damage from global warming is produced from scientific studies, economists in this field are somewhat restricted in the depth of their analysis. However, there have been several authors who have undertaken extensive studies of the likely damage from global warming. The most prominent writers in this field are Nordhaus, Cline and Fankhauser.

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[1] Other greenhouse gases include: methane, nitrous oxide, chloroflurocarbons and related compounds, non-methane volatile organic compounds, and water vapor.

2.1 Energy Outlook and Carbon Emissions: Developing Asian Countries

The developing countries in Asia have had the highest rate of economic growth in the world in recent years. With rapid growth expected to continue, the region as a whole is projected to have the highest level of energy consumption in 2015, surpassing North America. By 2015, the developing countries of Asia are expected to consume 3.7 billion toe of energy a year, about 29 percent of the total consumption by the world (Table 1).

Consumption of energy by fuel varies substantially by country in Asia, depending on the resources available in each country. Both China and India are heavily dependent on coal, although oil and natural gas consumption is growing at a faster rate than coal in both countries as they experience fast-paced development in the transportation sector and expand their use of natural gas for electricity generation, heating, and cooking. Both countries have large reserves of coal and have drawn heavily upon them in the course of their economic development. Coal is expected to remain the dominant fuel in the region - bolstered by the strong growth in China and India - although it has the lowest growth rate of the three major fossil fuels. Natural gas consumption is expected to grow at the fastest rate of any fuel, 7.9 percent per year, leading to more than a fourfold increase in consumption in 2015 from its 1995 level. Oil demand grows at 4.1 percent per year.

Energy combustion accounts for 85 of all greenhouse gas emissions. World carbon emissions are expected to increase by 3.5 billion metric tons over current levels by 2015, growing at a rate just over 2 percent per year. According to this projection, world carbon emissions in 2015 would exceed 1990 levels by 61 percent.

By 2000, carbon emissions in the rest of the world are expected to surpass those in the industrialized countries, even though developing countries will use less energy at that time. The sizable rise in emissions from developing countries is partially a result of their heavy dependence on coal, the most carbon-intensive of the fossil fuels. Coal is used extensively in the developing Asia region, which has the highest expected rate of economic growth. Carbon emissions in developing Asia are projected to increase from 1.5 billion metric tons in 1995 to 3.2 billion metric tons in 2015.

Table 1: World Total Energy Consumption in Millions of Tons of Oil Equivalent

Region/Country	**History**			**Projections**				**Avg. Annual % Change**
	1990	**1994**	**1995**	**2000**	**2005**	**2010**	**2015**	**1995-2015**
Developing Asia	**1,206**	**1,551**	**1,636**	**2,129**	**2,656**	**3,168**	**3,742**	**4.2**
China	634	801	839	1,080	1,343	1,625	1,948	4.3
India	182	228	247	323	417	508	611	4.6
Others	392	522	550	726	896	1,034	1,182	3.9
Industrialized Asia	**544**	**608**	**641**	**698**	**759**	**815**	**864**	**1.5**
Japan	423	488	504	556	605	652	692	1.6
Australasia	121	120	137	142	153	162	172	1.1
Rest of the World	**6,360**	**6,230**	**6,302**	**6,943**	**7,535**	**8,093**	**8,605**	**1.6**
North America	2,349	2,499	2,546	2,797	3,004	3,167	3,296	1.3

Europe	3,185	2,763	2,744	3,047	3,285	3,524	3,732	1.6
Others	826	968	1,012	1,099	1,246	1,402	1,577	2.2
Total World	**8,110**	**8,389**	**8,579**	**9,770**	**10,950**	**12,076**	**13,211**	**2.2**

Note: (1) **Developing Asia** (53 percent of the 1996 world population): Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia (Kampuchea), China, Fiji, French Polynesia, Hong Kong, India, Indonesia, Kiribati, Laos, Malaysia, Macau, Maldives, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Philippines, Singapore, Solomon Islands, South Korea, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, Vietnam, and Western Samoa. (2) **Australasia** includes Australia and New Zealand.
Source: IEA, 1997

While coal use grows at the slowest rate among the three fossil fuels worldwide, the relatively high level of carbon emissions per Btu of energy from coal leads to higher growth in emissions from coal than from oil or natural gas. A high rate of natural gas penetration is the principal factor curtailing the growth of emissions relative to the growth rate for energy in the projection period. Alternative energy sources are not expected to grow sufficiently to mitigate carbon emissions. Although the share of renewable in the overall energy supply is projected to increase slightly, that trend is offset by a reduction in the use of nuclear power.

Table 2: Total Carbon Emissions by Regions from Energy Use in Millions Metric Tons

Region/Country	**1995**			**2015**			**Combined Average Annual % Change 1995-2015**
	Coal	**Oil**	**Gas**	**Coal**	**Oil**	**Gas**	
Developing Asia	**938**	**468**	**69**	**1,865**	**1,052**	**316**	**4.0**
China	673	139	8	1,421	363	55	4.1
India	146	66	10	269	139	81	4.0
Others	118	263	51	179	550	180	3.8
Industrialized Asia	**141**	**283**	**49**	**156**	**386**	**83**	**1.4**
Japan	93	232	35	111	316	65	1.6
Australasia	48	51	14	45	70	18	0.8
Rest of the World	**1,306**	**1,980**	**1,004**	**1,426**	**2,722**	**1,699**	**1.7**
North America	547	739	377	666	957	547	1.3
Europe	601	821	485	579	1,046	906	1.4
Others	158	420	142	181	719	246	2.3
Total World	**2,386**	**2,732**	**1,123**	**3,448**	**4,159**	**2,097**	**2.2**

Source: IEA (1997)

Changes in energy intensity (the ratio of total energy consumption to GDP) also have a substantial influence on emissions of greenhouse gases. As economies grow, the energy intensity of the additional economic activity will influence the course of energy consumption. In industrialized countries, the expansion of economic activity has tended to be in areas that are less energy intensive. Further, more energy-efficient technology has been adopted in many areas. As a result, energy consumption in the industrialized countries has grown more slowly than GDP since the mid-1970s. The divergence, which developed after the Arab oil embargo of 1973-1974, has persisted even as oil and other energy prices have fallen to pre-embargo levels in real terms. Thus, by 2015, world GDP is expected to be almost 4 times its 1970 level but energy use only 3 times its 1970 level.

In contrast, energy demand has risen at a more rapid rate than GDP in some regions. This pattern is expected to persist during the early years of the projection period. While the future path of energy intensity for the developing nations and economies in transition is subject to much uncertainty and is therefore more difficult to project than that for industrialized nations, the IEA (1997) projections assume that, between 2000 and 2015, energy intensity will decline in developing regions. The dynamics of growth in energy consumption are demonstrated by considering an approximate measure of the elasticity of change in energy consumption relative to change in GDP.

For the industrialized nations as a whole, the energy to GDP elasticity has been less than 1. For developing nations, the average elasticity hovered around 1 for the 1970 to 1980 period, corresponding to relatively flat energy intensity values; from 1980 to 1985 the average elasticity was about 2, and it has since declined through 1995. The decline in energy to GDP elasticity for developing nations is projected to continue through 2015 in the IEA(1997) forecasts, but at a slower rate than that for industrialized nations. The projected reduction in energy intensity is based on the assumption that energy-efficient technologies used in industrialized nations will increasingly be adopted in the developing nations. The widespread use of efficient technology could come about through pressures for economic efficiency as the developing and transitional economies become more market driven and more integrated into a world market. Environmental considerations could be another factor contributing to the adoption of more efficient technologies around the world, but they will have to compete with more extensive use of energy technologies in industry, buildings, and transportation. The balance of that competition is uncertain, as is the pace at which energy-saving technologies will be introduced.

The reference case projections assume a substantial rate in energy intensity. Several recent reports on China illustrate different views on this subject. In one report, China: Issues and Options in Greenhouse Gas Emissions Control *(JOHNSON et al., 1996)*, which provides a forecast to the year 2020, the baseline forecast has an energy-to-GDP elasticity of 0.56, comparable to that assumed for IEA (1997). In contrast, the discussion paper, Energy Demand in Five Major Asian Developing Countries *(ISHIGURO and AKIYAMA, 1995)*, assumes an elasticity of 0.78 through 2005. Using this larger energy-to-GDP elasticity with the GDP growth assumptions in IEA, 1997 to 2015 (well beyond the intended range of the discussion paper) would give a total energy consumption for China in 2015 that is about 27 quadrillion Btu larger than the reference case forecast of 83 quadrillion Btu.

Still another report, Pacific Energy Outlook by the East-West Center *(FESHARAKI et al., 1995)* has a more optimistic view of the decline in China's future energy intensity, with an implicit energy-to-GDP elasticity of about 0.47 for the 1995 to 2010 period. This elasticity applied to the IEA, 1997 GDP growth rates would place total energy consumption for China at about 71 quadrillion Btu in 2015. Thus, the range of estimates for China's energy consumption, using this range of estimates for energy-to-GDP elasticity, is about 39 quadrillion Btu, or 47 percent of the IEA, 1997 reference case forecast for China's total consumption.

Because assumptions about energy intensity have such a strong influence on energy consumption projections, it is useful to consider the effects of alternative assumptions for the developing nations group. Under the possibly pessimistic view that development in the non-industrialized nations will not result in changes in energy intensity (an energy-to-GDP elasticity of 1.0), total energy consumption in 2015 by non-industrialized nations would be 435 quadrillion Btu, an increase of 134 quadrillion Btu over the reference case projection. On the optimistic side, if it is assumed that the average energy intensity for non-industrialized nations will decline on average at the same rate as that for industrialized nations, their total energy consumption in 2015 would be 55 quadrillion Btu less than in the reference case.

2.2 Environmental Issues

In future years, coal will face tough challenges, particularly in the environmental area. Increased concern about the adverse environmental impacts associated with coal use has taken a toll on coal demand through out industrialized areas. Coal combustion produces several air pollutants that adversely affect ground-level air quality. One of the most significant pollutants from coal is sulfur dioxide, which has been linked to acid rain. Many countries have implemented policies or regulations to limit sulfur dioxide emissions, which typically require electricity producers to switch to lower sulfur fuels or invest in technologies that reduce the amount of sulfur dioxide emitted. In addition, coal has the highest carbon content of all the fossil fuels. Carbon dioxide emissions per unit of energy obtained from coal are 80 percent higher than from natural gas and approximately 20 percent higher than from residual fuel oil - the petroleum product most widely used for electricity generation *(WEFA, 1996)*.

More than 100 countries are signatories to the United Nations Framework Convention on Climate Change (UNFCCC). The ultimate concern of the Convention is to encourage worldwide efforts to achieve stabilization of greenhouse gas concentrations at levels that would forestall the threat of global warming. Industrialized countries within the OECD have pledged to pursue efforts that could stabilize greenhouse gas emissions at their 1990 levels. The first binding international legal agreement dealing directly with climate change - the UNFCCC ("the Rio Treaty") - became effective in March 1994. The Convention's primary objective is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." It was initially presented at the Earth Summit in Rio de Janeiro in June 1992, where it was signed by representatives from 155 countries, including the United States and the countries of the European Union *(IEA, 1994b)*. Carbon dioxide, because of the large volumes emitted worldwide, is the predominant greenhouse gas.

Follow-up meetings in March 1995 and July 1996 (Conference of Parties I and II) have led to a strengthening of the commitments to stabilize or reduce emissions of greenhouse gases. The first meeting produced the "Berlin Mandate," which initiates a process to set quantified greenhouse gas limitation and reduction objectives for the time period after 2000. The second meeting produced the "Geneva Declaration," which calls for legally binding objectives and significant reductions in greenhouse gas emissions in the post-2000 period and endorses the Second Assessment Report (SAR) by the Intergovernmental Panel on Climate Change (IPCC).

In its second report, the IPCC acknowledges the strong potential for a significant rise in average worldwide temperatures (approximately 2 degrees centigrade) by 2100 *(CLINE, 1992)*. This outlook is based on the continuing build-up of greenhouse gases in the Earth's atmosphere that will occur without specific policies to mitigate emissions. A third meeting, to be held in Tokyo in December 1997, will focus on the implementation of a legally binding protocol or other legal instrument for controlling post 2000 emissions of greenhouse gases.

Decisions to maintain or reduce greenhouse gas emissions in the post 2000 period could have a substantial adverse impact on coal. Indeed, it will be difficult to moderate carbon dioxide emissions at the same time that world energy demand is growing, particularly when coal or petroleum products are used in increasing amounts to meet the demand for energy.

In the future, environmental regulation will represent a major challenge for coal markets in many areas of the world. On the other hand, increases in coal use are possible in countries that have not yet committed to greenhouse gas emissions reduction programs. Although local air pollution problems in those areas may intensify and encourage greater use of alternative fuels, the available alternatives are more costly, and increased use will require multilateral policy decisions. In other areas, coal use will diminish or its growth will slow. Competitive pressure from other fuels, particularly, oil and natural gas, has intensified because of their current low prices, the availability of new technologies that favor the use of natural gas for electricity generation, and increased costs of environmental compliance for coal-fired energy sources. Nonetheless, coal use in the IEA, 1997 reference case is projected to grow by 2.3 billion tons (45 percent) worldwide between 1995 and 2015.

2.3 Policy Towards Climate Change

Economic evaluation of policy towards climate change seeks to determine how much abatement of emissions of carbon dioxide and other greenhouse gases is socially efficient. Economists have approached the problem of climate change in two ways. First, most analyses have concentrated on the development of economic models of the cost of reducing carbon emissions (*MANNE and RICHELS, 1992*). Second, direct estimates of greenhouse damages against calculated abatement costs to determine whether abatement is efficient on economic grounds (*NORDHAUS, 1992*).
Table 3 provides a summary view of the alternative approaches to greenhouse policy evaluation, incorporating the dominant patterns of views among three communities: scientists; engineering-technological experts; and economists. Two principle alternative approaches, namely, "engineering" approach (i.e. "bottom-up" modeling) and economic cost approach (i.e. "top-down" modeling), are commonly used to calculate the abatement costs.

Table 3: Overview of the Alternative Approaches to Greenhouse Policy Evaluation

<table>
<tr><td rowspan="4">Green-
house
damage</td><td colspan="3">Abatement Costs</td></tr>
<tr><td>Approach</td><td>Bottom-up approach</td><td>Top-down approach (most economists)</td></tr>
<tr><td>Enumerative approach</td><td>Low abatement costs; modest greenhouse damage at 2 X CO_2:
↓
ACT</td><td>Moderate abatement cost;
greenhouse damage at 2 X CO_2:

1. At a high discount rate, with a low expectation of long-term warming:
↓
MINIMAL ACTION (Nordhaus)

2. At a low discount rate, with a low expectation of long-term warming:
↓
AGGRESSIVE ACTION (Cline)</td></tr>
<tr><td>Catastrophic approach
(most scientists)</td><td>Low abatement costs; risk of catastrophe assumed to be:
1. Significant:
↓
ACT

2. Negligible: ↓
DO NOT ACT</td><td>Moderate abatement cost; some risk of catastrophe: ↓

"HEDGE"
(some action; wait for confirmation before tracking major action-Manne and Richels; Schelling)</td></tr>
</table>

While bottom-up analysis treats the structure of the economy and performance of technologies in a detailed fashion, top-down analysis aggregates such data into a macroeconomics framework *(WILSON and SWISHER, 1993).* In the top-down models, the most important parameters are GDP, costs and prices, and parameters such as price and income elasticities, that describe the overall energy-economy interactions. The conflicting views and approaches between top-down and bottom-up analyses stem from the fact that the analysts are asking different questions, based on their different perceptions of reality. Bottom-up models seems to top-down analysts to be inherently normative, because they assume that existing market failures and institutional barriers will be removed. On the other hand, top-down models are structured to preclude asking what bottom-up analysts see as the key policy questions, such as "which barriers should be removed and how?" However, at least in principle, the two approaches should be complementary.

The enumerative approach (used *by NORDHAUS, 1991; CLINE 1992; FANKHAUSER, 1992; and TITUS, 1992*) identifies specific areas of warming impact (for e.g. on agriculture), and attempts to estimate an economic evaluation of the damage in each category. In the second approach, there is no attempt to quantify damages from global warming in economic terms. Instead, the effects of global warming, especially in the ecological sphere, are considered either potentially catastrophic, thereby requiring preventive action; or they are viewed as minimal and insufficient to warrant abatement, in part because the prospective extent of warming is seen to be very limited.

2.4 Economic Impacts of Climate Protection Policies

On an macroeconomic level, the economic mechanisms lead to impacts on the supply and demand side as well as the public deficit. Three different classes of effects can be separated: price and cost effects, demand effects and technological effects on competitiveness.

Price and Cost Effects

Climate protection policies can lead to price and costs effects on the supply side. This effect is most prominent in neoclassical theory. The actual effects on costs and prices consist of different partial effects, which can compensate for each other. The size of these effects depend on the actual situation analyzed and can not be generalized. Important parameters are the envisaged CO_2-reduction, the size of the no regret reduction potential and the way the revenue of an energy/CO_2-tax is channeled back into the economy.

Demand Effects

Demand effects are the centerpiece of the Keynesian model of employment. In total, positive growth and employment effects are to be expected if climate protection policies lead to and increase in effective aggregate demand. Analyzing the effects on aggregated demand, different partial effects can be distinguished. The direct demand effects of the political measures can be either positive or negative. Measures to increase the rational use of energy (substitution of energy with capital) require additional investments (demand increase), however, the demand for energy sources decreases simultaneously. Substituting energy sources for each other changes the demand for the respective forms of energy. As the production of a given demand requires numerous inputs from other production sectors, the direct demand effects lead to indirect effects as well. In addition to the direct and indirect effects there are the typical income effects on aggregate demand which are caused by changes in investment and savings behavior.

Technological Effects on Competitiveness

In addition to costs and demand effects, climate change protection policies can also change the competitiveness of a country for a technological reasons. The effects of these policies on the modernization of the capital stock and hence the productivity have to be taken into account.
Table 4 summarizes the economic mechanisms between climate protection policies and the economy.

Table 4: Economic Mechanisms between Climate Protection Policies and the Economy

Price and Cost Effects

☛ Additional costs in case of perfect competition, which lead either to reduction of real wages or to unemployment

- ☛ Macroeonomic cost reduction, if energy tax revenue is overcompensated by a lowering of other taxes or a reduction in interest costs
- ☛ Macroeonomic cost reduction, if climate policies induce economic feasible measures

Demand Effect
- ☛ Direct demand effect (positive and negative)
- ☛ Indirect negative effects due to interlinkages between branches (positive and negative)
- ☛ Positive or negative income effect

Technological Effects on Competitiveness
- ☛ Investments in climate protection measures are crowding out productive investments
- ☛ Modernization of capital stock through investments in climate protection policies leading to an increase in productivity
- ☛ Improvement in qualitative competitiveness in the market for climate protection goods

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III POLICIES AND MEASURES FOR COMMON ACTION IN ASIA

3.1 Economic/Fiscal Instruments : Taxation on Carbon/Energy

3.1.1 Objective of carbon/energy taxation

The principal reason for carbon/energy taxation is to increase prices according to the energy and/or carbon content of different fuel sources. Such price change encourages shifts in activity lower carbon/energy intensive activities without dictating what those shifts should be or how rapidly they should take place, and provides incentives for, inter alia, the development and penetration of more energy efficient or cleaner technologies. Carbon and energy taxes also have an informational value if they are applied with an aim to reduce externalities; i.e., they send price signals to consumers which better internalize certain external costs.

In the case of a carbon tax, the price-signal is straightforwardly applied on the carbon content of the fuel alone, and is mainly aimed at climate change impacts since CO_2 is only a pollutant in the greenhouse gas context. For an energy tax, the purpose may be to tackle broader externalities related to energy use as a whole, which means end-use prices are increased to reduce general energy consumption for a variety of reasons.

So far, energy taxes, applied mostly on gasoline and diesel in transportation, have been used to raise government revenues. They are usually considered to be efficient from a fiscal standpoint. Efficiency in a *fiscal* sense is when a tax raises revenues with as little impact as possible on production or consumption patterns (minimum market distortion, or deadweight losses), which also means they provide a sound revenue base over time. Efficiency in *environmental* terms refers to a policy that induces agents to reduce emissions at the socially optimal level, which can be set through social consensus or scientific measurements. A tax on externalities achieves that goal in the most cost-effective fashion, in theory. However, an environmental tax has potentially opposite fiscal effects since reduced consumption in response to such a tax also erodes the revenue stream,

if a stable tax is efficient in reducing emissions. The answer , here, is that the carbon/energy tax can be increased to reach some equilibrium level in the long term (equilibrium on emission level and budget revenues).
One should distinguish short term and long term price responses: a tax that successfully raises revenues in the short term nonetheless affects energy use and energy choices in the longer run. Second, current energy taxes are disproportionately applied to a single fuel, namely oil in transportation; if such taxes have already contributed to lower the efficiency potential on the use of gasoline in transportation, explaining the short-run inelasticity, this isn't nearly the case in the use of other fuels, or other refined oil products, especially when energy prices are relatively low.

3.1.2 Approach of the study of carbon/energy taxation as a measure for common action

The section looks at taxes based on the carbon and/or energy content of different fuels, from carbon taxes to energy taxes. These include standard energy taxes (e.g. BTU-tax), carbon taxes (Scandinavia), and taxes based on both the carbon and the energy content of the fuels (including the *European Commission tax proposal*).

A taxonomy of energy prices/taxes by fuel show how disparate price levels per unit of energy are depending on the fuel (and the region). For that reason, it is theoretically interesting to consider homogenizing energy tax levels based on the carbon/energy content of different fuels. either according to their carbon content or their energy content. This option is used *only as an illustration* of how existing taxes affect CO_2 emissions from energy use, since existing taxes have been introduced for (fiscal, environmental and other) purposes that cannot be overridden by the CO_2 issue. When looking at tax-restructuring, a sectoral approach should also be adopted, since average fossil fuel prices do not adequately reflect implemented energy pricing policies across sectors.

The schemes adopted for recycling tax revenues are crucial for the analysis of the economic impacts of carbon/energy taxes. Among others, the study looks at the opportunity of using tax revenues to finance carbon/energy efficiency improvements in sectors where the increase in energy expenditures would be most damaging, e.g. due to long lifetime of capital stocks. One should be cautious when considering such options: earmarking for environmental policies can lead to inefficiencies (and is discouraged by a theoretical approach of environmental policy), because spending doesn't necessarily go to the cheapest alternative. Such options should be taken for tools to ease the transition towards less carbon/energy- intensive equipment and uses, rather than as an improvement from a straight tax , recycled through the general budget, considered optimal from a theoretical standpoint. This study also touches on the possibility of coupling carbon taxation with carbon sequestration.

Different national circumstances (economic development, energy resources, energy prices) make it difficult to envisage a single carbon/energy tax as a measure for common action at the moment. A more constructive suggestion would be to agree on pricing as an instrument to reduce energy-related CO_2 emissions in the long run. This study is only able to provide qualitative results on this policy approach, and provide some options for further analysis.

3.1.3 Overview of modeling results on carbon, carbon/energy and energy taxes

In this section rely on the available literature covering various taxation of carbon/energy with insights on national differences. In some cases, we chose to use studies that shed some light on specific measures included in the scope of this study. It wasn't possible to rely only on IPCC material, nor was it possible to synthesize all available literature on carbon/energy taxation.
We consider carbon taxes, carbon/energy taxes, and energy taxes, with a focus on reduction levels obtained with various tax levels, over various time horizons, for different countries. Macro-economic costs, when relevant, are addressed in this section as well. We look at three variation of carbon/energy taxation:

- Carbon taxes. It is not always possible to find homogeneous studies looking at the same tax level; considering taxes necessary to achieve a similar reduction objective then provide s another useful angle for comparison,
- Carbon/energy taxes (EC proposal, and other derived studies), and
- Energy taxes ("BTU-tax")

3.1.4 Limitations of various modeling approaches to assess the effects of carbon taxes

The results reported in this study are based on four general categories of models:
- Computable general equilibrium (national and global)
- Macro-econometric analysis (mostly national and regional)
- Technology-oriented models, based on linear programming (national)
- Energy models (global; partial equilibrium models)

Most of the analysis on international taxation schemes rely on the first two types of models. These typically take a highly aggregated view of different energy sectors and end-uses. The "optimal taxation" solution these models generate is therefore robust in macro-economic terms, i.e. , estimated *economy-wide* GDP effects. These models do not account for sectoral differences, especially with respect to rigidities and costs at the micro-level . In designing taxation policies in the real world, as shown by experience to date, these sectoral differences in adaptability, and therefore micro-economic impacts, are extremely important, if not determinant in the policy chosen. Of course, such effects become even more difficult to assess when longer time frames are considered.

We summarize below the main features, strengths and weaknesses of these approaches. The reader should keep in mind that these comments apply to all the modeling results reported below:

<u>Computable general equilibrium models</u>

Key features and assumptions

- Markets, and the economy as a whole, reach equilibrium (supply=demand) through price adjustments
- Markets work efficiently *Strengths*
- Produce economically-consistent scenarios over long run time horizons, with complete economic interactions among sectors
- Assess economy-wide GDP cost of reduction strategies, including trade effects *Weaknesses*
- Energy end-use and technology are described through simplified production and consumption functions, even for sectors as different as private transportation and electricity production.
- Markets are assumed to operate efficiently; any departure from baseline entails a cost.
- Usually ignore transition costs, by assuming malleability of capital stocks and optimal decision -making
- No or little statistical basis (models usually calibrated on a single year)
- Technology is exogenous; economies of scale, and other increasing returns of adoption induced by the price signal cannot be rendered.
- Do not always account for resource depletion
- Rely on "closure rules" (e.g. evolution of government deficit) with unclear influence on results , including trade, investment and debt.
- Poor description of investment behavior as well as households energy use and choices.

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<u>Macro-econometric neo-keynesian models</u>

Key features and assumptions

- Forecasting tools based on short to medium term (10-15 years)
- The economy is not necessarily in equilibrium: "structural" unemployment is possible
- Monopolistic competition ("mark-up" pricing, as opposed to marginal cost pricing)
- Household behavior based on elasticities rather than utility functions *Strengths*
- Strong statistical basis
- Key output include impact of policy measures on prices, investment, employment, as well as GDP.
- Best suited to look at "double-dividend" issues *Weaknesses*
- Financial flows as opposed to physical flows
- Technology based on econometric analysis, little physical realism
- Econometric analysis may not be valid to estimate the effects of unprecedented *policy* changes, especially for longer time frames

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<u>Technology models</u>

Key features and assumptions

- Country-specific technology databases on different components of the energy system (cost, age , lifetime)
- Optimization of energy-environment systems under a set of user determined constraints
- Indicate what technology can contribute to meet a certain set of constraints *Strengths*

- Technological detail
- Constraints can be directly applied to reflect real world constraints of energy choices *Weaknesses*
- Assume agents respond perfectly to prices, leading to "technology optimism"
- Do not represent feedback of different energy choices to the rest of the economy (investment, increase in energy prices, etc.)

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Energy Models (partial equilibrium)

Key features and assumptions

- Project energy demand based on econometric analysis and exogenous economic growth scenarios
- Solve market equilibria for energy at regional and/or global level *Strengths*
- Coherent global energy picture; energy detail (from primary to final energy, or energy service)
- Amenable to sensitivity analyses *Weaknesses*
- No coherence-check on the underlying growth scenario
- Econometric analysis may not be valid for long-term projections
- No feedback on the economy

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3.2 Financing Energy Efficiency in Developing Countries of Asia

Emissions of CO_2 from Asia rose steadily from 350 Mt CO_2 in 1950 to 1,948 Mt CO_2 in 1995. The share of global emissions contributed by these countries increased from 15% to 24% during this period. The global share has fallen to 18%.

3.2.1 Energy Efficiency Potential

Energy Efficiency

Even when compared to some of the least energy efficient economies in OECD, Asian countries use between 2 to 9 times as much energy to produce a unit of economic output (measured in dollars at the official exchange rate). Comparing the Specific Energy Consumption (SEC) for building or industrial products, Asian countries use 20-70% more energy to heat buildings than Northern European countries. Producing a range of industrial products currently takes 15% to 100% more energy than in the OECD. There is enormous "achievable" energy efficiency improvements and CO_2 savings in Asia.

Economic Criteria for CO2 savings

Substantial savings of CO_2 may be achieved at no net cost by capturing the economic and achievable energy efficiency potentials in Asia. For these energy saving potentials, the up-front investment could be recovered through the stream of saved energy costs. Though there is great difficulty in making comparisons between a wide range of studies based on widely differing economic and other assumptions, it is possible to make some generalizations about the cost-effectiveness of the efficiency potential. Most energy saving investments considered in the categories of ‘economic’ and ‘achievable’ energy efficiency potential in this study show an internal rate of return of 12% or more -many have a return far greater than this. The energy saving potential is not constrained by the supply of cost-effective energy saving projects, but rather by the barriers associated with developing, managing and financing cost-effective projects.

Energy Prices

Energy prices have a major impact on the achievable efficiency potential in Asia. More expensive energy increases the value of savings, the return on investment for any project, and the number of projects that are cost-effective. A short review of energy price developments in Asia indicates that while subsidies still remain, particularly in the residential heating and electricity sectors, prices have converged significantly with market levels in the past 12 months. For the industrial sector, this has already happened or is close to being achieved in a number of countries. In a number of instances, energy prices are actually higher than in some OECD countries. The energy price trend is upward in all countries, subject to political and social. Given the lack of affordable capital for investing in efficiency, poor access to information, high levels of non-payment of energy bills in many countries (figures of 25% non-payment are not uncommon), and other barriers such as ownership uncertainties, raising energy prices alone will not ensure the capture of a significant part of the efficiency potential in Asia.

3.2.2 Barriers to Financing Energy Efficiency

There are extensive empirical data indicating that levels of energy efficiency in both OECD and Asian countries are below the optimum for economic efficiency. A range of market impediments inhibit the uptake of cost-effective efficiency opportunities. These are usually termed ‘barriers’ to energy efficiency. There is a substantial potential for energy efficiency projects with less than a 3 year payback, even at current energy prices. The major barriers in Asia countries are outlined as below:

1. Macro-economic climate

(i) High inflation, unstable currency,
(ii) Political and policy uncertainty
(iii) High incidence of debt, defaults, barter trading

2. Lack of information & experience

(i) General information on energy efficiency poor
(ii) Lack of metering
(iii) no standard measurement protocol for measuring savings
(iv) Lack of experience in business and risk management
(v) Donors and project developers unaware of opportunities

3. Lack of credit history, credit-worthiness

(i) enterprises, municipalities and other borrowers have not yet developed credit history
(ii) poor cash flow

(iii) lack of collateral

4. Institutions/ownership
(i) Historical legacy of central planning policies
(ii) State-owned energy monopolies
(iii) Split incentives for building tenants and owners; multi-ownership of buildings
(iv) weak institutional frameworks

5. Small scale of efficiency projects

6. Energy prices
(i) Low energy prices
(ii) Pricing uncertainties
(iii) Energy subsidies
(iv) Externalities not internalized

3.3 Agriculture and Forestry: Identification of options for net GHG reduction

On a global scale it has been estimated that agriculture presently contributes abut 21-25%, 57% and 65- 80% of the total anthropogenic emissions of CO_2 , CH_4 and N_2O respectively. Overall it accounts for one-fifth of the annual increase in anthropogenic greenhouse gas emissions mostly due to CH_4 and N_2O. Forests too are critical components of the climate system: forests contain up to 60-80% of the above ground, and approximately 40-50% of the below ground carbon of the terrestrial ecosystems. Noting these statistics, measures in the forestry and agricultural sectors are considered to be integral components of a comprehensive program of policies and measures to address climate change.

In the agriculture sector, the initial compilation of options considers a range of measures, including:

· the reduction and reform of agricultural support policies;
· cross compliance of agricultural support to environmental objectives;
· the promotion of organic (lower external input) systems of agricultural production;
· reduction of fossil-fuel use in agricultural production;
· enhancement of C sequestration and retention in agricultural soils;
· the reduction of methane emissions, inter alia, by improving manure management systems;
· taxes and levies on mineral nitrogen fertilizers;

In the forestry sector, the study catalogues management measures for:

· preserving biomass in forests with forest management (conservation, development and utilization policies) including conservation of existing C pools;
· encouraging afforestation for C storage;
· management for substitution by increasing the transfer of forest biomass C into products such as biofuels and long-lived wood products that can be used instead of fossil-fuel based products.

3.4 Reforming Coal and Electricity Subsidies

3.4.1 Policy Objective

Common action to reform electricity-related subsidies could contribute to a variety of policy objectives including: reducing greenhouse gas emissions and other environmental impacts of electricity and fuel use; increasing the flexibility of the electricity sectors; increasing economic efficiency; improving the targeting of employment and other social/economic policies; improving the conditions for and benefits of international trade; reducing government spending and increasing revenues.

3.4.2 Full Description of Measures

This study examines case study evidence on the effects of removing or reforming the following types of subsidy:

- Budgetary subsidies, such as: government grants towards the operation, investment or R & D costs of the electricity supply industry or those of its suppliers of fuel, services and equipment; tax exemptions and differential taxation of fuels and electricity; below-market-price government financing, government collateral for loans for energy supply projects, tax exemptions for bonds issued by utilities, government controls on rates-of-return from energy investments. The study identifies both subsidies whose removal is likely to increase greenhouse gas emissions - i.e. those which tend to increase production and consumption of fossil fuels, or which tend to increase the carbon intensity of the fuel mix - and subsidies that tend to reduce greenhouse gas emissions.
- Measures, or packages of measures, that result in energy producers receiving prices that are higher, or paying input prices that are lower, than would apply without the measures. (Note: indirect price supports will be addressed in the market reform study, but will also be discussed here, partly because removal of budgetary subsidies may be more effective when linked to removal of other supports for domestic producers, but also because many of the existing studies treat direct and indirect supports together.) Again, the study focuses on price supports for energy forms such as deep-mined coal, and also on measures that reduce the cost of capital.
- Measures, or packages of measures, that result in cross-subsidies among electricity consumers. These may include price and other market regulations, such as laws requiring utilities to supply electricity to high-cost consumers at prices below the long-run marginal cost of supply.

The section does not attempt to be comprehensive, and does not address all types of subsidy or support to the electricity sector; the exclusion of any measure from this paper does not imply that it is unimportant. Various types of common action that are examined are:

a) An agreement among countries engaged in subsidy reform, or interested in undertaking such reform, (i) to collect, share and monitor information on subsidies in their electricity sectors. Information might include: descriptions of all government interventions in the sector including grants, loans, taxes, regulations, planning constraints etc.; detailed information on fuel, electricity pricing and taxation; and detailed economic and environmental indicators for the electricity sector; (ii) to carry out and share analysis of the effects of their electricity policies on greenhouse gas emissions, and of the costs of these policies. The agreement could be reached in 1997, with a reporting and review format agreed during 1998 and implemented by 2000.

b) As measure (a), but including an agreement among countries engaged in subsidy reform to adopt targets for subsidy reduction according to some agreed metric such as the producer subsidy equivalent (PSE).

c) An agreement among countries to reform certain specific types of policy, such as those that support coal use in the electricity supply industry (ESI), or those that support electricity consumption by energy-intensive industries.

IV SUMMARY AND RECOMMENDATIONS FOR FUTURE ACTION

Asian emissions of carbon dioxide from the use of fossil fuels now exceed those from North America or Europe. These emissions are growing rapidly and are expected to continue growing until at least the early part of the 21st century. The rate of growth of emissions will be determined by a number of factors, including the rate of increase in economic activity, the priority given to local air quality concerns, and any limits on the emissions of greenhouse gases that might be agreed to by the parties to the Framework Convention on Climate Change. It would not be an exaggeration to say that the success of any such treaty to limit emissions would depend greatly on the active participation of the Asian Countries. It is thus essential that the countries of Asia be full and active partners in any global agreement to limit the emissions of greenhouse gases.

The design of mitigation options is currently in its initial phase in the region. The task is challenging, given the lack of funding for demonstration projects and only partial integration of global climate change concerns into governments institutions. The next steps taken to encourage implementation of effective mitigation project should include: (i) establishment of criteria for selecting mitigation options; (ii) promotion of institutional awareness; and (iii) acquisition of funding for mitigation projects.

REFERENCES / BIBLIOGRAPHY

Alcamo J., Krol M. and Leemans R. (1995). Stabilizing Greenhouse Gases: Global and Regional Consequences, RIVM, The Netherlands.

Alfred A. Marcus (1992), Controversial Issues in Energy Policy, SAGE Publications, Inc., Newbury Park, California.

Alfsen K., Birkelund H., Aaserud M. (1995): "Impacts of an EC Carbon/Energy Tax and Deregulating Thermal Power Supply on CO_2 , SO_2 and NO_x Emissions". *Environmental and Resource Economics*, 5: 165-189. Kluwer Academic Publishers, the Netherlands.

AMBIO, A Journal of the Human Environment, Special Issue, "Greenhouse Gas Emissions: Mitigation Strategies in Asia and the Pacific", Volume XXV No. 4, June 1996.

Baron, Richard (1996), Economic/fiscal Instruments: Taxation, Working Paper on Policies and Measures for Common Action, OECD/IEA.
Chakravorty U. (1997), Economic Development and the Environment in the Asia-Pacific Region: Critical Issues, Prepared for the EDAP Senior Forum on Sustainable and Balanced Development in the Asia-pacific Region, East West Center, Honolulu, Hawaii.
Chakravorty U., Roumasset J. and Tse Kin-Ping (1996), Extraction of Multiple Energy Resources and Global Warming, AREC, University of Hawaii, Honolulu, Hawaii.
Dixon R.K and J. Wisniewski, 1995, "Global Forest Systems: an Uncertain Response to Atmospheric Pollutants and Global Climate Change". Paper to Acid Rain 1995 Conference,
Dornbusch R. and Poterba J. M. (eds) (1991), "Global Warming: Economic Policy Responses", The MIT Press, Cambridge, Massachusetts.
EIA (1997), International Energy Outlook :1997, Energy Information Administration, US Department of Energy, Washington, DC, April.
EPRI (1994), Economic Impacts of Carbon Taxes: Detailed Results. Prepared by Charles River Associates and DRI/McGraw-Hill, Palo Alto.
Fankhauser S. (1992), "Global Warming Damage Costs: Some Monetary Estimates", Center for Social and Economic Research on Global Environment, mimeograph (August), London.
Fesharaki F., Clark A., and Intarapravich D. (1995), Energy Outlook to 2010: Asia-Pacific Demand, Supply, and Climate Change, No. 19, East West Center, Honolulu, HI, April.
Goto, Noriyuki (1995), "Macroeconomic and sectoral impacts of carbon taxation." *Energy Economics*, vol.17, No.4, pp.277-292.
Hedger M. M. (1996), Policies and Measures for Common Action, Agriculture and Forestry: Identification of Options for Net GHG Reduction, Working Paper 7, OECD, Paris.
Hoeller P. and Coppel J. (1992): "Energy taxation and price distortions in fossil-fuel markets: some implications for climate change policy", Chapter 12 in OECD (1992).
IAEA(1997), Energy and Sustainable Growth: Is Sustainable Growth Possible, Proceedings of the 20th Annual International Conference, Vol I, II and III, TERI, New Delhi.
Intergovernmental Panel on Climate Change (1996a): Second Assessment Report.
IPCC (1996b), Climate Change 1995. Economics and Social Dimensions of Climate Change: Contribution of Working Group III to the Second Assessment Report. Eds., Bruce J. Hoesung Le and E. Haites. Cambridge University Press.
Ishiguro M. and Akiyama T. (1995), Energy Demand in Five Major Asian Developing Countries: Structures and Prospects, World Bank Discuss Paper, Washington, DC, April.
Johnson T.M., Li J., Jiang Z., and Taylor R. P. eds. (1996), China: Issues and Options in Greenhouse Gas Emissions Control, World Bank Discussion Paper No. 330, Washington, DC, June.
Larsen B. and Shah A. (1992), World Fossil Fuel Subsidies and Global Carbon Emissions. Policy Research Working Paper Series, No. 1002. The World Bank, Washington, DC.
Manne A.S. and Richels R.G. (1990), CO_2 Emission Limits: An Economic Cost Analysis for the USA", *The Energy Journal*, Vol. 11, No. 2.
Michaelis, L., 1996a. Policies and Measures for Common Action: Measures to Restrict CO_2 Emissions from Vehicles. Working Draft. OECD, Paris.
Michaelis, L., 1996b. Policies and Measures for Common Action: Reforming Coal and Electricity Subsidies. Working Paper 2, OECD, Paris.

Newbery, D.M., 1995. Removing coal subsidies: implications for European electricity markets. *Energy Policy*, Vol. 23, No. 6, pp 523-534.

Nordhaus, William D. (1993), Reflections on the Economics of Climate Change, *Journal of Economic Perspectives*, Vol 7, No. 4, Fall, pp. 11-25.

OECD/IEA (1996), Financing Energy Efficiency in Countries with Economics in Transition, Working Paper 6, A study for the OECD Environment Directorate by IIEC-Europe, July.

OECD/IEA (1994b). World Energy Outlook 1994, Paris.

OECD (1994a), The Economics of Climate Change, Proceedings of an OECD/IEA Conference, OECD, Paris.

OECD (1993), Taxing Energy: Why and How, OECD/IEA, Paris.

Poterba J.M. (1991). “Tax Policy to Combat Global Warming: On Designing a Carbon Tax.” In Global Warming: Economic Policy Responses, R. Dornbusch and J.M. Poterba (Eds.) . Cambridge, MA: MIT Press.

Poterba, J. M. (1993), Global Warming Policy: A Public Finance Perspective, *Journal of Economic Perspectives*, Vol 7, No. 4, Fall, pp. 47-63.

Rajah N. and Smith S. (1994), Using Taxes to Reduce Externalities: Experiences in Western Europe. *Annual Review of Energy and Environment,* **19**, pp. 475-504.

Richard Schmalensee (1993), Symposium on Global Climate Change, , *Journal of Economic Perspectives*, Vol 7, No. 4, Fall, pp. 3-10.

Titus J. (1992), “The Cost of Climate Change to United States”, in S. K. Majumdar et al., eds., Global Climate Change: Implications, Challenges and Mitigation Measures, Pennsylvania Academy of Science.

WEFA (1996), World Economic Outlook, Vol. 1 , WEFA Group, Eddy-stone, PA, November.

Weyant, John P. (1993), Costs of Reducing Global Carbon Emissions, , *Journal of Economic Perspectives*, Vol 7, No. 4, Fall, pp. 27-46.

Whalley J. and Wigle R. (1991), "Cutting CO_2 Emissions: The Effects of Alternative Policy Approaches." *The Energy Journal*, Vol 12, No. 1. p.109-124.

Wilson, D. and Swisher J. (1993), Exploring the Gap: Top-down Versus Bottom-up Analyses of the Cost of Mitigating Global Warming, *Energy Policy* (March), pp. 249-363.

William R. Cline (1992), The Economics of Climate Change”, Institute of International Economics, Washington DC, June.