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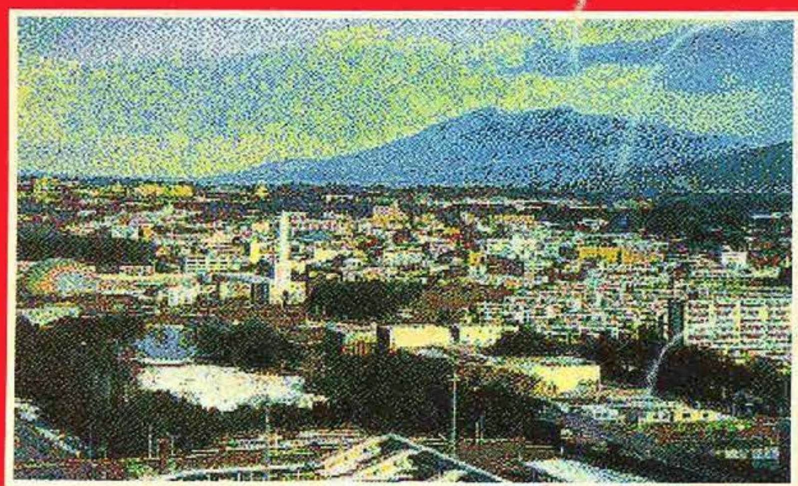
Climate Change:
Policy Instruments and their Implications



Science City, Tsukuba

Proceedings of the Tsukuba Workshop of IPCC Working Group III

Tsukuba, Japan, 17-20 January, 1994

Supporting material prepared for consideration by the Intergovernmental Panel on Climate Change. This supporting material has not been subjected to formal IPCC review processes.

WMO

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

World Meteorological Organization/United Nations Environmental Programme

UNEP

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Co-sponsored by
The Governments of Japan and Australia
Keio University

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Workshop of Working Group III of the
INTERGOVERNMENTAL PANEL
ON CLIMATE CHANGE
WMO World Meteorlogical Organization/United Nations Environmental Programme UNEP

Center for Global Environmental Research
National Institute for Environmental Studies
Environment Agency of Japan
CGER

Preface

The Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations Environmental Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to undertake technical-scientific assessments of issues related to climate change. The first assessment report of the IPCC, published in 1990, provided essential scientific and technical support for the negotiations leading to the Framework Convention on Climate Change in 1992.

When the Convention was signed, the IPCC was asked to provide further technical and scientific advice to the Intergovernmental Negotiating Committee (INC) as it prepared proposals for implementation of the Convention by the Conference of the Parties. The first meeting of the Conference of the Parties is expected to be held early in 1995. In November 1992 the IPCC agreed to prepare a special Report to the first meeting of the Conference of the Parties and a more complete Second Assessment Report (SAR) to be available later in 1995.

The IPCC organized three working groups to conduct the required scientific and technical assessments. Working Group I is responsible for assessing the literature on natural climate sciences. Working Group II is assessing the literature on the impacts of climate change and on the mitigation/adaptation options to respond to it. Working Group III was charged with assessing the literature on cross-cutting issues of the social and economic aspects of climate change. Working Group III was also asked to assess the existing greenhouse gas emissions scenarios.

One of the topics within the mandate of Working Group III is that of policy instruments to address climate change. The Tsukuba workshop focuses on policy instruments for mitigation of, or adaptation to, climate change, and the effectiveness and impacts of those instruments. It is a broad topic encompassing regulatory, economic and other instruments. The workshop was designed to:

- develop inputs to the Second Assessment Report of the IPCC due for completion in 1995;
- inform experts and IPCC authors on the status of the current experience with and understanding of available policy instruments and their applicability in the international and different national contexts; and
- provide policy advisors with an opportunity to exchange information on regional problems as well as providing a briefing to experts from the Asia-Pacific region on the nature and scope of the Working Group's activities.

While the workshop is a vital source of information for the Working Group III writing team on policy instruments and the Working Group III Bureau, conclusions reached by the workshop are not binding on the writing team nor the IPCC.

James Bruce — Co-Chair, Organizing Committee
Hoesung Lee — Co-Chair, Organizing Committee
Akihiro Amano — Chair, Local Organizing Committee
Masahiro Kuroda — Vice-Chair, Local Organizing Committee

March 1994

Editorial Note

This volume constitutes the proceedings of the Tsukuba Workshop for the IPCC Working Group III held on 17-20 of January, 1994 at Tsukuba, Japan. It reflects the dual objectives of the Workshop.

The first objective is to provide input to the current IPCC work of preparing for the Secondary Assessment Report, especially materials focusing on the assessment of such policy instruments for preventing global climate change as taxes, subsidies, regulatory measures and joint implementation. The larger part of this volume is devoted to the papers presented by distinguished researchers in these fields, including papers contributed by the lead authors of Writing Team 8 who are responsible for this area.

The order of the papers has been changed slightly from that in the workshop program for the convenience of readers. At the workshop, each session consisted of paper presentations, discussions by formal discussants, and open discussions. In the proceedings, open discussions have been summarized by rapporteurs.

Applicability of economic measures within the international and different national frameworks and efficiency-related issues such as leakage problems received considerable attention in the workshop. Another highlight was the question how developing countries assess the feasibility and effectiveness of these policy instruments. Chapter 8 of this volume summarizes the round-table discussion on this topic, which may hopefully contribute to working out the international response mechanisms in the future.

The second objective of the workshop is to afford a better understanding of the IPCC activities and to enhance the response capabilities to climate change in the Asia-Pacific region. A special session held on the final day was devoted to this end. The session was led by key note remarks of the IPCC experts, followed by reports of country participants. Every representative reported, either formally or personally, current activities of his or her country in the fields of policy and research. In the latter part of the proceedings we compiled their short reports, which together strongly suggest the necessity of close co-operation among countries in this region even though (or, perhaps, precisely because) natural, socio-economic and cultural conditions of the countries involved are so diverse.

In the rapporteurs' reports, we were not able to identify the names of all those who participated in the open discussions. The editorial committee therefore decided to mention only the names of paper-givers and formal discussants, although it is the active contributions of the "unnamed" participants that made the workshop so stimulating and fruitful.

Finally, on behalf of the editorial committee, we sincerely appreciate the effort of the editorial team which enabled us to publish this volume within such a short time after the workshop. We also thank Drs. N. Sundararaman, Erik Haites and Ata Qureshi, and Ms. Sally Thorpe for valuable editorial advice.

Akihiro Amano
Shuzo Nishioka

March 1994

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INTRODUCTION

OPENING ADDRESS[1]

James. P. Bruce
Co-Chair, WG III, IPCC

In many countries, policy makers and advisors are anxiously awaiting advice from IPCC's Second Assessment Report to which we are all contributing. They need our review of policy instruments to address climate change, that experience has shown to be effective, or possibly ineffective. In cases of some policy instruments, we may be able only to comment theoretically about their probable usefulness in certain defined circumstances. It is with great regret that I cannot join you on this occasion of the IPCC WG III workshop on Policy Instruments.

We must, of course, always keep in mind that IPCC's role is that of assessment of available knowledge in an impartial way, We are not expected to, and must refrain from, direct recommendations to any country on policies they should follow. At the same time, we must put in the hands of policy advisors and senior policy makers, the information they need to select, from options available, the policies best suited to their circumstances, to help meet the global need.

This workshop will undoubtedly contribute greatly to the deliberations of WG III's Writing Team on Policy Instruments and more broadly to the whole WG III Assessment Report. At the same time, especially on the last day, there should be a lively discussion of the full range of the WG III assessment and the socio-economic implications for countries of the Asia-Pacific region.

The Organizing Committee with Chairman Prof. Amano, the Executive Secretary, Dr. Nishioka, and all concerned with planning this workshop can be proud of the excellent job they have done. IPCC thanks them, the Center for Global Environmental Research, the Japanese government, the Australian government and Keio University for organizing and hosting this important gathering of experts.

It is now up to you, the participants, to make your contributions. Excellent speakers will be presenting the main topics, but everyone's involvement in the discussions is the key to achieving the most valuable outcome from the workshop.

Best wishes for a most successful event.

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1 This address was introduced by E. Haites, Head of Technical Support Unit, WG III for J. Bruce

OPENING ADDRESS

Hoesung Lee
Co-Chair, WG III, IPCC

I am very pleased to have opportunity to address this opening session of the IPCC Workshop on Policy Instruments and their Implications. On behalf of the Bureau of the IPCC Working Group III, I take this opportunity to express our sincere gratitude to the Governments of Japan and Australia for hosting this important workshop.

Since the establishment of IPCC Working Group III in Harare, Zimbabwe in November 1992, we have made good progress in establishing a framework for the Working Group. Last May Working Group III met in Montreal, Canada, to prepare a workplan for the Second Assessment Report. Last September, Lead Authors met in Seoul and developed detailed outlines of their chapters and agreed upon work assignments. Since then, the Working Group III Bureau and Lead Authors have engaged in assessing existing studies on the socio-economics of Climate Change as extensively as possible.

As you may know, Working Group III is charged with assessing the socio-economics of mitigation and adaptation options to and impact of climate change. A broad subject area of Working Group III is evaluation of policy instruments such as economic, regulatory and other instruments. Economic instruments include taxes, subsidies, tradeable permits, tradeable absorption obligations and deposit-refund schemes. Traditional regulatory mechanisms, such as emissions standards and efficiency standards, will also be important policy instruments for many countries. Other instruments such as land use programs, public awareness and environmental auditing are expected to play significant roles as well. The Working Group is also examining available greenhouse gas emissions scenarios.

It is expected that this workshop will provide a good opportunity to bring together experts and policy advisors, to exchange ideas related to mitigation, adaptation, and impact of climate change as well as regional issues. The Tsukuba Workshop is the first IPCC Working Group III workshop this year.

This workshop will focus on the current understanding of available policy instruments to deal with climate change, and their applicability in different national contexts. The outcome of the workshop will be a useful contribution to the Second Assessment Report of the IPCC expected to be completed in late 1995.

We will discuss a wide range of policy options covering regulatory instruments and economic instruments. While regulation has been the dominant instrument for environmental purposes, we have seen increased use of market instruments in environmental policy in recent years. One might claim that economic instruments are efficiency-oriented while regulations are performance-oriented. Beyond this simple delineation there are much more issues to be discussed in this workshop. Cost-effectiveness is an important aspect of any policy instrument while feasibility involves issues of practical nature. We should pay attention to the consequences of using a portfolio of instruments. Among those are free riding problem, international tax incidence, leakages and the time span involved.

Each policy instrument has its particular goals and individual strengths and weakness. When applied to global climate change, each type of instrument will face a much wider range of complex problems, particularly efficiency versus equity issues. Though economic efficiency is an important criteria, equity should not be disregarded. Efficient abatement from an international perspective may produce an unequitable burden that some of the political systems may be unable to respond to.

We could ask how the instrument performs in different economic environments, for example, in high growth and low growth economies. Policy instruments that work well in one economic system may have different consequences when applied in other political and economic environments. Among the crucial elements to be considered are sustainable development, trade, burden sharing and cost-effectiveness. More effort should be devoted to narrow the gap in understanding of the appropriateness of policy instruments in the context of different levels of development. In this regard, we should keep in mind that proper consideration of sustainable development in both industrialized and developing countries is the responsibility of IPCC.

In closing, I would like to take this opportunity to convey my sincere gratitude to speakers, moderators, discussants, and participants whose active participation will be extremely essential for IPCC activities. I am confident that this workshop will be a major contribution to the preparation of the IPCC Second Assessment Report.

Finally, I would like to express my deep appreciation for the work of the Local Organizing Committee and the National Institute for Environmental Studies for preparing the Tsukuba Workshop.

WELCOME ADDRESS

Atsunobu Ichikawa
National Institute for Environmental Studies

Good morning, distinguished guests, colleagues, ladies and gentlemen.

On behalf of the people engaged in making the local arrangements, it is my greatest pleasure to welcome you all to this Workshop and also to the science city, Tsukuba. I thank you very much for participating in this workshop. I particularly thank those of you who have come from overseas for their pains-taking long distance trip.

First, let me talk a little about Tsukuba science city. I suppose for some of you this occasion may be your first visit to Tsukuba. The notion of the science city was conceived by some government high officials in the beginning of 1960's to remove the national research institutes from the Tokyo metropolitan area and the proposal was approved by the cabinet in 1963. Construction began in 1968 and was almost completed in 1980. The total amount in land and buildings so far is about 1.9 trillions yen or US$160 billions. The total area is about 2,700 hectares, of which 1,500 are for institutes and 1,200 for residences. Now, Tsukuba is the site for 47 national research institutes and more than 60 private research laboratories, mainly in natural sciences and technology, including life sciences, physics, information and materials and, of course, environmental science and technology. The total annual budget for the national institutes in fiscal 1992 was about 270 billion yen or US$2.3 billion, and this accounts for 13% of total government R&D expenditure. The total number of research staff in permanent positions is about 10,500. 7,000 of them are in national institutes and 3,500 are in private. We also have about the same number in temporary positions. As for environmental research, I would say that almost all institutions are in some sense related to environmental research in their respective field of science and technology. Tsukuba is said to be a very good mixture of modern science and the traditional country life, so please enjoy the mixture during your time in this workshop.

The next commercial is for the Center for Global Environmental Research (CGER) which is serving as the Secretariat for this workshop and making local arrangements. The center started its activities in October 1990 soon after the National Institute for Environmental Studies extended its research activity to the global environment area in July 1990. The task of the center is to support, in the broadest sense, domestic and international global environment research by coordinating research activities, making large-scale research facilities available, managing data bases and monitoring global environment parameters. The center has been keeping strong ties with IPCC since its very beginning. For example, it joined in the preparation of the Working Group II Report in 1990, and worked together with Oxford University in preparing the report " Preliminary Guidelines for Assessing Impact of Climate Change" in 1992. The staff of the center are, therefore, quite pleased to serve you as the Secretariat of this workshop.

Let me come back to the serious issue. It may not be necessary to emphasize the importance of policy instruments and its implications in global environmental issues. We know clearly that all biological species have an explosive increase in population, or “big bang”, when the pressures from other species and the constraints imposed on resources are released. This is one of the innate features of genes. So far, we have also not witnessed any biological species that has escaped from an explosive decrease, or “big shrink”, sometimes even extinction, after the population “big bang”. Humankind is now in the “big bang” stage by controlling disease and temporarily releasing resource constraints by utilizing fossil fuels.

Our greatest concern is therefore, whether or not Homo sapiens is to be really sapiens after all. In other words, whether or not the acquired brain intelligence can go further beyond the innate genitor intelligence. Thing is entirely depend on the policy instruments, their implications and their social acceptance or the outcome of this workshop.

I am very happy that Tsukuba was chosen as the site of the workshop on this critical issue hosted by IPCC, Australian Government, Japanese Government and Keio university. And I sincerely hope, as an individual of Homo sapiens, that the Workshop will be really successful for the sake of survival of modern civilization.

Last but not least, I also hope that your stay here is enjoyable and fruitful. If you have any inconvenience during your stay please feel free to inform the staff of CGER, and they will be pleased to help you.

Thank you very much.

SCOPE OF THE WORK ON POLICY INSTRUMENTS

Brian S. Fisher
Australian Bureau of Agricultural and Resource Economics

I am very pleased that you have been able to give up your valuable time to attend this workshop. As Dr. Hoesung Lee has noted, the task in this workshop is to analyses the wide range of policy instruments that might be considered by governments in dealing with climate change.

The role of this workshop is to assist Writing Team 8, the team charged with the responsibility of assessing policy instruments, for IPCC Working Group III.

The greenhouse problem is a global one. It does not matter whether carbon dioxide is produced in Australia or China or Argentina. CO_2 has the same impact on the greenhouse effect no matter where it is produced.

It follows that no one country acting alone can solve the problem. Cooperation among countries is necessary. If we do not have cooperation there will be an incentive for some countries to free ride and share in the benefits of emissions reductions without sharing the costs.

Our task here is to discuss the range of policy instruments that are available and outline the consequences of their use. Which instruments will lead to both efficient and equitable outcomes? What is the optimal mix of instruments in different circumstances and in different countries? How will the adoption of particular policy instruments affect the performance of one sector of an economy relative to others? These are the types of questions we will address in the workshop and the issues that Writing Team 8 will be considering.

In much of the discussion of policy instruments we tend to think in terms of what new policies governments might put in place. But it is often just as important to consider existing policies that need to be changed. For example, the reform of energy markets in some countries could lead to a better allocation of resources and higher incomes as a consequence and also lead to a reduction in greenhouse gas emissions. In addition, there are many policies that have an indirect but beneficial effect with respect to climate change For example, forest policy, which is put in place for reasons of flora and fauna conservation, may enhance the size of carbon dioxide sinks.

Finally, when considering policy instruments we need to be aware of the level of uncertainty about our scientific knowledge. There are still many feedbacks in the natural environment that are either imperfectly understood or, in some cases, possibly unknown. It is possible that policies in one area may lead to action in another that has quite unintended consequences.

To summaries, our aim is to openly discuss the broad range of policy instruments available to governments, first of all as a guide to Writing Team 8 and second, to assist policy makers that are here with us at the Workshop in their thinking about policy assessment.

Rapporteur's Summary

Sally Thorpe
Australian Bureau of Agricultural and Resource Economics

Prof. Amano welcomed delegates on behalf of the Workshop organisers.

Co-chair of WG III, Dr. Lee, provided a broad overview of the role of WG III and of the scope of the Policy Instruments section in the Second Assessment Report. He noted that a range of criteria would be needed to assess greenhouse policy options. These included efficiency or cost effectiveness and equity or incidence.

Dr. Haites delivered a speech from Co-chair of WG III, Mr. James Bruce. Mr. Bruce emphasised that the IPCC's task is assessment of the relevant socio-economic literature on climate change issues. The Workshop is an input to Writing team 8's work on Policy Instruments.

Dr. Ichikawa offered opening remarks welcoming delegates, describing the Tsukuba Science City and the role of CGER. He noted the importance of the choice of policy options in determining the solution to the global warming problem.

Dr. Fisher built on the opening remarks by Dr. Lee in describing the scope of the Workshop. He saw the greenhouse problem as an externality problem of global proportions. The range of GHG policy instruments needed to be described and their efficiency and distributional consequences assessed. The optimal policy mix needed to cater for different country circumstances (over time and space). Dr. Fisher noted that there were a very good set of papers at the Workshop covering a range of policy instruments.

However, he stressed that we tend to think of the greenhouse problem from the perspective of what policies governments can put in place. But in many circumstances a discussion of the policies that governments should stop using is equally important--specifically misuse of pricing policy. For example, energy markets are distorted by subsidies on production and consumption.

In addition, there are policies that we should consider that may have an indirect but beneficial effect on emission reductions. For example, charging water prices to irrigators that reflect the full costs of water provision in countries where water is subsidised would tend to reduce the level of irrigation-based agriculture and perhaps methane production.

There are also other issues to bear in mind such as unexpected feedbacks and consequences of policy. An example here is that policy which reduces cattle numbers may actually increase emissions in Northern Australia where cattle keep the termite population in check.

Dr. Fisher summarized that the aim of the Workshop is to openly discuss the broad range of policy instruments available as a guide to Writing team 8 but also to assist the policy makers present in thinking about policy assessment.

General Discussion : Issues for discussion at the Workshop

A point was made that complimentarities between local and global pollution problems should be considered in assessing greenhouse policy options.

A participants pointed out, drawing upon his own research, that move attention should be paid to the importance of the removal of world energy subsides. Developing countries, particularly the former USSR, China and India, heavily subsidise fossil fuels. The removal of world energy subsidies could yield significant welfare gains to countries removing energy subsidies (gains of US$22 billion in total) and would improve global welfare and reduce global carbon emissions by 5 per cent. An equivalent emissions cut could require a US$60 carbon tax in

OECD countries.

A conference participant noted the importance of government distortions in the transport sector.

Dr. Lee, in response, stressed the importance of transparency and comparability criteria in assessing policy options.

Another conference delegate noted the existence of fragmentation in some parts of the energy market, and stressed the need for an integrated policy perspective.

There was a query as to how the results from the Workshop would feed into the INC. Dr. Haites noted that INC representatives were present and that the Workshop was part of the IPCC process and was an input to Writing team 8's chapter on Policy Instruments for the Second Assessment Report. An INC representative noted that he would be reporting back the key results from the Workshop.

A question was raised if energy subsidies could be readily removed in developing countries to the extent that they are currently used as a social welfare tool. In response Dr. Fisher noted that better welfare measures existed to address income redistribution objectives. Indeed,welfare gains from the removal of distorting energy subsidies could be combined with welfare gains from the use of more appropriate tools for social welfare policy. The participant asked that adaptation policies should be discussed at the Workshop.

Prof. Amano and Dr. Fisher noted that uncertainty and risk aversion were key elements of the greenhouse problem to be considered in policy design.

POLICY INSTRUMENTS AND THEIR IMPLICATIONS

1. Taxes

CLIMATE CHANGE POLICY AND INTERNATIONAL TRADE

Scott Barrett[1]
London Business School
and
Centre for Social & Economic Research on the Global Environment
University College London

Abstract: "Free riding" and "leakage" can both undermine international cooperation in abating CO_2. Free riding arises when countries do not contribute to global abatement, from which they themselves benefit. Leakage arises when a unilateral policy to abate CO_2 alters world prices in a way which makes other countries emit more CO_2 than they would in the absence of the unilateral policy. Leakage is transmitted through international trade; free riding is not. But leakage can be reduced, and free riding deterred, by restricting trade. Leakage can be reduced by applying tariffs to trade with "noncooperating" countries, and by taxing both the consumption and production of carbon. The problem with tariffs is that they may be applied unfairly against countries which would rather not accede to the agreement, for reasons other than free riding. Joint implementation can reduce leakage without treating "noncooperating" countries unfairly, since joint implementation is by definition voluntary. Free riding can be deterred by restricting trade between "cooperating" and "noncooperating" countries, and under some circumstances the (credible) threat of trade restrictions is enough to secure full cooperation. However, here again the agreement which is offered for accession must be fair.

1. Introduction

The Framework Convention on Climate Change makes only one reference to trade. Article 3 states:

> "Measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade."

The fact that the Framework Convention makes only one reference to trade might suggest that trade is of little importance to climate change policy. In this paper I shall argue, to the contrary, that trade issues are to a large extent responsible for the limited policies that have been undertaken so far, and that trade issues will have to be resolved before cooperation can be truly effective.

The reference to trade in the Framework Convention seems innocent enough. But the reference begs the question: Should trade measures be allowed if they are *rule-based*, *justifiable*, and *transparent*? I shall argue that some consideration should indeed be given to employing transparent trade measures in an enhanced climate change agreement. However, such measures must not be arbitrarily chosen and they must be justifiable.

The paper begins by considering the free rider problem under autarky. Section 3 then assumes that if some countries cooperate by increasing their abatement, then the remaining countries do not respond by reducing their abatement. In making this assumption, we are able to isolate the effects of trade on the incentives to cooperate. Even though noncooperating countries do not pollute more directly as a result of greater abatement by cooperating countries, they may pollute more indirectly through trade effects. I next present estimates of the magnitude of such increases--known as "leakage"--and we shall see that these estimates vary widely.

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1 My participation in IPCC Working Group III and in the Tsukuba Workshop has been funded by the UK Department of Trade and Industry. I am grateful to Akihiro Amano, Peter Bohm, and Andrew Dean for comments on the draft prepared for the workshop.

Section 4 discusses mechanisms which some countries have employed or have proposed employing, and others which theory suggests would reduce leakage optimally. These latter policies include tariffs which apply only to noncooperating countries and carbon taxes on both consumption and production. The problem with tariffs is that they may effectively harm countries which, for legitimate reasons, choose not to abate their emissions in line with the "cooperating" countries (tariffs are applied unilaterally). Tariffs, then, might reduce leakage but be seen to be unfair. Another policy which could reduce leakage without harming countries unfairly is joint implementation (joint implementation is voluntary), and Section 4 concludes with a brief analysis of this mechanism.

Section 5 returns to the free rider problem. Here we ask not what policies can be taken to reduce leakage alone but what policies can be taken to deter free riding. This discussion suggests that trade restrictions can, in some cases, be effective in deterring free riding. Importantly, the analysis argues that where this is the case, the credible threat of trade restrictions can be enough to secure full agreement. In other words, the restrictions themselves need never be employed. However, as in the case of tariffs, care must be taken to ensure that the cooperative agreement which is enforced by the (threat of) trade restrictions is itself fair.

The paper exposes some difficulties with the existing literature, and Section 5 enters territory which has not previously been explored analytically. For these reasons, it seems appropriate that the paper should conclude with some recommendations for future research. These are given in Section 6.

2. Free Riding Under Autarky

Suppose that a subset of countries (the "cooperators") negotiate an agreement to reduce their CO_2 emissions and that all other countries (the "noncooperators") do not participate in the agreement. *Leakage* arises if the noncooperating countries increase their emissions as a consequence of the abatement undertaken by the cooperating countries. Leakage is often confused with free-riding, but the two concepts are very different. *Free-riding* arises only if the noncooperating countries benefit directly from the abatement undertaken by the cooperating countries. One may have leakage without free-riding and one may have free-riding without leakage. The distinction is important, for while trade measures may have the effect of reducing leakage, they may not be justified unless the countries harmed by the trade measures are free riders. Trade measures introduce distortions into the global economy, and can only be justified from a global point of view if they succeed in reducing other distortions. Free-riding is such a distortion, and so trade measures may be justified if they serve to reduce free-riding.

Leakage is normally seen to be transmitted through trade. However, one may have leakage without trade. If the cooperating countries do not trade with the rest of the world, then their abatement policy cannot affect the prices of goods in noncooperating countries. Still, the policy may invite a response by these other countries, for if the policy reduces atmospheric concentrations of CO_2, it may alter the incentives for these other countries to reduce their emissions. Whether it will or will not depends on the nature of policy design and the effect of the unilateral action on the inputs to the design. If policy seeks to minimize the sum of environmental damages and abatement costs, then each country will choose a level of abatement at which its own marginal damage equals its own marginal abatement cost.[2] If the unilateral policy reduces the marginal damage facing other countries, then these countries may respond by reducing their own abatement. In this case, if CO_2 emissions were reduced by one ton unilaterally, global emissions would be reduced by a smaller amount. There would be leakage, but the leakage would not be transmitted by trade.

Alternatively, if the unilateral policy did not affect the marginal benefit of abatement facing other countries, then these countries would not change their policy. Provided the marginal

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2 I am ignoring here possible strategic incentives in environmental policy, which may alter this calculus. For an analysis of strategy in environmental policy, see Barrett (1994b).

benefit were positive, however, these countries would benefit from the unilateral action, despite not contributing to its provision; they would be free riders. Free-riding is a real policy concern. In defending its policy of complying with, but not exceding the requirements of, the Montreal Protocol, the United States Environmental Protection Agency (1988, p. 30576) argued:

> "In 1978 the United States restricted the use of CFCs in aerosols. While several nations adopted similar restrictions (e.g., Sweden, Canada, Norway) and others partially cut back their use (European nations, Japan), there was no widespread movement to follow the United States' lead. Concerns existed then that other nations had failed to act because the United States and a few other nations were making the reductions thought necessary to protect the ozone layer. Similar concerns exist today that unilateral action could result in 'free riding' by some other nations."

Free riding has implications for both equity and efficiency. In some cases, a public good may be provided by just a few parties, even while being enjoyed by a great many. This is a concern for equity. In other cases, a public good may not be provided, even though all parties would be better off if it were provided and the costs shared fairly. This is a concern for efficiency. Since global well-being is lower in this second case, it is this case which should cause greatest concern. In the case of climate change, a mixed result is more likely; abatement being positive but less than would be globally optimal, with some countries contributing less toward the provision of even this level of abatement than might be considered fair.

These aspects of the global warming "game" and their relation to policy have already been examined by Barrett (1992), who considers the effect of policy instruments, side payments, and free rider deterrence mechanisms on negotiated outcomes. The remainder of this paper builds on this earlier work by examining these issues under a regime of trade.

3. Leakage Under Free Trade

Let us suppose that an abatement policy by one country has no direct effect on the abatement policy of another country. If marginal abatement benefits were constant and countries chose to equate marginal benefits and marginal abatement costs, then this assumption would follow automatically. Given this assumption, other countries would not reduce their abatement in the wake of the unilateral policy under autarky. Under a regime of free trade, this may no longer be true. In the remainder of this paper I shall assume that leakage is *only* transmitted through trade. This assumption is consistent with the literature on leakage, but it should be remembered that this assumption is likely to *understate* the real magnitude of leakage.

Suppose that the reduction in emissions is effected by a unilateral carbon tax on the consumption of fossil fuels. Then the costs to domestic manufacturers will rise relative to those facing foreign competitors, and comparative advantage will be shifted from countries which impose the tax to those which don't. As the noncooperating countries produce more traded goods, their use of carbon-intensive fuels will rise and so, too, will their emissions. This increase in emissions by noncooperating countries is likely to be exacerbated by the effect of the policy on energy markets. The unilateral policy would reduce world demand for fossil fuels, and hence world prices of fossil fuels. In response, countries not adopting the carbon tax may increase emissions even more.

These are the two primary channels through which leakage may be transmitted, and on balance we should expect leakage to be positive. However, it is not necessarily true that every noncooperating country would increase emissions in the event that cooperating countries reduced emissions. Leakage depends on how energy markets are structured, and it is possible that the emissions of certain noncooperating countries may fall. For example, if a unilateral policy reduces world oil prices, but leaves coal prices outside the policy zone unaffected, some countries may substitute less carbon-intensive oil for coal.[3] Associated with the two primary leakage channels is also a possible change in incomes, and such a change may also affect leakage. For example, if the policy lowers world prices for carbon-intensive fuels, then incomes of energy exporters will fall, and this fall will lead to a decline in economic activity and carbon emissions in these countries.

Leakage is typically measured as a rate, with the *leakage rate* being defined as the increase in emissions outside the region undertaking the unilateral policy divided by the reduction in emissions within this region.[4] In a simple world of trade, the leakage rate would be bounded between zero and one, and decreasing with the size of the region undertaking the unilateral policy (Barrett, 1994a). However, the precise magnitude of the leakage rate is an empirical question. Further, in a richer, more realistic model, the leakage rate can be shown to be negative (as noted above and explained more fully below) or greater than one (as discussed below).

3.1 Empirical Estimates of Leakage

Empircal estimates of leakage vary widely. This is partly because of the different models and associated assumptions that have been employed, and partly because of the different simulations that have been run. The discussion below does not provide an exhaustive survey of the literature, but does indicate the range of estimates reflected in the literature.[5]

Pezzey (1992; see also Pezzey, 1991), using the Whalley and Wigle's computable general equilibrium model of trade (see Whalley and Wigle, 1991), finds that leakage rates are substantial. A 20% reduction in carbon emissions within the European Union alone relative to baseline was found to be associated with a leakage rate of 80%. In other words, for every 10 tons of carbon abated by the EU, global emissions of carbon would fall by only 2 tons. A 20% reduction in OECD emissions was found to be associated with a leakage rate of 70%. As theory and intuition would lead one to expect, leakage falls with the size of the region undertaking the policy (all else being equal). But what is most remarkable about these estimates is their magnitude. Pezzey (1992, p. 166) puts the implication plainly:

> "If this is a reliable result, unilateral action will therefore succeed in curbing global CO_2 emissions significantly only if other countries are persuaded to follow suit and abandon any free rider advantage. The need for international coordination of policy action on CO_2 therefore appears to be acute."

Unfortunately, Pezzey does not provide estimates of the carbon tax needed to achieve these unilateral targets, state whether the reductions are relative to a baseline or relative to emissions in a particular year, or provide estimates of the quantity of emissions actually abated. Consequently, comparison with other studies is difficult.

Probably the most thorough study of leakage is provided by Oliveira-Martins, Burniaux and Martin (1992; hereafter OBM), who use the OECD's GREEN model. Their analysis is also notable because, in contrast to Pezzey, they estimate relatively small leakage rates.

The main results of the OBM study are summarized in Table 1. In comparison with Pezzey

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3 This effect is predicted by Oliveira-Martins, Burniaux and Martin (1992) for a unilateral OECD policy, which leads China and India to substitute oil for coal.

4 Professor Amano correctly noted in his discussion that this definition is a bit loose and that the literature is not always consistent in calculating leakage rates.

5 Winters (1992) surveys some of the studies not included in this section, but does not survey the studies which are discussed here.

(1992), leakage rates for the EU and OECD are remarkably small. It is difficult to explain the difference because of the difficulty in interpreting Pezzey's results. However, the OBM study does vary a number of assumptions to indicate the sensitivity of its own estimated leakage rates, and I shall discuss these later.

One seemingly odd result in the OBM study is the larger leakage rate for OECD stabilization as compared with a unilateral US policy. This result seems odd because as the coverage of a policy expands, the size of the market to where emissions may leak becomes smaller. This seeming anomaly aside, the relative magnitudes of leakage rates do appeal to intuition. Japan's leakage rate is high mainly because its unilateral carbon tax is high, but also because its share of the global economy is small relative to the US and EU. The leakage rates decline over time, partly because capital investment reduces the distorting effect of the tax on relative prices, and partly because the GREEN model predicts that the unilateral policy would increase the price of oil in the long run compared to the case where no unilateral policy is undertaken. This higher price causes emissions to fall outside the region undertaking the policy, thus reducing leakage. Further, the unilateral policy, in reducing world oil prices in the early years, reduces incomes for the energy exporting regions, and this reduction in incomes will in turn lead to a reduction in economic activity and hence carbon emissions.

OBM vary a number of parameters within the GREEN model to determine the sensitivity of the estimated leakage rates. An increase in the elasticity of substitution between domestically produced and imported goods and among imports from different origins were tripled compared with the model runs reported above, but the effect of the change on leakage was fairly small in absolute terms: for an OECD policy, leakage rises from 2.4% in 2000 for the base case to 6.8%. The supply elasticities of fossil fuels were found to be more important parameters. If these elasticities are lowered, any given reduction in quantity demanded would bring about a larger change in price. A lower supply elasticity for oil alone was found to have very little effect on leakage. A lower supply elasticity for coal alone, however, increased leakage significantly--from 2.4% to 22% in 2000 for OECD stabilization. Further low supply elasticities for both coal and oil had an even larger effect: leakage increased to 40% in 2000 for OECD stabilization. In both of the latter two cases, negative leakage rates for individual regions and in the aggregate also disappear. Despite this sensitivity, OBM maintain that fairly high supply elasticities are more appropriate for coal, and hence that leakage rates are likely to be small.

Using still another model (12RT, based on an earlier model, Global 2100), Manne (1993) estimates leakage rates which fall somewhere between the extremes of Pezzey and OBM. The unilateral policy in this case is a 20% reduction in emissions by the OECD, and Manne (1993, p. 8) estimates that "Some 25 per cent of the OECD region's reductions in emissions could be offset indirectly through changes in the traditional patterns of international trade in oil, gas and carbon-intensive manufactured products." Again, it is difficult to compare this study with the others. Manne's (1993) scenario is of a 20% reduction in OECD emissions, whereas OBM considered only a stabilization of emissions. The former target is estimated to be achieved by a carbon tax $100-$250 per ton, whereas the weaker OBM target is achieved by a smaller tax. For this reason alone, one would expect greater leakage in Manne than in OBM, but without additional information, one cannot determine the effect of this difference on the estimated leakage rates.

Rutherford (1991) estimates leakage rates using another model (CRTM). In this analysis, the OECD reduces its emissions 2% each year relative to the baseline beginning in 1990. Leakage is estimated to be about 40% in the year 2000, but lower in later years. More interestingly, Rutherford considers different levels of emission reduction by the OECD. Once the reduction exceeds 3% each year, the *marginal* leakage rate approaches 100%. In other words, an additional one ton of abatement by the OECD would be almost completely offset by an increase in emissions outside of the OECD.

Finally, Horton, Rollo and Ulph (1992) consider the effects of a unilateral policy for an industry which exhibits increasing returns (fertiliser), and find that leakage is likely to be very substantial due to relocation. In fact, they argue that leakage may exceed 100%, as all the firms in cooperating countries move to non-cooperating countries, where it is optimal to use more carbon-intensive fuels than would be the case in cooperating countries, even before the policy was implemented.[6]

4. Policy Corrections for Leakage

4.1 Existing Policy

While economic models offer no consensus about the magnitude of leakage, policy does appear to take the phenomenon seriously--both with regard to the effect of unilateral policy on competitiveness and to the effect of such policy on global abatement. Most famously, the European Commission's proposal for a policy for meeting the European Union's (EU's) target of stabilizing EU CO_2 emissions at the 1990 level by 2000 makes three adjustments to a pure carbon tax.

First, a carbon tax is supplemented by what the Commission calls an "energy tax." The latter tax would fall not only on fossil fuels but also on nuclear energy. The European Commission (1991, pp. 8-9) justified the adjustment by reasoning that a carbon tax on its own

> "...would put a relatively high burden on coal, which is the most secure energy supply. Moreover, it would favour nuclear energy, which has advantages in terms of CO_2 reduction but which leads to its own particular problems. A 100% carbon tax option would also have, according to their energy structure, a significantly different impact on the industrial competitive position of the Member States."

This last concern reflects the fact that some Member States rely more substantially on nuclear power than others, and would be given a comparative advantage *within* the EU by a carbon tax.

Second, the proposal would exempt certain energy-intensive industries from paying the tax. The justification for this exemption is that these industries would lose competitiveness in international markets. The Commission (1991, p. 8) states:

> "It is essential to avoid more pronounced economic costs for some industrial sectors, in particular those employing energy intensive production processes and with a large involvement in international trade (steel, chemicals, non-ferrous, cement, glass and pulp and paper). Until the Community's main competitors take analogous measures, special treatment needs to be envisaged."

Finally, the entire tax package was made conditional on other OECD countries undertaking a similar policy. The proposal reads (European Commission, 1992):

> "Whereas, in order to safeguard the competitiveness of Community industry, the tax arrangements cannot be applied in the Member States until such time as other member countries of the OECD have brought in a similar tax or measures having an equivalent fiscal impact."

Notice that the conditionality applies to other OECD countries imposing a similar *fiscal* burden on their economies, and not to other countries achieving a similar level of CO_2 emission reduction. This suggests that the Commission's main concern is with leakage rather than free

6 This finding, though possible, seems unlikely, at least for relatively small carbon taxes. Studies examining the location decisions of firms have not found that environmental regulations play a dramatic role. See Lucas, Wheeler and Hettige (1992), Low and Yeats (1992), and Grossman and Kreuger (1992). For theoretical analyses of location decisions under imperfect competition, see Markusen, Morey and Olewiler (1992, 1993).

riding as such.

Countries which have actually imposed carbon taxes have also included exemptions, as shown in Table 2.[7] Denmark's carbon tax is half as large for industry as for other sectors, and energy-intensive industry may be given refunds of up to 100% if conservation projects are undertaken. Finland's tax, which is very small in magnitude, exempts raw materials in industrial production from paying the tax. The Netherlands' tax does not exempt industry, but this tax arose from a general restructuring of taxation, and so may have imposed no incremental burden on industry. Norway's tax was first imposed on the domestic use of gasoline and mineral oils and the combustion of natural gas offshore. The tax was later extended to include coal, but coal which is used as an input to industrial processes is exempt. Sweden's carbon tax was introduced in 1991. The tax does not apply to fuels used in electricity production, and was set at a lower rate for energy-intensive industry. Further, a ceiling was placed on the total tax payment for any energy-intensive firm at 1.2% of total sales. The Swedish carbon tax was revised in 1993 and increased for the residential and commercial sectors but reduced for industry. At the same time, industry was exempted from paying an energy tax.

4.2 Leakage with Industry Exemptions

Oliveira-Martins, Burniaux and Martin (1992) examine the effect of such exemptions on leakage for the case of the EU, and their results are reported in Table 3. As expected, if energy-intensive industry is exempted from the tax, the level of the tax must rise to squeeze greater reductions out of the rest of the economy. What may seem surprising is that the exemptions have virtually no effect on leakage. Further, output losses for energy-intensive industry are also vitually unchanged. The former finding probably arises because a greater burden is now placed on non-energy-intensive industry, and this industry is also engated in trade. The latter finding probably arises because while the exemptions ensure that the competitiveness of EU industry is not affected abroad, the higher carbon taxes reduce incomes within the EU and hence reduce EU demand for the output of energy-intensive industry. As we shall see, theory may suggest another reason for these findings.

4.3 Policy and Leakage: Theory

We have seen that policy has typically varied the carbon tax across sectors, with energy-intensive sectors facing a relatively low tax. Intuitively, one can understand the motivation for this. But are such variations in the carbon tax truly optimal?

If all countries participated in an agreement to limit CO_2 emissions, and if a carbon tax were chosen jointly, then the carbon tax should be uniform. But if cooperation is partial, and policy by one group of countries is unilateral, then it may be optimal to vary the tax across sectors. Hoel (1993b) shows that this will only be true if these countries are not able to employ tariffs (see also Markusen, 1975). If tariffs can be employed, then the carbon tax should be uniform across all sectors and all cooperating countries, and the effect of production and consumption of traded goods on the emissions of non-cooperating countries should be influenced through a tax or subsidy on net imports or net exports. In this case, the carbon tax should equal the marginal damage avoided for all the cooperating countries, and the tariff will consist of two terms. The first term is the usual optimal tariff.[8] The second term takes account of the effect

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7 The table and the information presented in this paragraph are from International Energy Agency (1992).

8 Roughly, the optimal tariff balances the gain from improved terms of trade with the loss from the distortion created by the tax wedge. Consider a net exporter of a good. The value to the country of an extra unit of export is not the price of the export but the marginal revenue. If the extra unit of export depresses the price of all exports, this marginal revenue will lie below price. The cost of the extra export is either a one unit reduction in domestic consumption or a one unit increase in production. If the domestic market is perfectly competitive, both of these will be equal to the domestic price of the good. Hence, welfare for the net exporter can be increased if a wedge can be driven between the domestic price and the export price. This

of the tariff on world prices and hence on the emissions of non-cooperating countries.

If pollution arises from one sector only, then the analysis is fairly straightforward (see Markusen, 1975). In this case, the optimal tariff will be positive if the good is a net import and negative if the good is a net export (exports should be taxed), while the second term should always be positive. Hence, if the good is a net import, one increases the tariff to take account of the global externality. Increasing the tariff improves the competitiveness of domestic firms (which face a carbon tax), relative to that of foreign firms, and emissions abroad will fall. If the good is a net export, concern about the global externality demands that cooperating countries reduce the export tax.

Where production of goods in two or more sectors causes pollution, one must take account of distortions *between* and not simply within sectors, and this substantially complicates the analysis. Hoel (1993b) shows that in this case the sign of both terms in the tariff are in general indeterminate, although given details about production the optimal tariff can be calculated.

If tariffs are prohibited, then the carbon tax becomes a second best policy instrument, and it will be optimal to vary the tax by sector. However, calculation of the optimal carbon tax is even more complicated than is calculation of the optimal tariff, and without detailed information one cannot determine how the carbon tax should be varied across sectors. Hoel (1993b, p. 16) concludes: "There is no simple relationship between e.g. fossil fuel intensity or the effect on foreign emissions on the one hand and the optimal carbon tax on the other hand." This suggests that the empirical results obtained by Oliveira-Martins, Burniaux and Martin (1992), which show that exempting energy-intensive industry from a carbon tax has little effect on leakage, may reflect the bluntness of the exemption. The optimal tariff might lower leakage by more.

These conclusions beg an important question: should countries which cooperate to reduce CO_2 emissions be allowed to impose tariffs against countries which do not? Hoel (1993b, p. 17) believes that the case for tariffs is strong:

> "Trade policy arguments could be made against import and export taxes/subsidies. However, similar arguments could also be made against differentiating taxes (in this case carbon taxes) across sectors. Moreover, the non-cooperating countries are not in a very strong position to argue against tariffs which might hurt them. The justification for the tariffs is after all an attempt to avoid excessive carbon emissions from the non-cooperating countries. Any non-cooperating country which claims to be adversely affected by the tariffs can avoid the tariffs by participating in the climate agreement instead of being a free rider."

The use of tariffs may nonetheless be opposed by the GATT (see GATT, 1992), as the GATT has argued against the use of trade restrictions between parties and non-parties to another international agreement, the Montreal Protocol (see below). It is certainly true that if pollution were not a problem and all countries cooperated on trade then the optimal tariff would be zero (the carbon tax would also be zero in this case). It is also true that if all countries cooperated on both trade and global pollution then the optimal tariff would be zero (in this case, the carbon tax would be positive). However, if countries cooperate on trade (through the GATT) but an agreement on reducing CO_2 emissions is undertaken by only a subset of GATT countries, then a tariff which discriminates between signatories and non-signatories is optimal (see below), but that tariff should only include the component designed to reduce leakage; it should not include

wedge is an export tax. In the case of a net importer, the cost of an additional import is not its price, but its price plus the effect an additional unit of imports has on the price of all imports. The benefit of the import, however, is given by price under perfect competition. Hence, welfare can be increased by placing a wedge between the foreign and domestic price. This is achieved by means of an import tax. Notice, that the optimal tariff is non-zero only if the country's policy is able to influence world prices.

the optimal trade tariff.[9]

The problem is that countries which do not undertake to reduce CO_2 emissions may not be free riders in the sense of Section 2. As the GATT (1992, p. 35) has noted, there may be legitimate reasons why a country might not want to join an international environmental agreement--it may not believe that the science is sufficiently understood, or it may attach a very low priority to the problem, or (and this is an important point which the GATT overlooks) it may believe that the burden for undertaking abatement is unfairly distributed by the agreement. Tariffs may be optimal from the point of view of the cooperating countries, but that on its own is not a sufficient reason for employing them. (This issue is discussed further in Section 4.5.)

4.4 Leakage and Energy Markets: Theory

The use of industry exemptions and tariffs arise from a concern about leakage through trade in manufactured goods. But, as we have seen, leakage may also be channeled through energy markets; a unilateral carbon tax may depress world prices for carbon fuels, and cause noncooperating countries to increase their consumption, thus partly offsetting the reduction in emissions by cooperating countries. Given that such leakage may occur, and as we have seen, be quantitatively significant, cooperating countries might wish to take account of the effect of policy on world prices. One possibility would be to supplement a carbon tax with a policy of reducing the supply of fossil fuels in noncooperating countries (see Bohm, 1993a). Another possibility, and the one I wish to discuss, would involve taxing both the production and consumption of carbon.

If all countries cooperate in a climate change agreement, taxing the consumption of fossil fuels is equivalent to taxing the production of fossil fuels as regards economic efficiency (ignoring income effects); see Hoel (1993a). (Of course the distributional consequences would be quite different under the two tax regimes--energy exporters would clearly do better under a production tax and energy importers would clearly do better under a consumption tax (for a confirmation of this, see Whalley and Wigle, 1991).)

If only a subset of countries cooperate, then this will no longer be true. Rather, Hoel (1993a) shows that:

1. the *sum* of the consumption and production tax rates must equal the marginal damage avoided by the abatement for all cooperating countries taken together;

2. if the marginal damage avoided by abatement is high, then both production and consumption of fossil fuels should be taxed; and

3. if the marginal damage avoided by abatement is low, then consumption should be taxed and production subsidized if the cooperating countries are net importers of carbon, and that production should be taxed and consumption subsidized if the cooperating countries are net exporters of carbon.

The theory behind theses taxes is similar to that described earlier for manufacturered goods. If there were no pollution problem, then the wedge that is driven between producer and consumer prices should be the optimal trade tariff. If the cooperating countries are net importers of carbon, then they want the international price of carbon to be low. This can be achieved either by an import tax or by taxing consumption and subsidizing production. If the cooperating countries are net exporters of carbon, then they want the international price of carbon to be high, and can make it higher either by taxing exports or by taxing production and subsidizing consumption.[10]

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9 Hoel (1993b) does not draw attention to this.

10 Again, there are parallels between Hoel's (1993a) paper and Markusen (1975).

Taking account of the effect of policy on the emissions of noncooperating countries only, cooperating countries will want to tax both consumption and production of carbon. To see this, note that a tax on consumption depresses the world price of fossil fuels, and hence encourages greater consumption by noncooperating countries. To reduce this leakage, cooperating countries will want to tax production.

When both effects are present, one or the other will dominate. If the marginal damage avoided is high, then the second effect will dominate, and both production and consumption of carbon should be taxed. If the marginal damage avoided is low, then the first effect will dominate.

It should be noted here the GATT would probably not oppose the use of both production and consumption taxes on fossil fuels. In discussing the use of discriminatory trade measures in international agreements, the GATT (1992, p. 21) has commented:

> "Past experience suggests that the organizers of an environmental agreement are also likely to consider trade provisions--that is, measures affecting trade only in the product or products covered by the agreement--designed to minimize the extent to which trade between participants and non-participants could undermine the agreement. Recalling that a country's trade in a particular product is nothing more than the difference between production and consumption, there is also the option of controlling both production and consumption in the participating countries. In this case there would be no need to have separate controls on trade flows."

The effect of making such adjustments on leakage rates is unknown. Whalley and Wigle (1991) have explored the use of production and consumption taxes, but only when their use is mutually exclusive and only in the context of a global regime of cooperation.

4.5 Leakage under Alternative Policy Instruments

The above analysis has examined the phenomenon of leakage when policy employs carbon taxes. However, in broad terms, these results would hold for alternative policy instruments such as tradeable carbon emission entitlements (see Hoel, 1993a, b).[11] If the cooperating countries employed tradeable carbon emission entitlements to achieve the same level of emission reduction as would be achieved by the carbon tax, and if trading in these entitlements obeyed certain assumptions, then marginal costs would be the same under both regimes, and so would the shift in comparative advantage and the change in world energy prices. What may differ under the two regimes are incomes. Depending on how transferable carbon emission entitlements are allocated initially, incomes will differ compared with a carbon tax regime which precludes international transfers, and such changes in incomes may affect leakage rates. However, such effects are likely to be of second order importance.

To reduce leakage requires that marginal costs in countries undertaking unilateral abatement be reduced relative to such costs in other countries. Since a carbon tax is an efficient instrument for effecting unilateral emission reductions, no alternative instrument can be expected to result in lower marginal abatement costs, and hence lower leakage rates, for given abatement by the cooperating countries. However, joint implementation can shift the burden of carrying out abatement (without shifting the burden of paying for the abatement) onto countries which unilaterally would not reduce their emissions, and in doing so reduce the marginal costs of reducing global emissions. Once these marginal costs are reduced, leakage rates should also fall.[12]

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11 If tradeable carbon emission entitlements were used by the cooperating countries, then in place of a consumption/production tax, consumption/production entitlements would be required. Note that there may be certain strategic advantages to using one instrument rather than another, but these advantages are generic and are not linked only to the leakage issue. See Ulph (1992) and Berger *et al.* (1991).

12 See Barrett (1993b). Bohm (1993b) offers a somewhat different view.

To take an example, imagine that Norway can stabilize its emissions at the 1990 level by 2000 by abating emissions at home at a marginal cost of \$50.[13] Unless other countries with which Norway trades adopt a similar policy, the competitiveness of Norwegian industry would be harmed by the policy, and one can expect that production of energy-intensive goods will shift away from Norway. Associated with this shift will be leakage, and for every ton of carbon abated in Norway, global emissions will fall by something less than a ton. Suppose, however, that Norway finances abatement in countries where the marginal costs of abatement are very low. Then Norway might be able to achieve its target at a marginal cost of, say, \$10 per ton. In doing so, Norway reduces the damage to the competitiveness of its industry, and hence its leakage.[14] Not only are its costs lowered, but every ton of carbon directly abated by the policy should result in more global abatement than would be the case without joint implementation.

There is much that is appealing in joint implementation. A policy of imposing tariffs on imports from countries which do not undertake abatement may be optimal from the point of view of those countries which do make such an undertaking, but it may not seem fair if the countries against which the tariff is levied are poor countries with little incentive to divert their own resources toward CO_2 abatement (unless, of course, side payments are offered to these countries such that they are not made worse off by acceding to the agreement; see the discussion in Section 5.3). After all, in this case these poor countries would not be free riders in the sense of Section 2 (and hence Hoel's argument in favor of tariffs, repeated in Section 4.3, would not seem to apply to these countries). Joint implementation succeeds in reducing leakage without discriminating against such countries. In the jargon of the GATT (1992, p. 36), joint implementation offers a "positive" incentive for countries to participate in an international agreement:

> "When cooperation is not voluntarily forthcoming, positive incentives are the best way to achieve sustained inter-governmental cooperation. Positive incentives can include offers of financial assistance and transfers of environmentally friendly technology directly related to the problem at hand, as well as more broadly based offers, for example, to increase foreign aid, to lessen debt problems and to make non-discriminatory reductions in trade barriers."

It would not seem appropriate, however, to "reward" free riders by offering them positive incentives. In the next section I consider the use of trade restrictions in deterring free-riding.

5. Trade Restrictions and Free-Rider Deterrence

Free rider deterrence is a major challenge for international environmental agreements (IEAs). To deter free riding, IEAs must punish countries which do not cooperate and reward those which do. To be effective, however, these punishments and rewards must be both substantial and credible. If they are substantial, then countries cannot gain by free-riding. To be credible, cooperating countries must be at least as well off carrying out the rewards and punishments as they would be by undertaking some other action. Unfortunately, these two requirements often clash: punishments and rewards often lose credibility as they become more substantial.

To take an example, suppose that cooperating countries reward an accession by undertaking more abatement and punish a withdrawal by undertaking less abatement than they otherwise would. Then both the reward and the punishment are costly to the cooperating countries, and it

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13 The example of Norway was not chosen randomly. Norway has initiated a pilot joint implementation project with Mexico and Poland. See Barrett (1993b).

14 Of course, leakage may also be associated with the abatement undertaken offshore. However, one can assume that this leakage is accounted for in calculating the "baseline" for the joint implementation project. Even if this leakage were not accounted for in this way, it seems that the overall rate of leakage should fall simply because the shift in comparative advantage will be lower under joint implementation. Still, pathological exceptions probably cannot be ruled out.

will not be credible for them to make the reward or punishment very large. Theoretical analysis shows that such punishments and rewards can do very little to deter free riding in IEAs (see Barrett, 1993a).

5.1 The Montreal Protocol

It is natural, then, that countries seek to expand the strategy space by employing restrictions in the trade of goods which are related to the environmental problem and, as it happens, trade restrictions are employed in about 17 IEAs (GATT, 1992). The most important example is the Montreal Protocol on Substances that Deplete the Ozone Layer, which was signed in 1987 and which came into force in 1989. The original agreement commits signatories (formally, parties to the agreement) to reduce their production and consumption of certain chloroflurocarbons (CFCs) and halons by half by the year 2000. The 1990 London Amendments to the Montreal Protocol, which came into effect in 1992, tightened these obligations considerably by requiring a complete ban in production and consumption (defined as production plus imports minus exports) by 2000. Subsequent negotiations in Copenhagen in 1992 accelerated this phase-out to 1996. In comparison with any other IEA, including the Framework Convention on Climate Change, these are substantial obligations.

An important and controversial requirement of the Montreal Protocol is the restriction of trade between signatories and non-signatories (formally, non-parties). These restrictions include:

1. A ban on imports of controlled substances to signatories from non-signatories beginning in 1991, and a ban on exports from signatories to non-signatories beginning in 1993.

2. A ban on imports to signatories from nonsignatories of products containing controlled substances (such as refrigerators, aerosols, automobiles equiped with air conditioners, and fire extinguishers) beginning in 1992.

3. A possible ban on imports to signatories from nonsignatories of products made using, but not containing, controlled substances (such as electronic components which use CFCs as a cleaning solvent), to begin in 1994.

4. Signatories are required to discourage the export to nonsignatories of technology for producing or using controlled substances.

The chief U.S. negotiator later explained why trade restrictions were included in the Montreal Protocol (Benedick, 1991, p. 91):

> "At the first session in Geneva in December 1986, the United States offered specific proposals to restrict trade in controlled substances with nonparties. The objective of such restrictions was to stimulate as many nations as possible to participate in the protocol, by preventing nonparticipating countries from enjoying competitive advantages and by discouraging the movement of CFC production facilities to such countries. These provisions were critical, since they constituted the only enforcement mechanism in the protocol."

Whatever their merits in sustaining global cooperation, however, the fact remains that the restrictions are discriminatory, for even while trade is permitted between signatories it is restricted between signatories and non-signatories. While the restrictions have not been contested by GATT member countries, the GATT Secretariat has voiced its opposition to such uses of trade restrictions.

5.2 A Theory of Trade Restrictions in IEAs

To better understand the implications of trade restrictions for both membership in an IEA and welfare, I have developed a theoretical model which captures a number of the important features of the Montreal Protocol (Barrett, 1994a). While the model is highly specialized, and hence its results may not hold generally, it does reveal some striking insights about trade and IEAs. Here, I shall discuss the most relevant insight to the climate change problem.

Intuitively, trade restrictions are good insofar as they succeed in increasing cooperation, but bad insofar as they deprive both signatories and nonsignatories of some of the gains from trade. A trade restriction that would be hard to argue against would be one which succeeded in securing universal participation, for such a restriction would achieve full cooperation in pollution abatement without diminishing the gains from trade. The Montreal Protocol has effectively succeeded in this, as the signatories to the agreement make up more than 95% of current world consumption and production of ozone depleting substances.

First consider a complete ban in trade in the relevant goods between signatories and nonsignatories. Imagine that we begin with no agreement. If one country accedes to an agreement, and the agreement requires that this one country not trade with non-signatories, then this country suffers a substantial loss in the gains from trade but gains nothing environmentally.[15] As a consequence, accession by this one country is not attractive. If a second country accedes to the agreement, there will be some environmental cooperation, but since the vast majority of countries remain noncooperators, the loss in the gains from trade will be large for the two cooperators. Imagine now that we begin with an agreement to which every country is a member. If one country then decides to withdraw, it is no longer allowed to trade with all the other countries, and hence suffers a substantial loss in the gains from trade. It benefits somewhat, however, from being able to reduce its abatement.[16] Withdrawal from an agreement which commands universal participation may not prove attractive to any country, but in some instances it will, and if withdrawal by one country is attractive then it will not be attractive for any country to remain a member of the IEA (assuming all countries are identical). Hence, with a trade ban, two self-enforcing IEAs are possible: one consisting of no countries and one consisting of all countries.

If an agreement between all countries is self-enforcing and if all countries would receive higher payoffs in this outcome than in the noncooperative outcome, then a device is needed to coordinate the actions of different countries. When the full cooperative outcome can be sustained by a trade ban, one can identify a threshold number of countries, where once the threshold has been met, it is not attractive for any country to remain a nonsignatory, but where, when the threshold is not met, it is not attractive for any country to become a signatory. To ensure that the threshold is exceeded, the agreement must simply specify a minimum number of countries which must accede to the agreement before the agreement comes into force. Then, no country loses by acceding if the threshold is not met, and once the threshold is met, all other countries will accede. The Montreal Protocol does include such a threshold: it would not come into force until ratified by at least 11 countries accounting for at least two-thirds of global consumption of the controlled substances.[17]

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15 It gains nothing because it can only cooperate with itself!

16 Of course, its environmental damages will fall if its abatement is reduced. However, in the model I am discussing the savings in cost exceed the reduction in abatement benefits for this one country.

17 It is common for IEAs to specify a minimum number of ratifications before entering into force, and the explanation offered here for such a requirement is probably only partial.

5.3 Credible Trade Restrictions

The problem with the above analysis is that the trade ban may not be credible, and if it is not credible then an agreement which employs a ban cannot be self-enforcing. The reason the trade ban may not be credible is that it may harm signatories as well as nonsignatories. If signatories ban exports, they lose export revenues. If signatories ban imports, they lose gains from trade.

Once credible trade restrictions are employed, the results obtained above change mainly in interpretation. I find that a ban on exports is never credible. Very roughly, the reason is that the signatories lose export revenues with no apparent reduction in environmental damages. However, a small reduction in exports is credible (much in the same way that an export tax can be optimal). I find that a ban on imports may be credible, but that a small reduction in imports is not. A reduction in imports yields some environmental benefit--it reduces output in nonsignatory countries where environmental standards are weaker--and if there were no other consequences associated with a reduction in imports, then a ban would be optimal. However, signatories lose some gains from trade when imports are restricted, and so if there were no environmental benefits from an import restriction, signatories would not want to restrict imports at all. Taking both of these effects into account, countries will not want to restrict imports until the environmental benefits of doing so exceed the losses in the gains from trade; once this point is reached, imports should be banned.

When employing credible trade restrictions, I find that the self-enforcing IEA once again consists either of all countries or none. The agreement will consist of all countries provided it is optimal for signatories to ban imports, for it is this ban which harms nonsignatories most severely. Since the import ban is only credible when the benefits of emission reductions are large, this suggests that trade restrictions can improve welfare substantially in IEAs. Moreover, since the self-enforcing IEA with trade restrictions seems to consist of all countries, trade restrictions are never in fact practiced; losses in the gains from trade are never realized. In short, the theoretical analysis discussed here suggests that trade restrictions can only be beneficial.

As indicated earlier, this analysis is based on a highly specialized model, and it would be hazardous to generalize. However, the analysis is useful insofar as it encourages us to consider the magnitude of credible trade restrictions and the effects that these have on participation in an IEA. If trade restrictions are never in fact practiced but the (credible) threat of using them is sufficient to command full participation in an agreement, then there would seem to be no reason why such restrictions should be prohibited. However, the above analysis assumes that all countries are identical. In a more realistic setting, trade restrictions imposed on "noncooperating" countries might be unfair, just as tariffs imposed on such countries might be unfair. To justify trade restrictions, the agreement that is made available for accession must be fair.

The Montreal Protocol offers an example of a fair agreement. The protocol distinguishes between developed and developing countries, and imposes much harsher requirements on the former. Further, the 1990 revision to the Montreal Protocol established a Multilateral Fund, which compensates developing countries for the costs of complying with the agreement. Hence, accession to the Montreal Protocol should not harm developing countries. If one believes that the developing countries would not benefit from the abatement of ozone-depleting substances, or that they should not be required to pay for the abatement (perhaps because one believes that developed countries are responsible for ozone depletion), then it seems one could not countenance the application of trade restrictions against developing countries which do not accede to an agreement which imposes the same obligations on both developed and developing countries. However, given that the Montreal Protocol essentially guarantees that developing countries are no worse off as signatories than they would be as nonsignatories, it is hard to object to the use of trade restrictions in this agreement.

6. Suggestions for Further Research

The paper has exposed three areas where more research is needed. First, the results of model simulations vary substantially and for reasons that are unclear. An attempt should be made to compare estimates of leakage using different models, as has been done previously for comparing cost estimates (Dean and Hoeller, 1992). Models like the GREEN model should also be employed to determine the effects on leakage of tariffs, combined consumption and production taxes on carbon, alternative allocations of tradeable carbon emission entitlements, and joint implementation.

The paper has shown that tariffs can be justified from the perspective of reducing leakage. However, in practice, such measures might discriminate unfairly against countries which are not free riders. Some analysis is needed to determine under what conditions tariffs can be justified from the perspective of free-rider deterrence. That is, some basis must be established for determining which countries really are free riders, and whether the tariff might reflect the extent of free riding as well as the extent of leakage.

Finally, the paper has discussed some recent theoretical work on the use of trade restrictions in deterring free riding. As already mentioned, this work has employed a highly specialized model, and the results may not hold generally. Analysis of this issue should be merged with the analysis of tariffs, and also examine in detail the issue of fairness. Further research is needed to determine whether the results discussed here would also hold using alternative models of trade and environmental cooperation, and alternative functional forms. This research might then be supplemented by an analysis of the use of trade restrictions in existing agreements.

Table 1

Estimated Leakage Rates for Unilateral Policies[1]

Unilateral Policy by	1995 Tax ($/ton C)	1995 Direct Abatement[2] (Million tons C)	1995 Leakage (Percent)	2050 Tax ($/ton C)	2050 Direct Abatement[2] (Million tons C)	2050 Leakage (Percent)
United States	23	75	2.8	70	997	-0.2
Japan	130	47	15.8	228	420	2.1
EU	26	35	11.9	91	468	2.2
Other OECD	17	15	7.7	95	225	0.6
OECD	38	172	3.5	92	2,109	1.4

[1] Each policy involves stabilization of CO_2 emissions at the 1990 level.

[2] Direct abatement is the abatement undertaken within the region undertaking the unilateral policy. Global abatement will be less (more) if leakage is positive (negative).

Source: Oliveira-Martins, Burniaux and Martin (1992), Tables 1 and 2.

Table 2 Carbon, CO_2, or Related Taxes in OECD Member Countries

Country	Tax in Original Units for Main Products	Tax in $/TC1	Fuel Covered	Effective Date	Exceptions	Effects on Fuel Prices	Comments
Denmark	*Private* DKr 242/t of coal DKr 0.10/kWh DKr 320/t of fuel oil DKr 270/m^3 of heating oil DKr 1.70/l of diesel oil *Industry* DKr 121/t of coal DKr 0.05/kWh DKr 160/t of fuel oil DKr 135/m^3 of heating oil DKr 0.85/l of diesel oil	*Private* 15.8 *Industry* 7.9	*Private* Coal Oil but not gasoline Electricity *Industry* Coal Oil but not gasoline Electricity	*Private* 15/5/92 *Industry* 1/1/93	For energy-intensive industry, refunds up to 100% if reasonable conservation projects have been carried through	*Private* Coal up 5% Electricity up 3% *Industry* Coal up 16% Electricity up 12% Fuel oil up 18%	CO_2 taxes shown are part of an integrated CO_2 and energy tax system.
Finland	Mk 26/TC	6.4	Fossil fuels	1/1/91	•Products used as raw materials in industrial production •Fuels in overseas planes and vessels	+1-2% for electricity, light fuel oil and natural gas +5-8% for coal, gasoline and heavy fuel oil +10% for diesel	Tax rate for motor fuels is larger than if it were proportional to carbon contact. Carbon tax was first instituted 1/1/90/. In 1991 all fuels taxes increased by 5% except those on motor fuel which increased 20%.
Netherlands	Gld 5.70/tonne CO_2 Gld 0.44/GJ	12.5 for CO_2 only	Fossil fuels, including industrial fuel gas	1992	None except non-energy uses and international sea/air traffic	Modest for transport; other wise 10-15% increase	Previous general environmental tax restructured to 50% CO_2 and 50% energy-based and raised in 1992

TC=Tons of Carbon. t=metric ton. Sources: Country submissions.

1. Sweden based on first quarter 1991 exchange rates: Norway and Denmark based on last quarter exchange rates: Finland and Netherlands based on third quarter 1992 exchange rates.

Table 2 (continued) **Carbon, CO_2, or Related Taxes in OECD Member Countries**

Country	Tax in Original Units for Main Products	Tax in $/TC1	Fuel Covered	Effective Date	Exceptions	Effects on Fuel Prices	Comments
Norway	NKr 0.8/l of gasoline NKr 0.3/l of diesel and fuel oils NKr 0.8/m^3 of natural gas NKr 0.3/k of coal[2]	196 (gasoline) 66 (diesel) 196 (natural gas) 47-70 (Coal)	Oil products, natural gas and coal[2]	1/1/91 Revised 1/1/92 except coal 1/7/92	•Fuels in all air and sea transport •Coal used as input to industrial processes	+10-14% for gasoline, diesel and light fuel oil +15% for heavy fuel oil	Diesel and fuel oil tax not increased in 1992
Sweden	SKr 250/t CO_2	166	Fossil fuels	1/1/91	Cap on total energy-intensive industrial CO_2 and energy taxes paid •Electricity sector •International sea and air traffic •Biofuels	With accompanying tax changes and simultaneous drop in crude oil prices, gasoline and diesel remained roughly the same	Major tax refrom in January 1991. Energy, sulphur and nitrogen taxes are also in effect
	Residential SKr 320/t CO_2	212	Fossil fuels	1/1/93	Same as above plus ethanol	Depends on base market price in 1993. Assuming same prices as beginning 1992, prices plus taxes could rise 5 to 13% for residential. Industrial prices plus taxes could drop 25 to 40%	For 1993, energy tax canceled for industry sector and for ethanol
	Industry SKr 80/t CO_2	53	Fossil fuels				

TC=Tons of Carbon. t=metric ton. Sources: Country submissions.

1. Sweden based on first quarter 1991 exchange rates: Norway and Denmark based on last quarter exchange rates: Finland and Netherlands based on third quarter 1992 exchange rates.
2. Coal covered by tax only after 1/7/92.

Table 3

Effects of Tax Exemptions for Energy-Intensive Industry -- Unilateral EU Stabilization Policy[1]

	Without Exemptions		With Exemptions	
	Carbon Tax ($/ton C)	Leakage (Percent)	Carbon Tax ($/ton C)	Leakage (Percent)
1995	26	11.9	35	11.7
2000	49	11.2	71	11.1
2005	50	8.6	79	8.6

[1] Emissions are stabilized at the 1990 level for the EU as a whole using a common carbon tax for all EU member states.
Source: Oliveira-Marins, Burniaux and Martin (1992), Tables 1, 2 and 5.

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ENERGY PRICING AND TAXATION OPTIONS FOR COMBATTING THE "GREENHOUSE EFFECT"

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Abstract: As countries worldwide debate how strongly to respond to the threat of global warming, cutting energy subsidies and levying carbon taxes rank high on the list of possible tools. Recent World Bank studies show that getting energy prices right makes good economic as well as environmental sense, and a modest domestic carbon tax would be an attractive option for a large number of countries.

1. Introduction

We are still no closer to answers on whether the buildup of "greenhouse" gases in the atmosphere could trigger a significant warming of the earth's surface. Nor do we know with any precision what the social and economic consequences of global warming might be. Yet countries all over the world are increasingly showing a willingness to act now, rather than wait for further scientific evidence:

- At the June 1992 "Earth Summit" in Rio de Janeiro, more than 150 countries signed a treaty aimed at stabilizing greenhouse gases--mainly carbon dioxide (CO_2), which is by far the largest contributor to the greenhouse effect.
- Most industrial countries have adopted national targets of stabilizing CO_2 emissions at 1990 levels by the year 2000.
- Between January 1990 and January 1991, Finland the Netherlands, and Sweden imposed "carbon taxes"--that is, taxes on the carbon content of fossil fuels.
- The European Community (EC) is considering levying a Community-wide tax on both carbon and energy in general.
- Many developing countries are beginning to weigh the various options, because although industrial counties account for around 43 percent of total CO_2 emissions from fossil fuel consumption, the developing world is fast contributing an increasing proportion.

But given the uncertainty surrounding the likelihood and possible consequences of a global warming, what steps should nations take that they could at least justify on economic or local environmental grounds? This is the question the Bank tried to answer in two recent studies (see Shah and Larsen, 1992a and Larsen and Shah, 1992c), one on the potential benefits of removing energy subsidies and the other on the desirability of carbon taxes. This paper summarizes main findings of these studies.

2. How large are world fossil fuel subsidies and what are their costs?

Economists have long argued that subsidizing energy distorts consumption and production decisions and have adverse consequences for government revenues and the protection of local and global environments. Yet such subsidies, measured as the difference between fossil fuels consumption evaluated at world prices and the same evaluated at domestic prices, are quite pervasive in emerging market economies and some developing nations. If energy resources were to be priced according to their true opportunity costs, these nations could improve their economic and fiscal performance while furthering local and global environmental objectives. In the following, we reflect upon potential opportunities associated with the reform of energy pricing regimes in developing nations. We conclude that getting energy prices right would yield rich dividends in terms of a healthy public sector, higher economic welfare, reduced global pollution and higher health standards associated with local pollution reductions.

2.1 What is being subsididized and by whom?

A closer look at energy pricing regimes in a sample of twenty-four countries responsible for 82% of global carbon emissions in 1991, reveals that eleven of these countries- all OECD members, do not provide any significant subsidies for fossil fuel consumptions whereas all the remaining thirteen countries price at least one fuel well below world prices. In absolute dollar values, subsidies to petroleum products account for 55% of total world subsidies, while coal and natural gas each account for 23% and 21% of these subsidies respectively. Among petroleum products fuel oils receive the largest subsidies in dollar value. Kerosene is usually subsidized, whereas gasoline is taxed in most developing countries. A large number of developing countries price electricity (hydro or fossil fuels generated) well below its long run marginal cost of production. In cases, when electricity is fossil fuel generated, this represents implicit fossil fuel subsidies. Oil producers/exporters tend to subsidize petroleum products more often than importers, and coal and natural gas subsidies are almost exclusively found in coal and/or natural gas producing countries. The following paragraphs identify countries that price energy below its opportunity cost by type of fossil fuel.

Coal: Former Soviet Union is the world's largest subsidizer of coal given its low dometic prices and sizeable consumption. Poland is among the five largest coal consumers in the world and has one of the world's highest carbon emissions from fossil fuels per dollar of GDP. Domestic prices were significantly less than one half of world prices in 1990 which makes Poland the second largest coal subsidizer in the world. Other countries that subsidize coal consumption include China, Czechoslovakia, South Africa and India. Coal prices in China as well as in India, during the 1980s, have gradually creeped upwards to narrow the gap with world prices, while no such trend is discernible from coal price movements in Czechoslovakia and South Africa (see Figure 1).

Natural gas: Former Soviet Union is the principal non-OECD natural gas consumer and accounts for most of gas subsidies. Subsidies in countries such as China, Poland and Argentina are significant relative to their own consumption, but are dwarfed in comparison to former Soviet Union.

Oil: Once again former Soviet Union takes the commanding lead in pricing petroleum products below world levels. Other countries in the same league include China, the larger Central and South American countries, Indonesia, Saudi Arabia, India, Egypt, Poland and Czechoslovakia. In Mexico, heavy industrial fuel oil and residential fuel oil are subsidized whereas industrial light fuel oil and gasoline are priced close to world levels. In Venezuela, all petroleum product prices including gasoline, are all substantially below world prices. Brazil and Argentina tax gasoline but substantially subsidize fuel oils and liquified petroleum gas. Indonesia levies lower prices for light fuel oil as well as kerosene but charges heavy fuel oil and gasoline close to world prices. Saudi Arabia subsidizes gasoline and automotive diesel while industrial light fuel oil prices are priced at about world levels and heavy fuel oil is taxed. India taxes gasoline but subsidizes kerosene. Egypt, Poland and Czechoslovakia all tax gasoline but subsidize fuel oils, and Egypt subsidizes kerosene as well.

Among smaller consumers of petroleum products, Ecuador is subsidizing all petroleum products and Peru subsidizes all except for gasoline. Most other smaller Central and South American countries tend to tax gasoline while fuel oils are priced close to world prices. In Asia, Pakistan subsidizes fuel oils and taxes gasoline while Sri Lanka, Thailand, Philippines and Myanmar tax gasoline and are pricing fuel oils close to world prices.

2.2 How large are world fossil fuel subsidies?

Total value of annual fossil fuel subsidies, in 1992, exceed US$230 billion or 25% of the total value of global fossil fuel consumption at world prices. Of these, petroleum products in aggregate receive US$128 billion in preferential treatment, coal US$53 billion, and natural gas

US$49 billion at 1992 market prices.

In terms of their geographical incidence, former Soviet Union alone accounts for US$172 billion or three-fourth share of total world subsidies (see Figure 2). This is because it continues to price coal, natural gas and petroleum products at less than 10% of what the same could fetch in international trade (see Figure 1). Note that Soviet subsidies were evaluated using the commercial exchange rate prevailing on January 1, 1992 (55 rb/$). Fairly large variations around this rate produce only small changes in total subsidies. The prices of fossil fuels, in former Soviet Republics, quadrupled during the past twelve months but their relative prices both in terms of other domestic goods as well as world energy prices have largely gone unchanged due to general inflation and depreciation of the currency. Besides, former Soviet Union, China and Poland together account for more than US$23 billion or 10% of total world fossil fuel subsidies. Other countries with more than US$2 billion or more in fossil fuel subsidies include Czechoslovakia, Brazil, Venezuela, Mexico. India, Indonesia, Saudi Arabia, Argentina and South Africa.

2.3 What are the impacts on carbon emissions?

The removal of fossil fuel subsidies, i.e. raising domestic prices to world levels, are estimated to reduce annual carbon emissions by nearly one third in the former Soviet Union (see Figure 3). Even with this change though, carbon emissions per dollar of GDP in the former Soviet Union would still be twice as high as in the United States and more than three times higher than in most Western European countries. Negative taxation of energy might have contributed to this relatively poor energy efficiency in former Soviet Union. Other reasons may be energy endowment (ex. hydropower), energy policy (ex. nuclear energy) and regulatory efficiency standards. Carbon reductions from subsidy removal in other subsidizing countries are estimated to fall in the range of 10-20% primarily because subsidies are less pervasive than in the former Soviet Union. In total, emission reductions in subsidizing countries are estimated to equal 9% of annual global emissions, or about 20% of emissions from OECD countries. This represents a large reduction in fossil fuel consumption and is therefore, as a second round effect, expected to reduce world prices of fossil fuels and thus induce increased consumption and carbon emissions in non-subsidizing countries by as much as 4% of global emissions. Net carbon emission reductions from subsidy removal would therefore be about 5%. This 5% figure may not seem like much at all, but our calculations indicate that OECD would have to adopt a US$60-70/ton carbon tax to achieve an equivalent carbon emission reduction. Such a tax would reduce emissions by about 20% of OECD emissions or 9% of global emissions if world fossil fuel prices would not fall and about 5% only accounting for estimated world price reductions.

2.4 How large are the welfare effects?

Subsidy removal would have welfare effects, measured as changes in the sum of consumer and producer surpluses, in subsidizing countries as well as non-subsidizing countries. There are two components to the welfare effects, of which the first is improved efficiency of production and consumption decisions from subsidy removal. The second effect stems from expected fall in world prices if subsidy removal induces a sufficiently large reduction in consumption. The first component is expected to be positive while the second is negative for fossil fuel exporters and positive for importers. Thus accounting for estimated fall in world fossil fuel prices, welfare effects would be positive for net importers, but may be negative for net fossil fuel exporters if losses in export revenues are larger than the gain stemming from more efficient production and consumption decisions.

Welfare from subsidy removal would increase by US$22 billion in former Soviet Union when accounting for world price effects in addition to affecting improvements in the local and global environments through improved resource and consumption allocation arising from undistorted market signals. The net fossil fuel importers of Poland, India, Czechoslovakia and Brazil would see their welfare increase by more than US$2 billion. Of net exporters, welfare effects in Saudi Arabia would be a negative US$1.5 billion and in the range of US$150-350 million for Egypt, Venezuela, Indonesia and Mexico. Western Europe, United States and Japan would see their welfare increase by US$15 billion because reduced fossil fuel prices imply lower import prices. Fossil fuel importing developing countries not in this analysis, would for the same reason also experience welfare gains, although insignificant on a global scale.

2.5 Are there any further economic dividends from Subsidy Removal?

Yes, indeed and some nations could consider these more important than the effects discussed earlier. These are the potential improvements in the local environments of subsidizing countries. Emissions of sulfur dioxide, nitrogen oxides and particulates would be reduced with lower consumption of fossil fuels unless subsidy removal on petroleum products and natural gas results in increased consumption of coal. By placing a dollar value on these local pollution reduction benefits one discovers that in Indonesia elimination of existing energy subsidies of US$2.5 billion results in US$490 million worth of health benefits or 20 cents per dollar of subsidy removal. In India, total removal of US$2.6 billion in energy subsidies translates into roughly US$1.7 billion in additional health benefits or about 65 cents to a dollar of subsidy elimination. Greater health benefits in India accrue because the pollution intensity of coal is much higher than alternate fuels being subsidized in Indonesia.

In sum adjusting energy prices to reflect their true opportunity costs is the first step in an environmentally responsible and fiscally prudent development strategy. The emerging market economies and developing nations that adopt such policies sooner than later will reap rich and multiple economic dividends in terms of a healthy public sector, higher economic welfare, reduced carbon emissions and improved health standards.

Combatting the greenhouse effect would require measures beyond "getting energy prices right" advocated here. One such potential measure is a tax on carbon content of fossil fuels levied by an international agreement or unilaterly. This option is discussed in the following paragraphs.

3. Global carbon tax

Given that carbon emissions contribute nearly three fourths of the long-run warming potential from the greenhouse gases, a global carbon tax has been advocated in recent years as the single most important way for the international community to combat global climate change. The arguments in its favor are several. When property implemented, it can be a low-cost insurance against a potentially large environmental threat; it is more desirable than an energy tax, because it better targets carbon emissions; and it would represent a more flexible, lower-cost alternative to regulatory responses--in fact, some studies show that there would be substantial cost savings of a move from regulatory responses to market-based incentives.

But most global carbon tax regimes in practice appear unworkable, in view of the difficulties of getting nations to agree on (1) a common framework for determining the level and base of such a tax; and(2) institutional arrangements for tax collection and administration, as well as revenue distribution among nations.

Thus the prognosis for the acceptance of a global carbon tax regime is slim, given the high degree of uncertainty surrounding global warming, the anticipated trade-offs with growth, and the inability of a uniform tax to take into account the differing local pollution problems at the sectoral and national levels. The critical question than becomes whether a strong enough case can be made for the adoption of a national carbon tax on economic and local environmental grounds.

4. National carbon tax

The idea of imposing a national tax on carbon--the first tax ever to be aimed specifically at global warming--has found increasing favor of late, perhaps because governments would welcome a politically popular way of raising revenue. Such a tax would fall most heavily on the fossil fuel with the greatest carbon intensity per unit of energy. This would mean a relatively higher percentage price increase for coal than for alternate fuels (petroleum and natural gas), because coal not only has the highest carbon content per unit of energy but it also has the lowest price. For example, a $50/ton carbon tax in Western Europe would on average increase end-user prices of coal by 35 percent, natural gas to households by 8 percent, and gasoline by 5 percent. This compares with price increases in the United States of 90 percent for coal, 13 percent for natural gas, and 12 percent for gasoline.

The carbon-cum-energy tax now being considered by the EC would start at $3/barrel of oil equivalency and increase by $1/barrel each year in real terms until it reached $10/barrel (roughly equivalent to a carbon tax of $70/ton) in the year 2000. Since the tax is supposed to be "fiscally neutral," governments would be expected to lower other taxes by a similar amount. But the chances of the EC adopting this tax anytime soon look poor, as the EC might well wait for others (the United States and Japan) to act, worrying about being at a "competitive disadvantage"--although to date no empirical work has been done to support such a fear.

5. Revenue potential

The revenue potential of carbon taxes is extremely large. Indeed, a moderate $10/ton carbon tax, if imposed individually by all nations, could raise $55 billion just in the first year. For some countries (China), such revenues could amount for about 2 percent of GDP, enough to wipe out the central government's budgetary deficit. In countries were 1987 per capita GDP was less than $900, such a tax would yield revenues worth an average of more than 1 percent of GDP and 5.7 percent of government revenues. For the OECD countries, the numbers are lower, but still significant--0.21 percent of GDP and 1 percent of government revenues. Moreover, carbon taxes tend to be easier to administer in developing countries than personal and corporate taxes and thus less prone to tax avoidance and evasion.

6. Distributional implications

The literature on industrialized countries typically portrays carbon taxes a regressive, because outlays on fossil fuel consumption as a proportion of current annual income falls with income. But recent studies using US data show that carbon taxes are considerably less regressive relative to life-time income or annual consumption expenditures than to annual income, at least for industrial countries. Moreover, there is a reason to believe that the same holds true for the rest of the world, although for quite a different reason: in developing countries, institutional factors also pay an important role.

Auguring for progressivity, or at least low regressivity in the developing world, are:

- If there is a significant degree of foreign direct investment from countries where investors are allowed foreign tax credits against domestic liabilities, then a significant tax burden could be passed on to foreign treasuries, producers, and consumers.

- If price controls apply, producers often cannot pass the tax on to consumers in terms of higher prices.

- With binding import quotas or rationed foreign exchange, a tax would reduce the excess profits made by the privileged class.

Auguring for regressivity would be factors such as full market power. In this situation, the producer could increase product prices to fully pass on to consumers the carbon tax.

As it turns out, in most developing countries, there is some combination of the above elements, creating a situation where taxes can be only partially shifted to consumers. This means that a carbon tax would either be progressive or much less regressive than most people believe (see Table 1). Further, it is likely to be regressive only for the lowest income groups, which could be protected through direct subsidies or alternative measures. In addition, the overall tax structure could be made even less regressive by using the carbon tax to reduce personal income taxes (the latter are not necessarily progressive because of high tax evasion and urban-rural migration.

7. Efficiency cost

By their very nature, taxes in general distort decision making, creating losses for both consumer and producers. But can carbon taxes contribute to economic efficiency by replacing other, more distortionary taxes? To answer this question, we examined four scenarios, using a sample of five countries, (India, Indonesia, Japan, Pakistan, and the United States). Welfare loss (efficiency costs) was measured in terms of additional income required to make the consumer indifferent to a package of policy change, not counting any benefits of reduced global warming or local pollutant reductions (see Table 2).

Case A: Revenue neutral introduction of a $10/ton carbon tax that displaces a personal income tax. In this case, we found an overall deterioration in welfare, ranging from a low of $1.5 cents per dollar of carbon tax revenues in Indonesia to a high of 17.5 cents in Pakistan (see table). The difference stem mainly from variations in pr-existing fossil fuel taxes, labor income axes, carbon prices (market value of total fossil fuel consumption divided by carbon emissions), and energy price changes from the carbon tax.

The study indicated that a country with a relatively low level of pre-existing energy taxes (Indonesia) would do much better than a country with a high one (Pakistan). Although energy taxes are even higher in Japan than in Pakistan, welfare loss is lower in Japan--mainly because of lower carbon reductions, which would stem from the very high pre-existing carbon price. The loss for India compares well with that for the United States, even though pre-existing taxes in India are much lower, since India has a high consumption of coal and thus its carbon price is only half that of the United States.

Case B. Revenue neutral introduction of a $10/ton carbon tax that partially replaces a corporate income. Under this scenario, with the major exception of the United States, the sampled countries would be better off--lending support to a widely held view that corporate income taxes are far more distortionary than labor income taxes, because higher corporate income taxes reduce investment. The estimated net welfare gain varies from a high of 16.9 percent of carbon tax revenues for India to a low of 8.7 percent for Indonesia. The US welfare loss--about 6.2 percent of carbon ax revenues, or 0.017 percent of GDP--may result from the country's relatively lower marginal taxation of corporate income.

Case C: Introduction of a $10/ton carbon tax to raise additional revenues, with no change in existing taxes. In this case, we assume that tax revenues are redistributed as a lump sum. Here, again, we find a deterioration in welfare. But the losses--ranging from a low of 1.5 cents per dollar for Indonesia (0.005 percent of GDP) to a high of 17.7 cents per dollar for Pakistan (0.087 percent of GDP)--although significant, represent only a small fraction of carbon tax revenues. The welfare losses for India, Indonesia, and Pakistan are only slightly higher than those obtained in Case A, because income tax evasion in these countries is pervasive, meaning that changes in the income tax would have little bearing on the labor supply. The difference in the two cases is larger for the United States and Japan because of the higher pre-existing labor income taxes and higher tax compliance.

Case D: Introduction of a $10/ton carbon tax to raise additional revenues, with no tax change in existing taxes but accounting for fossil fuels subsidies. In this scenario, the outcome depends on the level of existing subsidies, underscoring the point that efficiency costs of carbon taxes are overstated if subsidies are ignored. By incorporating existing energy subsidies into the analysis, the tax would not hurt aggregate welfare in India and Indonesia, where fossil fuel price subsidies are high.

Thus, these four scenarios show that a case for carbon taxes on efficiency grounds alone rests upon introducing them in a revenue neutral manner, either as a replacement for corporate income taxes or when fossil fuel subsidies exist. Such taxes do not fare so well as a substitute for personal income taxes, at least in countries with pre-existing energy taxes and no subsidies.

8. Local environmental benefits

Economic benefits aside, however, can carbon taxes be justified on local environmental grounds, particularly through the reduced emissions of pollutants such as nitrous oxides, carbon monoxides, particulates (soot and smoke), and sulphur dioxides? To answer this, we compared the efficiency costs of carbon taxes to the potential health benefits of local pollutant reduction in the same five countries. We determined the benefits by using estimates from three studies, adjusted by purchasing power parity indexes to afford a rough measure of comparability across countries.

Here too, we found evidence that developing and developed countries alike stood to gain, especially if they already had low or nonexistent energy taxes. Our calculations suggest that Indonesia, India and the United States could benefit substantially from a carbon tax on local environmental grounds alone, as benefits exceed costs under all three health benefit estimates (see table). For Pakistan and Japan, however--in view of high pre-existing energy taxes and thus high welfare costs of carbon taxes--the benefits-cost ratios are significantly lower.

9. Policy options for the 1990s

Faced with the uncertainty of global warming and the economic costs that concrete actions to stem global change would impose on this and future generations, policymakers must find tools that can be justified purely on economic and local environmental considerations. For any nation with energy subsidies, the first priority must be the elimination of these subsidies. This would release $230 billion in revenues for developing and emerging market economies, reduce global carbon emissions by 5 percent, improve the allocation of economic resources, and make scarce public funds available for development projects.

For countries that have eliminated energy subsidies but have little or no taxation of energy, or for countries that cannot overcome political obstacles to removing the subsidies, small carbon taxes would be in order. Such taxes would discourage fossil fuel consumption and reduce local pollution, while raising large amounts of revenues at lower administrative costs than the prevalent taxes entail. They would also impose lower economic costs for the society as a whole than do corporate income taxes, without unduly hurting the poor.

Thus, eliminating energy subsidies and levying small carbon taxes are shaping up to be critical elements of an environmentally responsible development strategy for the 1990.

BOX 1

10. A Case For Greater Energy Efficiency to Combat Global Climate Change

Energy consumption per unit of output is often far higher in developing than in developed countries. Two recent World Bank studies reveal that substantial improvements can be made in energy use efficiency, in reducing technical transmission and distribution losses in the electric power sector, and in reducing losses in refining in the petroleum sector. Importantly, these improvements can often be made at a positive net economic benefit, not even counting the benefits of pollution reductions.

Main reasons for higher energy intensity in developing countries are lower or subsidized energy prices, lack of accountability and competitive markets, and an inadequate regulatory and institutional framework. A top priority should be to develop an incentive structure that induces energy efficiency and conservation in both supply and demand. Efficient energy pricing, i.e. removal of energy subsidies, would be an important element of that incentive structure, whether it is prices of fossil fuels and electricity to end-users or of fossil fuels to the power sector. Besides efficient pricing, constraints to energy efficiency improvements must be removed, only then can and will energy users respond effectively to price incentives.

Constraints to efficiency improvements are many, of which an important is that in many cases prices do not matter. For instance, large energy users, such as public utilities, public sector enterprises, subsidized and/or protected industry, are often shielded from competitive pressures and accountability, and have therefore less incentives to stay cost competitive. Thus they tend to use energy less efficiently than in a competitive market structure. Furthermore, there are also constraints on availability of energy efficient appliances and equipment. Such constraints include trade restrictions and lack of competitive industrial strucure. Relaxing these constraints would increase the effectiveness of higher energy prices.

In closing, it is interesting to note that if all countries in the world had carbon emissions per dollar of GDP similar to Japan, Germany and the USA, global carbon emissions would be curtailed by 68%, 48% and 10% respectively (see Larsen and Shah (1992c).

Table 1

Carbon Taxes Incidence

		Tax incidence with respect to		
Institutional considerations	Implications for tax shifting	income	expenditure	life time income
a. Foreign ownership and control	Borne by foreign treasury through foreign tax credits	Nil	Nil	Nil
b. Full market power	Full forward shifting (100% on final consumption)	Regressive (pro-rich)	Less regressive	Less regressive
Perfectly inelastic demand or perfectly elastic supply				
c. Price controls and legal pass-forward of the tax disallowed	Zero forward shifting (100% on capital income)	Progressive (pro-poor)	Progressive	Progressive
Completely inelastic supply	"	"	"	"
	Reduced rents	"		
Import quotas and rationed foreign exchange	No effect on prices (100% on capital income)		"	"
d. An intermediate case of (a) and (b) above	Partial forward shifting (31% to capital income, 69% to final consumption)	Proportional	Progressive	Progressive

Table 2

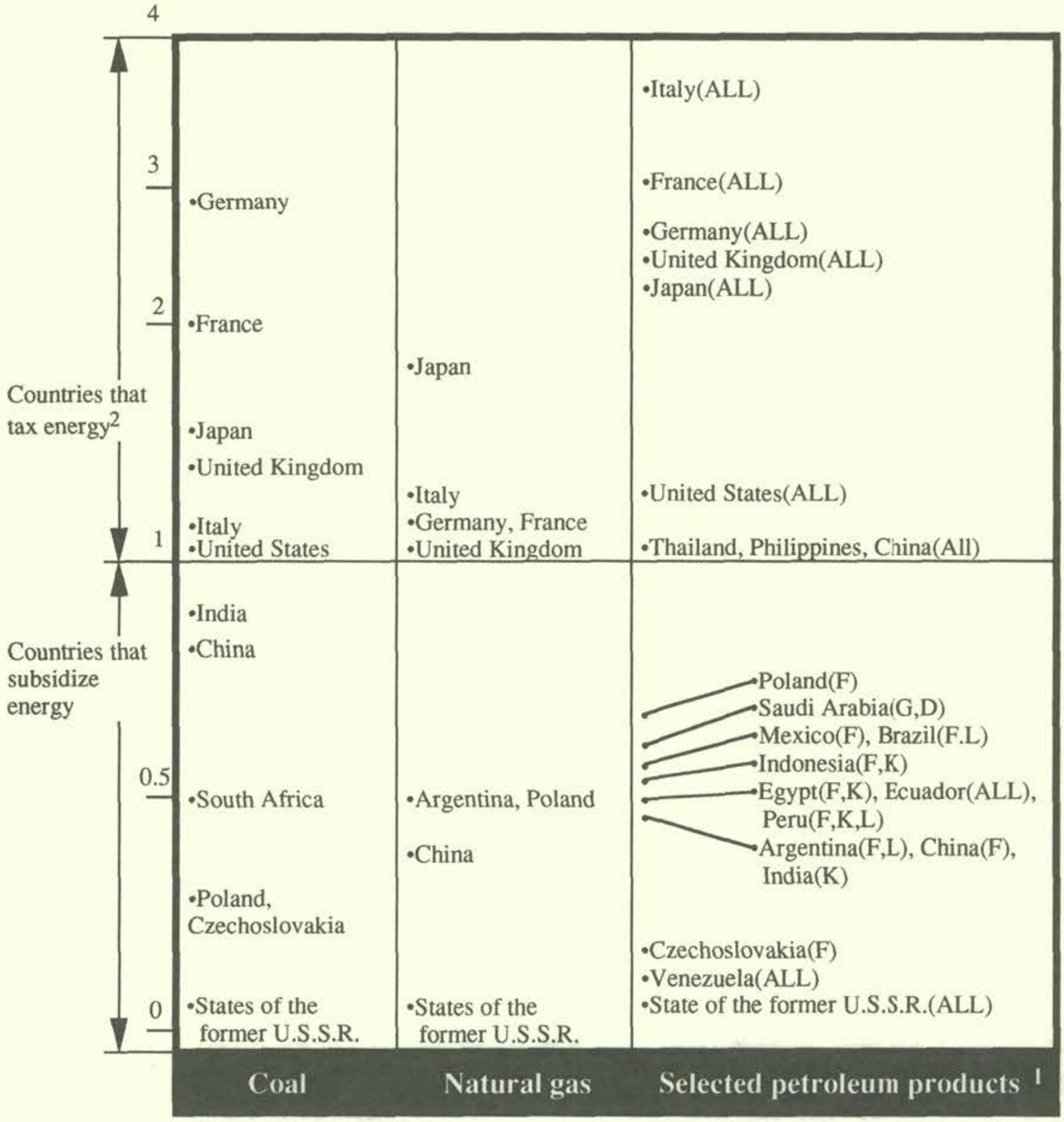
Low Carbon Taxes Make Sense
(costs and benefits of a \$10/ton carbon tax for selected countries, 1987)

	Pakistan	Indonesia	India	United States	Japan
Fossil fuel consumption (million dollars)	3,345	5,330	17,266	246,502	126,100
Carbon emissions					
(millions of tons)	13	26	148	1,246	23
(tons per capita	0.12	0.15	0.18	5.0	1.9
Price of carbon (per ton in dollars)	253	200	117	198	538
Energy taxes (dollars/ton of carbon)	65	0	11	27	105
\$10/ton carbon tax revenues (million dollars)	132	266	1,482	12,461	2,371
Price increase from \$10/ton carbon tax (percent)					
Coal	38	18	26	18	9
Petroleum products	3	6	2	3	1
Natural gas	3	4	3	4	1
Efficiency costs of a \$10/ton carbon tax as percent of carbon tax revenues:					
Case A. Revenue neutral change by equal yield reductions in personal income taxes	-17.5	-1.5	-8.7	-8.4	-11.4
Case B. Revenue neutral change by equal yield reductions in corporate income taxes	+9.0	+8.7	+16.9	-6.2	+9.0
Case C. Rising additional revenues with no change in existing taxes	-17.7	-1.5	-8.8	-10.2	-12.3
Case D. Raising additional revenues with no change in existing taxes but accounting for subsidies	-17.7	+0.4	0.0	-10.2	-12.3
Efficiency costs of carbon reductions (dollars/ton) (efficiency costs in Case C to tons of carbon reductions)	39	4	7	14	79
Benefit-cost ratios associated with the impact of carbon taxes on local pollutants:[1]					
High	1.8	17.9	9.5	11.2	1.3
Medium	1.6	12.9	7.5	8.7	1.0
Low	0.5	2.2	1.9	2.1	0.2

Source: Shah and Larsen (1992), "Carbon Taxes, the Greenhouse Effect, and Developing Countries." World Bank Working Paper Series No. 957.

[1] Includes sulfur dioxides, nitrous oxides, and particulate matter. "High" is based on a Norwegian study by Glomsrod et al (1990): "Medium" is based on a U.S. study by Bernow and Marron (1990); "Low" is based on a U.S. study by the U.S. Environmental Protection Agency and Energy and Resource Consultants, Inc. (the "low" study does not include chronic health effect of nitrous oxides emissions).

Chart 1 How Large are Energy subsidies?
(Ratio of domestic price to world price)



1 For developing countries, selected petroleum products are mainly fuel oils (gasoline is often taxed and in those cases not included). For industrial countries, however, all petroleum products are included. Petroleum products: ALL-weighted avarage of all petroleum products; F-fuel oils; K-kerosene; L-liquefied petroleum gas; G-gasoline; D-automotive diesel.

2 Difference between domestic and world prices is due to both taxes and other distortions.

Chart 2

How much do we subsidize fossil fuels?

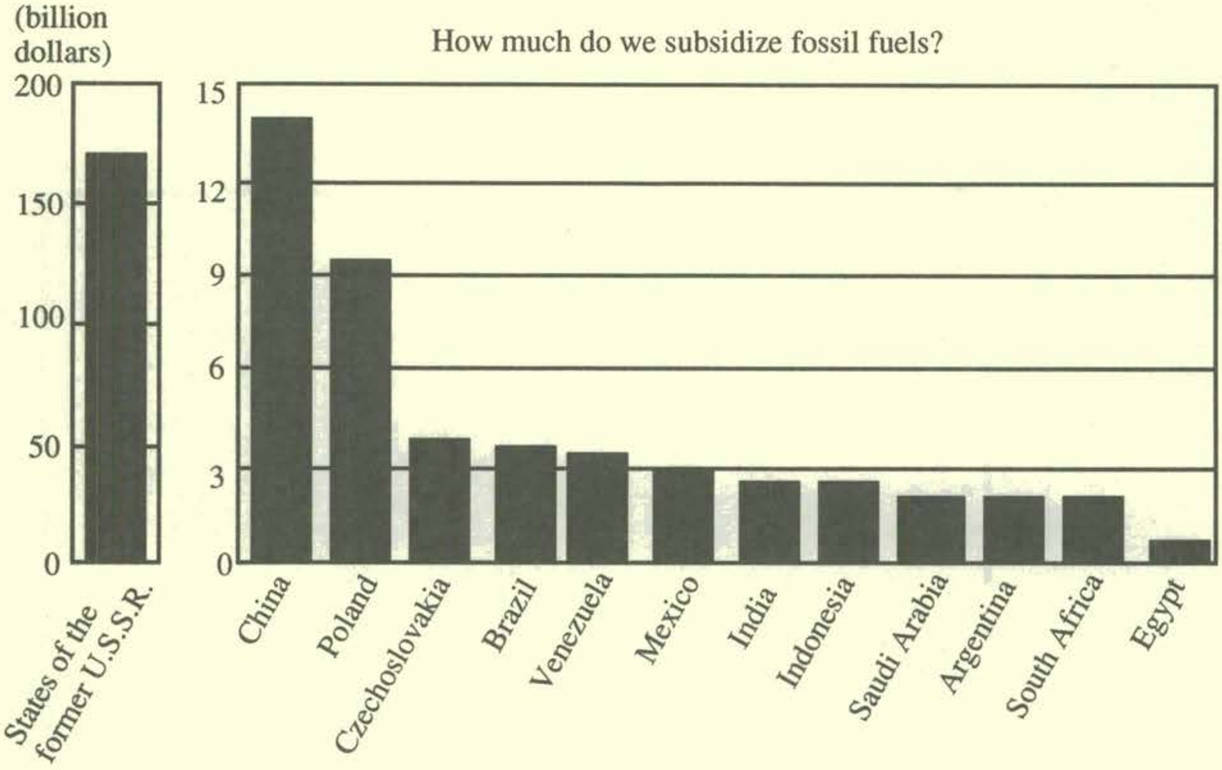
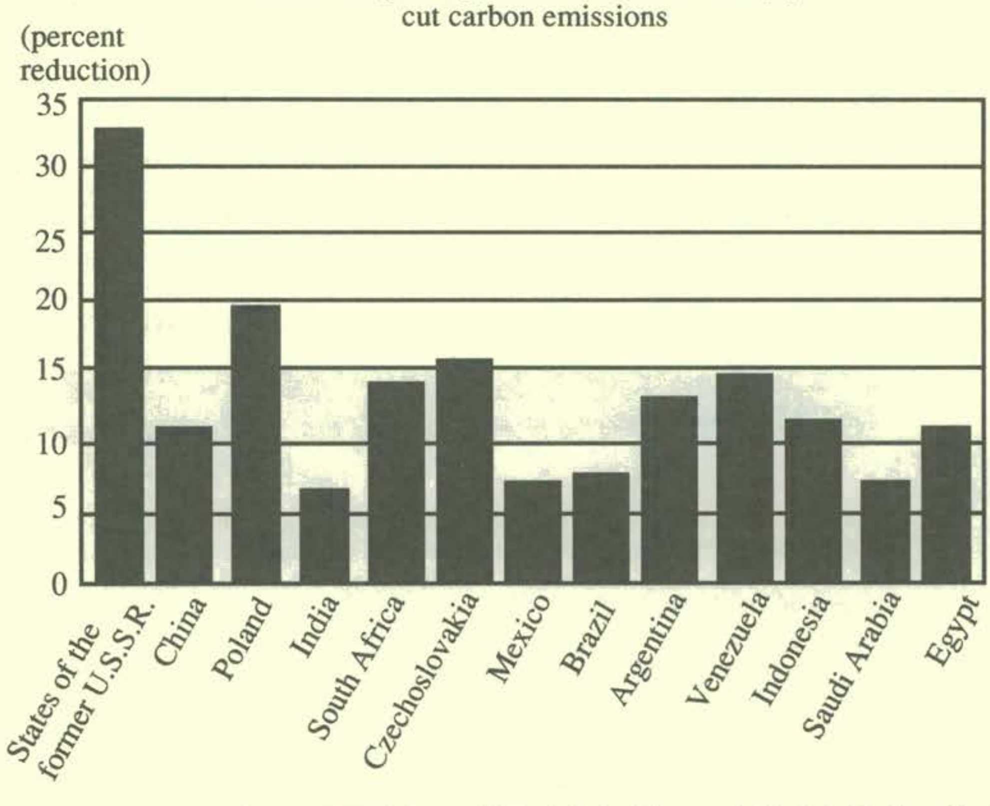


Chart 3

Removing energy subsidies would sharply cut carbon emissions



Source: Larsen and Shah, "World Fossil Fuel Subsidies and Global Carbon Emissions."

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THE EFFECTIVENESS OF CARBON TAXES AT THE INTERNATIONAL LEVEL

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Abstract : The effectiveness of carbon taxes can be judged both by parted evidence from existing energy taxes and by analysis based on theory and models. Cross-country analysis shows that there is a strong relation between the price of fossil fuels per ton of carbon and CO_2 emission intensities. Energy taxes are also shown to be an important component of end-use energy prices. This suggests that carbon taxes could be a powerful instrument to reduce CO_2 emissions. Model results indicate the range of estimated carbon taxes that might be necessary to reduce emissions. Differences in taxes across countries indicate that more cost-effective outcomes can be achieved by tradeable permits or internationally-agreed common carbon taxes. But ensuring maximum participation and hence global efficiency will require equity issues, specifically shaving arrangements, to be considered. In practice, equity and efficiency objectives both need to be considered in order to ensure environmental effectiveness at least cost.

1. Introduction

Since there are very few existing examples of carbon taxes -- and none on an international scale -- it is not easy to assess the effectiveness of such taxes when applied internationally. One has to rely on "secondary" evidence, from energy taxes more generally and from relevant analysis of the likely effects of such taxes. In the absence of evidence from well-tested examples, economists estimate the hypothetical effects of taxes using the tools of economic analysis, including complex models, taking into account uncertainties and hence likely error bands. Failure to carry out such analysis risks acting in the dark, with the consequent possibility of moving to a solution which is much more costly than the optimal. And in the case of climate change, specifically policies to reduce carbon dioxide emissions, the stakes are very high and the potential costs of a sub-optimal solution enormous.

This paper attempts to throw some light on the issue of the international effectiveness of carbon taxes by first drawing on existing studies of the effects of various taxes on energy use and hence carbon emissions (Part 2). It then looks at various estimates of the carbon taxes that might be required to achieve certain specified reductions in carbon emissions (Part 3). The use of emissions trading or a global carbon tax to achieve a cost-effective reduction in emissions is examined (Part 4). Finally, it mentions some general considerations that are relevant to assessing the potential usefulness of carbon taxes internationally (Part 5).

2. The Evidence from Energy Taxes

In considering how effective carbon taxes might be in curbing carbon dioxide there is evidence of a strong impact of energy taxes on energy consumption and, by extension, of carbon taxes on "carbon consumption" (emissions of carbon from the burning of fossil fuels). There are many national studies of such effects. But there is also compelling cross-country evidence of the effects internationally.

Carbon taxes have received much attention because they are an economic instrument which is used directly to influence carbon emissions. Energy taxes of various sorts are a blunter instrument because they are not levied directly on the carbon content of CO_2-emitting fossil fuels but on other aspects of energy, such as the heat supplied or the weight or volume of the fuel. Nevertheless, energy taxes on fossil fuels do indirectly penalise carbon emissions, though

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1 The views in this paper are presented by the author in his personal capacity and do not necessarily reflect the views of individual OECD countries.

to a very different extent across different fuels and different countries. It is thus possible to express a tax on energy in terms of an equivalent tax on the carbon content, hence giving the implicit carbon tax. Such an exercise is instructive since, when comparing across countries, one can assess the extent to which the implicit taxation on carbon emissions has tended to influence the level of carbon emissions. A significant pattern across countries -- higher carbon taxes being linked with lower carbon emissions -- would provide evidence of the power of carbon taxes as a policy instrument to limit climate change.

The calculation of implicit carbon taxes and the relationship of such taxes to carbon emissions has been examined by Hoeller and Wallin (1991) and Hoeller and Coppel (1992), on which the rest of this section draws. Figure 1 shows the relationship between the average price of fossil fuels per ton of emission and the carbon emissions per unit of GDP[2]. It shows that countries with relatively low fossil fuel prices per ton of carbon, such as the United States, Canada and Australia, have a high emission intensity, while the high price countries, such as Italy or Portugal, have low carbon intensities. The relationship suggests that the relative price of energy has a considerable influence on carbon emissions so that carbon taxes could therefore be a useful economic instrument for reducing CO_2 emissions. Nevertheless the relationship plotted out is clearly a partial one, ignoring various other factors and feedbacks of any policy interventions that need to be assessed in a more comprehensive general equilibrium framework.

There are many caveats in this sort of exercise, one of the most important being that some countries have an important share of hydroelectric or nuclear energy which would tend to reduce their emission intensity. Other factors such as population density, urbanisation and climate would also be expected to play a role, but in testing econometrically for the effects of these various factors it is only the hydro and nuclear share for which a significant, correctly-signed coefficient could be found. The share, denoted as HN in the regression shown on the figure, helps to explain the position of France, Switzerland, Sweden and Norway to the left of the estimated curve. However, a high non-fossil fuel share does not guarantee a low emission intensity. Canada, with about three-quarters of its electricity requirements coming from hydro and nuclear, has one of the highest carbon intensities, suggesting that other factors still play an important role.

The suggestion that the energy price/emission intensity relationship analysed above indicates that carbon taxes could be a powerful instrument of policy depends in addition on taxes being an important determinant of final energy prices. The end-use price of energy (in terms of dollars per ton of carbon) varies considerably across countries, with the tax component being an important but not the only determinant of the relative price of energy across countries. The implicit tax per ton of carbon varies from about \$30 (in the United States) to something like \$230 (in France) for 1988, the year for which this analysis was carried out. But there is also an unexplained "wedge" between the end-use price and the estimated before-tax "reference" price (Figure 2)[3]. The residual wedge seems to be particularly important for Japan, but is also - sizeable for New Zealand and Switzerland.

The wide variation in end-use prices, regardless of whether it is due to tax or non-tax distortions, has implications for the implementation and effectiveness of any carbon taxes, particularly if applied internationally. First, any absolute tax, in terms of a flat-rate dollar tax per ton of carbon, will have different impacts across countries depending on initial tax and price levels. A tax of \$100 per ton of carbon, for instance, which is the equivalent of about \$12 on a barrel of oil, would amount to a direct arithmetic increase on end-use prices of 50 per

2 There are various ways of defining this relation ship, which are discussed in Hoeller and Coppel (1992).

3 Figure 2 is also taken from Hoeller and Coppel (1992) but is expressed in terms of US dollars converted at market exchange rates while purchasing power parities are used for conversion to dollars in Figure 1 -- hence the different prices in terms of dollars per ton of carbon in the two figures. For Japan, the residual wedge is particularly large for gas, with distribution costs likely to be particularly significant, but it is also large for oil.

cent in the United States (in terms of 1988 dollars, as shown in Figure 2) and represent roughly a tripling of the tax rate. In contrast, it would represent a direct increase in end-use prices of less than 20 per cent for Switzerland and just over 20 per cent for France or Japan. The impact of an equivalent absolute carbon tax could therefore be expected to be very different across these countries, quite apart from differences arising from different price elasticities, substitution possibilities, fuel composition and so on. However, ceteris paribus, such a tax could be expected, given the sort of inverse relationship depicted in Figure 1, to have environmentally-favourable effects in terms of inducing larger cuts in the highest carbon-emitting countries, smaller cuts in the lower emitters. The tax would also be economically efficient, if applied internationally, achieving maximum reductions for the given cost represented by the tax.

There is one complicating factor concerning the cost, however, which relates to the initial level of the tax. The deadweight cost of a tax increases with the square of the tax rate, given certain conditions about the demand and supply schedules. Hence, a small initial tax will often have little cost while large taxes can have disproportionately higher costs. This means, too, that a $100 carbon tax imposed on top of an existing small carbon tax (the US example) will have a far smaller economic cost than a similar tax imposed on top of an existing tax which is already large (as in France)[4]. This fact is rarely taken into account in cost calculations -- perhaps it seems too esoteric -- but it could have important practical implications for any international discussions on carbon taxes and the relative costs incurred since lower costs might be expected in the currently low-tax, high-emitting countries if a given dollar tax was applied across-the-board.

At the other end of the spectrum, energy subsidies -- and their possible removal -- can be interpreted in similar ways as regards their welfare impacts. Subsidies represent a distortion, with resulting welfare costs, so that their removal can be welfare enhancing. Energy subsidies are especially prevalent in developing countries. Shah and Larsen (1991) estimated world energy subsidies in 1990 to be $230 billion and estimated that their removal would reduce global carbon emissions by 9 1/2 per cent and improve allocative efficiency, generating a welfare gain in subsidising countries. Similar results have been obtained by Burniaux *et al* (1992) who use the GREEN model and find that the elimination of all existing distortions on energy markets would yield an estimated increase in world real income of 0.7 per cent per year while cutting world emissions by 18 per cent in 2050. The rapid and unilateral dismantling of energy subsidies in China and to a lesser extent in other energy subsidising countries will already have important effects in the coming years.

While all these estimates are uncertain, there are clearly large reductions in carbon emissions than can be achieved through carbon taxes and/or the reduction of energy subsidies.

3. Using Models to Examine the Carbon Taxes Required to Reduce Carbon Emissions

In order to examine the likely effects of carbon taxes applied internationally it is necessary to move from the type of partial equilibrium analysis represented in the section above and exemplified in Figure 1 to a more comprehensive approach. General equilibrium models have two specific properties that are particularly useful for the examination of the climate change issue and the potential impact of carbon taxes; the first is that they can be used over an extensive time horizon, as befits the issue, and the second is that various economic feedbacks can be incorporated, including the redistribution of income between sectors within economies and across economies. In addition, it is also possible to model carbon emissions and policy interventions on a global scale and to examine regional effects. Such a property is important if the issue is not to examine the effectiveness of carbon taxes nationally but to assess the international effectiveness of carbon taxes.

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4 The fact that the combined impact of two taxes on the same product is not equal to the sum of the individual deadweight losses has been pointed out by Newbery (1990) and has been analysed in terms of a simple numerical example by Hoeller and Coppel (1992).

The work by the Economics Department of the OECD has tended to focus on the regional and global costs of emission-reduction policies and on the economy-wide effects of policies rather than the detailed sectoral and distributional effects within an economy as typified in the work by Dale Jorgenson presented to this workshop. This work has focused on:

- first, surveys of different studies and a comparison of standardised results from six different models; and

- second, the development of a multi-sector, multi-region, dynamic general equilibrium model which goes under the name GREEN.

The OECD model comparisons project, like the similar Energy Modelling Forum exercise carried out at Stanford University, was designed to standardise time horizons, the key economic assumptions on growth, population and resource prices, and the reduction scenarios for six global models, the GREEN model, the IEA model and four North American models -- the Edmonds-Reilly Model(ERM), Global 2100 of Alan Manne and Rich Richels(MR), the Carbon Rights Trade Model(CRTM) of Tom Rutherford and the Whalley-Wigle model[5]. All of these models are now in the process of evolution and new ones have now been constructed so that a second comparisons exercise is now under way with results to be reported later this year.

The first, rather startling conclusion of the first model comparisons project was that despite standardisation on key assumptions, business-as-usual emission paths were very different. CO_2 emissions at the end of the next century were in a range running from 20 billion to 40 billion tons, compared to the current 6 billion tons. Although this range was narrowed considerably once adjustments were made for different assumptions on the exogenous improvement in energy efficiency, sensitivity analysis also showed how wide the range could be once one starts playing with the assumptions on growth, population, nuclear capacity and so on. This was confirmed by the different scenarios displayed in the IPCC Supplement work released in 1992. This uncertainty on emissions complicates the costing exercise because restricting emissions to any specific, absolute target level -- such as stabilisation at the 1990 level of 6 billion tons -- will mean different amounts of emission reduction according to the different models and even for the same model different degrees of reduction for different countries.

Turning now to the results of the reduction scenarios for the six models covered in the OECD project, the <u>carbon taxes</u> required to reduce world CO_2 emissions to certain levels in terms of billions of tons of carbon are set out in Figure 3 in a series of tax curves for different years. Each curve plots out for each model the results of three scenarios in which the growth rates of emissions in each region are reduced by, respectively, 1, 2 and 3 percentage points. There are two main points shown by the tax curves in Figure 3:

- first, the curvature indicates the need for rising tax increments per unit of reduction in carbon emitted. There are diminishing marginal returns from the tax as cheaper options to reduce emissions are used up and it becomes increasingly difficult to substitute for, or economise on, fossil fuels. Furthermore, squeezing out the very last units of carbon would entail very high carbon taxes, the world average tax being more than $500 per ton (equivalent to $60 on a barrel of oil) by the second half of the next century;

- second, in the earlier periods (2000 and 2020), the model results for the world tax curves are reasonably similar, but this is no longer the case once deep cuts are being made in the later years (2050 and 2100). This is because there are no backstop technologies in the Edmonds-Reilly model and thus no limit to the rise in the tax. Hence, already by 2050, taxes in this model rise beyond $1000 a ton, and these taxes

5 The full results of the OECD model comparisons project, including six papers on the individual models, were published in OECD (1993). See also Dean and Hoeller (1992) for an overview of the main results of the project.

rise to above $2000 a ton by 2100. The backstops act to limit the rise in the required tax in the other models because switching to the new technologies is induced by higher carbon taxes.Hence, for some models the tax curves rise and then come back down again as economic developments induce switches to new, less carbon-intensive or even carbon-free technologies. In Global 2100, for instance, the taxes are restricted in the longer term to just over $200 per ton, because of the assumptions made about the cost, timing and availability of backstop technologies.

The GDP losses across models associated with the different reduction scenarios also rise rather sharply through time, as indicated in Figure 4. The initial GDP costs in 2000 lie between 1 and 3 per cent of GDP in the case of the fastest cut in emissions (3 percentage points per annum), while the costs in the case of slower cuts (the 2 per cent case) are half or less. This reflects the upward curvature of the tax curves, indicating that the speed of adjustment may be important and that the most stringent cuts will be much more costly to achieve. By 2020 the range of GDP losses for the largest cuts (the rather extreme 3 per cent per annum reduction case) is from 3 to 6 per cent of GDP and by 2100 the range is 4 to 8 per cent. Note, however, that this is an extreme case, far more severe than any likely agreement on emission reductions and the higher end of the range is associated with the absence of backstop technologies.

While there is significant variation in tax rates and costs for the same amount of emission reduction among models, three messages emerge:

i) small amounts of emissions reduction can probably be achieved at low cost;

ii) large reductions can only be achieved at high tax rates, i.e. marginal reduction costs rise with emission reductions; and

iii) carbon-free backstop technologies are likely to slow the rise of the carbon tax or halt it altogether, if they are available at constant marginal cost.

The required carbon taxes and associated costs vary significantly across regions in all of the models. The results by region for the 2 per cent scenario are summarised in Table 1. These results indicate that the same proportional reductions in emissions across all regions would give rise to very different costs in different regions and would thus be globally inefficient -- with great potential for savings in the global cost of reducing emissions, as discussed in the next section.

One of the most important factors which helps explain the differences between models is the degree of substitution between fuels -- the ease with which producers and consumers can switch from high-carbon content fuels to low-carbon content fuels. But there are other important aspects of modelling which influence the cost estimates:

- first, expectations about future energy prices and taxes will influence the future path of consumption, saving and investment as well as the energy efficiency of capital installed; the required taxes and the aggregate costs are likely to be lower if there is forward-looking behaviour based on perfect foresight, since adjustments costs are reduced;

- second, the speed of emission reduction will also be important, with a rapid phase-in of reductions likely to be more costly because of premature scrapping;

- third, the way in which revenue is recycled will influence the overall costs, since recycling would allow reductions in distortionary taxes, although it is an open question whether gains here should be netted against the costs of emission reduction policies since such gains should be realisable irrespective of such policies;

- the same applies to energy subsidies; their removal may raise welfare, because of improved resource allocation, but should such subsidy removal be counted as part of the net cost of climate change policies? As mentioned in the previous section, the GREEN model has been used to simulate the removal of energy subsidies and shows that world CO_2 emissions would be 18 per cent lower in 2050, with gains in world welfare; similar results have been found in the study by Shah and Larsen for the World Bank.

Drawing together these various strands there are no precise answers about the taxes required and the costs of cutting CO_2 emissions although carbon taxes are shown to be a very powerful and effective instrument for cutting global emissions. There is a range of results across models depending on assumptions as regards substitution possibilities, energy efficiency improvements, backstop technologies, the type of trade links and a host of other technical and economic factors. In addition there are various policy decisions -- concerning revenue recycling, subsidy removal, the distribution of emission reductions to be aimed at and the speed of reduction -- that can be shown to have an important bearing on the cost outcome.

But for cuts in emissions of close to 50 per cent below baseline in 2020 (as in the 2 per cent annual reduction in emissions in Table 1) the required tax might be in the range of $150 to $300 per ton of carbon and the cost might be in the range of 1 to 3 per cent of GDP.

Efficient solutions, i.e. the lowest cost for the desired global objective, would avoid sharing out the emission cuts equally and would focus instead on trying to make the emission reductions where it would be cheapest to do so. It is also necessary to take into account issues such as the scope for achieving reductions cheaply by removing existing distortions in energy markets, including subsidies, and ways in which technology transfers and improvements in energy efficiency can be encouraged. These considerations suggest that the cost estimates presented above may represent the maximum cost to the global economy of emission reduction and that policy should be designed to keep such costs to a minimum. Because the taxes and costs could be large, and with the uncertainty on both costs and benefits being great, "no regrets" solutions and efficient agreements have obvious appeal.

4. Cost-Effective Reductions in Emissions

The range of taxes and abatement costs across regions in the different reduction scenarios suggests the potential for savings in the global cost of reducing emissions. If, at the margin, it is more expensive (as reflected in the carbon tax rates) for one region to achieve the reduction objective than another, then it is in principle possible to achieve a mutually-beneficial redistribution of the emission reductions between regions combined with a cross-region payment. To get globally cost-effective reductions in emissions, the marginal costs of abatement, as reflected in the regional carbon taxes, should be equated across regions. All the models indicate that equi-proportionate cuts in emissions are incompatible with this condition. A system of emission trading between countries or regions or a global carbon tax would allow cuts in emissions to be concentrated where abatement is cheapest. Emissions trading, for instance, if feasible, would allow for a more efficient distribution of emission reductions across region by letting countries trade emission rights to the point where carbon taxes were the same in all countries. A global carbon tax would also lead to the marginal cost of reducing emissions being equal for all countries.

Three of the models in the comparisons project (ERM, GREEN and MR) have carried out an emissions-trading scenario. The results for emissions trading are shown for 2020, 2050 and 2100 for the case of the 2 per cent scenario in Table 2. The largest gain is for GREEN; with larger cuts in the regions where abatement is cheapest and smaller reductions elsewhere, the global output loss halves from 2 per cent to 1 per cent of GDP in 2020[6]. All of the models point to gains from this type of emissions trading (Table 2). However, the gains are less in the models with a smaller dispersion in carbon taxes in the no-trade case, for instance ERM

6 The model results underestimate the possible gains from co-operative strategies since the model regions combine numerous countries together and trading of emissions takes place between regions and not between the countries within regions.

and MR. Furthermore, the dispersion of taxes narrows with time as backstop technologies come into play so that the gains from emissions trading diminish correspondingly. This can be seen with the GREEN results for 2050 where the gain from trading is less than in 2020. The sums involved in emissions trading are significant. In 2050 they range from $200 billion in GREEN to over $400 billion in MR, but the revenues fall off thereafter in MR as the backstops reduce the tax dispersion and hence the potential gains from trade. This underlines again the critical importance of the assumptions on backstop technologies for all aspects of the assessment of taxes and cost, including the gains from cost-effective agreements.

5. General Considerations Concerning the International Effectiveness of Carbon Taxes

In considering the possible use of a carbon tax to limit CO_2 emissions, one needs to be able to compare such a tax with alternative instruments in order to judge whether it is an efficient (least-cost) instrument of policy. So long as the country is one where there are well-functioning markets, a carbon tax will provide incentives to consumers and producers to economise on the use of carbon-emitting fossil fuels and could be expected to be more efficient than the blunter instrument of energy taxes (not directly aimed at carbon content) or the even blunter instrument of regulatory control (which sets certain standards or target reductions regardless of the cost of achieving the cuts)[7]. A carbon tax will also encourage continued technological innovation in order to move to more efficient techniques and to save on costs. Regulation may encourage some initial technological change but will not generally provide a continuing incentive to develop new technologies, quite apart from failing to achieve abatement at lowest cost.

One complaint raised against the use of carbon taxes is that the effect on emissions is uncertain compared with a quantitative target which is imposed by some other means. The issue of prices or quantities is an important one that is relevant in dealing with many environmental problems. With a tax, the quantitative effect is indeed uncertain but the price, i.e. the cost of the policy, is relatively well known and assured. With a quantitative target it is the cost which is relatively uncertain. In general, setting volume standards without adequate information about costs may lead to inefficient outcomes, as the error on costs would be open-ended. Optimisation requires a balancing of costs and benefits which means that it is not possible in advance to set the "volume" outcome before analysing the costs and benefits of different degrees of abatement. This does not preclude a government or set of governments from establishing some objective on emission-reduction, such as stabilisation at current levels, and then trying to attain this target in a cost-effective manner. But the risk is that the cost of meeting the chosen objective will not match the estimated benefits so that there will be either excessive or insufficient abatement. Phasing in a carbon tax would have the advantage of allowing governments to work towards a quantitative objective which could be established over time as estimates of costs and benefits become better defined. Adjustments to the tax path could then be made in order to work gradually to establish an optimal degree of abatement.

It is also a mistake to focus discussion too narrowly on carbon dioxide emissions, for other greenhouse gases as well as carbon sinks need also to be considered if there is to be cost minimisation. The fixed link between carbon emissions and the burning of fossil-fuels makes taxation of CO_2 emissions from this source a relatively easy greenhouse gas emission to tax. However, since other gases also influence climate change the cost-effectiveness of both reducing other greenhouse gas emissions and engaging in forestry options must also be assessed. Since net emissions can be curtailed both by emission abatement and carbon sequestration (afforestation), a carbon tax alone will be inefficient since the tax treatment of mitigation and sequestration will differ. An efficient solution would allow for the forestry option, perhaps through a subsidy to sequestration activities equivalent per unit of carbon affected to the tax on emissions.

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7 This looks just at the costs side. Work by Chichilnisky and Heal (1993) which examines the public good aspect of a "better" atmosphere and incorporates it in utility functions indicates that conclusions on the equalisation of marginal abatement costs with carbon taxes may need to be qualified, an issue that has also been addressed by Manne (1993) in a paper on integrated assessment.

In designing carbon taxes, it has been common practice to examine the exemption of energy-intensive industries on competitive grounds. But any exemption negates the effectiveness of such taxes. It is especially important that energy-intensive industries adapt through fuel-switching or improved efficiency. For this to occur the taxes must be imposed fully and be reflected in final prices, so that the necessary incentives to economise are given. The competitiveness issue is nevertheless one of concern, and is one reason why concerted international action has been called for. Unilateral national or regional action, besides not being enough to ensure sufficient global reduction in emissions, may also suffer from the problem of "carbon leakage" -- increased emissions in competitor countries who increase their production of carbon-based products.

So far, the equity issue has been entirely neglected and the focus has been entirely on efficiency. But there are strong reasons for thinking that, at least at the international level, there will be strong links between the two. For ensuring sufficient participation internationally -- and hence an efficient outcome globally -- will require distributional questions, including the issue of burden-sharing, to be addressed[8]. Furthermore, the issue of gainers and losers from a carbon tax cannot be separated from the issue of gainers and losers from climate change. If it is possible to establish the net gainers and losers then it is in principle possible to design a set of transfers which would maximise participation, be globally efficient and be equitable.

Carbon taxes can be an effective instrument for reducing carbon emissions. But if serious inroads are to be made in reducing carbon dioxide emissions, then action needs to be international. Action by OECD countries alone would not be sufficient to stem the rapid rise in emissions expected in the next century when a large part of the increment to emissions is likely to come from outside the OECD area. For a carbon tax to be effective internationally, it is therefore necessary for there to be wide participation. Although a global carbon tax or a tradeable permits system would in principle deliver an efficient outcome internationally, the equity issue cannot be ignored since in practice some burden-sharing will be necessary to ensure global participation. There are important practical design issues which need to be addressed if carbon taxes are to be used as one part of a strategy to deal with climate change, but the key one will be how to marry up considerations of efficiency and equity so as to ensure a comprehensive internationally-accepted policy.

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8 How any side payments are structured may be a decisive feature in harnessing extensive participation which will be crucial for policy effectiveness. Various possibilities are explored in Coppel (1993).

Table 1 A Summary of Results from OECD's Model Comparisons Project

Simulation results for a 2 percentage point reduction in baseline emission growth

A. Carbon taxes ($/ton of carbon) (1)

	Barns et al. (1992)			Oliveira Martins et al. (1992)		Manne (1992)			Rutherford (1992)		
Year	2020	2050	2095	2020	2050	2020	2050	2100	2020	2050	2100
United States	351	1095	2754	223	340	354	208	208	324	754	208
Other OECD	342	734	1240	239	299	241	208	208	233	365	208
China	182	341	651	26	67	271	240	208	320	1109	208
Former USSR	104	325	719	69	180	301	990	758	322	2245	758
RoW	430	1012	2021	184	329	399	727	208	409	763	208
Total	283	680	1304	149	230	171	448	242	325	884	235

B. Change in GDP relative to baseline (% loss)

	Barns et al. (1992)			Oliveira Martins et al. (1992)		Manne (1992)			Rutherford (1992)		
Year	2020	2050	2095	2020	2050	2020	2050	2100	2020	2050	2100
United States	2.0	4.9	8.8	1.1	1.3	2.2	2.7	3.1	1.3	2.5	2.6
Other OECD	1.9	3.4	4.8	1.2	1.6	1.1	1.6	1.9	0.4	1.1	1.5
China	2.8	4.3	6.2	0.7	1.5	2.7	3.8	5.0	2.0	3.1	3.6
Former USSR	0.9	2.3	3.7	1.7	3.7	3.1	6.4	5.6	1.5	5.8	4.1
RoW	2.0	3.5	5.1	3.8	4.4	4.9	5.1	5.6	2.3	2.1	4.5
Total	1.9	3.8	5.8	1.9	2.6	2.9	3.7	4.7	1.5	2.4	3.6

(1) Carbon taxes for the United States and the other OECD are $376 and $548, respectively, for the IEA's model in 2005.

Note: The 2 percentage point reduction in the growth rate of emissions corresponds to a cut from the BaU emissions path of about 45 per cent in 2020, 70 per cent in 2050, and 88 per cent in 2095/2100.

Table 2 Cost Differences for Emission Trading

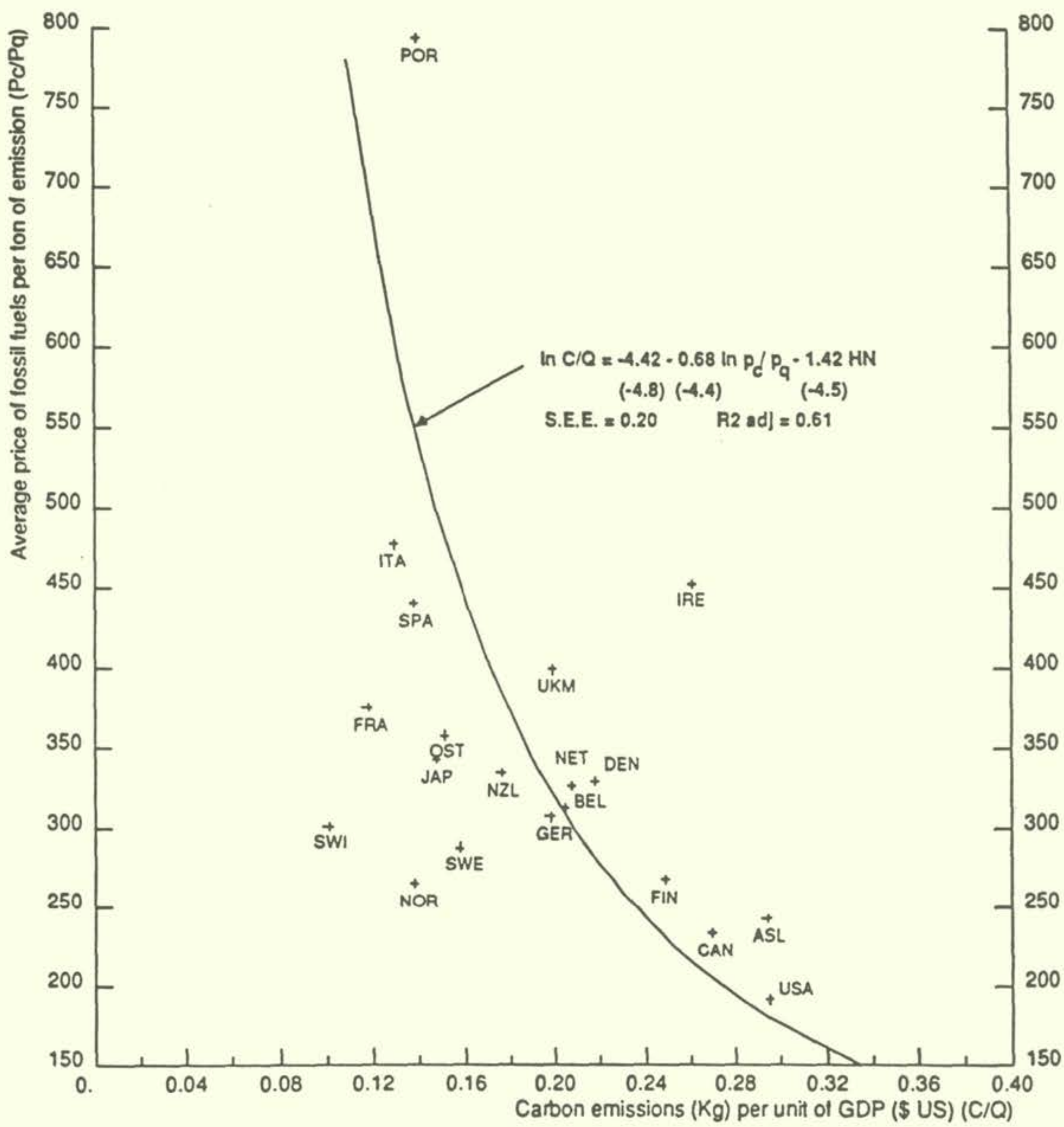
Numbers refer to a 2 percentage point reduction in emissions from the base line and are global aggregates

		ERM (1)		GREEN		MR	
		Tax ($/tC)	GDP loss(%)	Tax ($/tC)	GDP loss(%)	Tax ($/tC)	Welfare loss (2)
2020	No trade	283	1.9	149	1.9	325	...
	Trade	238	1.6	106	1.0	308	...
2050	No trade	680	3.7	230	2.6	448	...
	Trade	498	3.3	182	1.9	374	...
2100	No trade	1304	5.7	...	...	242	8.0
	Trade	919	5.1	...	...	208	7.5

(1) End-year is 2095 for ERM.

(2) Consumption losses through 2100 -- discounted to 1990 at 5 per cent per year -- in trillions of 1990 dollars.

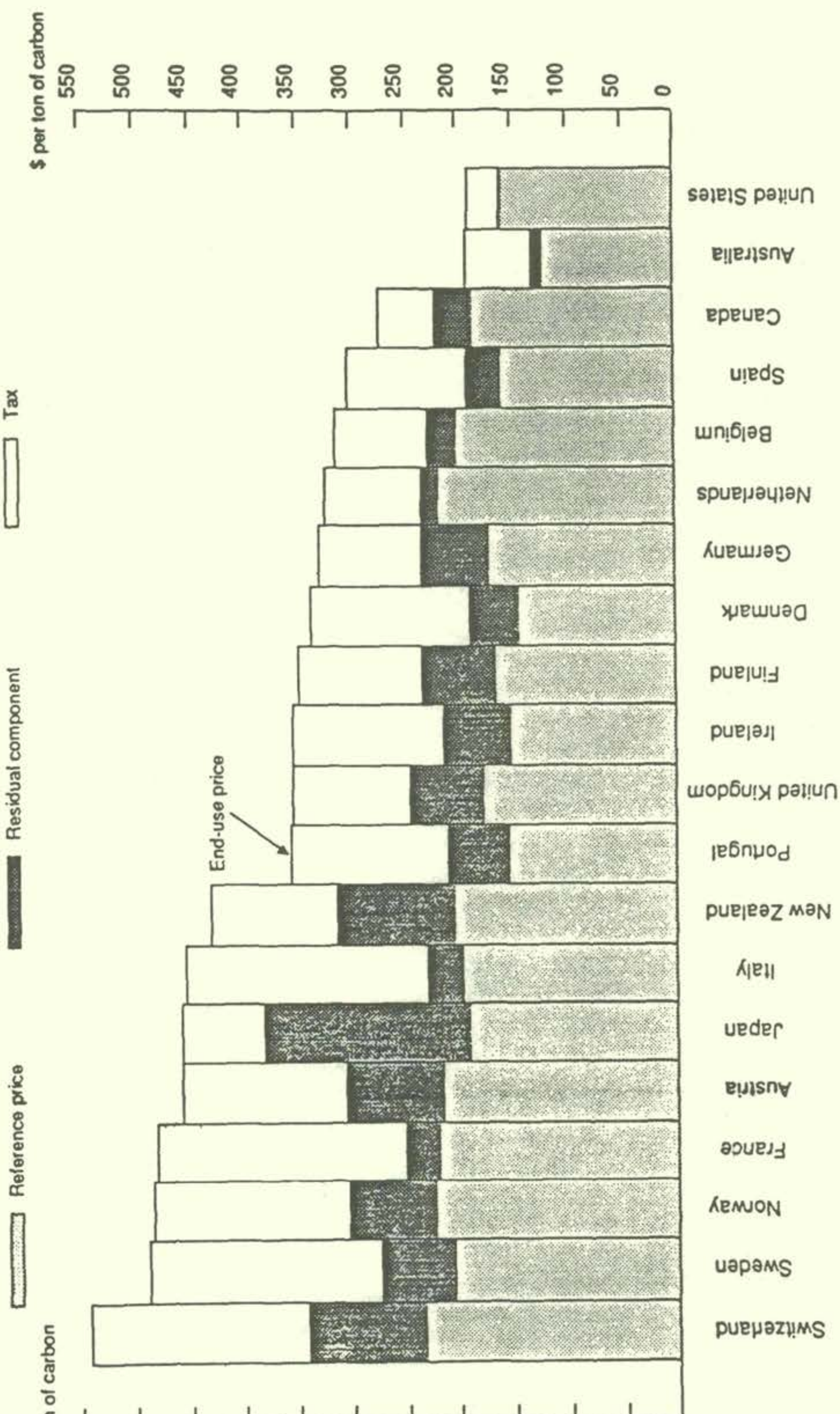
Figure 1 . Prices per ton of emission and emission intensities (Dollars 1988)



Source: Estimates based on IEA data.

Note: The relationship between carbon intensity and prices is adjusted for the average contribution from the hydro and nuclear energy share (HN). This affects in particular France, Norway, Sweden and Switzerland. Country codes which may not be obvious are ASL and OST which are respectively Australia and Austria.

Figure 2. The tax and total wedge between a reference and end-use price
(Dollars 1988, U.S. exchange rate)



Source : Estimates based on IEA data.

Figure 3. **World emissions and carbon taxes**

Note: The scales on the different panels are not standardised.

GREEN ------- MR ERM CRTM

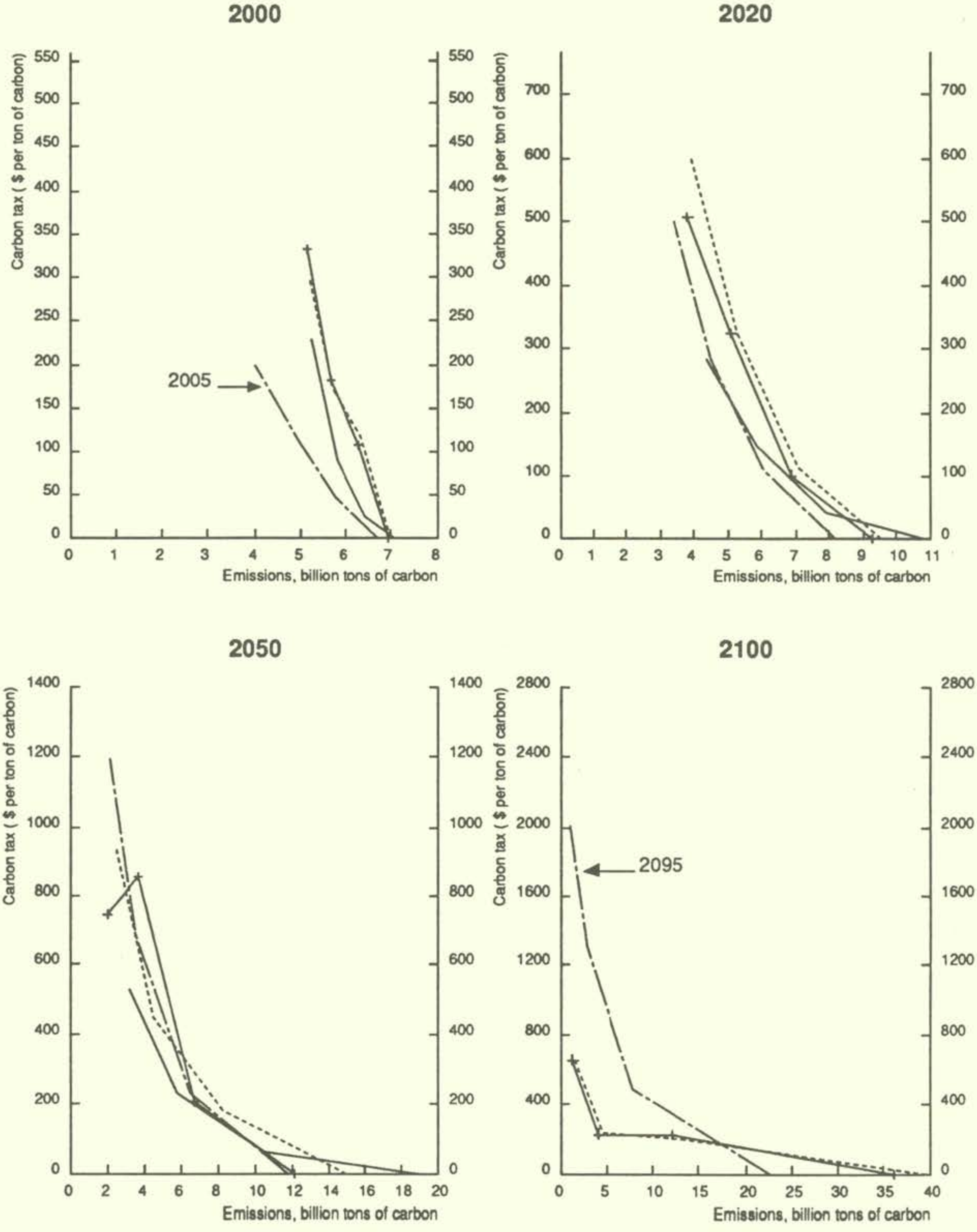
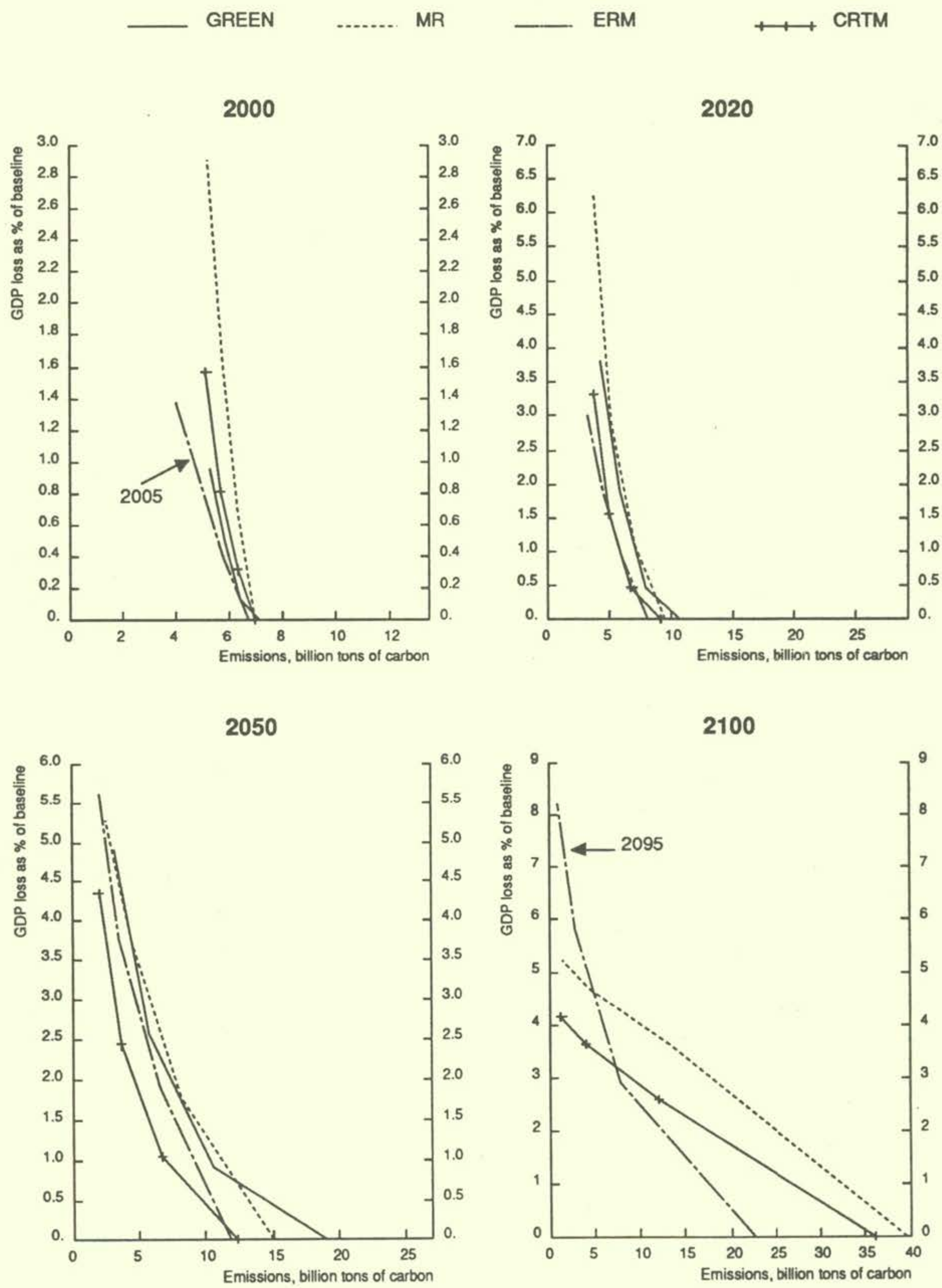


Figure 4. **World emissions and GDP losses**

Note: The scales on the different panels are not standardised.



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THE ECONOMIC EFFECTS OF A CARBON TAX

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1. Introduction

A carbon tax, such as the one proposed by Stram in the previous chapter, would have effects throughout the economy. It would raise the price of energy, increase the cost of products produced by energy-intensive processes, reduce employment in energy sectors, increase employment elsewhere, generate tax revenue, and, finally, reduce carbon dioxide emissions.

In this paper we use a derailed model of the U.S. economy to calculate the magnitude of these and other effects. Our findings are roughly as follows. A carbon tax would raise fuel prices, particularly for coal. Coal demand would fall substantially, leading to a large drop in coal production. Oil and gas output would also decline but by a much smaller percentage. Higher coal prices, in turn, would raise the cost of electricity. Consumers and firms would demand less electricity, which will slow productivity growth and capital formation. This, in turn, will tend to reduce gross national product (GNP).

What actually happens to GNP, however, will depend very strongly on how the revenue from the tax is used. A carbon tax large enough to have much effect on emissions would raise tens to hundreds of billions of dollars annually. If this revenue were used to reduce distortionary taxes elsewhere in the economy, the impact of the tax on GNP would be much smaller. In fact, we show that GNP would actually increase if the revenue were used to reduce taxes on capital.

The next section presents our model and uses it to show how a carbon tax large enough to stabilize carbon emissions at 1990 levels would affect the United States. We then consider a series of possible refinements on the basic tax: reducing emissions further; different uses of the tax revenue using BTU or ad valorem taxes instead; the distributional effect of the tax; and finally, whether a tax in OECD countries alone would be likely to improve the global environment. Appendix A provides more detail about the model and base case.

2. Modeling Approach

The results we present below are based on a set of simulations we conducted using a detailed model of the U.S. economy designed specifically for examining the effects of energy and environmental policies. One feature of our approach which distinguishes it from many others is that we use a general equilibrium model. General equilibrium models are constructed by dividing the economy into a collection of interdependent sectors which interact through markets for goods and services. (The behavior of each sector is represented by an appropriate submodel.) When a new policy, such as carbon tax, is introduced, prices and wages adjust until demands and supplies are equated in every market and the economy reaches equilibrium. Our model is composed of thirty-five producing sectors, a consumer sector, an investment sector, a government sector, and a foreign sector. Appendix A presents an overview of the model by describing the submodels used to represent each of these sectors. It also discusses our base case simulation.[2]

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2 For more detail on the specification of the model or the base case simulation, see Jorgenson and Wilcoxen (1990)

3. The Cost of Stabilizing Emissions

Somewhat surprisingly, the United States has had an extended period of stable carbon dioxide emissions once before: from 1972 to 1985. During that period high oil prices reduced energy demand and lowered carbon dioxide emissions substantially. The relationship between oil prices and carbon emissions can be seen by comparing historical oil prices, shown in Figure 1, with the history of U.S. carbon emissions, shown in Figure 2. The large increases in oil prices in 1974 and 1979 led to drops in the trend rate of emissions growth. However, this reduction came at a very high price: the oil price shocks reduced U.S. GNP growth by 0.2% per year during the period from 1974 to 1985.[3] The lesson from this episode is that 0.2 percentage points of annual GNP growth is an upper bound on the cost of stabilizing U.S. carbon dioxide emissions.

The policy most often proposed for reducing carbon emissions is a carbon tax.[4] It would be applied to fossil fuels used for combustion in proportion to the carbon dioxide the fuels emit when burned. From the standpoint of economic efficiency, a carbon tax is the ideal way to reduce carbon dioxide emissions because it is very close to a tax on the externality itself: if firms and individuals must pay to emit carbon dioxide, they will emit less. A carbon tax would stimulate users to substitute other inputs for fossil fuels and to substitute fuels with lower carbon content, such as natural gas, for high-carbon fuels such as coal.

Fossil fuels differ substantially in both price and the amount of carbon dioxide produced per BTU of energy (see Table 2). One BTU from oil, for example, costs more than three times as much as a BTU from coal but produces only 80% of the carbon dioxide. The least carbon-intensive fuel is natural gas: one BTU of natural gas produces only about half as much carbon

Table 2 Relative Carbon Content of Fossil Fuels

		Fuel	
Characteristic	Coal (ton)	Oil (bbl)	Gas (mcf)
Million BTU per unit	21.94	5.80	1.03
Tons of carbon per unit	0.649	0.137	0.016
Carbon per million BTU:			
Tons	0.030	0.024	0.016
Relative to coal	100%	80%	54%
Approximate price before tax:			
Per unit of fuel	$22	$21	$2.4
Per million BTU	$1.00	$3.62	$1.36
Tax equal to $10/ton of carbon			
Per unit	$6.49	$1.36	$0.16
Per million BTU	$0.30	$0.24	$0.16
Percentage increase per unit	29.50%	6.48%	6.67%

dioxide as one BTU of coal. Together, the differences in price and carbon content mean that a carbon tax would produce very different percentage changes in the prices of the fuels. A $10 per ton tax on carbon would raise the price of coal by 29 percent, the price of oil by 6 percent, and the price of gas by almost 7 percent.

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3 For a more complete discussion, see Jorgenson and Wilcoxen (199lb).

4 A carbon tax was first proposed by Nordhaus (1979).

The carbon tax policy which has been debated most widely would impose a tax larrge enough to limit emissions to 1990 rates. To measure the effect of such a policy on the United States we constructed a simulation in which the carbon tax rate was allowed to vary from year to year but was always chosen to be exactly enough to hold U.S. carbon dioxide emissions at their 1990 value of 1576 million tons.[5] We returned the revenue raised by the tax to households as a lump sum rebate. Without the carbon tax, emissions would increase over time, so the tax grows gradually over the next few decades (see Figure 3). By 2020 the U.S. population is likely to crest and emissions growth will begin to slow, reducing the rate of carbon tax growth.[6]

The tax would produce significant reductions in carbon emissions, as shown in Figure 4. By 2020, emissions are sixteen percent lower than they would have been without the tax. The tax also produces considerable revenue: $31 billion annually by 2020.[7]

The principal direct effect of the tax is to increase purchasers' prices of coal and crude oil. By 2020, for example, the tax reaches $22.71 per ton of carbon. As shown in Table 3, this amounts to a tax of $14.75 per ton of coal, $3.10 per barrel of oil or $0.37 per thousand cubic feet of gas. The tax would increase the prices of fuels but leave other prices relatively unaffected (see Figure 5). The price of coal would rise by forty-seven percent, the price of electricity would rise by almost seven percent (coal accounts for about thirteen percent of the cost of electricity), and the price of crude oil would rise by around four percent. The prices of refined petroleum and natural gas utilities would rise because of the tax on the carbon content of oil and natural gas.

Table 3 Selected 2020 Results for the Stabilization Scenario

Variable	Unit	Value
Carbon Emissions	%Δ	-16.12
Carbon Tax	$/t	22.71
Tax on Coal	$/ton	14.75
Tax on Oil	$/bbl	3.10
Tax on Gas	$/mcf	0.37
Price of Capital	%Δ	0.40
Capital Stock	%Δ	-0.83
Tax Revenue	$B	31.41
Real GNP	%Δ	-0.55
Coal Price	%Δ	46.99
Coal Output	%Δ	-29.28
Electricity Price	%Δ	6.60
Electricity Output	%Δ	-6.17
Oil Price	%Δ	4.45
Oil Output	%Δ	-3.90

Changes in the relative prices for fuels would affect demands for each good and lead to changes in industry outputs (see Figure 6). Most sectors show only small changes in output, Coal mining is an exception: its output falls by almost thirty percent. Coal is affected strongly for three reasons. First, coal emits more carbon dioxide than oil or natural gas per unit of

5 A tax which varies from one year to the next in order to keep carbon emissions absolutely constant is a useful analytical device but is not a likely policy. The tax could not be adjusted quickly enough to keep emissions constant in every year.

6 As noted above, our population projection is based on forecasts made by the Social Security Administration in which population growth approaches zero early in the next century.

7 All dollar amounts are in 1990 prices.

energy produced. Thus, the absolute level of the tax per unit of energy content is higher on coal than other fuels. Second, the tax is very large relative to the base case price of coal for purchasers: at the mine mouth, the tax would increase coal prices by around fifty percent. (In contrast, oil is far more expensive per unit of energy so in percentage terms its price is less affected by the tax. The price of crude oil rises only about ten percent.) Third, the demand for coal is relatively elastic, Most coal is purchased by electric utilities, which can substitute other fuels for coal when the price rises. Moreover, the demand for electricity itself is relatively elastic, so when the price of electricity rises, demand for electricity (and hence demand for coal) falls substantially.

Outside the energy industry, the main result of the tax is to increase the prices of electricity, refined petroleum and natural gas, each by a few percent. This would have two effects. First, higher energy prices would mean that capital goods (which are produced using energy) would become more expensive. Higher prices for capital goods mean a slower rate of capital accumulation and lower GNP in the future. Second, higher energy prices discourage technical change in industries in which technical change is energy-using. Together, these two effects cause the capital stock to drop by 0.7 percent and GNP to fall by 0.5 percent by 2020 (relative to the base case). Average annual GNP growth over the period 1990-2020 is 0.02 percentage points lower than in the base case. About half of this is due to slower productivity growth and half due to reduced capital formation.

4. Greater Reductions in Emissions

Even if emissions were stabilized at 1990 rates, atmospheric concentrations of carbon dioxide would continue to rise for decades. Thus, holding emissions at 1990 rates would not prevent further global warming. This observation has led many observers to call for much larger cuts in carbon dioxide emissions. To see how the economy would be affected by a more stringent carbon dioxide control policy we constructed a second carbon tax scenario in which emissions were required to decrease 20% below 1990 levels by 2010. (Key results are shown in Table 4; results from the stabilization simulation are also shown for comparison.)

Table 4 Selected Results for Two Emissions Targets

Variable	Unit	Reduce by 20%	Stabilize at 1990
Carbon Emissions	%Δ	-32.90	-16.12
Carbon Tax	$/t	74.49	22.71
Price of Capital	%Δ	1.10	0.40
Capital Stock	%Δ	-2.35	-0.83
Tax Revenue	$B	82.52	31.41
Real GNP	%Δ	-1.71	-0.55
Coal Price	%Δ	149.86	46.99
Coal Output	%Δ	-55.03	-29.28
Electricity Price	%Δ	19.46	6.60
Electricity Output	%Δ	-16.43	-6.17
Oil Price	%Δ	15.06	4.45
Oil Output	%Δ	-12.35	-3.90

Increasing the stringency of the policy increases its cost substantially. Moving from the stabilization scenario to the 20% reduction case doubles the effect of the policy: emissions fall by 32.90 percent instead of 16. 12 percent. However, this comes at the cost of tripling both the carbon tax and the loss of output. The more stringent policy has a relatively larger effect on sectors other than coal mining. In particular, doubling the emissions reduction does not cause the reduction in coal output to double. Coal users, particularly electric utilities, find it increasingly difficult to substitute away from coal. Thus, the larger reduction in carbon emissions requires a larger reduction in oil use. Under the 20% reduction case, the drop in oil use is three times what it was under stabilization.

We determined the economy's cost curve for a variety emissions targets. The results are summarized in Figure 7, which shows the reduction in U.S. GNP in 2020 as a function of the percentage by which emissions are below 1990 levels. Reducing emissions by more than 20% imposes large losses of GNP. To put these numbers in perspective, stabilizing the atmospheric concentration of carbon dioxide (leading to an eventual stabilization of temperature) would require reducing emissions by 50% relative to 1990, a very costly policy.

5. Use of Carbon Tax Revenue

Any tax large enough to reduce carbon dioxide emissions significantly will raise an enormous amount of revenue. In the simulations above the tax produces 30 to 80 billion dollars a year. Precisely how this revenue is used will have a large effect of the overall economic cost of slowing global warming. In particular, if the revenue were used to reduce distortionary taxes elsewhere in the economy, or if it were used to lower government budget deficits, there would be large welfare gains which would offset some or all of the welfare losses associated with the carbon tax itself.

To determine how large this welfare improvement might be we constructed three simulations in which the revenue from a carbon tax was used to reduce different taxes. In each simulation we imposed a carbon tax of $15 per ton in 1990 with the rate rising by 5% annually in subsequent years. In the first simulation the revenue was returned to households by a lump sum rebate; in the second it was used to lower taxes on labor, such as social security taxes; and in the third it was used to lower taxes on capital, such as corporate income taxes.

Table 5 Selected Results for Revenue Experiments in 2020

	Unit		Revenue Policy	
Variable		Lump Sum	Labor Rebate	Capital Rebate
Carbon Emissions	%Δ	-32.24	-32.09	-31.65
Carbon Tax	$/t	64.83	64.83	64.83
Price of Capital	%Δ	0.97	-1.86	0.23
Capital Stock	%Δ	-2.13	-1.36	1.89
Tax Revenue	$B	79.65	79.82	80.35
Real GNP	%Δ	-1.70	-0.69	1.10
Coal Price	%Δ	143.49	140.57	142.06
Coal Output	%Δ	-54.14	-54.19	-53.45
Electricity Price	%Δ	18.57	15.97	16.99
Electricity Output	%Δ	-15.93	-15.37	-14.66
Oil Price	%Δ	14.20	12.28	14.55
Oil Output	%Δ	-11.92	-11.54	-11.39

Our results show that the disposition of revenue from a carbon tax has a very significant effect on its overall impact on GNP (see Table 5). In the lump sum case, output in 2020 drops by 1.70 percent relative to the base case. When the revenue is returned by lowering the tax on labor the loss of GNP is less than half as much: only 0.69 percent. The improvement is due to an increase in employment brought about by the drop in the difference between before- and after-tax wages. If the revenue were returned as a reduction in tales on capital, GNP would actually increase above its base case level by 1.10 percent. In this case, the gain is due to accelerated capital formation generated by all increase in the after-tax rate of return on investment. These results suggest that a carbon tax would provide an opportunity for significant tax reform.

6. Other Tax Polices

The concentration of costs in the coal sector raises the possibility that the coal lobby would be able to block passage of a carbon tax in the U.S. Congress. As a result, two alternative taxes are sometimes proposed: a tax on the energy content of fossil fuels (a BTU tax) and an ad valorem tax on fuel use.[8] Like a carbon tax, both of the other taxes would operate by raising the cost of fuels and inducing fuel users to substitute away from fuel use.[9] In a separate paper we compared energy and ad valorem taxes to a carbon tax and found that although carbon taxes have the largest effect on coal mining, they have the smallest overall effect on the economy as a whole.[10] Energy taxes were fairly similar to carbon taxes but with slightly less impact on coal mining (a drop in output of 25% instead of 26.3%) and slightly greater overall cost (a drop in GNP at 2020 of 0.6% instead of 0.5%). In contrast, ad valorem taxes fell much more lightly on coal mining (a 19.5% drop in output rather than 26.3%) at the expense of having much greater effect on the rest of the economy through higher prices of oil (a 1.0% drop in GNP instead of 0.5%; see Table 6).

Table 6 Effects of Different Tax Instruments at 2020

			Instrument	
Variable	Unit	Carbon Tax	BTU Tax	Ad Valorem
Carbon Emissions	%Δ	-14.4	-14.4	-14.4
Carbon Tax	$/ton	16.96	--	--
BTU Tax	$/MBTU	--	0.47	--
Ad Valorem Tax	%	--	--	21.6
Tax on Coal	$/ton	11.01	10.21	--
Tax on Oil	$/bbl	2.31	2.70	--
Tax Gas	$/kcf	0.28	0.48	--
Tax Revenue	Bil.$	26	31	53
Capital Stock	%Δ	-0.7	-0.8	-1.4
Real GNP	%Δ	-0.5	-0.6	-1.0
Price of Coal	%Δ	39.9	37.2	26.1
Quantity of Coal	%Δ	-26.3	-25.0	-19.5
Price of Oil	%Δ	3.6	5.0	12.8

7. Distributional Effects

Carbon taxes are sometimes opposed on the grounds that they are regressive. It is certainly true that a carbon tax could have widely varying effects across households. However, it is not clear that the tax would be significantly regressive.[11] Poterba has estimated the impact of a $100 per ton carbon tax on U.S. households having different levels of total expenditure.[12] He concluded that the impact of a carbon tax would be slightly regressive by this measure, falling

8 An example of an ad valorem fuel tax that has often been proposed is an increased tax on gasoline.

9 This reduction in energy use is often proposed as a goal for its own sake.

10 See Jorgenson and Wilcoxen, 1991b.

11 The distributional effects of a carbon tax have been examined by Poterba (1991), DeWitt, Dowlatabadi and Kopp (1991) Jorgenson, Slesnick and Wilcoxen (1992), and by Schillo, et al. (1992).

12 Poterba. 1991.

more heavily on households having low total expenditures. Classifying households by income rather than expenditure makes the tax appear slightly more regressive. DeWitt, Dowlatabadi and Kopp conducted a study with more regional detail and found that there would be substantial differences in the economic impact across different geographic regions.[13] Both Poterba and Dewitt, Dowlatabadi and Kopp point out that non-energy prices will also change, so that a general equilibrium approach is required to assess the full impact. This approach has been taken by Jorgenson, Slesnick and Wilcoxen who found that the tax is mildly regressive, although the size of the effect varied across different consumer groups.[14]

8. International Aspects

Unlike many environmental problems, carbon emissions are a global externality. This would make implementing a carbon tax difficult for several reasons. First, the tax would have to be levied by individual governments, some of which might not be willing to participate. In particular, most OECD nations have now agreed that some sort of limit should be placed on carbon dioxide emissions. However, many less developed nations have been reluctant to adopt any carbon dioxide policy that might reduce their economic growth. Schelling (1992) has suggested that this poses an insurmountable obstacle to a unanimous international policy. Thus, a more likely outcome is that any global carbon dioxide policy would be incomplete: OECD nations would adopt the policy while developing nations would not.

A tax with only partial international coverage could be vitiated by movement of energy intensive industries away from participating countries to other nations. In fact, Hoel (1991) has shown that it is theoretically possible for such a policy to result in a net increase in world carbon dioxide emissions if nonparticipating nations have less efficient energy technologies. This is particularly likely to be a problem if the policy in question were an OECD tax and production moved to less developed nations. To date, however, there has been only a modest amount research on how an incomplete carbon policy would affect patterns of international trade. The principal study was conducted by Felder and Rutherford (1992), who found that the amount of redirected emissions could be considerable. An OECD carbon tax could reduce OECD oil demand enough to lower the world price of oil substantially. Lower world oil prices would lead, in the Felder-Rutherford model, to a very large increase in oil demand by developing countries.

A second reason why the global nature of carbon dioxide emissions would make implementing a carbon tax difficult is that the point at which the tax is applied has important distributional effects. Whalley and Wigle noted that carbon taxes could be applied in several different ways, each achieving the same reduction in carbon emissions but having large differences in the distribution of costs.[15] A carbon tax large enough to reduce emissions substantially would raise an enormous amount of revenue. If the tax is applied at the point of production, it would be collected by the governments of producing countries. Were the tax to be applied to consumption, on the other hand, the revenue would flow to governments of consuming nations. Since the revenues are likely to be large, this is important.

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13 DeWitt, Dowlatabadi and Kopp used a detailed econometric model of U.S. household energy consumption to estimate the response of energy consumption patterns to the tax.

14 Jorgenson, Slesnick and Wilcoxen used a detailed, econometrically estimated intertemporal general equilibrium model to measure the lifetime incidence of a carbon tax on consumers in different demographic groups.

15 Whalley and Wigle (1990) used a dynamic global general equilibrium model to assess the distributional effects of various carbon dioxide abatement policies.

9. Summary

In this chapter we have examined the likely economic effects of a carbon tax. We find that a carbon tax would reduce U.S. gross national product relative to its level in the absence of the tax because it would raise the price of energy. Moreover, the effects of the tax will be very similar to the effects of a tax placed solely on coal. Of all fossil fuels, coal is the least expensive per unit of energy and produces the most carbon dioxide when burned. Thus, a tax levied on carbon emissions will raise the cost of coal-based energy far more in percentage terms than the price of energy derived from oil or natural gas. In response to this price change, the demand for coal will fall substantially. The demands for oil and natural gas will also decline, but by much smaller percentages.

Almost all coal consumed in the U.S. is used to generate electric power. As the price of coal rises, electric utilities will convert some generating capacity to other fuels. However, substitution possibilities are fairly limited, particularly in the short run, so the tax will raise the price of electricity significantly. Consumers and firms will devote more effort to conserving energy by substituting other inputs for electricity, leading to a fall in electricity demand. Higher energy prices will lead to slower productivity growth, reduced capital formation, and a reallocation of labor to lower-wage industries, all of which will cause gross national product to be lower than it would have been in the absence of the tax.

The tax rate needed to achieve a fixed absolute emissions target, such as maintaining emissions at 1990 levels, will depend on how fast emissions grow in the absence of the tax. Baseline emissions growth, in turn, will depend on the rate of productivity growth, the rate of capital accumulation, the rate of growth of the labor force, any energy-saving biases in technical change, and the path of world oil prices. More rapid economic growth will generally lead to higher baseline emissions and will thus require higher tax rates if emissions are to be held at a fixed absolute level. Moreover, deeper absolute cuts in emissions will require sharply increasing tax rates.

A carbon tax large enough to have much effect on emissions would raise tens to hundreds of billions of dollars annually. Thus, it would provide an opportunity for significant tax reform, and this reform could soften the effect of the tax on gross national product. If the revenue were used to reduce distortionary taxes elsewhere in the economy, the impact of the tax on GNP would be reduced. In fact, it is possible that GNP would actually increase if the revenue were used to reduce taxes on capital.

Finally, several additional observations should be kept in mind regarding carbon taxes. First, the United States did, in fact, stabilize its carbon dioxide emissions during the 1970s and early 1980s when oil prices were very high. However, the cost in terms of lost GNP was much larger than if emissions had been controlled by a carbon tax. Costs would also be much higher if other inefficient instruments, such as a BTU or ad valorem tax, were used instead of a carbon tax. Second, the distributional effect of a carbon tax will be regressive, but only very slightly. Third, if an international carbon tax were imposed in some countries but not others, changes in trade patterns would shift carbon-intensive activities to countries where they were not taxed, compromising the original policy to some extent.

Appendix

This appendix presents an overview of the general equilibrium model and base case that we used to estimate the effects of a carbon tax on the United States. The model includes thirty-five producing sectors, a consumer sector, an investment sector, a government sector, and a foreign sector. For more detail on the specification of the model or the base case simulation, see Jorgenson and Wilcoxen (1990).

Production

Production is disaggregated into the thirty-five industrial sectors listed in Table 1. Most of these industries match two-digit sectors in the Standard Industrial Classification. Each industry produces a primary product and may produce one or more secondary products. This level of industrial detail makes it possible to measure the effect of changes in tax policy on relatively narrow segments of the economy. Since most anthropogenic carbon dioxide emissions are generated by fossil fuel combustion, a disaggregated model is essential for capturing differences in the response of each sector to a carbon dioxide control policy.

Table 1 Industry Definitions

Num	Description
1	Agriculture, forestry and fisheries
2	Metal mining
3	Coal mining
4	Crude petroleum and natural gas extraction
5	Nonmetallic mineral mining
6	Construction
7	Food and kindred products
8	Tobacco manufactures
9	Textile mill produucts
10	Apparel and other textile products
11	Lumber and wood products
12	Furniture and fixtures
13	Paper and allied products
14	Printing and publishing
15	Chemicals and allied products
16	Petroleum refining
17	Rubber and plastic products
18	Leather and leather products
19	Stone, clay and glass products
20	Primary metals
21	Fabricated metal products
22	Machinery, except electrical
23	Electrical machinery
24	Motor vehicles
25	Other transportation equipment
26	Instruments
27	Miscellaneous manufacturing
28	Transportation and warehousing
29	Communication
30	Electric utilities
31	Gas utilities
32	Trade
33	Finance, insurance and real estate
34	Other services
35	Government enterprises

The behavior of each industry is derived from an industry-specific nested cost function. At the highest level, the cost of each industry's output is assumed to be a transcendental logarithmic (translog) function of the prices of capital services, labor, energy, and materials. The price of energy, in turn, is assumed to be a translog function of prices of coal, crude petroleum, refined petroleum, electricity, and natural gas, while the price of materials is a translog function of the prices of all other intermediate goods. Given this structure we derive demand equations for capital services, labor and intermediate inputs for each of the industries.

We estimated the parameters of each industry submodel econometrically, using a set of consistent inter-industry transactions tables constructed for the purpose. The tables describe the U.S. economy for the period 1947 through 1985.[16] Estimating the production parameters over a long time series ensures that each industry's response to changes in prices is consistent with historical evidence.

An unusual feature of our model that productivity growth is determined within the model. Other models used lo study global warming, for example, Manne and Richels (1992), take productivity growth to be exogenous. In our model the rate of productivity growth in each industry is determined endogenously as a fiction of input prices. In addition, each industry's productivity growth may shift it toward some inputs and away from others. Biased productivity growth is a common feature of historical data but is often ignored when modeling production. By allowing for biased productivity growth, our model is able to capture the evolution of industry input patterns much more accurately.

Consumption

We represent consumer behavior by assuming that households follow a three-stage optimization process. At the first stage, each household allocates full wealth (the sum of financial and human wealth, plus the imputed value of leisure time) across different periods. We formalize this decision by introducing a representative agent who maximizes an additive intertemporal utility function subject to an intertemporal budget constraint. The portion of full wealth allocated to each period is called full consumption. At the second stage, households allocate each period's full consumption to goods and leisure in order to maximize an indirect utility function. This allows us to derive demands for leisure and goods as functions of prices and full consumption. The demand for leisure implicitly determines labor supply, while the difference between current income and consumption of goods implicitly determines savings.

The third stage of the household optimization problem is the allocation of total expenditure among capital services, labor services, and the thirty-five commodities. At this stage, we relax the representative consumer assumption in favor of the approach of Jorgenson, Lau and Stoker (1982) to derive separate systems of demand functions for households with different demographic characteristics. We distinguish among 1344 household types according to demographic characteristics such as the number of household members and the geographic region in which the household is located. The spending patterns of each household type are derived from a hierarchial tier-structured indirect utility function. This allows us to derive household demands for individual commodities.

As with production, the parameters of the behavioral equations for all three stages of our consumer model are estimated econometrically. Our household model incorporates extensive time series data on the price responsiveness of demand patterns by consumers and also makes use of detailed cross-section data on the effects of demographic characteristics on consumer behavior. In addition, an important feature of our approach is that we do not require that the pattern of household demands be independent of income.[17] As total expenditure increases, spending patterns may change even in the absence of price changes. This captures an important feature of cross-sectional expenditure data which is often ignored.

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16 See Jorgenson and Wilcoxen (1990) for details on how the dataset was constructed.

17 Formally, we do not the restriction that the utility function be homothetic.

Investment and Capital Formation
We assume there is a single capital stock in the economy which is in fixed total supply in the short run. However, we also assume that capital is perfectly malleable and can be reallocated among industries and between industries and final demand categories at zero cost. Thus, the price of a unit of capital services will be equal in every industry and there will be a single economy-wide rate of return on capital.

In the long run the supply of capital is determined by investment. Our investment model is based on the assumption that investors have rational expectations and that arbitrage occurs until the present value of future capital services is equated to the purchase price of new investment goods. This equilibrium is achieved by adjustments in prices and the term structure of interest rates. New capital goods are produced from individual commodities according to a model identical to those for the industrial sectors so the price of new capital will depend on commodity prices. We estimated the behavioral parameters for new capital goods production using final demand data for investment over the period 1947-1985. Thus, the model incorporates substitution among inputs in the composition of the capital.

Government and Foreign Trade
The two remaining parts of the model are the government and foreign sectors. To specify government behavior, we begin by computing total government spending on goods and services. We start by assuming that tax rates will be fixed at current levels in the absence of changes in policy. We then apply these rates to taxable transactions in the economy to obtain total tax revenue. To this we add the capital income of government enterprises and non-tax receipts to obtain total government revenue.[18] Next we assume the government budget deficit can be specified exogenously and add the deficit to total revenue to obtain total government spending. To arrive at government purchases of goods and services, we subtract interest paid to holders of government bonds together with transfer payments to domestic and foreign recipients. We then allocate spending among commodity groups according to fixed shares constructed from historical data.

In modeling the foreign sector we begin by assuming that imports are imperfect substitutes for similar domestic commodities. The mix of goods purchased by households and firms reflects substitution between domestic and imported products. We estimate the price responsiveness of this mixture econometrically from historical data. In effect, each commodity is assigned a separate elasticity of substitution between domestic and imported goods. Since the prices of imports are given exogenously, intermediate and final demands implicitly determine the quantity of imports of each commodity.

Exports are determined by a set of isoplastic export demand equations, one for each commodity, that depend on foreign income and the foreign prices of U.S. exports.[19] Foreign prices are computed from domestic prices by adjusting for subsidies and the exchange rate.The demand elasticities in these equations are estimated from historical data. Without an elaborate model of international trade it is impossible to determine both the current account balance and the exchange rate endogenously so we take the current account to be exogenous and the exchange rate to be endogenous.

The Base Case
To assess the effect of a carbon tax we must first determine the fume path of the U.S. economy in the absence of the tax. To construct such a scenario, which we will call a "base case," we adopted a set of default assumptions about the time path of each exogenous variable in the absence of changes in government policy. Since savings and investment are determined by the expectations of households and investors, we must specify the values of the model's exogenous variables far into the future. Through 1990 2050, we forecast values of the

18 The capital income of government enterprises is endogenous while non-tax receipts are exogenous.

19 We take foreign income to be exogenous.

exogenous variables on, the basis of their behavior in the sample period. After 2050 we assume the variables remain constant at their 2050 values to allow the model to converge to a steady state by the year 2100.

Our projections for 1990-2050 were made as follows. First, all tax rates are set to their values in 1985, the last year in our sample period. Next, we assume that foreign prices of imports in foreign currency remain constant in real terms at 1985 levels. We then project a gradual decline in the government deficit through the year 2025, after which the nominal value of the government debt is maintained at a constant ratio to the value of the national product. Finally, we project the current account deficit by allowing it to fall gradually to zero by the year 2000. After that we project a current account surplus sufficient to produce a stock of net claims on foreigners by the year 2050 equal to the same proportion of national wealth as in 1982.[20]

Some of the most important exogenous variables are those associated with growth of the U S. population and corresponding changes in the economy's time endowment. We project population by age, sex and educational attainment through the year 2050, using demographic assumptions consistent with Social Security Administration projections. After 2050 we hold population constant, which is roughly consistent with Social Security projections. In addition, we project the educational composition of the population by holding the level of educational attainment constant beginning with the cohort reaching age 35 in the year 1985. We transform our population projection into a projection of the time endowment by assuming that the pattern of relative wages across different types of labor remains as it was in 1985. Since capital formation is endogenous in our model, our projections of the time endowment effectively determine the size of the economy in the more distant future.

20 That is, we project the U.S. to return to its 1982 position of being a net lender to the rest of the world.

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THE ECONOMICS OF STABILIZING ATMOSPHERIC CO_2 CONCERTRATIONS[1,2]

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1. Introduction

The United Nations Framework Convention on Climate Change has as its ultimate objective the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." Under the terms of the Convention, the costs of the policies and measures for achieving the target are to be given little weight in establishing the level at which concentrations are to be stabilized. The level is to be based upon our understanding of the greenhouse effect and its potential consequences -- not upon a balancing of benefits and costs.

Whereas economic considerations play little role in establishing the target, they play an important role in determining how the target is to be achieved. The Convention states that "policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost." A particular concentrations target can be achieved in a variety of ways. Some will be more costly than others. Economic analysis is needed to identify emission paths that minimize the costs of achieving the desired concentrations level.

This paper addresses the issue of cost-effectiveness in the selection of an emissions time-path. The focus is on carbon dioxide, the most important anthropogenic greenhouse gas. A reduced form carbon cycle model is used to identify alternative emission paths for achieving a given CO_2 concentrations target. Using two widely-used energy-economy models, we then calculate how costs to the global economy vary with the choice of emissions trajectory. It turns out that the emissions time-path is as important as the concentrations level itself in determining the ultimate price-tag.

2. Carbon Emissions and Concentrations under Business as Usual

We begin by examining how CO_2 emissions and atmospheric concentrations are apt to evolve under business as usual. That is, in the absence of explicit abatement measures. For purposes of the present analysis, emissions are divided into three categories: 1) fossil fuels, 2) net deforestation and land-use change, and 3) others.

The fossil fuel emissions baseline is established with the Global 2100 model of Manne and

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Richels (1992). Global 2100 is a dynamic nonlinear optimization model which divides the globe into five geopolitical regions: the US, the other OECD countries, the former Soviet Union, China, and the rest of the world. The model is designed to evaluate the options that are realistically available to each region as the world moves away from its heavy dependence on fossil fuels and toward a more diversified energy economy.

The model's key parameters are calibrated using the results of a recent expert survey (Manne and Richels, 1993).[5] Figure 1 reports the business-as-usual emissions path. For purposes of comparison, we also show the range of emissions scenarios contained in the recent supplement to the IPCC scientific assessment (IPCC, 1992). Note that the results are quite similar to the IPCC 's central case (IS92a).

For emissions from net deforestation and land-use change, we assume a "neutral biosphere". That is, that the net biospheric input of CO_2 is exactly balanced by natural uptake mechanisms.[6] Further, we suppose that global cement production will contribute an additional 200 million tons of carbon to the atmosphere annually.

Ocean uptake of carbon is approximated by the impulse-response function of Maier-Reimer and Hasselman (1987).[7] Figure 2 shows atmospheric concentrations under business as usual. According to our calculations, concentrations will be double pre-industrial levels in the middle of the next century and exceed 700 ppmv by the year 2100.

3. Stabilizing Atmospheric CO_2 Concentrations

The level at which "dangerous anthropogenic interference with the climate system" will occur has yet to be established. Indeed, the question of what constitutes an appropriate level is likely to remain the subject of intense discussion for sometime. The present analysis makes no attempt to contribute to this debate. Nor does it endorse any particular set of limits. Rather, we explore the economic implications of holding concentrations to a range of alternative levels.

It is noteworthy that most proposals for dealing with climate change have focused on emissions and not concentrations. For example, the Toronto Conference on "The Changing Atmosphere" called for a 20% worldwide reduction in CO_2 emissions by the year 2005 and the Hamburg Conference (November of 1988) called for a 30% reduction by the year 2000.

More recently, the focus of National Action Plans mandated by the Framework Convention has been to return emissions to their 1990 levels by the year 2000. This is seen as the first step in achieving the Convention's ultimate objective of stabilizing atmospheric concentrations. The second step, however, remains unclear. As a point of departure, we explore the implications of a policy which would permanently hold global emissions to 1990 levels.

Figure 2 shows the impact of such a policy upon atmospheric concentrations. The rate of increase has been considerably reduced. Atmospheric concentrations in 2100 are now only 500 ppmv. Stabilizing emissions, however, does not serve to stabilize concentrations. Although the rate of increase is slowing, the absolute level is still increasing.

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5 A group of knowledgeable individuals were polled on their beliefs about five factors that are important to future CO_2 emissions. These are: 1) potential GDP growth rates, 2) the elasticity of price-induced substitution between energy and capital-labor, 3) the rate of autonomous energy efficiency improvements, 4) the availability of economically competitive carbon-free alternatives to coal-fired electricity and 5) the costs of a nonelectric backstop alternative to liquid fuels. The Global 2100 model runs reported here are based on the poll averages.

6 This hypothesis is consistent with the post-World War II historical record (Post et al, 1990).

7 The model partitions carbon emissions into five classes, each with different atmospheric lifetimes. Parameters are least-square fitted to the computed response of a full ocean carbon cycle model.

A particular concentrations target can be achieved in any of a number of ways. Figure 3 shows three alternative emission trajectories that would lead to 500 ppmv in 2100. The line labeled 500a represents a scenario in which emissions are allowed to follow the business-as-usual path through 2010; are reduced gradually between 2010-2050; and are reduced sharply thereafter. The line labeled 500b represents an emissions scenario which lies between the 500a and the emissions stabilization scenarios. Note that the areas under the lower three curves are approximately the same.

Figure 4 shows the corresponding curves for atmospheric concentrations. The 500a and 500b emission scenarios were chosen so as to stabilize concentrations at 500 ppmv by the end of the twenty-first century. This is in contrast to the emissions stabilization scenario where concentrations continue to rise into the twenty-second century.[8]

The alternative concentration profiles have implications for temperature change. Emissions stabilization results in lower atmospheric concentrations prior to 2100. Hence, it is apt to produce slightly less temperature change during the next century. Over the longer-term, however, the scenarios which succeed in stabilizing concentrations are likely to be more effective in limiting temperature change.

4. The Economic Costs of Holding Concentrations to 500 ppmv

Next, we turn to the economics of holding emissions to 500 ppmv in 2100.[9] Two models are used to quantify economic losses: Global 2100 and the Edmonds-Reilly-Barns Model (ERB). For a description of the latter, see Edmonds and Barns (1993). The models are alike in a number of respects. They are both long-term energy-economy models. They both provide relatively detailed representations of the energy system. And they both evaluate the losses from a carbon constraint through the impacts on the price of energy.

The models differ, however, in a number of important ways. ERB is a recursive rather than an intertemporal optimization model. It employs a so-called "putty-putty" rather than a "putty-clay" approach to the vintaging of capital stocks. And it provides more regional disaggregation -- nine versus five regions. (For a detailed model comparison, see Energy Modeling Forum, 1993).

The two models were chosen, more because of their differences, than their similarities. The application of alternative approaches can provide valuable insights into the robustness of a set of the results.

For the present analysis, the models were calibrated to the same emissions baseline. Independent cost analyses were then conducted to identify the least-cost strategy. From Figure 5, we see that the results are quite similar. Costs are evaluated through 2100 and presented as a percentage of gross world product. Stabilizing emissions at 1990 levels is by far the most costly strategy. Shifting the emission reductions into the outer years reduces costs by as much as fifty percent.

There are several reasons why a less restrictive near-term emissions path may turn out to be less expensive. First, the shift to a less carbon intensive economy cannot happen overnight.

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8 The principal conclusions of our paper turn out to be independent of the choice of carbon cycle model. We performed the same exercise with the model of Wigley (1993) using a balanced carbon cycle model with feedbacks and the IS92a land-use emissions trajectory. While the atmospheric concentrations associated with stable 1990 fossil fuel carbon emissions are somewhat lower, 461 ppmv in 2100, cases 500a and 500b stabilize concentrations at 462 and 463 ppmv, respectively. Thus, the characteristic relationship between the time path of emissions and atmospheric concentrations holds.

9 Nordhaus (1979) was the first to couple a carbon cycle model and an energy-economy model in order to explore cost-effective strategies for stabilizing atmospheric concentrations.

The time scale for large-scale deployment of new supply technologies is typically measured in decades. Widespread adoption of highly-efficient end-use technologies also takes time. Energy efficient systems are often embedded in long lived durable goods (autos, housing, equipment, structures), and these will not be replaced instantaneously. The process can be accelerated, but at a cost.

Secondly, there is apt to be a shortage of low-cost substitutes during the early decades of the 21st century. There are constraints on the rate at which new supply and end-use technologies can enter the marketplace. Having more time to manage the transition away from fossil fuels will be worth a great deal. We can emit more in the early years when the marginal cost of emissions abatement is high. The "pay back" can come in later years when low-cost technological alternatives are more plentiful.

Finally, scenarios 500a and 500b are less expensive because of the time value of money. With a positive discount rate, a dollar in the future is worth less than a dollar today. Even if the cost of reducing a ton of carbon were the same in all years, we would still prefer to make the expenditures later on. Doing so will result in a lower discounted present value.[10]

5. The Economic Costs of Stabilizing Concentrations at Alternative Levels

The focus thus far has been on holding concentrations to 500 ppmv. As noted earlier, our selection of a particular target was arbitrary. The goal was to explore the sensitivity of compliance costs to the choice of emissions trajectory. Costs are also a function of the target itself. To explore the nature of this relationship, we examine the costs of holding concentrations at alternative levels. For each target, we have attempted to identify an emissions path close to the least-cost solution. That is, we have selected paths which provide the greatest degree of near-term flexibility.

Figure 6 shows emission trajectories for stabilizing concentrations at 400, 450 and 500 ppmv. Figure 7 presents the corresponding time profiles for atmospheric concentrations. In the case of the most stringent target, there is little alternative but to reduce near-term emissions. In 1990, concentrations were already at 353 ppmv. Limiting concentrations to 400 ppmv will require an early and rapid departure from the business-as-usual trajectory.

As the concentrations limit is relaxed, we gain in degrees of freedom. Stabilizing concentrations at 450 ppmv allows for some growth in near-term emissions. Stabilization at 500 ppmv allows for more growth still.

Figure 8 shows abatement costs for the alternative targets. The figure highlights the importance of flexibility in the early years. This is when the marginal cost of emissions abatement is likely to be highest. Concentration targets requiring sharp reductions in near-term emissions will be particularly costly.[11]

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10 It is important to distinguish between the rate of time preference and the marginal productivity of capital. The above discussion relates to the latter. We have assumed a net real rate of return on capital of 5% per year. For purposes of illustration, suppose that it costs $100 to remove a ton of carbon -- regardless of the year in which the reduction occurs. If we were to remove a ton today, it would cost $100. Alternatively, we could invest $25 today to have the resources to remove a ton of carbon in 2020. Hence, if the focus is on the cumulative total rather than year-by-year emissions, we will prefer strategies which shift reductions into the outer years.

11 The explanation for why the two cost estimates differ so markedly for the 400 ppmv case is staighforward. Unlike ERB, Global 2100 keeps track of the economic lifetime of the existing capital stock. As a result, its price responsiveness is lower in the short run than over the long run.

6. Final Comments

The economic costs of stabilizing concentrations will depend upon both the target and the manner in which the target is achieved. Under the terms of the U.N. Framework Convention on Climate Change, implementation costs are not a principal consideration in the choice of a concentrations limit. The decision is to be based on a scientific assessment of what constitutes "dangerous anthropogenic interference with the climate system." Nevertheless, international negotiators would do well to recognize the nonlinear relationship between concentration levels and implementation costs. The perceived price tag will undoubtedly influence the willingness of nations to abide by the treaty.

One way to increase political acceptability is to ensure that benefits are attained at the lowest possible cost. A particular target can be achieved in a variety of ways. The analysis has shown that the emissions time-path may be as important as the target itself in determining economic losses. Rather than choosing arbitrary emission trajectories, more attention needs to be devoted to identifying those paths that minimize the costs of achieving a particular target.

The analysis also points to the importance of research and development. Currently, more than ninety percent of the world's commercial energy is derived from fossil fuels. The transition to a low-carbon economy will likely involve significant costs, but there are steps we can take to reduce the size of the ultimate bill. The key will be timing. Time is needed both for an economical turn over of the existing capital stock and to develop ample supplies of low-cost substitutes.

There are a number of promising carbon-free options -- both on the supply and demand sides of the energy sector. New technologies, however, take many years for market penetration. A sustained research effort is needed to clarify their potential role and to ensure that cost-effective options are available to the greatest extent possible.

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Figure 1. Global Carbon Emissions

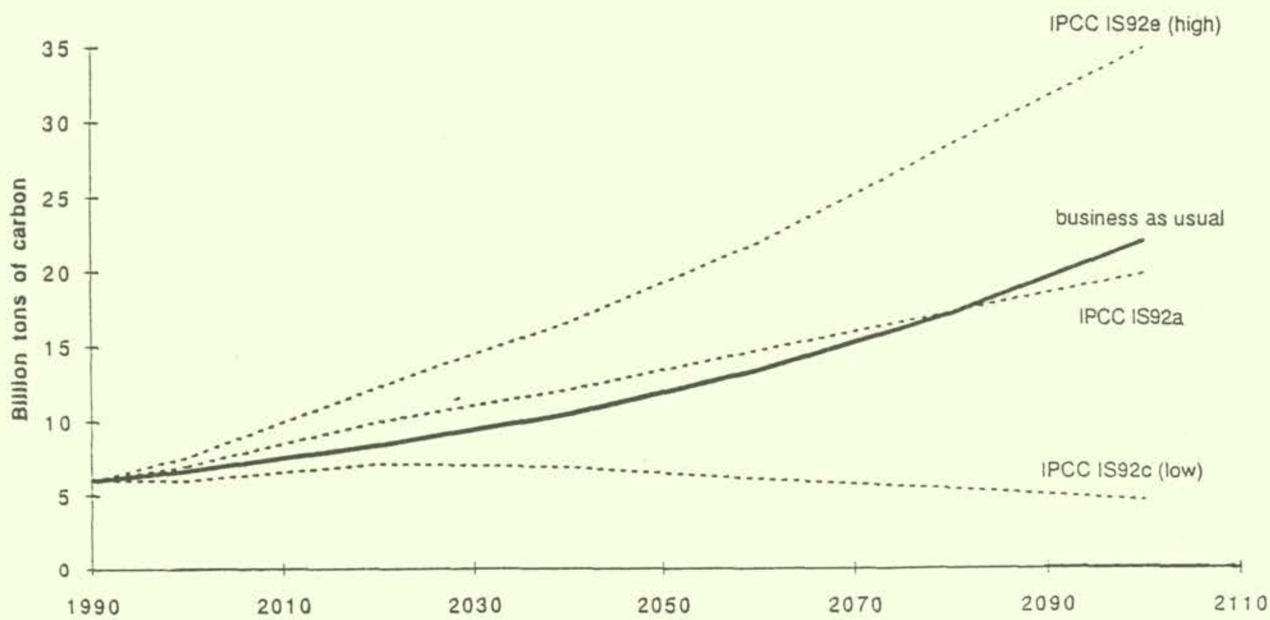


Figure 2. Atmospheric CO2 Concentrations
– business as usual and emissions stabilization

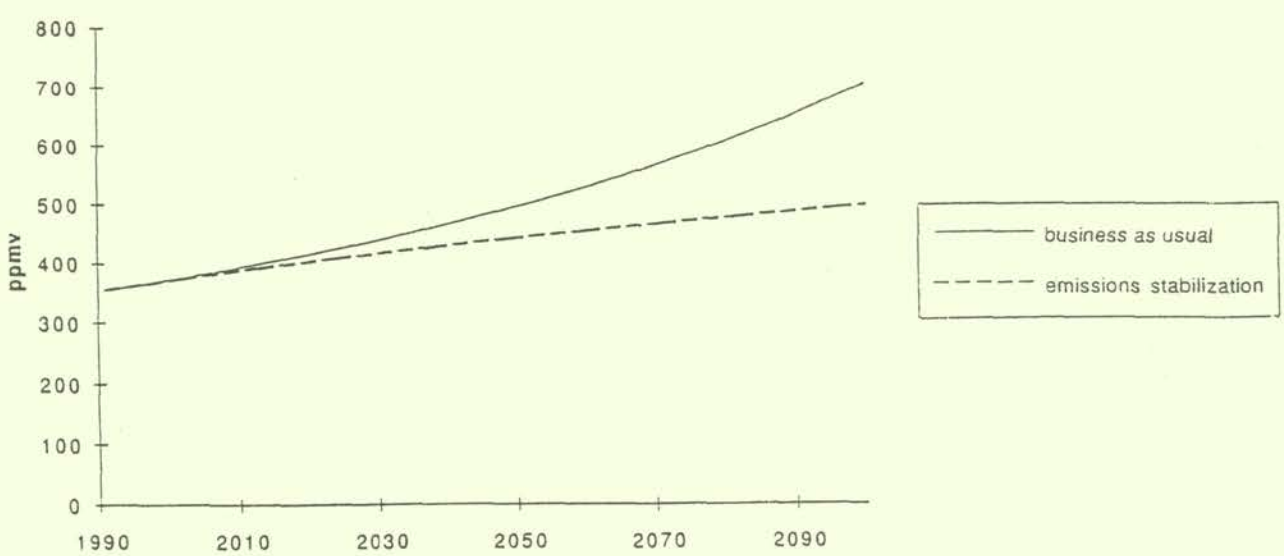


Figure 3. Global Carbon Emissions

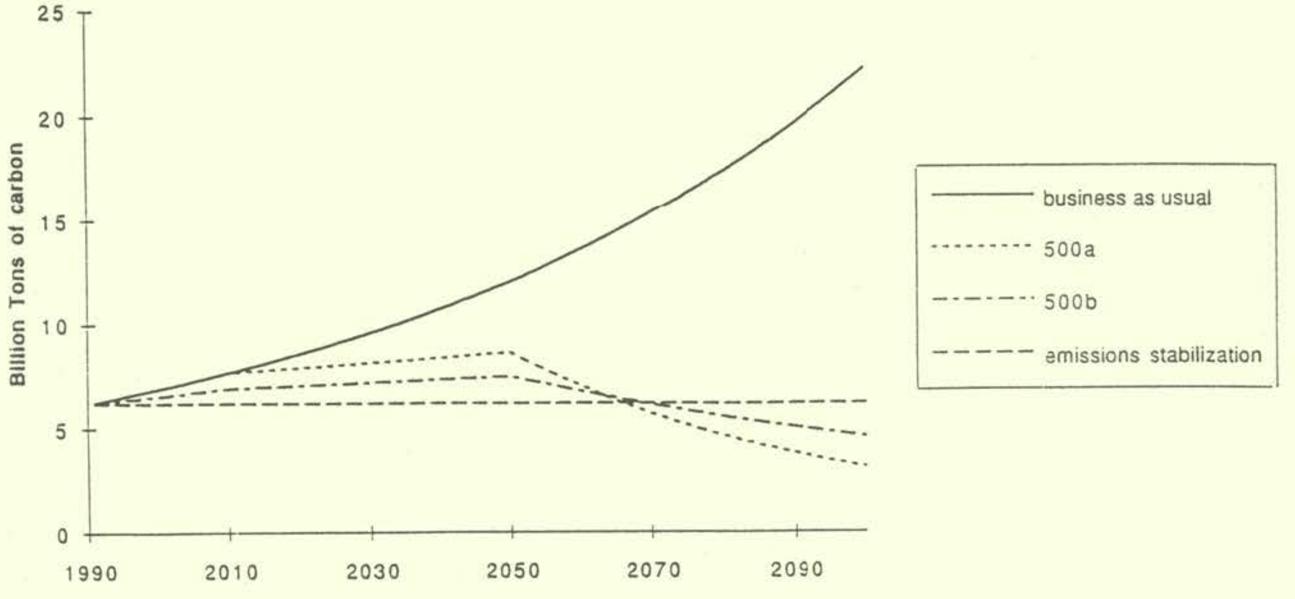


Figure 4. Atmospheric CO2 Concentrations

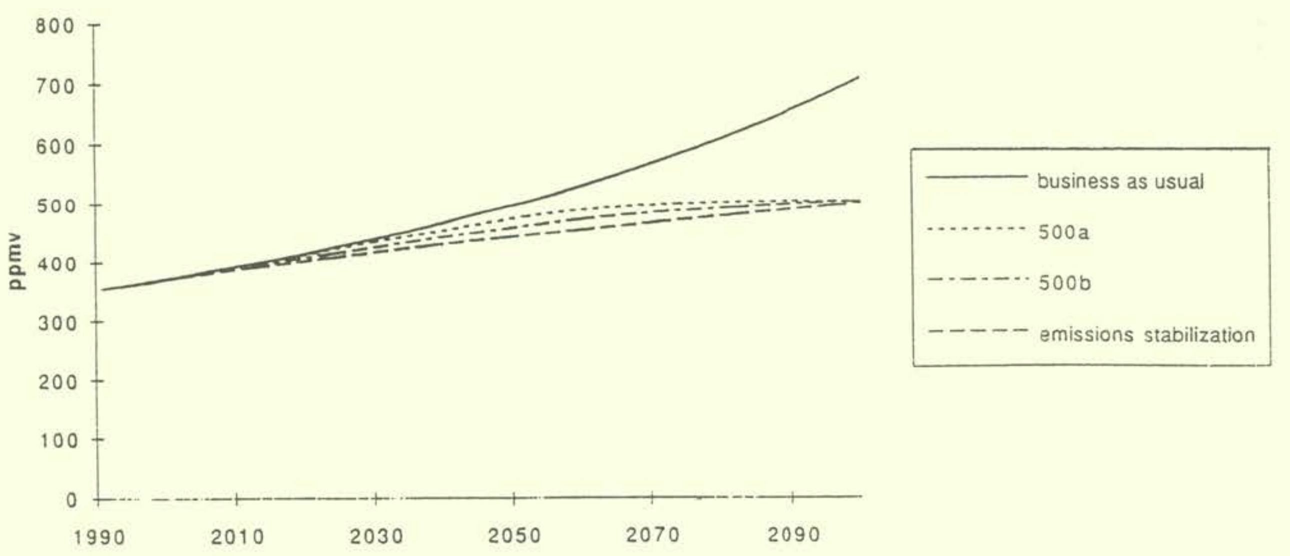


Figure 5. **Costs of Stabilizing** Atmospheric CO2 Concentrations at 500 ppmv **by 2100**

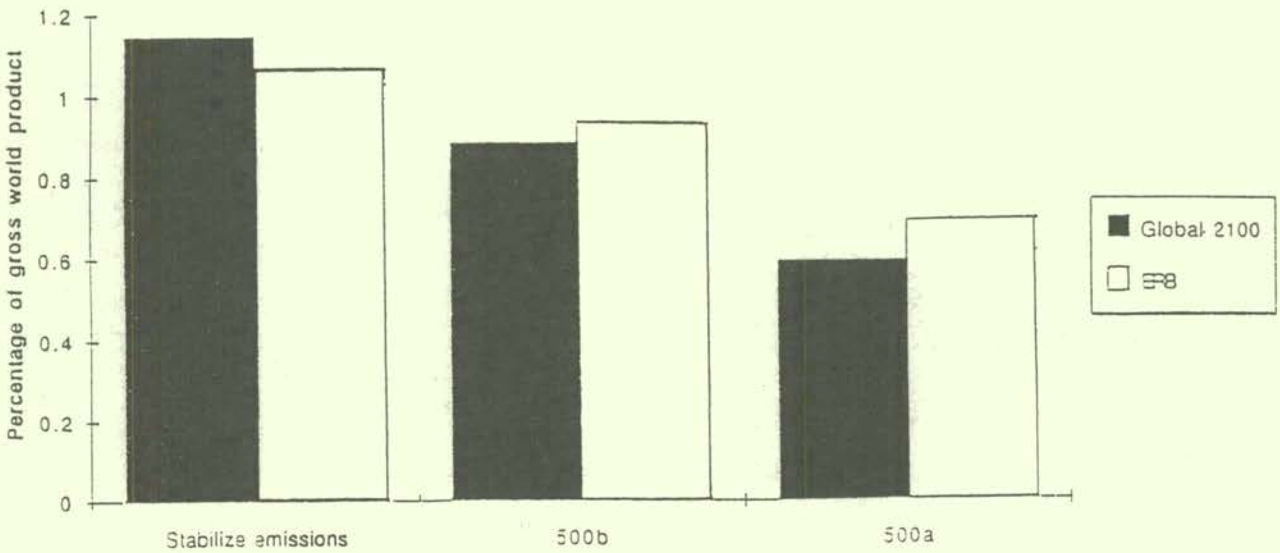


Figure 6. **Global Carbon** Emissions **Associated with Alternative** Concentration **Levels**

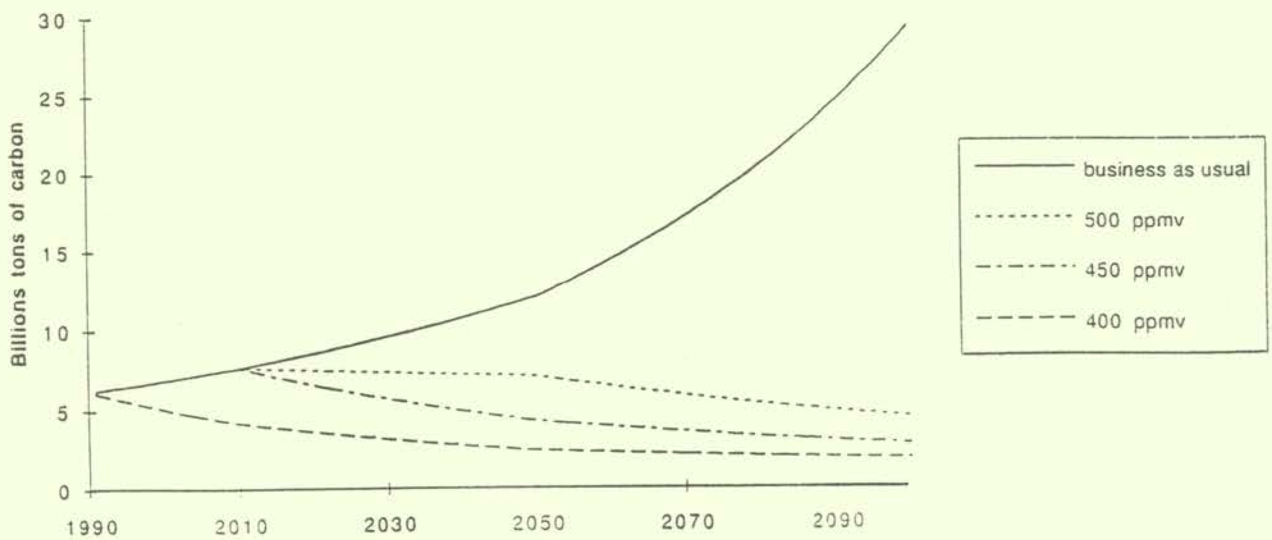


Figure 7. Alternative Concentration Levels

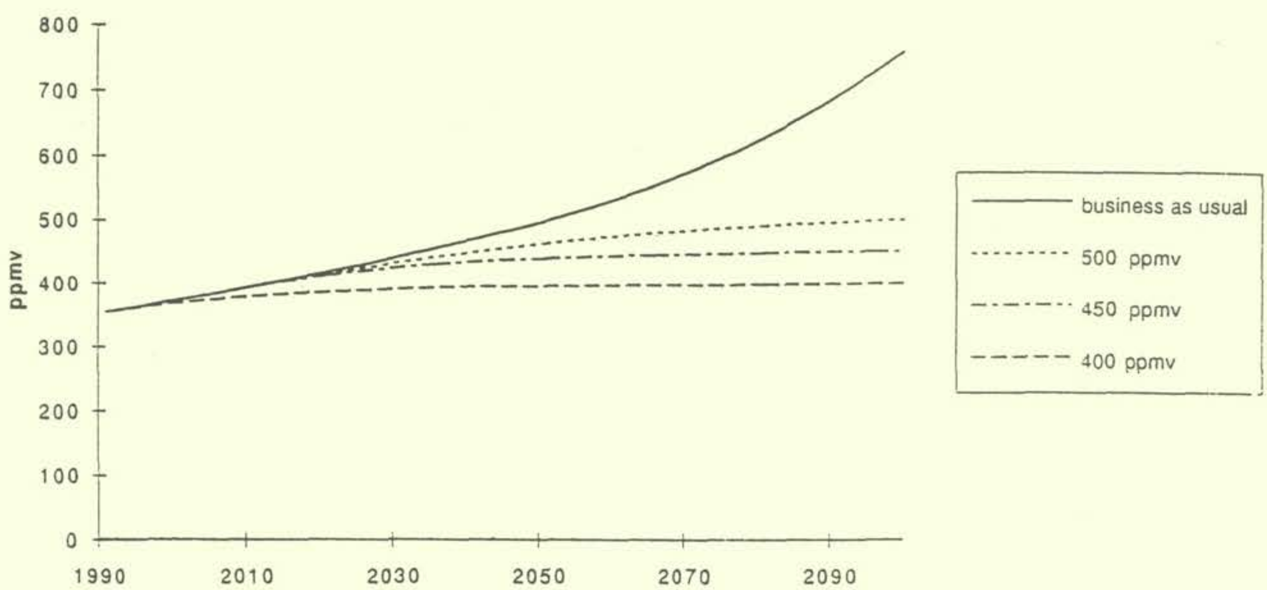
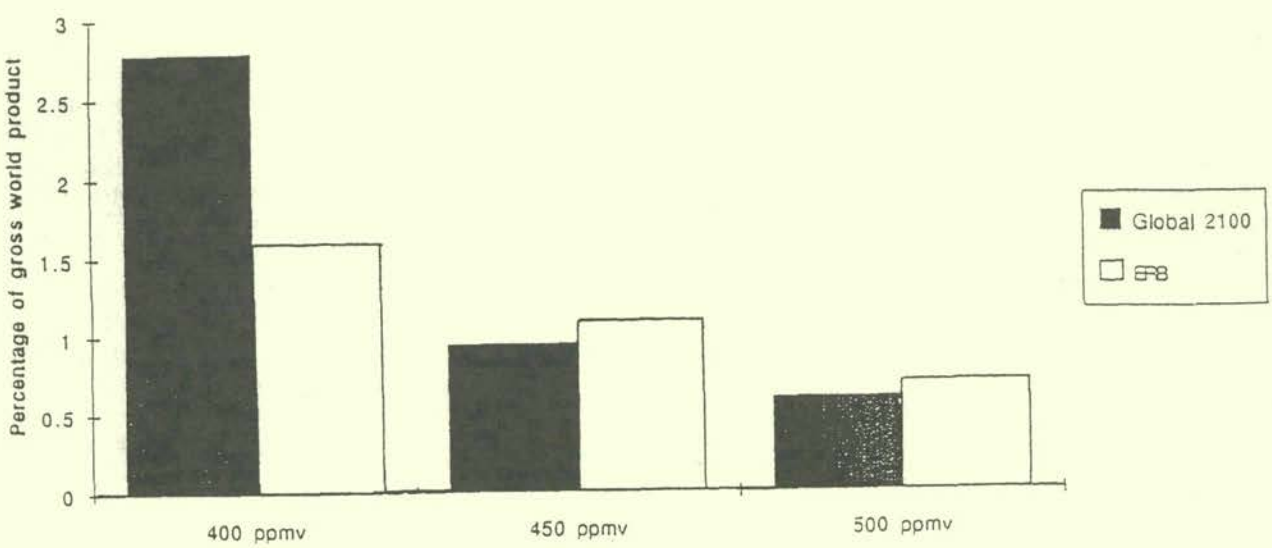


Figure 8. Costs of Stabilizing Atmospheric CO2 Concentration at Alternative Levels



Discussant's Comments

Irving Mintzer
University of Maryland

Two excellent papers were presented in this session. These papers provoke me to raise potentially painful questions concerning the system boundaries and the initial conditions that are assumed for their analysis.

Prof.Barrett's paper on Climate Change and Trade raises a number of interesting questions. Barrett's paper suggests that we are addressing a purely technical or scientific question. It implies that we start from a situation in which the global economy is in equilibrium and that current price levels are set to achieve maximum economic efficiency. This leads him to see substantial risks in the prospect that policy responses to the risks of rapid climate change will cause significant distortions to the current equilibrium and will thus reduce global GNP. Barrett also implies that we must be seriously concerned with the prospect that developing countries might take a "free ride" on the good faith efforts of industrial countries to reduce future emissions of greenhouse gases. Unfortunately for his analysis, none of these conditions exist today.

Starting first with the last issue, I note that the free-rider effect did not commence with current promises by the OECD to make emissions reductions in the future. In my view, the problem became important one hundred or more years ago when currently industrialized countries "funded" their own development through the profligate use of cheap fuels with little attention to environmental protection--either at the local or the global level. The appropriate question therefore is not how can we keep developing countries from free-riding on the current efforts of OECD to reduce the risks of rapid climate change. The "real" question is how can those of us in the OECD pay back our "natural debt", the debt that accumulated over the last century from dumping carbon dioxide and other pollutants freely into the atmosphere that we share with the developing countries of the South.

I want to turn now to the question of system boundaries and initial conditions. Prof. Barrett's discussion suggests that one can treat the climate change issue as a question of emissions reductions, in isolation from the other aspects of the North-South relationship, specifically isolated from the consideration of the responsibilities that were taken on by the North in the Framework Convention to support sustainable development. In the context of the on-going negotiations under the INC, I believe that this assumption is incorrect and distorting of the overall analysis. Where Barrett assumes that the global economy is now in equilibrium and the analysis of such issues as leakage and free-rider effects should begin from the present forward. I would argue, as suggested above, that the initial conditions for analysis of the free-rider effect should not begin with the initiation of the INC but with the initiation of uncontrolled dumping of the products of fossil fuel combustion into the atmosphere at the onset of the Industrial Revolution.

Specifically on the subject of leakage, Barrett implies that leakage of emissions from North to South due to transfer of technology is a serious problem. This, I believe, is not necessarily the case. If, for example, the leakage results from the transfer of advanced, highly efficient manufacturing technology to the South and a corresponding shift of market shares for energy-intensive production, the transfer may result in providing strong support for the economic development goals of the receiving country. In addition, the use of the new technology to support domestic development might reduce overall emissions relative to what would have occurred in the absence of this transfer of technology. Even if this means, for example, a decline in the U.S. steel industry in favor of new steel-making facilities in Mexico, it might be beneficial for both countries and for the global atmosphere.

Dr. Anwar Shah has offered a very provocative analysis of the potential importance of carbon taxes in developing countries. To the extent that Dr. Shah argues that imposition of this tax will enhance the development objectives of the Third World country, these taxes make sense. To the extent that some have argued that such taxes are necessary to protect the planet while preserving historical patterns of excessive consumption in the North, they are very hard to justify.

Dr. Shah notes that domestic carbon taxes represent a flexible, reversible tool and a low-cost alternatives to burdensome regulatory structures. He notes that they are more practical than a BTU tax and have the potential of being eminently reversible. These arguments are persuasive in support of a modest tax in the developing countries.

Dr. Shah proceeds to evaluate the effects of a carbon tax where the proceeds are returned to citizens as a credit, either against the individual income tax or against the corporate income tax, divided between taxes paid on capital and taxes paid on final consumption. He also tests the effects of dividing the credits between taxes paid on income and taxes paid on final consumption. He concludes from this comparison that low carbon taxes make sense, if the taxes are revenue neutral.

This is an interesting conclusion. Its power and robustness might be strengthened by doing one more sensitivity test. This additional simulation might well test the effects of a revenue-neutral measure in which the tax was rebated for purchases and investments that increase energy efficiency or stimulate the introduction of advanced, low-emissions technologies. In any event, Dr. Shah has opened a valuable debate on the domestic benefits of a carbon tax in many developing countries.

Discussant's Comments

Stefan P. Schleicher
University of Graz

The first half

Both papers deserve special attention since they contain valuable material for a better insight into the highly complex discussion about the impact of climate change related tax policies on international trade.

Scott Barret approaches the topic of "free riding" and "leakage" from a theoretical point of view which is complemented by an interpretation of some simulation results from the OECD GREEN-Model and a survey of carbon-related taxes in Scandinavian countries. As a reference for comparing various modes of behavior of the trading partners the hypothetical case of a single country or region is assumed which chooses to reduce emissions unilaterally. It is assumed that under the aspect of cost minimization this will lead to a policy under autarky which equals own marginal damage with own marginal abatement costs. For reasons which we want to motivate in the context of the second paper I want to suggest a different reference case. I also want to add to the agenda of suggested research that at least three categories of traded commodities should be distinguished because of their different reaction toward tax policies: primary energy, commodities with a high and commodities with a low energy content.

Anwar Shah and Bjorn Larsen provide ample empirical material about the prevailing differences in energy prices both in industrialized and developing countries. The authors' conclusion that worldwide energy subsidies amount to an equivalent of US$40 per ton of carbon deserves special attention. The removal of these subsidies could translate into a 21% reduction in carbon emissions in the subsidizing countries and a more than 9% reduction of global carbon emissions. Japanese standards of energy efficiency applied on a world wide level would lead to an almost 70% reduction of global carbon emissions. The authors also emphasize the significant additional benefits of carbon taxes for developing countries: reduction of other pollutants and a source of revenues. In general the authors emphasize carbon taxes on national interest considerations.

A common problem shared in these two papers is the issue of a "right" reference price for energy from which current prices and distortions caused by various policy regimes could be evaluated. We want to put forward the hypothesis that current prices or criteria of optimally based on current prices - as cost minimization - might be very misleading. At least three arguments support this point of view. Firstly, the current prices do not yet reflect welfare criteria which may become very relevant for the problem to be analyzed. Emission limits, e.g., most probably are not yet reflected in the information set which generated the current price system. Secondly, especially prices for energy reflect to a large extent market imperfections caused by asymmetric information and market power. Thirdly, we certainly have no markets which attempt to reflect the expectations about supply and demand conditions decades ahead from now.

We, therefore, would like to sketch the following methodological approach. Neoclassical theory of allocation suggests that the efficient allocation can be obtained either in terms of prices (for given demand and supply relationships with implicit information about factor endowments, technologies and welfare targets) or in terms of quantities (for explicit factor endowments, technologies and welfare criteria). Instead of using currently observed price relationships for supply and demand we suggest to use for longrun considerations the quantity relations which in turn determine the incentive compatible price system.

This suggestion can be made operational as follows. The longrun goal of our analysis is obviously the achievement of a required amount of energy services with a specified emission target. Energy and capital can be widely substituted for a given level of energy services. Then the specified emission level determines the efficient energy-capital ratio. The lower the accepted emission level, the higher the amount of capital required to provide the energy services. Thus the exogenously specified emission level not only determines the energy-capital ratio but also the marginal rate of substitution between energy and capital. This rate of substitution in turn determines the relative prices between energy and capital under competitive conditions. This procedure enables, therefore, not only to select the technology which is compatible with the desired emission target but also to obtain those prices which are incentive compatible with the desired emission target under competitive market conditions. These prices could be termed efficient prices and serve as a reference for the various policy analyses.

The second half

All three papers presented in this session provide a comprehensive coverage of modeling efforts to investigate the potential of tax policy as an instrument to meet policy targets which may be more than one hundred years ahead from now. The common tool applied are computable general equilibrium models although the various model designs differ significantly. All of these models deserve credit for their tremendous efforts to tackle a policy problem with a time horizon which has been unknown to economic policy analysis so far.

The overall picture which emerges from reading these papers is put into three questions which are supposed to stimulate the discussion about what have we achieved with this modeling exercises so far and into which direction shall we put our further research efforts.

(1) Is there a need to improve the measurements needed both to evaluate the energy intensity of economic activity and the relationship to economic welfare?

Energy intensities and corresponding emission intensities are related to GDP in US Dollars in the publications referred to. A number of caveats should be mentioned before this measures are used for international comparisons. Firstly, it is energy services, like square meters of heated space, passenger-kilometers or ton-kilometers, which are really relevant from a welfare point of view. Secondly, the conversion of domestic GDP figures into a common currency may not reflect the purchasing power parity. Thirdly, GDP itself is increasingly questioned when used uncritically as a measure of economic welfare. It might be highly desirable, therefore, to come up with a new generation of measurement concepts which evaluate energy flows and emissions in relation to energy services. In addition for a decision analysis spanning many decades we need a better welfare measure than GDP. Increased energy efficiency, for example, which provides the same energy services with lower energy flows leads to a decrease in GDP. This may lead to a misinterpretation of the policy effect when GDP is used uncritically as an indicator for economic welfare.

(2) How relevant are current prices to evaluate over many decades various policy proposals?

This answer can't be decouple from an evaluation of the current price system with respect to its optimality or efficiency properties. If current prices meet these efficiency criteria already there is not much justification left for "distorting" them by imposed taxes. If the current prices are not considered to meet the desired efficiency criteria these prices are rather irrelevant for evaluating various policy options. Increasing costs as a consequence of tax hikes then only mean that the new prices reflect better the whole costs then the previous deficient price system. Closely linked to the relevance of observed prices is the issue to what extent can econometrically estimated price elasticities or elasticities of substitution serve as inputs for models which in turn are used for a policy horizon comprising a multiple of the sample period. A more relevant approach might be to rely more on technical information, the corresponding technical rates of substitution between factors of production and the consequences for a price system which is incentive compatible with these technological parameters.

(3) Are there still important missing links in the current generation of models?

Many models are still treating crucial technological parameters like energy efficiency or energy productivity as exogenous. These parameters determine, however, most of the simulation results. In two ways models with mainly exogenously determined technology might lead to misleading results. Firstly, all simulation results - above all a simulated tax policy - are extremely sensitive with respect to these parameters. Secondly, attempts to endogenous technological change as a consequence of incentives provided by prices and institutional regulations indicate that this redesign of the capital stock stimulates at least temporarily economic activity. Models which lack these explicit technological links are heavily biased, therefore, towards depressive effects caused by higher energy prices while a more complete specification might lead to a reverse result.

Rapporteur's Summary

Sally Thorpe
Australian Bureau of Agricultural and Resource Economics

The first half

Prof. Barrett (Main Presenter) posed the question whether in principle, if not in fact, trade measures should be considered as greenhouse policy instruments. He argued that trade measures, such as import tariffs on carbon intensive goods, may be justified to reduce positive emission leakage in countries which are otherwise free riders. Free riding occurs when countries benefit from abatement made by other countries without ever sharing the abatement costs. Leakage occurs when a greenhouse policy to reduce emissions in one or more countries increases emissions in other countries. Under a unilateral carbon tax domestic carbon intensive goods become less competitive with substitute imports in the absence of an import tariff. He also noted that the evidence of the potential positive leakage problem is strongly dependent on the simulation model used. He argued that positive leakage concerns are reflected in the conditional targets set by some countries.

Dr. Shah (Main Presenter) argued that a global carbon tax raises significant problems in compliance, tax administration and in its revenue redistribution consequences and is therefore unlikely to be feasible given the uncertainty regarding global warming. However, he noted that a domestic carbon tax has several desirable features. The revenue potential of carbon taxes is very large (even for a relatively small domestic tax). While the incidence of a domestic carbon tax in developing countries depends on a range of institutional factors in addition to the welfare measure used it may be progressive. If a US$10 domestic carbon tax is imposed in his model provided the tax revenue is used to reduce corporate income tax, this increases real GDP in most countries. If one adds to this the benefits from reducing local pollution (such as to health) then there are simulated net benefits in all countries from domestic carbon taxation except under a low health impact scenario.

Prof. Schleicher (Discussant) argued that optimal policy to meet a particular target required equalising the marginal rate of substitution between energy and capital in all applications. Compensatory measures would be needed to deal with the equity consequences of this efficiency criterion.

Dr. Mintzer (Discussant) argued that policy choices should focus on FCCC objectives and in particular, the long term goal of stabilising the atmospheric concentration of greenhouse gases as well as ensuring sustainable and equitable development. He noted that some leakage may be negative and that policies which make long term economic sense must also be designed to be acceptable given the short political terms of governments. He emphasised the importance of having mutually reinforcing policy measures. For example, tax revenue could be used to rebate energy efficiency improvements, provide investment credits for accelerated scrapping, or subsidise new technologies. Given the problems associated with a global carbon tax joint implementation could be considered. He also asked about the measurement of health benefits and was told that the results for the low health benefits scenario reflected a conservative lower bound on health gains.

Prof. Jorgenson noted that given the problems with a global carbon tax Dr. Shah identified, an international tradable permit scheme could be used to harmonise global emission reductions. This could be integrated with the domestic tax proposals Dr. Shah described.

Dr. Dean was, however, unsurprised that marginal leakage rates for unilateral carbon tax initiatives differed little with respect to assumptions about exemptions. He was concerned that distorting tariffs be used to reduce leakage arising from lack of international agreement. Prof. Barrett responded that trade policy was justified to reduce leakage where free riding would otherwise exist.

Prof. Read said that under optional greenhouse policy the rate of absorption subsidy would exceed the rate of emission tax and also suggested that equity be measured using per capita income.

A conference participant noted how trade measures figured in the Montreal Protocol and asked how tariffs on carbon intensive products would be measured. Prof. Barrett responded that Hoel has shown how to do this rather complicated calculation.

Prof. Amano suggested that technology transfer could be used to reduce leakage.

The second half

Dr. Dean (Main Presenter) cited econometric work by Hoeller and Coppel which shows that carbon emission intensity is negatively correlated with the relative price of carbon-based energy. Fitted values for fossil fuel prices were decomposed into world price, energy tax and residual components. This, he argued, showed that carbon taxation would be relatively more costly in countries which already have large energy taxes. Results from the OECD Model Comparison project were cited. In particular, the cost of emission reductions rise sharply with the intensity of emission reductions, and control costs toward the end of the model horizon are very sensitive to assumptions regarding the commercial viability of available backstop technologies. Differences between models in their business-as-usual projections is a key explanator of differences in control cost estimates. The results from GREEN also highlight the large potential savings in control costs from a least cost policy such as an international tradable permit scheme or global carbon tax. He further noted that the way backstops had been modelled in GREEN meant that there were few cost efficiency gains to be exploited in the later part of the simulation period.

Prof. Jorgenson (Main Presenter) concluded that carbon taxes are an important potential source of revenue that can be used to reduce distortionary taxes elsewhere as well as having desirable environmental impacts. For example, the Jorgenson-Wilcoxen model was used to show that GNP could actually increase if carbon tax revenue is used to reduce taxes on capital since the after tax rate of return on investment increases stimulating accelerated capital formation. Indeed three scenarios were discussed. The first involved redistributing carbon tax revenue as a lump sum rebate to households; in the second it was used to lower taxes on labour such as social security taxes; and in the third to lower capital taxes. He stressed that a carbon tax provides an opportunity for significant tax reform and noted that it could have widely varying effects across households, but that it was not clear it would be significantly regressive. He noted that, for example, reductions in labour taxation would increase household welfare while reductions in capital tax could increase some households welfare but reduce others. GNP was not an appropriate welfare measure and he referred participants to one of his studies on the welfare effects of carbon taxes in the Brookings Papers on Economic Activity.

Dr. Edmonds (Main Presenter) focused on the timing and magnitude of emission reductions for the costs of GHG control using Global 2100 and the Edmonds-Reilly-Barns models. Shifting emission reductions to the future significantly reduces control costs because of discounting and the availability of lower cost less carbon-based technologies in the future. That is, there are significant gains from waiting to reduce GHG emissions. Rather than choosing arbitrary emission paths, more attention needs to be devoted to identifying those paths that minimise the costs of achieving a particular target such as stabilisation of atmospheric concentrations of greenhouse gases. Gains from waiting include the opportunity to develop new cost effective energy technologies.

Prof. Schleicher (Discussant) questioned the Hoeller and Coppel econometric research discussed by Dr. Dean suggesting that rather than focus on the carbon intensity of GDP the carbon intensity of energy service tasks was more important. He questioned the relevance of GDP as a welfare measure over a one hundred year period. He questioned the relevance of current price relationships for fossil fuels in determining long term future costs of GHG mitigation and the reliability of current price elasticities for such an analysis. He asked how do relative prices determine the capital stock in these models. He was optimistic about the current availability of cost effective substitutes for carbon-based energy forms and disagreed with the practice of discounting revenue and cost streams.

Dr. Dean responded by saying that the past is the best guide to the future. For example, price elasticities were estimated over the period including the major oil price hikes, but accepted the need for sensitivity testing of model results. OECD GREEN makes technological change exogenous, but relative prices are a vital determinant of the capital stock in GREEN. He emphasised the role of carbon taxes in stimulating technology innovation.

A conference participant wondered how recent information on the role of backstop technologies was being incorporated in GREEN. Dr. Dean commented that energy technologists' data is the basis for the description of backstops in GREEN and that he would incorporate any reliable up-to-date information provided.

Another conference participant questioned the meaning of the residual wedge in the Hoeller and Coppel model.

Other participants wanted to know how renewable, and specifically photovoltaics, featured in the models discussed. Dr. Edmonds specifically responded that they appear as a generic backstop technology. He also noted that technological change was exogenous in his model and that he had not yet experimented with a negative AEEI which Prof. Jorgenson found evidence of in the United States.

Another conference participant questioned the competitive markets assumption in many models used.

Another conference delegate wondered if any external benefits from carbon taxes had been incorporated in Prof. Jorgenson's analysis such as from reductions in local pollution. These were not incorporated. He also queried if reductions in labour taxes had been considered for redistributing carbon tax revenue and found this to be so.

Prof. Amano wanted the issue of optimal R&D expenditure to be separately analysed in Dr. Edmonds' research in order to delineate the gains from waiting to reduce GHG emissions. He also queried if the benefits from avoiding damage had been incorporated in the analysis to find that they were not. He also wanted to see the international distribution of the costs of emission reductions in Dr. Edmonds' work. These results were not at hand but Dr. Edmonds agreed that they were important results to consider.

Dr. Edmonds noted that learning-by-doing impacts on the rate of technology diffusion could be incorporated in his modelling.

Dr. Dean's response to the discussants' queries were reiterated by Prof. Jorgenson. Prof. Jorgenson also noted that the welfare equivalent lifetime consumption path needed to be compared with and without policy to determine a summary measure of welfare gain, and that discounting was used in deriving this measure.

2. Subsidies & Financial Incentives

INCENTIVES TO ENVIRONMENTAL INNOVATIONS[1]

Stefan P. Schleicher
University of Graz

Abstract : The need for environmental innovations is strongly motivated by the potential threat of irreversible damages caused by currently used technologies. This is probably the most important consensus emerging from research about sustainable economic development, the innovative goal for economic development formulated by the World Commission for Economic Development (WCED, 1987).

A crucial role in this redesign of our economies has to be attributed to the energy system since the majority of environmental damages is caused by activities related to the inadequate use of energy. Therefore, this paper focuses in particular on the potential and the incentives for innovations related to the use of energy.

We link our presentation of technical innovation to the emerging theory of endogenous growth. Traditionally, and in the modeling of energy in particular, technical change has been treated mainly as an exogenous phenomenon. Almost all energy models make generous use of assumptions about exogenous increases in energy efficiency and energy productivity.

In contrast to this widely used practice we follow a different approach for our presentation of the innovation problem. We start with a discussion and description of the technical relations and technical options of an energy system. We then present the microeconomic perspectives which guide the choice of these technologies. Finally we incorporate these findings into the framework of a macroeconomic analysis.

"... the future of energy is much more
a matter of choice than of prediction."
Goldemberg et al., 1988.

1. Introduction

The need for environmental innovations is strongly motivated by the potential threat of irreversible damages caused by currently used technologies. This is probably the most important consensus emerging from research about sustainable economic development, the innovative goal for economic development formulated by the World Commission for Economic Development (WCED, 1987).

Two major lines of required technical changes seem to be fairly obvious:

- A general reduction of the material flows without necessarily reducing the welfare relevant services which are generated by these material flows. This implies a switch to technologies with a higher mass efficiency, with cascading or recycling capabilities and with an increased service productivity.
- A reduction of the use of exhaustible resources, in particular fossil energy resources, and an increase of the use of renewable resources mainly based on the ample availability of solar energy. This implies obviously a major redesign of our energy systems which still require about four quarters of primary energy inputs as fossil fuels.

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1 JEL Classification
O33 Technological Change: Choices and Consequences
Q43 Energy and the Macroeconomy
Keyword
Endogenous Technical Progress
CO_2 Reduction Policies
Energy Taxes

A crucial role in this redesign of our economies has to be attributed to the energy system since the majority of environmental damages is caused by activities related to the inadequate use of energy. Therefore, this paper focuses in particular on the potential and the incentives for innovations related to the use of energy.

We link our presentation of technical innovation to the emerging theory of endogenous growth. Traditionally, and in the modeling of energy in particular, technical change has been treated mainly as an exogenous phenomenon. Almost all energy models make generous use of assumptions about exogenous increases in energy efficiency and energy productivity.

In contrast to this widely used practice we follow a different approach for our presentation of the innovation problem. We start with a discussion and description of the technical relations and technical options of an energy system. We then present the microeconomic perspectives which guide the choice of these technologies. Finally we incorporate these findings into the framework of a macroeconomic analysis.

2. The Technical Perspective of Energy Systems

2.1 A View on Crucial Energy Technologies

A quick view on some indicators of the Austrian energy system which is fairly representative for most countries of Western Europe reveals which energy technologies require the highest priority for innovation:

- A quarter of the energy which enters the energy system is lost in transformation processes, above all in the conversion to electricity in thermal plants.

- About 40% of end-use energy is employed for low temperature heating services, like space heating. This energy requirement is almost completely supplied by energy of highest energy quality, namely fossil fuels and electricity.

- About one quarter of end-use energy is needed for transport with energy efficiencies of passenger cars on the average below 25%.

These obvious leaks in the energy system can be improved by a number of available technologies:

- The cogeneration of heat and electricity increases the combined fuel efficiency to more then 90%. If in addition a heat pump is added to the system the additional available ambient heat lifts the fuel efficiency to 130%.

- The current average fleet fuel consumption for passenger cars in Europe is around 10 litters per 100 km. A new generation of middle class cars reduces the fuel consumption significantly below 5 litters per 100 km. All major manufacturers have developed prototype models which again cut this number by half.

- Because of the high share of energy consumption for space heating the thermal structure of buildings deserves special attention. Empirical evidence for Austria indicates that in the cities about 160 kWh/m^2 per year of end-use energy are required for this purpose.. New buildings need on the average less than half of this amount and low energy houses need less than one third of the overall average.

These first findings of the obvious wide range of quality of installed energy equipment raises the question what determines the choice of technology and how can this choice be influenced.

2.2 From Energy Flows to Energy Services

A fundamental requirement for the analysis of the energy sector of an economy is a careful distinction between energy services and energy flows.

Energy enters an economy as primary energy E in the form of coal, crude oil, natural gas, uranium, hydro power and energy from biomass.

The transformation system converts primary energy to energy for final consumption or end-use energy F in the form of coal products, gas, oil products, electricity and heat. Conversion and distribution losses are an indicator of the efficiency of the transformation system.

The application system in households (appliances, cars) and industries (motors, heaters) converts end-use energy to useful energy U. Application losses are an indicator of the efficiency of the application system.

Primary energy, end-use energy and useful energy are energy flows usually measured in thermal equivalents like Joule, Oil Equivalents or Coal Equivalents. In Austria, for example, of 100 units primary energy only 72 are available as end-use energy and less than 40 serve as useful energy. The missing 60 energy units indicate the technical potential for improving the efficiency of the energy system.

Ultimate aim of an energy system is to provide energy services S. These may be thermal services, like providing a certain amount of heated space for residential use, mechanical services, like mobility in a transport system, or chemical services in the production of a chemical fiber. Distinguishing features of energy services are that, firstly, they cannot be measured as an energy flow and that, secondly, there is usually a wide range of substitution between capital, labor and useful energy to provide a required amount of energy services.

This distinction between energy flows and energy services leads to a number of important recommendations:

- The only relevant indicators to measure the contribution of the energy sector to economic wealth are energy services rather than energy flows. Energy flows, therefore, are no useful indicator of economic development.
- There is in most cases a wide range of substitution between energy flows, capital and labor to provide the amount of energy services needed.
- All measures of energy productivity should be based on energy services rather than energy flows.
- The mix of energy flows and other factors of production to provide energy services depends under competitive conditions on the relative prices of energy flows and the other factors.
- Energy statistics, however, do not yet reflect this distinction between energy flows and energy services. It is rather difficult to obtain data on useful energy and even more difficult to obtain information about energy services.

2.3 The Technological Relations of an Energy System

We introduce an analytical framework for the specification of the fundamental technological relationships between energy flows and energy services. The following notation is used:

S	energy services,
U	useful energy,
F	final consumption energy,
E	primary energy,
K	capital,
N	labor.

Energy services are composed of various types, like

St	thermal energy services,
Sm	mechanical energy services,
Sc	chemical energy services,
So	other energy services.

Useful energy Uj of type j (e.g. heat from a heat exchanger in a room) provides the energy services Si of type i (e.g.. keeping the room at a comfortable temperature). The volume of these services depends on the selected energy service technology Sij together with the amount of capital Ksi (e.g. thermal structure of a building), labor Nsi and useful energy Uj employed for these services:

(1) $$Si = Sij(Ksi, Nsi, Uj) .$$

Useful energy Uj of category j results from end-use energy Fk, of type k (e.g. heating oil). Again the volume of useful energy Uj depends on the selected energy application technology Ujk (e.g. burner and heater) together with the amount of capital Kaj, labor Naj and end-use energy Fk,

(2) $$Uj = Ujk(Kaj, Naj, Fk) .$$

The third technological relationship describes how final consumption energy (end-use energy) Fk of category k is obtained by transforming primary energy El of type l. Similarly the volume of final consumption energy Fk is determined by the selected transformation technology Fkl (e.g. a refinery), the amount of capital stock Ktk, labor Ntk and primary energy El:

(3) $$Fk= Fkl(Ktk, Ntk, El) .$$

A number of useful definitions follow from these basic technological relationships.
We define transformation efficiency et,*kl* by

(4a) $$e_{t,kl} = Fk / El \ ,$$

application efficiency ea,jk by

(4b) $$e_{a,jk} = Uj / Fk \ ,$$

and service productivity $s_{s,jk}$ by

(4c) $$s_{s,ij} = Si / Uj \ .$$

Obviously both the two energy efficiency measures and the energy productivity measure depend on the selected transformation, application and service technologies together with the amount (and quality) of corresponding capital and (in some cases) of labor.

Substituting (4) into (1) we obtain

(5) $$Si = s_{s,ij}\, e_{a,jk}\, e_{t,kl}\; El = s_{il}\, El$$

This relationship links a primary energy flow El to an energy service Si via a total energy productivity measure sil .This measure of total energy productivity is obviously composed of the efficiency and productivity measures of the transformation, application and service technologies which in turn depend on the selected technologies and the amount of capital and labor employed in these subsystems.

It is widespread practice to link this total energy productivity to an exogenous rate of technical progress. This is like treating the energy sector as a black box without asking where this technical progress comes from. Opening this black box, however, reveals the sources and consequences of technical change in an energy system.

3. The Choice of Energy Technologies: The Microeconomic Perspective

3.1 Microeconomic Decision Problems for Energy Services

An illustrative example serves to indicate some microeconomic aspects which determine the choice of energy technologies and the resulting technological changes which too often are just referred to as exogenous technological progress.

Let us consider the thermal services for an apartment building. On the average in Austria approximately 160 kWh/m^2 per year of useful energy are necessary to provide the service of residential space heating. New buildings require on the average less than 80 kWh/m^2 and low energy buildings need not more than 45 kWh/m^2. In the terminology developed above this means that depending on the selected energy service technology, in our example the thermal structure of the building, the amount of useful energy required can vary almost in a range 1 to 4.

In the next step we are interested in the application technology employed. The worst case would be individual coal stoves with fuel efficiencies as low as 30%. A very advanced heating system would consist of a gas totem, a combustion engine fueled by gas, providing both heat and electricity and raising the fuel efficiency as high as 90%. If we added to this system a heat pump the fuel efficiency could climb up to 130% because of the ambient heat collected by this technology. In the framework of our previous analysis the totem would be the selected transformation technology and the distribution net for heat and electricity together with the heat exchanger and controls would be the selected application system. Summing up we have plenty of evidence that for the same thermal energy services we can observe a variation of required primary energy inputs which exceed the range of 1 to 10.

What are the reasons for this considerable range of variation in total energy productivity? Why do we observe such a wide range of thermal standards in the selection of technologies for new buildings? What are the causes for the observed dynamics in these technological changes? And finally: Are there economic instruments which provide incentives for certain technologies which meet certain goals of energy policy, e.g. CO_2 reduction strategies?

3.2 Selecting Cost Minimizing Energy Technologies

From the perspective of a potential investor who will also be the user of the selected technology this is a typical microeconomic decision problem of minimizing the cost of factor inputs capital and energy for a required energy service:

(6) $\min (p^K K + p^E E)$

$s.t.\ \ S^0 = S(K, E)$

The potential investor will collect information about the range of technological options which will provide the required thermal services S^0 and select - given the rental price for capital p^K and the price for a unit of energy p^E - the cost minimizing variant.

The first order condition of this problem of cost minimization requires that the ratio of marginal input services of energy and capital, S_E and S_K, is equal to the ratio of corresponding input prices p^E and p^K:

(7a) $S_E/S_K=P^E/P^K$

Together with the relationship describing the technology for generating energy services

(7b) $S = S(K, E)$

we can solve (7) to obtain cost minimizing input demand equations for energy and capital:

(8a) $E = E^d(p^E; p^K, S)$,

(8b) $K = K^d(p^E; p^K, S)$.

Equations (8) reveal how for a required level of energy services S the energy intensity, the ratio of energy flows to capital stock is determined by the relative prices of energy and capital.

In reality a number of additional influences complicate this decision problem. Firstly, separation of owner and tenant might induce a bias toward lower investment costs and higher operating costs for the required services. Secondly, estimates about future relative prices between capital and energy might contain considerable uncertainties. Thirdly, building codes and other regulations might limit the range of technological options.

3.3 Policy Recommendations from a Microeconomic Perspective

What are the main insights following from this microeconomic perspective of the choice of energy technologies?

(1) Under competitive conditions the relative prices of energy and capital determine the search for technologies which provide the required energy services with minimal costs.

(2) A switch from high energy intensive to low energy intensive technologies which maintain the required level of energy services can be induced by increasing the price of energy in relation to the price of capital.

(3) The adjustment to less energy intensive technologies induced by an increase of the energy-capital price ratio may be hampered, however, by institutional and informational barriers. They explain the widely observed phenomenon why less energy intensive and cost reducing technologies for a required energy service are not chosen.

(4) Higher energy prices in relation to capital prices need not necessarily increase the costs for a required energy service. The cost effect depends crucially on the elasticity of substitution between energy and capital. If this elasticity is one, the price induced switch of technologies is cost neutral. If it is larger than one we even obtain a cost reduction. There is ample empirical evidence of such investment opportunities.

(5) Technical change in this microeconomic perspective becomes to a large extent an endogenous phenomenon. It may be induced by taxes and subsidies which change the relative prices of energy and capital. The policy measures must be accompanied, however, by the elimination of institutional barriers and by providing information about the available technical opportunities.

Additional policy recommendations can be derived for an energy policy which aims at providing incentives for the choice of technologies which meet, e.g., certain emission targets. Firstly, because of the long operating horizon of the initial investment decision the investor should be signaled a long term commitment by the policy authorities that they will stabilize the energy prices - if necessary by taxes - on a long term growth path. Secondly, in most cases it is cheaper to switch to a technology with a higher energy productivity from the very beginning than to attempt to improve an investment by some kind of retrofitting.

4 Macroeconomic Perspectives of Innovative Energy Technologies

We complement the microeconomic perspectives of the choice of energy technologies by a macroeconomic perspective. There are a number of transmission channels for the interaction between energy and the various macroeconomic indicators.

4.1 Macroeconomic Energy Linkages

We start from the basic aggregate supply - demand relationship relating imports M, gross domestic product Q, private consumption C, public consumption G, investment I and exports X:

(9) $$M + Q = C + G + I + X .$$

We split this relationship into its energy and non-energy components denoted by superscripts n and e, respectively:

(10) $$M^n + M^e + Q^n + Q^e = C^n + C^e + G + I + X^n + X^e .$$

The following balance equation for the energy sector states that supply has a domestic Q^e and import M^e component which is matched by demand of consumers C^e, demand by the domestic production sector D^e and exports of energy X^e:

(11) $$M^e + Q^e = C^e + D^e + X^e .$$

Similarly we obtain the following balance condition for non-energy supply and demand components:

(12) $$M^n + Q^n = C^n + G + I + X^n .$$

These non-energy demand components are determined mainly by economic activity.

Finally we specify the demand for labor Nn and investment In in the non-energy sector based on an underlying production function and profit maximizing behavior. Domestic prices are assumed as result of a mark-up on factor costs.

The energy components are linked with the non-energy components both via flow and price relationships. Following the microeconomic arguments outlined in the previous section we postulate both for energy demand for private consumption Ce and energy demand for production De that the corresponding not directly observable services Sc and Sq are determined by energy flows and non-energy capital stock. In addition we assume that there is a range of substitution between energy flows and capital stock depending mainly on the time span allowed for substitution.

A number of important substitution relationships can now be observed.

- In the production sector capital and labor can be substituted at least to some extent depending on relative factor prices. Both taxes on labor and on capital determine these price ratios.
- Energy flows for consumption C^e can be substituted by increasing the corresponding capital stock K^c of the energy application system of the households (e.g. the thermal quality of buildings).
- Energy flows for production D^e can also be substituted by changing the energy relevant capital stock K^q of production equipment (e.g. by using more energy efficient transformation technologies like cogeneration equipment).

In addition there are price linkages between energy and non-energy sectors. Import prices of energy P^{me} and non-energy P^{mn} determine together with the domestic prices P^{qe} and P^{qn} the aggregate price level of energy P^e and non-energy products P^n which again effects the various demand components.

4.2 Macroeconomic Impacts of Policy Induced Technical Innovations

We use the analytical framework presented above for the simulation of two types of policy measures which are designed to stimulate the switch to innovative energy technologies.

4.2.1 Tax Shift Policies

The basic idea of this type of policy measures is to induce technological change by shifting the tax base from income to material inputs, notably energy. This can be achieved, for example by imposing an excise tax on energy and by reducing in the same amount some income based taxes which are cost effective for employers, e.g. payroll taxes or social security contributions.

The macroeconomic impacts of such a policy package are triggered by two changes in relative prices: labor becomes relatively cheaper in relation to capital and energy becomes relatively more expensive in relation to capital. Producers notice incentives to switch to more labor intensive production technologies which will cause ceteris paribus an increase in the demand of labor and a decrease in the demand of fixed investment capital. Users of energy will notice a similar incentive to switch to energy saving technologies thus demanding additional energy related investments.

If the higher energy prices reduce purchasing power and thus have a depressing effect on demand this has to be carefully analyzed. Obviously as long as the impact of the induced investments for energy efficiency has not become effective both producers and consumers have to cope with higher energy costs for the same energy services. According to the findings in the microeconomic analysis of such a shift in relative energy prices the new technologies may lead to a reduction of energy flows which compensates the energy price hikes and, therefore, does not lower purchasing power for non-energy demand.

The main objections to such a policy package which solely relies on technical adjustments caused by price signals are the adjustment lags. Only in the medium and long run labor can be substantially substituted by capital. The demand effect on labor is rather weak in the short run. Also obvious informational and institutional barriers prevent the new cost minimizing energy-capital mix from becoming effective in the short run. These objections, therefore, deserve to be considered seriously when energy policies are designed which mainly rely on tax shift effects.

4.2.2 Demand Shift Policies

The basic idea of this type of policy packages is to overcome the long and unreliable adjustments to the changing prices by stimulating directly the demand for energy efficient technologies.

As in the case of tax shift policies energy prices are increased by an excise tax on energy. The additional revenues, however, are not compensated by reducing other taxes but by supporting special programs which aim at improving the energy quality of buildings and equipment. The administrative setup for such policies could be an energy efficiency fund which subsidizes, e.g. a program for improving the thermal structure of buildings, the propagation of cogeneration in industry and the development of advanced biomass technologies. These programs should have a sunset character in the sense that their aim is to open new markets and to stimulate the development of the desired technologies but not to make these technologies dependent on permanent subsidies.

The macroeconomic impacts of such a policy package rely on two immediate demand effects. Firstly, investments in new equipment and buildings become effective. Secondly, energy flows are reduced due to the quick implementation of the efficient technologies. Altogether such a package induces a demand shift from energy flows to investments into new technologies. This design considerably lowers any inflationary pressure caused by the energy price hikes and unfavorable distribution effects due to the regressive tendencies of indirect taxes. It is expected that the immediate demand effects for investment goods dominate all remaining offsetting effects due to the increased energy prices.

4.2.3 Mixed Tax and Demand Shift Policies

There are a number of arguments in favor of a mix of the proposed policy packages. Demand shift policies have the advantage of becoming quickly effective thus stimulating the economy with the demand for products which may become very relevant for the long run competitiveness of an economy. There are good reasons, however, to limit such a policy package over a preannounced and very limited time span. Tax shift policies serve primarily as a guiding signal for long run investment decisions. The credibility of such a package relies heavily on the ability of the policy authorities to make long run policy commitments. Another advantage of a mixed package is the rather low volume of additional taxes on energy which will suffice to induce the desired impacts.

An operational concept for such a mixed package might be to return to the nominal level of energy prices which our economies experienced around 1985 when the price setting power of the oil producers peaked. This will raise the energy price level by about 15%. Of the resulting tax revenues around two thirds could be used for tax shift policies and one third for demand shift packages. Over a period of about three years with decreasing intensity the remaining funds could be recycled into the economy via an energy efficiency fund. The decreasing funding of the demand activities would eventually lead to a full tax shift policy.

4.3 Simulation Results of Policy Induced Technical Progress

Glueck and Schleicher (1993) applied the above presented policy concepts to a macroeconometric model for Austria. For the simulations an energy price hike is assumed which maintains the energy price level of 1985. The main findings support the above theoretical arguments discussed above.

A pure tax shift policy yields rather disappointing effects as far as positive impacts on economic activity are concerned since the demand for new technologies is almost completely offset by the decline of investment goods due to the relative increase of prices for capital goods in relation to labor costs. The inflationary effect of a pure tax shift policy also very much depends on the willingness of companies to lower the prices for produced goods due to the lower factor costs for labor. We, therefore, simulated two packages of mixed tax and demand policies. In both cases half of the additional revenues are devoted over five years to an energy efficiency fund.

The first package is used to subsidize energy efficiency investments for household and companies. Estimates have to be made about the potential energy saving effect and the impact on investment and non-energy consumption. A conservative estimate drawn from various pilot projects leads to the conclusion that the energy conservation investments spurred by this program would lead to an annual reduction of energy flows of 15%. There is also plenty evidence that at least at the margin an energy unit saved is not more expensive than an energy unit consumed. Thus the subsidies of the energy fund are sufficient to maintain a 15% reduction of energy flows without reducing the related energy services. According to the model simulations this demand management oriented policy package will generate between 10,000 and 26,000 additional jobs over the first five years and will have a strong positive short term impact on real GDP.

The second package differs from the first by spending the additional revenues not only on energy efficiency projects on the demand side but also on supply side measures. These activities would propagate the utilization of renewable energy resources. A typical example would be the use of biomass in high efficiency technologies, e.g. by converting biomass to gas which is used in cogeneration technologies together with heat pumps. These policies would both save imported fossil fuels and would increase the efficiency of energy supply. The model simulations suggest that such an integrated resource management package will generate between 20,000 and 40,000 new jobs over the first five years. The impact of this policy is mainly the substitution of imported energy by domestic renewable resources. Thus the substitution of energy flows is smaller than in the previous package.

4.4 Policy Recommendations from a Macroeconomic Perspective

The analysis of the macroeconomic linkages of the energy sector with the remaining sectors of the economy leads to the following suggestions:

(1) A deliberate increase of relative energy prices has the potential to stimulate innovative energy saving technologies. This induced investment demand should overcompensate all negative price effects on economic activity. The microeconomic arguments of market failures due to informational and institutional barriers warn, however, that the desired adjustment process may be seriously hampered.

(2) Policy packages aiming at a shift to innovative energy technologies may be either based on tax shifts or on demand shifts. While tax shift programs seem to become effective only in the long run and demand shift programs have advantages in the short run a mix of both policy packages might be a suitable design for innovative policy programs.

(3) Inflationary pressures are reduced by demand shift policies due to the immediate effect of energy savings. In tax shift packages provisions have to be made to let the tax reductions become effective in the pricing of products.

5. Incentives and Institutions

The arguments for incentives to environmental innovation with special emphasis on energy technologies so far have rested on policy instruments based on price and demand signals.

Especially in the United States the utilities have collected considerable experience over the past years in providing efficiency incentive programs through rebates, competitive bidding mechanisms, loans to customers and direct installation of new equipment with the customers.

These activities are mainly motivated by a widespread failure of the investors in buildings and equipment to make use of the available costminimizing energy technology. The reasons for this failure can mainly be attributed to the behavior of investors:

- They lack information about recently commercialized or rapidly evolving new technologies.

- They face uncertainty regarding potential energy savings, payback of the investments.
- They often do not adequately include operating costs in the investment decision.

This evidence led to a number of institutional changes. Firstly, traditional energy companies have already shown that they are able to play an important role to overcome these informational barriers. They are in the process of switching from the traditional supply side orientation to demand oriented policies which support the selection of cost minimizing technologies for the required energy services.

Secondly, new energy service companies have started to provide services for finding cost minimizing energy strategies. Thirdly, special information programs have been launched in many countries to overcome the informational barriers which limit the adjustment via conventional market processes. Special mention deserves the RAVEL program of Switzerland which provides a comparatively low fund to a private consulting company which in turn uses this seed money to organize a very successful information program on electricity related energy saving technologies.

6. Designing Incentives for Technical Change

Almost all environmental damages are closely linked to the use of energy. Therefore, a better understanding of the innovation potential of energy systems seems to deserve high priority on all research activities aiming at environmental innovations.

A prerequisite for any meaningful statement about the understanding of innovations in energy systems is the distinction between energy services and energy flows. The majority of energy models still focuses on energy flows thus being exposed to a number of misleading conclusions.

The first benefit of this distinction between energy flows and energy services is the welfare aspect. Only energy services are relevant from a welfare point of view. Due to a wide range of technical substitution between capital and energy flows the required energy services can often be obtained by energy flows varying by a factor of ten.

The choice of energy technologies reflects a long line of historical decisions. These decisions were governed besides prices also by institutional and informational barriers. Any attempt to provide incentives for switching to technologies which meet accepted environmental goals must, therefore, first deal with the widespread phenomenon of disincentives for environmental innovation.

A careful micro- and macroeconomic analysis of the energy linkages in an economy reveals not only the vastly underestimated technological potential for energy efficient technologies but indicates also a wide spectrum of incentives to switch to these technologies.

Most promising seems to be a well designed mix of tax shift and demand shift policies which provide incentives for the rapid implementation of available high efficient energy technologies.

Simulation results obtained with a macroeconometric model strongly advocate policies for promoting energy technologies via an energy efficiency fund which is financed by the revenues of a moderate energy tax. Thus in addition to the rather weak and lagged technological changes induced by a change in relative prices we obtain immediately a demand effect for innovative technologies financed out of the additional tax revenues. Such a double dividend policy appears to emerge as an effective and attractive instrument for CO_2 reduction policies.

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INCENTIVES TO RENEWABLE ENERGY[1]

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1. Summary and Recommendations of the United Nations Solar Energy Group on Environment and Development (UNSEGED)[2]

A. Impetus

l. Development, economic growth and population increase lead to ever-greater energy service requirements. These growing requirements must be met in a sustainable way. Current patterns of energy production, transportation and use do not meet these requirements and do not lead to a sustainable world.

2. Energy production, transformation, transportation and utilization account for at least as many global or regional man-made environmental problems as all other human activities combined and also cause major national and local environmental damage.

3. Energy issues are central, therefore, to discussions of the environment and development.

4. The energy sector represents a large fraction of national and international economies. Globally, energy accounts for 25-30 per cent of present investments in development and economic growth. Energy sector investments are therefore important determinants of the direction of societal development.

5. Maintaining current patterns of fossil fuel use will cause unprecedented rates of global surface temperature increase, resulting in the disruption of the Earth's climate. The scientists on the Intergovernmental Panel on Climate Change concluded that, in order to stabilize atmospheric concentrations of carbon dioxide (CO_2) at today's levels, an immediate reduction of anthropogenic CO_2 emissions by more than 60 per cent would be necessary. Fossil fuel use is the main source of anthropogenic CO_2 emissions. Such a reduction implies, therefore, a profound change in the commercial energy system, of which about 88 per cent is currently supplied with fossil fuels.

6. Energy strategies should be used as instruments for sustainable development and environment preservation. Increasing the share of renewable energy sources in the total world energy supply and improving energy efficiency will be the essential elements of any strategy for achieving sustainable development and environment preservation. Public concern about nuclear power has increased and investments have slowed considerably, reducing the potential role nuclear power might play in such a strategy. The present report deals solely with renewable energy sources. The term solar energy is hereinafter used broadly to mean all renewable energy sources.

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1 T.B.Johansson made his presentation using "Summary and Recommendations of the United Nations Solar Group on Environment and Development" from U.N. publication and "Public Policy Issues" from *Renewable Energy: Sources for Fuels and Electricity* published by Island Press for the session on "Subsidies & Financial Incentives" in Tsukuba Workshop.

2 This paper is a reprint from United Nations Publication by The United Nations Solar Energy Group for Environment and Development (Chair: T.B.Johansson) : United Nations document A / AC.218 / 1992 / 5 / Rev.1.

B. Background on renewable energy sources in the United Nations system

7. Concern in the 1970s over uncertainties of fuel supply and future depletion of fossil fuels led to increased interest within the international community in expanding the utilization of new and renewable energy sources. The Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy (NPA) was established in 1981 as a comprehensive international effort for developing and utilizing new and renewable energy sources.

8. The decade following adoption of the Nairobi Programme of Action was essentially lost, not because of lack of technical progress or failure of individual projects, but because the political resolve expressed in the Nairobi Programme of Action was not supported by: agreed-upon targets quantifying the objectives of the Nairobi Programme of Action; correspondingly, financial commitments; and adequate institutional support, especially in the industrialized countries.

9. The absence of those fundamental structure-forming mechanisms left room for the continuation of national policies that inhibited the promotion of renewable energy sources. Such policies included:

(a) Lack of support, policy development and legislation for broad dissemination of new technologies;

(b) Small and declining support for research and development (R&D) on renewable energy sources at the national level in most Organization for Economic Cooperation and Development (OECD) countries (after a build-up period, expenditures of International Energy Agency (IEA) Governments on energy research and development were reduced by more than 70 per cent between 1980 and 1987. Only 7 per cent of the 199O expenditures was directed to renewable energy sources);

(c) Exclusion of external costs and non-monetary benefits in economic evaluations of energy technologies and systems;

(d) Large subsidies provided in many countries for conventional energy sources. Some of these subsidies were made directly in the form of large State-run development programmers or tax relief while others were indirect and manifest in ignored environmental costs and government responsibility, inter alia, for insurance and waste disposal.

10. The government signals reflected in (a) through (d), along with new discoveries of fossil fuel resources, changing economic conditions and falling oil prices, led to small and declining private investments in renewable energy.

C. Renewable energy sources

11. The flow of renewable energy to the Earth's land surface is thousands of times greater than mankind's present rate of total energy use. Utilizing on: a small fraction of this resource would provide humanity with an alternative and environmentally sound path towards meeting future energy needs.

12. The present total commercial world energy supply is about eight gigatons of oil equivalent (Gtoe) per year. Renewable energy sources contribute about 7 per cent, most of which is large-scale hydropower, of that supply. Including non-commercial energy sources, renewable energy sources contribute 14-20 per cent of the total primary energy supply.

D. Technologies

13. Renewable energy sources can be used to produce a variety of energy carriers, such as liquid-d fuels and electricity, which can be utilized within the existing transmission,

distribution and end-use infrastructure in both industrialized and developing countries.

14. Several technologies for utilizing renewable energy sources are mature and economically competitive, and they are diffusing through the market even under present conditions. Electricity generation in biomass-fuelled plants in the United States of America increased from about 250 to 9,000 megawatts (MW) during the 1980s. Solar thermal plants of 350 MW of installed capacity are selling electricity to the grid at competitive prices in California and more 350-MW plants are being built. World-wide geothermal power capacity increased from 2,000 MW in 1980 to 5,830 MW in 1990. Wind farms provide 1,900 MW of electricity to the grid in locations such as California, Denmark, India and the Netherlands and, after a dramatic cost reduction in the 1980s, are now economically competitive with coal-based plants on sites with favorable wind regimes. Ethanol from biomass is used in Brazil as an automotive fuel in approximately 4 million automobiles and is also used as an octane enhancer. Current production volumes exceed 200,000 barrels per day. About 110,000 small wind generators and 1,600 wind pumps are operating in China. Several million household anaerobic digester are operating in China and India and several million household solar water heaters are in use in those countries. Passive solar technologies for heating and cooling, if introduced at the design stage, are paid back in three to five years.

15. Some renewable energy technologies and energy carriers show great promise. The two most important examples are photovoltaic and new advanced uses of biomass for gasification/power generation and liquid fuel production. Doubling its size about every four years, the photovoltaic market has grown steadily to present sales of 50 MW of power per year. Photovoltaic electricity-generating costs have decreased markedly, making some applications economically feasible, and with adequate research, development and demonstration (RD&D) efforts are expected to be competitive with central-station generation after the year 2000. Many advanced biomass production and conversion technologies are being developed. Large-scale RD&D efforts would greatly improve and accelerate the economic potentials of such technologies.

16. A renewable energy system will, by nature, include a wide variety of technologies that harness a range of energy forms. Such a system will be decentralized, with components of different scales designed to meet local and regional needs. The energy flows into the system will vary spatially and fluctuate over time. The supply technologies used in a renewable energy system and the endues technologies used to meet the demand for energy services must therefore be well integrated. The technologies needed for providing such integration are already available.

E. Potentials

17. Taking into account the availability of cost-effective technologies and levels of energy endues in different climate zones, the near-term (1990-2000) global economic potential to supply energy based on renewable sources is about 3.3 Gtoe per year, that is, 2.5 times the 1985 contribution. The major quantitative increments of the near-term renewable potential are expected to derive from the sustainable use of biomass and large-scale hydropower. The rate at which emerging technologies are developing indicate a minimum potential contribution of 5 Gtoe per year in 2020, that is, an increase of 3.5 Gtoe over the present contribution. Emerging energy technologies, such as photovoltaic and new biomass technologies, can come to play a dominant role in the early twenty-first century. In the long term, the utilization of renewable energy sources is not likely to be constrained by the availability of resources or cost-effective technologies. At present, political and administrative decisions are its primary constraints. The opportunity now exists to start the transition to an energy system for a sustainable world.

F. Advantages

18. Replacing conventional energy sources with renewable ones would reduce many environmental impacts caused by the current energy system, including greenhouse gas emissions, land degradation, air and water pollution, acid precipitation and emissions of radioactive substances.

19. The scale of facilities for manufacturing devices for utilizing renewable energy sources can be comparatively modest. With access to some of these technologies, developing nations will be able to reduce foreign capital outlays by developing endogenous manufacturing capabilities. Such industries can contribute to local economic growth. Producing alterative fuels can also reduce foreign capital expenditures in many countries.

20. Utilizing renewable energy sources can provide training and employment opportunities that would otherwise not be available, thereby supporting development based on self-reliance.

21. Locally available primary energy resources are, in essence, free from control outside national boundaries. They therefore provide a secure, independent energy supply, an important element of sustainable and autonomous development.

22. The time period required from planning through implementation of renewable energy supply projects is often much shorter than that of conventional, large-scale supply projects. This characteristic offers flexibility and reduces investment and (as a consequence) delivered-energy costs.

23. Most renewable energy technologies are designed in modules, simplifying installation and maintenance and offering the added advantage of flexibility in increasing supply capacity.

24. The opportunity exists for establishing rational and efficient energy systems based on technologies that utilize renewable energy sources. For environment- and development-related reasons, establishing such systems must be a goal for the first' part of the next century.

G. Constraints on the rate of expansion

25. The technological limits to the diffusion of existing competitive technologies for utilizing renewable energy sources derive mainly from the time needed to increase global capacities for producing them.

26. Because financial resources are scarce, the setting of priorities for energy-sector investments will determine the penetration rate of technologies that utilize renewable energy sources. A transition to a global energy system based on renewable energy sources will not take place unless the share of energy-sector investments devoted to renewable energy technologies is greatly increased.

27. Current practices for distributing development aid favor large-scale projects. Project orientation must be replaced by programme orientation in order to make funds available for small-scale decentralized technologies that utilize renewable energy sources.

28. Global renewable energy resources are more than sufficient for meeting the demand for energy services. However, conflicting demands on natural resources, such as food- versus energy-production-related demands on arable land, must be addressed in evaluating the accessible potential for utilizing biomass resources within individual countries.

29. Within the limitations posed by technological, financial and natural resources, the extent to which renewable energy sources contributes to the future world energy supply will depend on energy-policy decisions made by Governments and on coordinated international cooperation.

H. Recommendations

30. Seizing the opportunity to develop a sustainable global energy system based on renewable energy sources will require fundamental structural, economic and institutional changes in industrialized and developing countries. None of these changes can be achieved without unyielding political will, international cooperation, and active public and private involvement.

31. Adopting a long-term approach is vital for the development of the physical as well as the policy and institutional infrastructure needed for utilizing renewable energy sources.

32. Implementing such an approach will require both transitional and foundation-building policies. Towards those ends, we make the following recommendations.

33. At the national level, it is essential to formulate integrated energy policies and programmers compatible with sustainable development and to promote increased investments in renewable energy supplies. We therefore recommend that Governments:

(a) Adopt and implement an integrated national action programme on the development and utilization of renewable energy sources within the framework of strategies and policies for the transition to energy systems compatible with sustainable development;

(b) Establish targets for contributions of the different renewable energy sources to their energy supply, commensurate with the time-frames of technical feasibility outlined above. Such targets should be linked to environmental as well as social and developmental objectives;

(c) Establish and strengthen institutional arrangements that facilitate the implementation of the national programme, including policies and programmers for achieving the set targets. Appropriate governmental institutions should be given the mandate of promoting the utilization of renewable energy sources through education, training and information programmers; energy/environment planning and policy coordination; and research, development and demonstration;

(d) Enlarge markets for renewable energy applications by adopting new regulatory and fiscal legislation that, inter alia, ensures that all costs and benefits (environmental and social, among others) are included in the market price and in economic comparisons of public and private energy-sector investment options, and public procurement policies;

(e) Increase public funding of research into the utilization of renewable energy sources by a factor of at least t~ree, on average, within five years;

(f) Ensure that the share of public energy investments devoted to promoting research, development, demonstrations and training related to renewable energy sources is commensurate with the potential of those sources to meet national energy needs and global responsibilities;

(g) Ensure that renewable energy sources are not discriminated against in domestic energy markets by the subsidizing of other energy sources directly or indirectly, and that small or independently owned producers are not discriminated against by utilities or denied access to transmission and distribution systems:

(h) Establish and implement procedures for recording statistical data on renewable energy applications in their country. Such data should be collected in a harmonized form, so that they can be useful at the international level;

(i) Report on their national programmers of action for promoting renewable energy sources in order to facilitate an international dialogue (see paras. 34 (a) and 35).

34. At the international level, arrangements must be made, in close collaboration with national and international institutions and non-governmental organizations, to strengthen international cooperation for promoting the utilization of renewable energy sources. Those arrangements should intensify research, development and demonstration in the area of renewable energy technology, stimulate broad dissemination and application of available renewable energy technologies and provide for exchange of information and manpower training for use of such technologies. Towards these ends, it is necessary to:

(a) Promote and support policy planning, inter alia by organizing a dialogue with each nation based on national renewable energy policy and programme reports (see para. 33 (i));

(b) Promote rapid implementation of systems based on renewable energy sources, especially in industrial countries because of their dominant use of fossil fuels;

(c) Restructure energy-sector expenditures so that renewable energy sources and technologies for their utilization, together with energy-efficiency improvements, are given first priority;

(d) Promote increased funding, inter alia, from new and additional financial resources, in support of the implementation of national action programmers on renewable energy sources, in particular in the developing countries;

(e) Promote rapid and effective transfer of environmentally sound technologies for utilizing renewable energy sources among countries in general and (on favorable and confessional terms) to developing countries in particular. In this regard, action should be taken to (i) adapt currently available technologies to local conditions, (ii) promote the build-up of the endogenous expertise and infrastructure needed to enable the implementation of renewable energy programmers, and (iii) promote local production of technologies to enhance national self-reliance;

(f) Prepare and disseminate studies on new technological developments, techniques and strategies for identifying, locating and evaluating new and renewable energy sources;

(g) Allocate, in the coming years, a minimum of 20 per cent of all funding aid from bilateral, multilateral and international agencies devoted to the energy sector to viable renewable energy projects, in addition to large-scale hydropower. The same arrangement should apply to grants and loans from international development banks, and this percentage should increase over time;

(h) Increase capacity-building efforts, particularly in developing countries, to ensure increased development and implementation of renewable energy programmers;

(i) Coordinate international activities aimed at promoting the utilization of renewable energy sources;

(j) Promote research, development and demonstration programmers in developing countries for technologies that utilize renewable energy sources;

(k) Coordinate the exchange of information and experience on research, development and applications of renewable energy technologies:

(l) Gather statistics from individual countries on, and perform evaluations of applications of, renewable energy sources;

(m) Implement the proposal by the Colloquium of High-level Experts on New and Renewable Sources of Energy (Castel Gandolfo, Italy, S-7 October 1987) to establish a network of international centers in new and renewable sources of energy.

35. We believe that a strong international institutional arrangement is needed to carry out the above tasks and give renewable energy necessary visibility and weight in such areas of relevant international negotiations as the framework convention on climate change. The creation of an international renewable energy agency responsible for promoting renewable energy sources is therefore recommended. This agency should be responsible for the activities enumerated above in paragraph 34 (a), (b), (d), (e), (f), (h), (i), (j), (k), (l) and (m) and should act as a network focal point for national and international institutions, stimulating and supporting two-way communication between them.

2. Public Policy Issues[3]

A renewables-intensive global energy future is technically feasible, and the prospects are excellent that a wide range of new renewable energy technologies will become fully competitive with conventional sources of energy during the next several decades. Yet the transition to renewables will not occur at the pace envisaged if existing market conditions remain unchanged. Private companies are un likely to make the investments necessary to develop renewable technologies because the benefits are distant and not easily captured by individual firms. Moreover, private firms will not invest in large volumes of commercially available renewable energy technologies because renewable energy costs will usually not be significantly lower than the costs of conventional energy. And finally, the private sector will not invest in commercially available technologies to the extent justified by the external benefits (e.g., a stabilized world oil price or reduced greenhouse-gas emissions) that would arise from their widespread deployment. If these problems are not addressed, renewable energy will enter the market relatively slowly.

Fortunately, the policies needed to achieve the twin goals of increasing efficiency and expanding markets for renewable energy are fully consistent with programs needed to encourage innovation and productivity growth throughout the economy. Given the right policy environment, energy industries will adopt innovations, driven by the same competitive pressures that have revitalized other major manufacturing businesses around the world. Electric utilities will have to shift from being protected monopolies enjoying economies-of-scale in large generating plants to being competitive managers of investment portfolios that combine a diverse set of technologies, ranging from advanced generation, transmission, distribution, and storage equipment to efficient energy-using devices on customers' premises. Automobile and truck manufacturers, and the businesses that supply fuels for these vehicles, will need to develop entirely new products. A range of new fuel and vehicle types, including fuel-cell vehicles powered by alcohol or hydrogen, are likely to play major roles in transportation in the next century.

Capturing the potential for renewables requires new policy initiatives. The following policy initiatives are proposed to encourage innovation and investment in renewable technologies:

- Subsidies that artificially reduce the price of fuels that compete with renewables should be removed; if existing subsidies cannot be removed for political reasons, renewable energy technologies should be given equivalent incentives.
- Taxes, regulations, and other policy instruments should ensure that consumer decisions are based on the full cost of energy, including environmental and other external costs not reflected in market prices.
- Government support for research on and development and demonstration of renewable energy technologies should be increased to reflect the critical roles renewable energy technologies can play in meeting energy, developmental, and environmental objectives. This should be carried out in close cooperation with the private sector.
- Government regulations of electric utilities should be carefully reviewed to ensure that investments in new generating equipment are consistent with a renewables-intensive future and that utilities are involved in programs to demonstrate new renewable energy technologies in their service territories.
- Policies designed to encourage the development of a biofuels industry must be closely coordinated with both national agricultural development programs and efforts to restore degraded lands.
- National institutions should be created or strengthened to implement renewable energy programs.
- International development funds available for the energy sector should be directed increasingly to renewables.

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3 This paper is a reprint of pages 7-9 from *Renewable Energy: Sources for Fuels and Electricity* (Co-edited by H.Kelly, A. Reddy, R.H.Williams and T.B.Johansson) published by Island Press, 1993, by courtesy of Island Press.

- A strong international institution should be created to assist and coordinate national and regional programs for increased use of renewables, to support the assessment of energy options, and to support centers of excellence in specialized areas of renewable energy research.

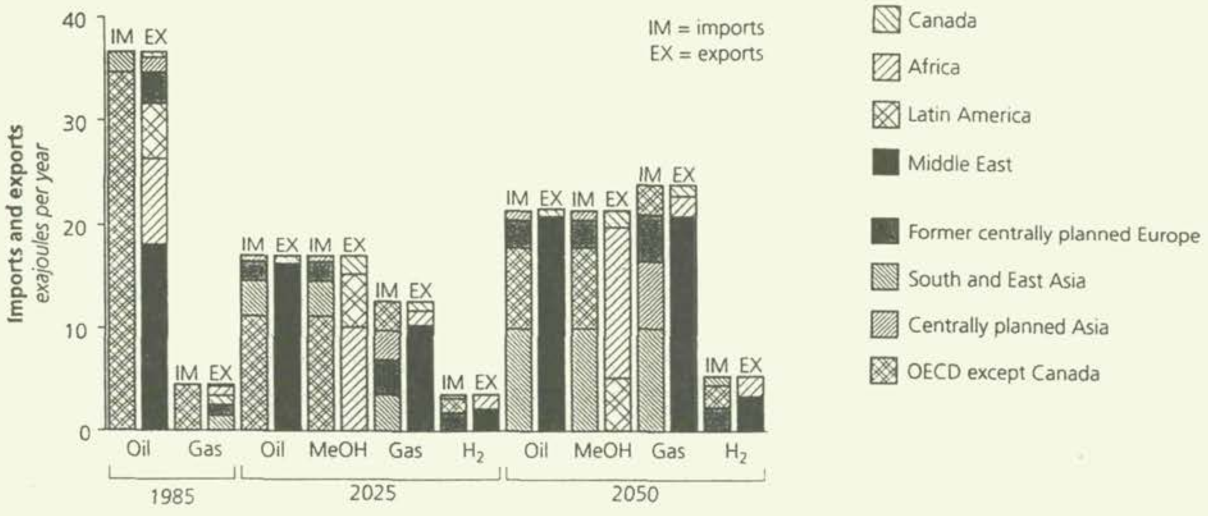
There are many ways such policies could be implemented. The preferred policy instruments will vary with the level of the initiative (local, national, or international) and with the region. On a regional level, the preferred options will reflect differences in endowments of renewable resources, stages of economic development, and cultural characteristics.

The integrating theme for all such initiatives, however, should be an energy policy aimed at promoting sustainable development. It will not be possible to provide the energy needed to bring a decent standard of living to the world's poor or to sustain the economic well-being of the industrialized countries in environmentally acceptable ways, if the present energy course continues. The path to a sustainable society requires more efficient energy use and a shift to a variety of renewable energy sources.

While not all renewables are inherently clean, there is such a diversity of choices that a shift to renewables carried out in the context of sustainable development could provide a far cleaner energy system than would be feasible by tightening controls on conventional energy.

The central challenge to policymakers in the decades ahead is to frame economic policies that simultaneously satisfy both socio-economic developmental and environmental challenges. The analysis in this book demonstrates the enormous contribution that renewable energy can make in addressing this challenge. It provides a strong case that carefully crafted policies can provide a powerful impetus to the development and widespread use of renewable energy technologies and can lead ultimately to a world that meets critical socio-economic developmental and environmental objectives.

Figure Interregional Flows of Fuels for the Renewables-Intensive Global Energy Scenario



The importance of world energy commerce for the renewables-intensive global energy scenario is illustrated here. This figure shows that in the second quarter of the next century there would bc comparable interregional flows of oil, natural gas, and methanol, and that hydrogen derived from renewable energy sources begins to play a role in energy commerce. This diversified supply mix is in sharp contrast to the situation today, where oil dominates international commerce in liquid and gaseous fuels.Most methanol exports would originate in sub-Saharan Africa and in Latin America, where there are vast degraded areas suitable for revegetation that will not be needed for cropland. Growing biomass on such lands for methanol or hydrogen production would provide a powerful economic driver for restoring these lands. Solar-electric hydrogen exports would come from regions in North Africa and the Middle East that have good insolation.

Discussant's Comments

Stephen F. Harper
US EPA

Both of the papers presented in this session, by Professors Schleicher and Johansson, underscore the importance of increasing energy productivity in the worldwide economy to the realization of sustainable development. Reducing greenhouse gas emissions will of course be a significant part of making progress towards susceptibility. But increased energy productivity, or increasing the amount of energy services derived from initial energy inputs, also will yield other environmental benefits in the form of improved air and water quality. In the U.S., for example, the utility industry is the largest single source of a number of air pollutants, including sulfur dioxide, nitrogen oxides, and numerous air toxic. Sustainable development is the right paradigm or framework in which to discuss increasing energy productivity because such increases will benefit both the environment and the economy, in the form of lower production costs and greater resource security.

Professor Johansson's treatment of renewable energy source under-emphasizes the variety of such sources in terms of the contribution they can make to progress towards sustainable development. Ethanol, for example, presents considerable environmental disadvantages that cannot be ignored in the comparison to the impacts of fossil fuel use. Ethanol presents significant volatility problems, for example, that have made controversial in U.S. policy discussions about automobile fuel reformulation. Significant increases in the production of ethanol from corn, for example, would greatly increase pressure on land resources, leading to tillage of marginal land, increased soil erosion, nonpoint runoff of pesticides and fertilizers, etc.

Both Professors Johansson and Schleicher correctly point to the need for greater emphasis on stimulating the demand for energy efficiency technologies. Neither, however, goes far enough in my view. Johansson advocates that 20 percent of all bilateral and multilateral agency funding related to the energy sector should be devoted to renewable energy projects. That may be an appropriate near-term target, but over the coming years a bigger shift will be necessary if such assistance is to have a driving influence on the development of energy technologies and infrastructure in recipient countries and in the worldwide market. Similarly, Prof. Schleicher, in advocating a mix of tax shift and demand shift policies, argues for a three-year phase-out of demand-shift investments. In my view, three years is too short an investment period to even begin addressing some of the market failures that Schleicher correctly points out as barriers to the spread of energy efficiency technologies.

I would also add to Prof. Schleicher's menu of policy approaches governments can take to stimulate demand for energy efficiency technologies. In addition to funneling tax money into energy efficiency technology investments, governments can provide a powerful demand stimulus in their roles as consumers of energy products and services. Governments can also affect the market by fiat, through setting minimum energy efficiency standards for key consumer appliances and automobiles. Finally, government can act as a very effective educator, demonstrating the cost savings potential of energy efficiency technologies and helping to overcome the imperfect information problem. In the U.S., for example, EPA's "Green Lights Program" has greatly spurred the penetration of energy efficient lighting systems into the private sector by actively working with industrial "partners" to demonstrate the cost savings potential of such systems.

Discussant's Comments

Anwar Shah
World Bank

Dr. Stefan Schleicher has examined the implications of incentives for environmental innovation in Austria. The paper makes a contribution in drawing a distinction between energy flows and services associated with such flows. The model developed by Dr. Schleicher is quite useful but is not able to capture short and intermediate run effects of policies. The model assumes that adjustment takes place costlessly and without lags. A dynamic disequilibrium model with imperfect competition (price-cost margins) with adjustment costs may be able to shed light on the path of adjustment as well as costs of adjustment. The so-called variable profits sub model where policy changes are reflected in the rental rate of capital, may serve as a useful framework for determining regional and sectoral impacts of such policies. An interesting policy simulation may be equal yield introduction of an energy tax accompanied by investment tax credit for R&D and adaptation of new technologies. Finally, emphasis should be on market based incentives as the experience shows that government bureaucrats are not very good at picking winners in the market place.

Dr. Thomas Johansson argues for the elimination of energy subsidies; making full costs of energy use more apparent; and enhancing government support for R&D. I support these recommendations. The following recommendations presented in the paper, however, require further review.

- Governmental regulation of electric utilities should emphasize renewable intensive future. Such a heavy handed public direction would not be justified as at the present time renewable energy sources have not yet proven to be cost-effective alternatives. It may be desirable for governments to simply set energy efficiency standards and leave the choice of technology to the private sector.

- National and international institutions should be established to encourage increased use of renewable. Could this role not be fulfilled by reorienting existing institutions rather than creating new and perhaps costly bureaucracies?

Rapporteur's Summary

Clarissa C. Arida
Department of Environment and Natural Resources, Philippines

A participant questioned Prof. Johansson on the call for subsidies for renewable sources of energy as pointed by Prof. Johansson. He also questioned the progress made in this area.

Another query was on the relationship between research on nuclear energy and research on renewable. Why is it that more expenditure is on nuclear research than research on renewable? It should be the other way around.

Prof. Scleicher was asked whether it would be possible to have tax on energy and carbon? and what is the sensitivity of the model with respect to energy efficiency share (the 40% share is very large)? The economic benefits of tax share could be maximized at 15% as in France.

Another participant queried on the penetration rate of renewable whether 10% - 40% is acceptable in all areas in the US. Does the model take into account the availability for example of hydropower and wood fuel in the US and its absence in some areas?

On the issue of energy and economy a participant noted that a lot has been said and done but he would like to see some urgency on climate change issue and not the business as usual scenario. Can the speakers help to see what advice should be given to governments who face the issue of climate change.

Another participant underlined the technological innovation on environmentally social and friendly technologies. Incentives is focused only on energy efficiency. What about incentives for environmental innovations for building materials and construction design? This should take into consideration climatological differences in adopting technologies from one country to another. The participant supported the idea of energy conservation and its applicability in developing countries. He raised question on the effectiveness of solar energy or this is only applied presently on a small scale. Solar energy is good, but what about its feasibility? Do we need new innovations or incentives for this?

Prof. Schleicher responded to the questions as follows :

- The proposed increase of energy prices could increase tax by 15% and only 2% would go to energy efficiency fund. This set-up would decrease the role of governments.

- On the question of what derives technological changes, be noted that all changes are very deliberate decisions.

- Prof. Johansson replied that not all renewable are necessarily good but we must identify only those that make sense under appropriate conditions.

- Government made larger mistakes in the market, maybe yes or no, but take into account larger problems e.g. climate change, acid rain bearing in mind boundary conditions.

- Cost of solar electricity should be reduced.

- Incentives are needed because if technologies are left alone in the market, it would not proceed as expected.

- Some renewable are quite competitive e.g. hydro power developments but wind is fairly new and biomass is at its demonstration stages. Although in the US because of availability of biomass resources about 80 gigawatts is generated. Can biomass be those to bring electricity cost at acceptable levels. Yes, there are opportunities and this should be taken seriously.

3. Tradable Permits

A DYNAMIC GAME APPROACH TO GREENHOUSE POLICY SOME NUMERICAL RESULTS

Mike Hinchy, Kevin Hanslow and Brian S. Fisher
Australian Bureau of Agricultural and Resource Economics

Abstract: In this paper a numerical dynamic games analysis is undertaken of some greenhouse policy issues. Costs of reducing emission functions are derived for 15 regions from a general equilibrium model of international trade. Greenhouse damage functions are derived under some rather arbitrary assumptions. The dynamic game analysis is used to contrast the gains from unilateral action with international cooperation. The gains from international cooperation appear to be substantial. However, side payments would be needed to maximise the gains from international cooperation. The direction of side payments would be from developed regions where the costs of reducing emissions are high to developing regions where the costs of reducing emissions are low. Shapley values are computed to determine the required size of side payments.

1. Introduction

There would be little dispute that the economic analysis of greenhouse policy response needs strengthening in at least two areas. The first area is the explicit treatment of the dynamics of the policy problem. Scientific estimates of the average length of life of carbon dioxide in the atmosphere range from 50 to 230 years (Lashof and Ahuja, 1990). Once the threshold level of greenhouse gases in the atmosphere is reached where climatic changes may occur, current emissions may have effects extending over a very long time span. Induced climatic changes may extend well beyond the length of life of the emissions in the atmosphere. While static policy analysis is a useful 'first-pass' at the problem, some important policy issues arise only in a dynamic context. These issues include the time profile of policy response and the appropriate level of discounting.

The second area where there is a need for strengthening of analysis is in the interdependence of the costs of policy response among countries. Many studies have been undertaken of the costs of reducing emissions in different countries suppressing international repercussions. However, if account is taken of changes in international trade and international capital movements, it is clear that the costs of reducing emissions in any country will depend on the greenhouse policy response of other countries. To induce a cooperative international response, some redistribution of wealth among countries may be required through side-payments. Such a redistribution of wealth through its international trade effects may further modify the costs of reducing emissions in different countries. A final area of interdependence is in greenhouse damage. Greenhouse damage in one country will have international trade repercussions that will affect assessments of the costs of damage in other countries.

A dynamic general equilibrium model of the world economy is required to address these issues. Several models of this type such as GCUBED (McKibbin and Wilcoxen 1992) are at various stages of development. ABARE is constructing such a model known as MEGABARE. MEGABARE will include a number of features such as induced technical change that are not present in other models. A building block for MEGABARE is the 37 sector 15 region general equilibrium international trade model known as GTAP (Hertel and Tsigas, 1993).

While general equilibrium models provide a useful tool for positive analysis, game theory is a useful tool for policy analysis. Static game theory has been widely applied to greenhouse policy issues on both a theoretical and empirical level (see Hoel 1991, Barrett 1992 and Hinchy, Thorpe and Fisher, 1993). A number of recent theoretical papers (Hoel 1990, Martin, Patrick and Tolwinski 1993 and Dockner and Long 1993) have illustrated how game theory can be extended to dynamic greenhouse policy issues. However, as far as the authors are aware, no dynamic game analysis of greenhouse policy issues based on actual model data has yet been attempted.

In this paper a dynamic game analysis is undertaken of greenhouse policy issues using data on the costs of reducing emissions generated from the GTAP model. The analysis is exploratory and the results at best are illustrative. Nevertheless, the analysis is useful in raising policy issues and suggesting directions for model development since a number of important issues emerge only when an attempt is made to assign numbers to parameter values.

The framework outlined in this paper can be used to address both the issues of dynamics and policy interdependence. In this paper the concern is solely with dynamics. The functions representing the costs of reducing emissions have been derived to suppress interdependence among countries. Such an analysis provides a baseline against which the effects of taking account of interdependence can be assessed. A future paper will report on the results of this analysis.

The paper is structured in the following way. A brief discussion of numerical analysis with dynamic games is first given. The method used to derive the functions representing the costs of reducing emissions and greenhouse damage functions is next discussed. A dynamic game analysis of policy response under both unilateral action and international cooperation is next presented. The policy and modelling implications of the results are discussed in the final section.

2. Numerical solution of dynamic games

An analytical solution for linear-quadratic games has been known for almost three decades. However, general solution methods for other types of dynamic games have not been developed in the intervening years and there are formidable difficulties.

In the linear-quadratic formulation, players are assumed to maximise temporal quadratic objective functions that may contain both state and control variables subject to a dynamic linear model that describes the evolution of the system over time. A solution to the game satisfies the familiar properties of a Nash equilibrium. No player can improve their welfare by changing variables under their control given the choice of control variables by other players. The solution algorithm used in this study is based on Kydland (1977).

There are some difficulties in expressing greenhouse policy problems in a linear-quadratic framework as will become evident. However, the gains from being able to express the problem in a dynamic games context appear to outweigh the limitations of the linear-quadratic framework.

In dynamic games, as in optimal control problems, there is a distinction between the *closed-loop* or *feedback* solution and the *open-loop* solution. The distinction is based on two features, namely the information structure and period of commitment. Under the *open-loop* solution, it is assumed that each player can observe only the initial values of state variables. Each player must commit to a strategy over the entire time horizon of the game on the basis of this information. Under the *feedback* solution, it is assumed that each player can observe the value of state variables in the current period. Each player is only committed to their strategy for the current period. Future strategy may be revised in the light of future information. The feedback solution is usually more plausible than the open-loop solution in economic applications and is the one used in this study.

The feedback solution satisfies the condition of *subgame perfectness*. This means that the optimal strategy for the whole game is the optimal strategy for any subgame starting at any arbitrary state and time period within the time horizon of the whole game. For example, the solution to the last period in the dynamic game is identical to that which would be obtained in treating the last period as a static game with initial conditions given by the values of the state variables at one period before the terminal period. To satisfy subgame perfectness, backward recursion techniques based on dynamic programming principles are used.

3. Derivation of welfare functions

In the theoretical papers treating the greenhouse problem as a dynamic game (Hoel 1990, Martin, Patrick and Tolwinski 1993 and Dockner and Long 1993), each country is assumed to maximise a net benefits function expressing the difference between benefits and costs of emissions. The benefits of emissions function is used to determine the costs of reducing emissions. The costs of emissions functions relates emissions to greenhouse damage.

The model structure used in this paper is similar to the above theoretical papers. The dynamics in the model come from the relationship between emissions and greenhouse damage. Benefits of emissions functions used for each country are not dynamic. It is assumed that the same benefits-emissions relationship holds at each period of time. Past actions have no influence on the current relationship between benefits and emissions. The derivation of the benefits and damages functions will be described in turn.

3.1 The relationship between income and emissions

The quadratic relationship between income (gross national product) and carbon dioxide emissions for each country was derived using the GTAP model. Data used relate to 1990. The basic approach described in appendix A was to apply a sequence of shocks corresponding to different levels of carbon dioxide emissions to the energy sector in each country. A closure of the model was determined that minimised the international trade spill-overs of these shocks. Using the modelled results of these shocks, a scatter of points relating gross national product to emissions for each country was produced.

A quadratic relationship was then fitted to the scatter of points for each country using ordinary least squares. The relationship was constrained so that the base-period level of emissions and gross national product in each country corresponded to the maximum point of the estimated relationship. Such a constraint corresponds to the assumption that the base-period observation represents maximising behaviour for each country. It also assists in developing the baseline for the dynamic game analysis. Imposing such a constraint results in a constant term in the quadratic relationship.

For all but one region, the quadratic relationship gave a reasonable fit to the data with the estimated coefficients having the expected sign. Nevertheless, the bunching of positive and negative residuals suggested that the quadratic may not be the most appropriate functional form. Indonesia was the one region where there was little evidence of a systematic relationship between emissions and gross national product. The estimated coefficients actually had perverse signs. A study of the results suggested that the problem lay in an interaction between the high energy intensity of Indonesian exports and the model closure used to minimise international trade repercussions. Given the computational burden in deriving these results and the illustrative nature of the paper, rather than experiment with alternative closures a benefits function for Indonesia was simply assumed.

The base case for the dynamic games analysis was taken to be the situation where all countries chose their emission levels as if there was no greenhouse damage. It will be recalled that it was assumed that the base period level of emissions and gross national product maximised the quadratic relationship between these two variables. Thus, in the absence of greenhouse damage, countries would simply choose their base period emissions indefinitely into the future.

3.2 Damages functions

In the standard theoretical formulation, greenhouse damage is modelled as a function of the stock of gases in the atmosphere. The sum of emissions from all countries adds to the stock of gases. The control variable for each country is its level of emissions.

There are some difficulties when numbers are applied to this approach. The effect of annual emissions from each country on the stock of gases is so small that implausibly high damage has to be assumed to create an incentive to cut emissions. For example, under some widely used assumptions about conversion rates (see Thorpe, Sterland, Jones, Wallace and Pugsley 1991) annual carbon emissions in 1990 would have increased the global concentration of carbon dioxide by only about 0.4 per cent (World Resources Institute, 1992). As a result of this leverage problem, it is very difficult to choose parameter values that do not result in either an extreme or little policy response. Policy becomes reactive only when implausibly high damage is assumed.

It is probably more reasonable to assume that there is some threshold concentration of carbon dioxide in the atmoshphere beyond which greenhouse damage will occur. Direct modelling of a threshold effect would give rise to an inequality constraint that cannot be handled in a linear-quadratic framework. However, if it were assumed that the threshold level had just been reached, damage could be modelled as a function of subsequent cumulative emissions. This was the approach adopted. Thus, damage was taken to be a quadratic function of cumulative emissions from the base period onwards.

The model was calibrated to yield the same percentage loss in gross national product for all countries at the base period level of world emissions. Many qualifications need to be attached to expressing greenhouse damage as a common percentage of gross national product, but it is a useful first approximation given the current state of information (for further discussion see Hinchy, Thorpe and Fisher 1993). The specific value of the base period percentage loss in gross national product for all countries was set equal to 0.06 of 1 per cent. Such a factor was chosen to ensure that emissions remained non-negative over a reasonable time horizon in the dynamic game simulations. If a factor much larger than 0.06 were chosen, it was found that negative emissions tended to result under some cooperative game simulations. A non-negativity constraint cannot be enforced in the linear-quadratic framework.

Negative emissions in themselves do not create conceptual problems. If enough effort were put into creating sinks, absorption from the atmosphere could exceed emissions. Since the net effect would be to reduce the atmospheric concentration of carbon dioxide, it would be appropriate to model the outcome as negative emissions. However, activity to extend sinks is not included in the present model. Negative emissions in the present model imply negative economic activity and negative gross national product. Mathematically, negative current emissions may represent the optimal solution to a dynamic game problem. The immediate loss in gross national product could be more than offset by reduced greenhouse damage over the time horizon of the game. However, negative emissions are not economically plausible in the current model.

Expressing greenhouse damage as a function of cumulative emissions creates difficulties for the steady state properties of the model. In numerical work with optimal control and dynamic game models, the time horizon is often chosen to be long enough to ensure that the model converges to a steady state. In such a case, optimal current policy becomes invariant to any further lengthening of the time horizon. In a model with cumulative emissions as the state variable, one possible steady state would be if cumulative emissions ceased to grow. However, such a state could be attained only if emissions tended to zero which would imply zero economic activity given the model formulation. A further difficulty is that for a sufficient lengthening of the time horizon without discounting, negative current emissions may become increasingly attractive. Lower cumulative damage from the reduced stock of gases may eventually offset immediate losses from negative emissions.

A possible solution would be to take account of decay over time in the damage arising from current emissions. If account were taken of decay, it would be possible to have a steady state with positive current emissions and stable cumulative emissions. However, as noted above, scientific estimates of the average life of carbon dioxide in the atmosphere range from 50 to 230 years. Furthermore, damage from emissions may persist beyond the average life of the gas in the atmosphere. Even if the rate of decay was taken to be at the lower end of the estimates of the average life of the gas, any convergence to a steady state would be slow. Furthermore, the problem of the increasing attractiveness of negative current emissions as the time horizon lengthens would remain.

After experimenting with various decay rates which confirmed that if there was any convergence to a steady state it would be extremely slow, it was decided to remain with the simpler formulation of damage as a function of non-decaying cumulative emissions. Although simulations were run with this formulation to as many as 1000 periods, there was no sign of convergence to a steady state. For some issues that are sensitive to the actual value of variables, results over different time horizons are reported. For some less sensitive issues, a time horizon of 20 periods seemed adequate.

It would be expected that a slow rate of convergence to a steady state will be a common problem in optimal control and dynamic games work on the greenhouse problem. Such an outcome appears inevitable given the long-lived dynamics.

To summarise, in the dynamic game analysis each country $(i=1,...,n)$ was assumed to choose their own level of emissions, e_i, to maximise a welfare function of the form

$$\sum_{t=1}^{T}(k_i + a_i e_{it} + b_i e_{it}^2 - c_i s_t^2)$$

subject to

$$s_t = s_{t-1} + \sum_{i=1}^{n} e_{it}$$

where s_t is the cumulative stock of emissions, a_i, b_i and c_i are parameters, k_i is a constant and T represents terminal time.

4. Dynamic game results

4.1 Unilateral action

In the first set of simulations, various aspects of unilateral action are considered. Unilateral action was modelled as the Nash equilibrium to the dynamic game where all countries independently maximise their own level of net benefits.

The first issues of concern are the aggregate level of emission reduction and its relative distribution among countries. For this purpose, the model was run over 20 time periods under the assumption of no discounting of future relative to current net benefits yielding the results shown in table1. Emission reduction is measured from a baseline of emissions that would result under the assumption of no greenhouse damage. It will be recalled that under the baseline, countries repeat their base period emissions indefinitely into the future. The share of each region in world carbon dioxide emissions in 1990 is shown in the first column to indicate the contribution of each region to the total reduction in world emissions.

Under unilateral action there would be a 2.2 per cent reduction in cumulative world emissions over the 20 periods. This result is dominated by the level of emission reduction in the Rest of the World and the United States which together account for about two-thirds of world emissions. Both of these regions undertake a greater percentage reduction in emissions than the world average while other regions undertake less than the world average. Larger regions tend to undertake a greater percentage reduction in emissions than smaller regions.

The level of emission reduction for the world is likely to be overstated by the aggregation of independent countries into the Rest of the World which is responsible for 44 per cent of world emissions. The Rest of the World includes the former Soviet Union, Eastern Europe, major Middle East oil producing countries, Africa and South America. In calculating its optimal emissions, the Rest of the World in effect acts as a coalition and takes account of the damage its total emissions create for all members in the group. If the decision making unit were the individual country, each country would not be concerned with the damage its emissions inflict on other group members. Thus, a lower level of emission reduction would tend to result if the Rest of the World were broken up into its member countries.

The relative intensity of emission reduction by a country will depend on both the marginal costs and cumulative marginal benefits of emission reduction over the 20 period time horizon. It will be recalled that the benefits of emission function for each country was calibrated to be at a maximum at the initial level of emissions and gross national product. Thus, the marginal costs of reducing emissions are zero at this initial level. However, the relative marginal costs of reducing emissions can be calculated at some other level of emissions, such as a 10 per cent cut in initial emissions. The results of such a calculation are shown in table 2.

The relative regional ranking of marginal costs of reducing emissions is somewhat similar to those in Hinchy, Thorpe and Fisher (1993). This lends some plausibility to the results since quite different methodologies were used in the two studies. Marginal costs of reducing emissions tend to be lower in developing than developed countries with the United States having the lowest marginal costs of reducing emissions of the developed countries. It is widely believed that sustained policies of low energy prices in the United States have not encouraged a high level of efficiency in energy use. Marginal costs of reducing emissions are high in Australia reflecting the heavy dependence on fossil fuels and limited substitution possibilities. High marginal costs of reducing emissions in Japan are consistent with the view that a high level of energy efficiency has been achieved.

The marginal benefits of reducing emissions, as evaluated in calculating the Nash equilibrium level of emissions, will increase with the level of emissions of a country. Since the benefits of reducing emissions is an increasing function of the stock of emissions, the more a country adds to the stock of emissions, the higher the marginal benefit of reducing its own emissions. The marginal benefits of reducing emissions will also be an increasing function of the level of gross national product given the calibration of the damages function for each country to yield a loss of 0.06 per cent of gross national product at the initial level of world emissions.

The largest level of emission reduction occurs in the Rest of the World where the marginal benefits of reducing emissions are high due to the initial size of emissions and the absolute size of gross national product as well as the low marginal costs of reducing emissions. A high level of reducing emission occurs in the United States for similar reasons. A relatively low level of emission reduction occurs from smaller developing countries even though their marginal costs of emission reduction are low. This is because both the initial level of emissions and gross national product for these countries is low.

Discounting

In economic problems involving time it is standard to assume that discounting occurs. In the case of major environmental problems, such as the greenhouse issue, the use of discounting raises rather complex problems. Current generations may shift major costs onto unborn generations. There is an extensive literature on these problems centred on the so-called 'overlapping generations' model.

Without taking a position on the appropriateness of discounting or the choice of a discount rate, it is of interest to see how discounting modifies the results. A dynamic game simulation was run over 20 periods assuming all countries used a discount rate of 10 per cent. There are two distinctive features of the results. First, as would be expected, the overall level of emission reduction is lower since countries discount the net benefits of future emission reductions. Only a 0.29 per cent reduction in global emissions is achieved compared with the 2.21 per cent reduction without discounting.

The second distinctive feature of the results is the change in the time path of reducing emissions, at least for the larger emitters where the change is most evident. Such a result is consistent with the effect of discounting in giving greater weight to more immediate relative to more distant net benefits. There is a forward shifting of the benefits of emissions and a backward shifting of the costs of reducing greenhouse damage. A higher level of greenhouse damage (in undiscounted terms) occurs in the future due to the lower level of emission reduction. Similar results are evident even more strongly as the time horizon is extended.

Some difference in discount rates between developed and developing countries might be expected. With lower per person incomes, developing countries may be less willing to sacrifice the benefits of current emissions for reduced future greenhouse damage. Regions 1 to 7 in table 2 were classified as developed and assigned a discount rate of 10 per cent. Regions 8 to 15 were classified as developing and a discount rate of 20 per cent was assumed. The dynamic game algorithm was run over a 20 period time horizon. The results were not surprising. The overall cut in global emissions was further reduced to 0.24 per cent on the base case. Developing regions undertook less emission reduction than in the previous case with uniform discount rates. There was no change in reducing emissions by developed regions. There was some forward shifting of the period of maximum emissions for the developing regions. The higher discount rate was sufficient to shift the period of maximum emission reduction from the base to the terminal period.

4.2 Cooperation

In this section the potential gains from international cooperation as opposed to unilateral action in reducing carbon dioxide emissions are examined. There are two potential sources of gain from cooperation. First, the damage each country inflicts on other countries would be taken into account in determining the optimal level of emissions for each country. Secondly, differences in the marginal costs of reducing emissions across countries would be taken into account in minimising the costs of reducing emissions.

The global welfare function was taken to be the sum of the welfare functions for the individual countries. Although the problem of determining the optimal level of global emissions is an optimal control problem, it can be solved using the dynamic game algorithm. It was assumed that each country chose its emissions to maximise the global welfare function.

The first run was over a 20 period time horizon and involved no discounting. Results on the percentage reduction in emissions are shown in table 3. As expected there are potentially significant gains from international cooperation. There is almost a 7 fold increase in the level of global emission reduction that would result compared with unilateral action. Such a result almost certainly understates the increase in reducing emissions from cooperative action. It will be recalled that emission reduction under unilateral action is probably overstated by grouping a number of independent countries into the Rest of the World region that is responsible for 44 per cent of world emissions.

If cooperation is to be preferred to unilateral action, there would need to be significant gains. Regions could temporarily gain from violating the cooperative solution. Thus, the gains from cooperation need to be sufficient to cover the associated enforcement costs.

A second feature of table 3 is that there are quite marked changes in the distribution of emission reduction among regions compared with unilateral action. In particular, there is an increase in emission reduction in developing relative to the larger developed regions with the sharpest increase in China. These changes in the regional pattern of reducing emissions are brought out more clearly in table 4 which shows the contribution of each region to the global reduction in emissions.

Under cooperation, since the global benefits of reducing emissions are taken into account, the optimal distribution of reducing emissions across regions is not influenced by regional differences in cumulative marginal benefits. The optimal distribution is determined solely by the relative marginal costs of reducing emissions. In the absence of corner solutions, the cost minimising allocation would equalise the marginal costs of reducing emissions across regions. Thus, regions with the lower marginal costs of reducing emissions would undertake the heavier reductions in emissions.

The impact on the cooperative solution of lengthening the time horizon and introducing discounting was broadly similar to the results discussed under unilateral action. The results will not be reported in detail. One exception was that lengthening the time horizon without discounting did not change the shape of the time path of emissions in the same way as under unilateral action. However, negative emissions from some regions emerged as the time horizon was lengthened which is likely to have affected the results. Negative emissions did not emerge when discounting was introduced and the shape of the time path of emissions was similar to that under unilateral action with discounting.

Since developing regions would bear an increasing burden in reducing emissions under cooperation, there is particular interest in seeing how this result would be modified if developing regions applied a higher discount rate than applied in developed regions. On theoretical grounds it can be shown that such a difference in discount rates will result in both less emission reducing by developing regions and more emission reducing by developed regions. The higher discount rate for developing regions can be thought of as equivalent to an increase in the marginal costs of reducing emissions since it results in less emission reduction. Since the cooperative solution equalises marginal costs of reducing emissions across regions, there must be an increase in emission reduction by developed regions to maintain this equality. Under unilateral action an increase in the discount rate of developing regions had no effect on the level of emission reduction by developed regions. However, this is no longer the case when there is cooperation and emissions by both groups of regions will be affected.

The same classification of developed and developing regions as previously described was used assuming discount rates of 10 per cent and 20 per cent, respectively. The results for equal discount rates were identical to those obtained under the assumption of no discounting. The difference in discount rates resulted in a shift in the burden of reducing emissions away from developing regions toward developed regions. Nevertheless, at least for the difference in discount rates considered, developing regions still made a greater relative contribution to reducing emissions than they would under unilateral action.

Finally, it is of interest to note that in line with the results for unilateral action, the introduction of discounting greatly reduces the cumulative reduction in emissions. In the absence of discounting there would be an almost 15 per cent reduction on cumulative baseline emissions but this becomes a 2.2 per cent reduction when there are equal discount rates of 10 per cent and a 1.7 per cent reduction when discount rates differ as specified.

Cooperative mechanisms

The cooperative solution maximises the sum of the welfare functions of the individual countries and achieves a higher level of global welfare than unilateral action. However, all countries may not be better off compared with unilateral action if they are restricted to the net benefits they actually receive under the cooperative solution. Nevertheless, it will be possible to re-distribute the gains from cooperative action through side payments in such a way as to make all countries better off.

The payoff (the value of the welfare function) to each country under unilateral action and the payoff they actually receive under cooperation were computed over a 20 period time horizon without discounting. All countries, apart from China and Indonesia, actually receive (without side payments) a better return under cooperation than from unilateral action. As previously noted, the data for Indonesia should be treated with care. However, the position of China is consistent with the findings in Hinchy, Thorpe and Fisher 1993. China would play a major role in reducing world emissions but would require significant side payments to be induced to play this role.

Although other developing countries play a greater role in reducing emissions under cooperation than unilateral action, they experience less greenhouse damage due to the higher level of global emission reduction. Thus, these countries actually do better under cooperation than unilateral action.

A basic issue is how the gains from cooperation should be shared to induce all countries to join together in a coalition. For countries to be induced to join the grand coalition, they would have to be offered a superior payoff to that which could be obtained from membership of any other partial coalition of countries including unilateral action as a special case. This problem has been extensively studied in cooperative game theory and a number of solution concepts have been proposed. The Shapley value is the most widely used solution concept and is the one used in this study.

The Shapley value assigns to each player the average of the gain the player creates for each coalition of which the player can be a member. It is an extremely simple solution concept in spite of the apparent complexity of the formula. In the case of a two player game, each player receives one-half of the gain from forming the 2 player coalition irrespective of the return either player could obtain by acting independently. More generally, if there are n players, each player receives $1/n$ of the marginal gain from creating the n-player coalition. The Shapley value has some intuitive appeal since equal division rules may represent a type of 'focal point'. In spite of its equal division properties, the Shapley value is successful at assigning more to more powerful players (in the sense of a player who can obtain a larger payoff from independent action). On average 'strong' players are able to form more coalitions with high marginal gains than 'weak' players.

To compute the Shapley value, the payoff to $2^n - 1$ possible coalitions has to be considered. In the present study, with $n = 15$, $2^n - 1 = 32768$. Given the illustrative nature of the calculation, to reduce computation the analysis was restricted to the 7 largest carbon dioxide emitting regions which were responsible for 97.2 per cent of world carbon dioxide emissions in 1990. In computing the payoff to all possible coalitions of the 7 regions, it was assumed that the specified coalition maximised its collective net benefits against the excluded regions which in turn independently maximised their net benefits against the coalition. The payoffs were computed at the Nash equilibrium to the resulting dynamic game over a 20 period time horizon assuming no discounting.

The results obtained are shown in table 5. The exclusion of a number of developing regions from the game with low costs of reducing emissions resulted in the Rest of the World playing a more significant role in reducing emissions. It would now do slightly worse under cooperative action than unilateral action and would require a side payment from other regions to be induced to enter into the grand coalition. Nevertheless, China still plays the major role in reducing world emissions and under the Shapley value allocation would receive a large side payment mainly financed by the EC, the United States and Japan.

The Shapley value allocation to a region will depend on both the contribution of the region to reducing emissions and the benefits the region receives from reduced emissions in various possible coalitions. Thus, in the EC and Japan where the marginal costs of reducing emissions are high, neither region makes a major contribution to reducing emissions. However, both regions receive major benefits from reduced emissions according to the model and can afford to make significant side payments to other regions where the marginal costs of reducing emissions are lower. In contrast, the United States makes a relative greater contribution to reducing emissions due to its lower marginal costs and as a result of the costs incurred can afford relatively smaller side payments. There is a similar contrast between Australia and Canada. Canada has the lower marginal costs and reduces emissions more whereas Australia makes the larger side payments to other lower cost regions.

An unfortunate property of the Shapley value is that there is no guarantee that it will lie within the *core*. The *core* is the set of inequality constraints that must be satisfied if the allocation to each player in the grand coalition is to yield a superior payoff to that which could be obtained from membership of any other possible coalition. If the Shapley value does not lie within the core, at least one region could always do better through membership of some partial coalition. However, in the present case the Shapley value does lie within the core.

For simplicity, the above analysis has been based on the payoff to each region over the entire 20 period time horizon. If a system of international cooperation with side payments were to be introduced, side payments presumably would be made on a periodic rather than a 'one-off' basis. Under a more realistic base case scenario with differences in regional growth rates in emissions, the relative level and even direction of required side payments may change over time. Shapley value allocations at the required points of time could be computed as a guide to negotiations.

There has been some discussion of the possibility that countries may attempt to extract a bargaining advantage by deferring joining the grand coalition. However, regardless of bargaining advantage, there will always be an incentive to defer joining to 'free ride' on the reduced emissions of other countries that may enter into a coalition. Given the nature of the free-riding problem, it would seem desirable to try to design an incentive structure to make all major carbon dioxide emitters simultaneosly join the coalition. Developed countries may be prepared to tolerate some free-riding by smaller developed countries.

5. Policy implications on the choice of instruments

A central result of the paper is that the optimal emission reduction strategy for a country will vary with time whether under unilateral or cooperative action and regardless of the level of discounting. Such a result was derived using a baseline where countries would indefinitely repeat their base period emissions into the future in the absence of greenhouse damage. Such a result would be expected to hold even more strongly under the more realistic baseline of country differences in exponential growth rates in emissions. Under some model formulations, eventually there may be convergence to a steady state. However, given the long lived nature of greenhouse dynamics, such convergence would be slow. Thus, optimal policy would be expected to be time varying for the immediate future under a wide range of model formulations.

The time varying nature of optimal policy has a bearing on the choice of policy instruments. The standard discussion of the optimal choice of instruments under uncertainty in a static setting is based on Weitzman (1974). It is shown that if the damages curve is more steeply sloped than the cost of reducing emissions curve, there is a premium on achieving the optimum quantity. A small error in a price control (such as an emission tax) can produce large differences in damages. If there is a threshold level of greenhouse gas emissions beyond which damage will occur, the damages curve may well be more steeply sloped than the cost curve. Since there would be uncertainty about the tax rate required to achieve a given quantity target, some experimentation would be needed and there is a high probability of error in setting the price control. In such a case quantity controls (such as a tradable permits scheme) would be preferred over price controls.

The time varying nature of optimal policy would seem to strengthen the case for quantity controls. If experimentation would be needed to determine the tax rate required to achieve a given quantity target, the probability of errors in setting the price control would tend to increase if the quantity target were moving.

Some other time related issues also seem to favour a tradable permits scheme. The enhanced greenhouse effect creates major risks over time. In particular, investors in emission producing activities and investors in emission reducing technology will be concerned with the future costs of policies applying to emissions. A futures market based on emission permits provides a way of efficiently spreading these risks (see Hinchy, Thorpe and Fisher 1993). Investors would be able to hedge the risks of uncertainty about future policies through futures trading. Emission taxes and a tradable permits scheme theoretically can achieve the same effects in a world of certainty. However, if there is uncertainty, an emission tax scheme cannot efficiently spread risks as would a futures market based on a tradable permits scheme.

A tradable permits scheme could be operated to effect the side payments required to achieve international cooperation. Developing regions requiring side payments would be allocated permits surplus to their requirements. Developed regions required to make side payments would be given less than their desired allocation of permits. The purchase of permits by developed from developing regions would effect the required side payments.

To maximise the chances the permit market was competitive, in the scheme discussed in Hinchy, Thorpe and Fisher (1993), it envisaged that there would be direct trading in permits between major emission sources within and across countries such as electricity generators and smelters. However, for dispersed emission sources such as motor vehicles, transactions costs would probably be lower if governments made the initial purchase of permits. The costs of such purchases could be financed by taxes on motor vehicle users. These taxes would have to be set at such a level to attempt to ensure that aggregate motor vehicles emissions complied with the permits held. Taxes could be used in conjunction with other policies such as emission standards to attempt to achieve compliance. It may be that the problem of uncertainty about appropriate tax rates is present to some extent when the practical details of a tradable permits scheme are considered. Nevertheless, the problem is not of the same magnitude as if there were total reliance on emission taxes.

6. Conclusions

In this paper, the enhanced greenhouse effect has been considered from a dynamic game perspective. Numerical results were derived using estimates of the costs of reducing emissions developed from the GTAP model.

Greenhouse dynamics will typically be long-lived. Optimal policy under a wide variety of formulations will be time varying. Discount rates applied will have a significant bearing on the speed in reducing emissions.

There appear to be potentially major gains from international cooperation over unilateral action. Under cooperation large cost savings could be achieved by placing greater weight on emission reduction in developing regions such as China where the marginal costs of reducing emissions appear to be low. However, significant side payments from developed regions would be required to induce developing regions to play this role.

The framework developed in this paper is able to handle both dynamics and policy interdependence. In future work it is intended to explore more fully policy interdependence in the costs of reducing emissions. Such interdependence arises through international trade linkages.

Appendix A: Fitting quadratic functions to the GTAP simulation results on emission reduction

Reductions in energy use from 1 per cent to 10 per cent, in steps of 1 per cent, were simulated for each of the 15 countries in the model, the other countries holding energy use constant. So as not to advantage imports of energy over domestically produced energy, taxes were applied to reduce usage of both by 10 per cent in the emission reducing country, or to hold both constant in the other 14 countries. Further, in the emission reducing country the export of energy which was now no longer required domestically was constrained to remain constant by the application of an export tax. This latter aspect of the closure was chosen so as to minimise the international trade spillovers of the emissions reductions, as it was desired to estimate unilateral cost functions.

For the analysis, the 37 sectors in GTAP were aggregated into 5 sectors as shown in table 6. Data on global carbon dioxide emissions (World Resources Institute, 1992) in 1990 were combined with the GTAP database which also relates to 1990.

Table 1 Percentage reduction in cumulative emissions under unilateral action relative to baseline of no emission reduction over 20 time periods

Country	Share of world emissions in 1990 (a) per cent	Reduction in cumulative emissions per cent
Australia	1.2	0.01
New Zealand	0.1	0.02
Canada	2.1	0.38
United States	22.3	2.86
Japan	4.8	0.32
Korea	1.0	0.06
EC	11.8	1.17
Indonesia	0.6	0.19
Malaysia	0.2	0.03
Phillipines	0.2	0.04
Thailand	0.4	0.10
China	10.9	0.90
Hong Kong	0.1	0.01
Taiwan	0.3	0.02
Rest of World	44.1	2.97
WORLD	100	2.21

(a) Source: World Resources Institute, 1992.

Table 2 Estimated marginal costs of reducing emissions evaluated at 10 per cent below base period emissions

Country	Marginal costs of reducing emissions ($USm per '000 tonnes of carbon dioxide emissions)
Australia	2.34
New Zealand	0.18
Canada	0.11
United States	0.14
Japan	0.59
Korea	0.25
EC	0.37
Indonesia	0.04
Malaysia	0.14
Phillipines	0.10
Thailand	0.06
China	0.23
Hong Kong	0.80
Taiwan	0.65
Rest of World	0.11

Table 3 **Percentage reduction in cumulative emissions under cooperation relative to baseline of no emission reduction over 20 time periods**

Country	Share of world emissions 1990 (a) per cent	Reduction in cumulative emissions per cent
Australia	1.2	0.57
New Zealand	0.1	7.24
Canada	2.1	11.60
United States	22.3	9.48
Japan	4.8	2.25
Korea	1.0	5.34
EC	11.8	3.61
Indonesia	0.6	31.93
Malaysia	0.2	9.29
Phillipines	0.2	12.84
Thailand	0.4	12.86
China	10.9	57.43
Hong Kong	0.1	1.65
Taiwan	0.3	2.04
Rest of World	44.1	11.61
WORLD	100	14.68

(a) Source: World Resources Institute, 1992.

Table 4 **Percentage contribution to cumulative emission reduction under unilateral action and cooperation over 20 time periods**

Country	Unilateral action per cent	Cooperation per cent
Australia	0.01	0.05
New Zealand	0.00	0.06
Canada	0.36	1.65
United States	28.81	14.37
Japan	0.79	0.73
Korea	0.03	0.37
EC	6.23	2.90
Indonesia	0.05	1.37
Malaysia	0.00	0.14
Phillipines	0.00	0.16
Thailand	0.02	0.55
China	4.45	42.76
Hong Kong	0.00	0.01
Taiwan	0.00	0.04
Rest of World	59.22	34.84
WORLD	100.00	100.00

Table 5 Payoff to regions under various arrangments $US(1990)'0,000m (a)

Country	Unilateral	Cooperative	Shapley	Side payment to achieve Shapley allocation
Australia	5078	5179	5114	-64
US	90310	91654	90976	-679
Japan	48870	49840	49213	-626
EC	97007	98887	97664	-1223
Canada	9888	10025	9981	-45
China	4700	3149	5384	2234
ROW	75994	76305	76705	400
WORLD(b)	331848	335040	335040	0

(a) Totals may not add due to rounding. (b) Sum for 7 regions.

Table 6 Concordance between 5 sector and 37 sector versions of GTAP

GTAP Commodity	Mnemonic	Aggregated Commodity
Paddy rice	PDR	Agriculture
Wheat	WHT	Agriculture
Other grains	GRO	Agriculture
Non-grain crops	NGC	Agriculture
Wool	WOL	Agriculture
Other livestock products	OLP	Agriculture
Forestry	FOR	Agriculture
Fishing	FSH	Agriculture
Coal	COL	Energy
Oil	OIL	Energy
Gas	GAS	Energy
Other minerals	OMN	Energy intensive processing
Processed rice	PCR	Agriculture
Meat products	MET	Agriculture
Milk products	MIL	Agriculture
Other food products	OFP	Agriculture
Beverages and tobacco	B&T	Agriculture
Textiles	TEX	Manufacturing
Wearing apparel	WAP	Manufacturing
Leather, fur and their products	LEA	Manufacturing
Lumber and wood products	LUM	Agriculture
Pulp, paper and paper products	PPP	Manufacturing
Petroleum and coal products	P&C	Energy
Chemicals, plastics and rubber	CRP	Energy intensive processing
Non-metallic mineral products	NMM	Energy intensive processing
Primary iron and steel	I&S	Energy intensive processing
Primary non-ferrous metals	NFM	Energy intensive processing
Fabricated metal products	FMP	Manufacturing
Transport equipment	TRN	Manufacturing
Other machinery and equipment	OME	Manufacturing
Other manufacturing	OMF	Manufacturing
Electricity, gas and water	EGW	Energy
Construction	CON	Services
Trade and transport	T&T	Services
Other services private	OSP	Services
Other services government	OSG	Services
Ownership of dwellings	OOD	Services

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TRADEABLE PERMITS: PRACTICAL LESSONS FROM THE U.S. EXPERIENCE

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Abstract: The United States has accumulated considerable experience in the design and implementation of tradeable permits and other types of emissions trading schemes to address air pollution problems. This paper overviews the progress of trading programs in the U.S. and draws some lessons the author believes have relevance to the design of tradeable permits approaches to reducing greenhouse gas emissions.

1. Introduction

The prospect of significant climate change on a global scale presents perhaps the most difficult, yet critical environmental protection challenge in the world today. Clearly, doubts persist in many quarters about the scientific underpinnings behind calls for massive national and international campaigns to reduce greenhouse gas emissions. The economic dislocations that will result from taking aggressive action make it important that considerable resources be devoted to improving our understanding of global climatic processes and the impacts of human activities on those processes. In the meantime, however, failure to act precautiously would appear to be foolhardy in light of the potentially great, perhaps irreversible, consequences of global warming.

Global warming presents an especially promising context for the use of policy instruments that can deliver results most cost-effectively. If we choose to act in the face of uncertainty, and if our actions can impose significant economic dislocations, we should emphasize those effective actions that are most economically prudent. With this in mind, there has been considerable interest expressed in the use of economic incentive- or market-based instruments, both at the national and international levels, including international tradeable permit schemes. Various other forms of Joint Implementation (JI) also are being examined.

The many advantages of JI are articulated in the U.S. Climate Change Action Plan announced by President Clinton in October of last year. The plan points out that JI potentially could achieve greater emission reductions than would be achieved by countries pursuing solely domestic strategies, and that these reductions could be more cost-effective. In addition, the plan highlights the technology transfer and export promotion benefits that JI might provide. At the same time, the Climate Change Action Plan identifies a series of "significant questions" that must be addressed in evaluating the feasibility of JI, including whether JI approaches promise real emission reductions, how to measure and track the net reductions achieved, how to ensure that reductions in one location are not matched by increases elsewhere, and how to ensure that emission reductions are not lost or reversed over time. The plan establishes the U.S. Initiative on Joint Implementation as a pilot project effort to establish an empirical basis for judging the utility of JI. (Clinton)

The emphasis on cost-effectiveness is also reflected in a separate U.S. initiative, the President's Council on Sustainable Development (PCSD). The PCSD is the principal U.S. effort to bring domestic economic and environmental policymaking into a complementary relationship. The formation of the PCSD, which is comprised of leaders from government, private companies, and non-governmental organizations, complements United Nations-sponsored and other international sustainable development efforts. A major focus of PCSD activity over the next 18 months will be the development of policy recommendations to the President on how the U.S. can increase the use of market-based policy instruments in all layers of environmental decision-making. "Getting the prices right" and utilizing the market itself to correct for market failures is seen as a key strategy for operationalizing the concept of sustainable development.

This paper focuses on key aspects of tradeable permit and related trading strategies as they have been applied in air quality management programs developed in the U.S. As background for that discussion, the paper first briefly overviews the principal applications of trading programs in the U.S., tracing the evolution in the concept as experience accumulated over time. Finally, the paper briefly identifies and discusses a series of "lessons learned" in that evolutionary process that may have applicability to the use of tradeable permits to reduce global greenhouse gas emissions.

2. Overview of Trading Instruments in the U.S. Air Quality Management

Market-based environmental policy approaches have found more frequent application in the U.S. than in any other country. And within the U.S., economic incentives -- principally in the form of trading programs -- have been applied to air quality management problems more than in any other context.[1] The first application of trading approaches to air pollution in the U.S. was the so-called "offset" program developed in 1976 to reduce the potential conflict between economic growth and air quality improvement in areas of the U.S. that did not meet the national, health-based ambient air quality standards. The offset program allows new facilities to locate, and existing facilities to modify, in these nonattainment areas by securing equal or greater emission reductions from other sources to offset potential increases associated with the new project. Under the 1990 Clean Air Act Amendments, the worse the air quality in such areas, the higher the offset ratio. According to a 1992 EPA review, approximately 2,500 offset trades have occurred, ten percent of which involved trading between two companies. (Carlin)

EPA added an additional tool with the development in 1979 of the "bubble" policy for existing stationary sources. Under this policy, within defined conditions and limits, sources can meet their emission limitations by treating multiple emission points as if they were subject to a single, overall limitation. It is as if a set of sources were enclosed in a bubble, and all that EPA cared about was the total level of pollution emerging from the bubble, not the contribution of the individual sources within the bubble. The Agency's bubble policy is summarized in the 1986 Emissions Trading Policy Statement. (USEPA) In part because of the complexities involved in developing EPA-approvable bubbles, there has been much less use of this tool than of offsets. It is also significant that offsets are mandatory as a condition of permit approval for new projects in nonattainment areas, whereas bubbles are an optional tool available to sources.

Another approach available to new sources is "netting." This tool allows sources undergoing modification to avoid potentially burdensome permitting requirements by reducing emissions from other points in their facility so that there is no net emissions increase. Netting is the most widely used form of emissions trading in the U.S.

Another important addition to the U.S. emissions trading ensemble is "banking," through which emissions reduction credits (ERCs), the currency of trading, can be stored for future use by a source or for trading to another source. Although few states have established banking programs in the past, a number of states are now developing or considering banking under the newly- amended Clean Air Act.

An increasingly used variety of economic incentive in U.S. clean air regulations is "emissions averaging." Averaging approaches can be used by sources in many different contexts. In some cases, sources can change their compliance time-frame by averaging their emissions over a longer period. In other cases, sources are allowed to average emissions across multiple emission points. Under a newly-proposed air toxics rule covering the synthetic organic chemical industry, sources will be able to average emissions of multiple different hazardous air pollutants. Averaging has also been applied in the amended Act as a means of complying with various mobile source requirements, including certain fuel specifications.

The use of emissions trading, banking, and averaging is expected to grow substantially in the years ahead as implementation of the Clean Air Act Amendments of 1990 (CAAA) gains

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1 A detailed survey of specific applications is not possible here. See Carlin, Alan, *The United States Experience With Economic Incentives to Control Environmental Pollution,* U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation, Publication No. 230-R-92-001, July 1992.

momentum. The Agency currently is finalizing its Economic Incentives Program rule that, together with guidance documents on various specific permutations of trading, will establish the "rules of the road" for developing trading programs, emission fee schemes, and other incentive strategies. The CAAA in fact mandate the development of such strategies in jurisdictions that do not meet certain air quality progress requirements for carbon monoxide and ozone.

3. Market-Based Approaches Get a Bad Name

Despite the manifest success of netting and offsets as early applications of market-based approaches to air pollution problems, the experience of the "bubble" policy until recently dominated debate about the success or failure of such approaches in the U.S. The experience with bubbles was marred by "paper trades" (defined below) and other problems that convinced many at EPA and within the environmental community that economic instruments were fundamentally flawed.

In fact what was flawed was both the then current generation of bubble proposals and the underlying command-and-control system onto which they were grafted. The latter point is important and somewhat subtle. Many 1970s and early 1980s treatments of how emissions trading might work were written by academic economists and focused on the theoretically elegant solution that trading could provide. These theories have a prima facie appeal that did not stand up to the "rough-and-tumble" reality of implementation.

The specific rocks on which these theories foundered were the state implementation plans (or "SIPs") that are the mechanism by which states in the U.S. implement the Clean Air Act. A collection of emission inventories, monitoring and modelling results, and emission control regulations, the SIPs are the cornerstone of the process for improving air quality in areas that violate the national ambient standards. SIPs have been developed by resource-strapped state agencies operating between conflicting pressures -- federal pressure to attain the national ambient air quality standards and state political pressure not to be so stringent as to disadvantage businesses in the state relative to their competitors elsewhere. Although SIPs vary in quality from state to state, it is fair to say that at the time the bubble policy was conceived, there were widespread inaccuracies in emissions inventories, variations in the adequacy of modeling techniques, and demonstrations of future attainment that were often optimistic. Moreover, the emissions limits set in the SIPs typically are set for broad source categories and were not at all representative of the emissions performance of individual sources.

The 1986 Emissions Trading Policy Statement represents a concerted effort to respond to these problems by improving the rules for bubbling. This policy statement was developed through an interagency process at EPA that balanced the Agency's policy office's enthusiasm for trading with the air program's skepticism. The result was a compromise set of guidelines that corrected for many of the deficiencies in the SIPs and in the previous policy. The policy established stricter baseline requirements and other safeguards against "paper trades." Bubble activity dropped considerably after the ETPS was published, no doubt in part due to the new safeguards.

4. Coming in From the Cold -- The "Paradigm Shift"

Despite a growing body of experience in the U.S. with the application of market-based approaches to air pollution, such strategies have remained on the margins of environmental policy, exceptional tools applied in specialized circumstances. The climate is very different now. At least in the air quality arena, market-based instruments have become much more widely accepted, moving from the periphery to the center of the stage.

The reasons for this "paradigm shift" are difficult to pin down. Part of the explanation lies in the fact that the problematic experience with bubbles had been countered by successful experiences with tradeable permits in the lead and CFC phase-out programs. Lead as an air pollutant has been of concern to EPA for many years. Lead is one of the pollutants for which there is a national ambient standard that states have to attain through their state implementation planning process. Of particular concern has been lead in gasoline, since auto emissions historically were the largest source of human exposure to lead. EPA promulgated its first market-based program for limiting lead in gasoline -- a lead content averaging scheme -- in 1973. This program included special provisions to mitigate the impact of lead restrictions on smaller, less technically sophisticated refiners.

This averaging approach was succeeded by a second phase program in 1982-3 that moved to trading in lead usage rights. Under this program, refiners could trade lead rights among themselves, across facilities and across company lines. Under this scheme, older, smaller, less sophisticated refineries could meet their requirements by buying lead usage rights from other refiners who could more easily meet and exceed their limits. In 1985, the program was amended to provide for much more stringent lead limits, leading to a phase-out of lead from most fuel uses by 1987. As a means of compensating for the tighter standard, banking was added as a feature of the program, in effect extending the time duration of the lead bubble created over the refining industry. Banking greatly increased the attractiveness of trading to refiners and increased the amount of trading. In effect, because lead rights no longer expired on a quarterly basis, refiners had much more flexibility in their planning and lead rights became a much more valuable commodity. (Nussbaum) The general consensus has been that the lead trading program was a very successful transitional approach that enabled the removal of lead from U.S. automotive fuel supplies in a relatively smooth and cost-effective manner.

The CFC phase-down program began in 1988. This program was then accelerated through Title VI of the Clean Air Act Amendments. As a means of implementing U.S. obligations under the Montreal Protocol, EPA established a marketable permits system to implement a phase-down of CFC production. The target was a 50 percent phase-down by June 30, 1998, with 1986 (the target set by the Protocol) production and use levels set as the baseline. An important feature of this program was that production allowances could be transferred internationally, under certain conditions. The initial allocation of permits was based on the historic levels of production/use of seven large domestic CFC makers. This simple allocation scheme conferred large "windfall" profits to these companies, a fact that Congress addressed by imposing a tax on the production of CFCs in 1989. This tax, the amount of which is weighted by an ozone-depletion factor for each specific chemical, was intended to aid in the development of substitutes for CFCs in critical applications.

Clearly the watershed event that most clearly evidenced the paradigm shift was the passage of the CAAA in late 1990. More than any other U.S. environmental statute, the CAAA embraces market incentives, including in the acid rain control program (Title IV), the CFC phase-down program (Title VI), in the Economic Incentives Program provisions (Title I), and elsewhere in the Act. Possibly the most dramatic illustration of the central role of market-based approaches in the CAAA is the requirement in Title I that certain ozone and carbon monoxide nonattainment areas that fail to meet progress requirements must implement economic incentive programs to help correct the deficiency. Leading up to that watershed event, however, were a series of developments that helped to make trading concepts respectable among environmentalists and government officials, and not just among economists and regulatory reform idealogues.

One of the most influential events was "Project 88," a public policy study sponsored by two U.S. Senators -- Timothy Wirth (D-Colorado) and the late John Heinz (R-Pennsylvania). The Project 88 study presented a persuasive case that market-based environmental strategies could be successfully applied to a number of local, national, and global environmental problems. The study's bipartisan origins undoubtedly lent its recommendations credibility.

Another of the important developments forcing a change in the role of economic incentives was the removal of the longstanding political logjam over how to address the acid rain problems. This logjam had for many years held up reauthorization and much needed improvements to the Clean Air Act. The crafting of a workable tradeable allowances program forced open the logjam by making it possible to balance competing economic and geographic interests. Use of trading as the implementation mechanism, with the cost savings thereby provided, made it possible to get agreement on a very substantial reduction in total SO_2 loadings. In effect the benefits of a market-based approach were shared between industry (in the form of substantial cost savings) and the environment (in the form of greater reductions than would have been possible had a command-and-control approach been used). In addition, continuous emissions monitoring was included in the program, ensuring achievement of environmental results.[2]

One of the most notable aspects of the acid rain abatement program that was adopted in the CAAA is that a major national environmental group -- the Environmental Defense Fund -- was very influential in its design and "marketing." EDF's leadership in designing a market-based solution to acid deposition, and their earlier work applying similar tools in the regional water policy arena, helped make it respectable for environmentalists to support market-based approaches.

The successful crafting of a tradeable allowance-based acid rain control program, and the adoption of other economic incentives elsewhere in the CAAA, demonstrate how the substance, as well as the politics, of the debate over market-based approaches has changed since the Emissions Trading Policy Statement was issued in 1986. The "bad old days" of "paper trades" and the advocacy of trading concepts as regulatory relief masquerading as regulatory reform, largely have been superseded. There is today a large and growing consensus that it is desirable, and possible, to design economic incentive solutions that provide equal or better environmental results as well as cost savings. The focus now, both in the academic literature and in policy deliberations at EPA, is much more on the "nuts-and-bolts" of how best to structure market-based programs than on the theory, ideology, or morality of such approaches.

5. Lessons From the U.S. Experience

Drawing on this experience with applying a variety of trading approaches to air pollution problems in the U.S., what are the principal lessons that can be identified that might have applicability to the design of tradeable permit systems for reducing greenhouse gas emissions? The following are perhaps the most important such lessons of a political, economic, and practical nature:

<u>Concerns about localized impacts of trading can be minimized but perhaps not avoided.</u> In the literature on emissions trading systems, it is a common prescription that the scale of the trading market and the scale of the environmental problem that the trading system is intended to address should match. Otherwise, perverse results may occur -- "hot spots" of pollution, for example. Following this prescription, the global warming problem would seem to be ideally suited to an international trading scheme, since greenhouse gases generally mix uniformly in the atmosphere.

In most U.S. trading systems this geographic principle is honored. Most systems are local in scope and are designed to address localized problems of ambient standards nonattainment. The two broadest current programs -- the CFC phase-out program and the SO_2 allowance trading system -- are both designed to address broader environmental problems, one global, the other regional. The lead trading program was somewhat different in that limits applied to the refining of gasoline at facilities in specific locations but the gasoline itself was consumed in a broader region.

Although U.S. programs generally have honored the principle that the scale of the problem and the market should match, the problem of localized impacts has not been completely avoided. A significant issue in the development of the RECLAIM (Regional Clean Air Incentives Market) trading program in Los Angeles, the most ambitious local trading program to date, has been the potential for "hot spots" of pollution to occur in areas with concentrations of facilities that buy credits on the market to meet their annual SOx or NOx cap. The local air pollution control

2 For details on the how the acid rain allowance trading program was crafted, see Kete, Nancy, "The U.S. Acid Rain Control Allowance Trading System," in Organization for Economic Co-operation and Development, *Climate Change: Designing a Tradeable Permit System* 1992.

district has conducted analyses that indicate that this problem will not occur. Nonetheless, this concern remains among local activists, whether out of genuine alarm or as a tactic to undermine support for the program. This issue will likely become bigger if the district forges ahead to develop a trading market in reactive organic gases (ROGs), where the toxicity of the compounds involved will be much greater.

The localized effects problem also has reared its head in the acid rain SO_2 allowance trading market. In the case of oxides of sulfur, there are local regulations designed to ensure attainment with the national ambient standard. These source-specific limits have to be achieved even by utility sources who purchase allowances as a means of meeting their national-level acid rain control obligations.Thus, in theory, local health is protected irrespective of allowance trading. Nonetheless, at least in a few cases, local interest groups have opposed utilities in their area purchasing allowances (as opposed to installing controls or switching to cleaner fuels) because of the local air quality improvements that would be sacrificed as a result of that choice.(This was most notably the case in a trade involving a Wisconsin utility and the Tennessee Valley Authority.) In at least one other case, New York State has sued EPA to block trades in which New York utilities sell allowances to out-of-state utilities that might contribute to the state's acid deposition problem. And the New York State and Wisconsin legislatures both have legislation before them that would subject trades to a scrutiny of local air quality impacts.

One can imagine that analogous objections might occur in the case of greenhouse gases. Although CO_2 itself is not a pollutant on a local scale, other products of fossil fuel combustion are. Local interests in areas where sources are on the "buy" side of a greenhouse gas tradeable permits market might perceive that they are being disadvantaged by the system even though they are benefitting, along with everyone else, from a net reduction in the greenhouse effect.

Looking to Europe, the localized effects problem is one of the greatest obstacles to the adoption of trading or other forms of joint implementation as a means of controlling acid deposition. The United Nations Economic Commission for Europe (UNECE) is approaching agreement on its Second Sulfur Protocol, which will greatly reduce national targets for emissions of oxides of sulfur. While there is great interest in many countries in adopting some form of joint implementation as a means of reducing the cost of the new round of emissions reductions, progress toward formulating anything approaching the freely functioning market in the U.S. has been stymied by concern that trading will result in negative impacts to "third parties," i.e., countries other than those involved in a specific trade. Current discussion focuses on a variety of elaborate exchange rate schemes and other forms of third party protection. What has been lost in this discussion has been the fact that implementation of the Second Sulfur Protocol will reduce acid deposition throughout the continent, and that an effective joint implementation scheme might accelerate emissions reductions by making the process less costly.

<u>Trading can change the psychology, and politics, of environmental policy-making and compliance.</u> The recent history of trading systems in the U.S. clearly has demonstrated that the use of trading approaches, and the compliance cost savings they provide, makes it possible to get agreement on tougher restrictions than would otherwise have been possible. It can be argued that such approaches can dramatically change the psychology of environmental policy-making and compliance, and thereby the politics as well. The U.S. program for reducing acid rain is the best illustration of this lesson.

As has been noted, the crafting of a tradeable allowance program that could credibly promise cost savings, compared to the alternative of command-and control, made it possible to design the program around a more ambitious reduction in total sulfur loadings. As Kete has argued from experience in the development of the program, the stringent reduction target, the overall emissions cap, and the trading system (including initial allowance allocations) were part of a total package necessary and sufficient to break the policy logjam that had delayed both addressing acid rain and, more broadly, reauthorization of the Clean Air Act. (Kete)

The politics of the RECLAIM program in Los Angeles also bear on this point. Facing the worst air pollution in the U.S., Los Angeles air quality authorities faced a difficult dilemma: How to make further progress toward attainment of national standards without crippling an already limping regional economy. The crafting of a program with a tough and declining cap and a system for trading among sources made it possible for the local district to win passage of its total program. The alternative -- increasingly stringent source-specific limitations -- was seen by many local interests as too expensive and unlikely to succeed in reaching attainment.

The use of trading mechanisms also can change the psychology of compliance with stringent air quality requirements. The flexibility built into well-designed trading programs provides significant cost savings that can mollify attitudes toward the stringent standard itself. Trading also provides a motivation for sources to beat the standard; they can turn their over-performance into a financial asset to be traded or used to foster their own future growth. Under command-and-control programs, the only motivation is to do just enough better than the standard to provide a margin for error and protection against non-compliance penalties.

Emissions caps provide important environmental security. The concept of tradeable permits incorporates application of a cap on total source-specific emissions or emissions in individual jurisdictions. One of the principal flaws with EPA's original approach to "bubbles" was the prevalence of trades denominated in emission rates, rather than emission quantities. Absent other protections, it is difficult to ensure that environmental equivalence is achieved in a trading program based on emission rates. Although an individual trade may feature a balance of emission rate increases and decreases, the under-controlled source may be cheaper to run, and be run for longer hours, than the over-controlled source. This scenario would result in an increase in total pollution. The Emission Trading Policy Statement of 1986 includes provisions related to defining the baseline for trading that were intended to ensure what the policy terms "ambient equivalence" by requiring a before-and-after the trade analysis of emissions. A related problem historically has been the use of allowable emission limits (even where expressed in total loadings) as the baseline. Because most sources have actual emissions well below their legal limit, the ability to trade this differential to another source clearly can create emissions increases. The Emissions Trading Policy Statement partially corrected for this problem by requiring many sources to define their baseline in terms of the lower of actuals or allowables for all three components of the baseline -- the emission rate, hours of source operation, and capacity utilization. Only where a source could show that their allowable limit was assumed in the state implementation plan could a higher allowables factor be used in baseline calculation. (USEPA)

A priority concern of environmental critics of trading systems has been the phenomenon of "paper trades," trades which because they were rate-based, or based on an allowable emissions baseline, or for other reasons, resulted in no decrease or an increase in net emissions. Support for the validity of these concerns was provided by an EPA-commissioned review of the 40 bubbles approved by EPA as SIP revisions as of January 1985. Among other disturbing findings, this study concluded that 13 of the 40 bubbles involved solely paper credits, with 8 trades involved either partial paper credits or emissions decreases that were less than would have occurred under application of source-specific controls. The clear implication of this thorough permit-by-permit analysis was that the then current system was being "gamed" to a significant degree. (Energy and Environmental Analysis)

In the current state of debate about emissions trading systems in the U.S., the concept of using emissions caps, both on total area emissions and on source's baseline emissions, has become accepted practice. It is recognized that caps provide the greatest certainty regarding the environmental results from trading. As has already been noted, a stringent cap was adopted in the acid rain allowances program. A declining cap is the basis for the CFC phase-out program. At the regional and local level, emissions caps are in increasing vogue. The RECLAIM program in southern California utilizes declining source-specific caps as the basis for motivating trading among sources. The source-specific caps are derived from an annually declining area-wide emissions cap that is designed to bring the region into attainment with federal standards over time. In the Northeastern U.S., states collectively are examining the feasibility of a regional NOx trading program built on an emissions cap.

The protective or insurance power of emissions caps is a significant advantage of tradeable permits approaches over emissions charges, fees, taxes, etc. This advantage is noted in EPA's proposed Economic Incentive Program rules. Charge and fee programs are referred to in EPA parlance as "market-response" strategies, as distinct from "emission-limiting" strategies such as tradeable permits. A market-response strategy creates one or more incentives for affected sources to reduce emissions, without directly mandating emission-related requirements for individual sources or even for all sources in the aggregate. This insurance effect is not simply environmental in nature. Application of a cap, both on total and source-specific emissions, has proven essential politically in the design and adoption of trading programs in the U.S.

The advantage of caps in tradeable permit programs would seem to be even greater in the international context. Opportunities for "paper trades" may increase as the geographic scope and source diversity of a program increase. Application of source caps, based themselves around national emission caps or quotas, provides a starting point for ensuring that a trade results in a net emissions reduction -- necessary if total greenhouse gas emissions are to be reduced.

Trading does require greater compliance verification. There is a school of thought in the emissions trading literature that argues that such systems do not require any greater level of compliance verification than traditional command-and-control systems. While in theory this a reasonable argument, practical U.S. experience does not support this contention. Trading programs require greater verification for both environmental and political reasons. Greater flexibility necessitates greater accountability.

Traditional command-and-control regulations require sources to install specific control technology -- "best available control technology" or its functional equivalent. This is done either explicitly or implicitly, through the imposition of performance standards based on specific technology. In the U.S. experience, application of this technology at most sources results in actual emissions below the performance standard. While it is true that some sources do not install the required technology, and other sources do not run or properly maintain the control equipment at all times, overall air quality regulators employing a reasonable enforcement regime can be sanguine about the results of their effort. It is generally quite easy to determine source compliance: you inspect the facility to see if the intended equipment is in place and being operated. Providing sources greater flexibility in meeting their control obligations, including by paying another source to meet it for them, complicates this job. While market incentive programs present distinct economic efficiency advantages, they do introduce greater uncertainties regarding the effectiveness of the overall emissions reduction effort.

In the context of international trading, the technical verification problem could be compounded significantly due to the widely varying national infrastructures and capabilities to determine and enforce compliance. Verification may be made more difficult still if the tradeable permits program is complicated in terms of the numbers of chemicals involved, the numbers of trading parties, and the inclusion of forestation projects and other "sink enhancement" projects as generators of tradeable rights. For this reason, the ability to confidently verify results should be a central criterion in the design of an international program.

The technical considerations surrounding verification translate into perhaps even more fundamental political problems. Many skeptics of trading programs view them as "shell games" in which emissions are merely moved around, rather than reduced. Verification of emissions reductions has proven in the U.S. to be absolutely essential to the political acceptability of such systems. In the acid rain program, the requirement that sources install continuous emissions monitoring systems (CEMS) was an integral part of the political compromise. In the development of the RECLAIM program in Los Angeles, the development of adequate emissions "protocols" -- the procedures for verifying emissions performance -- have been one of the most politically contentious issues. The difficulty of developing acceptable protocols for reactive organic gases (ROGs) has delayed the adoption of a ROG market as part of RECLAIM.

There are numerous ways of addressing the verification problem. One is to simply require that all sources involved in trades or joint implementation schemes be outfitted with CEMS to track performance. Another approach, and one adopted in EPA's Economic Incentives Program rule, is to apply a discount or uncertainty factor to trades. The specific discount factor can be arbitrarily (and conservatively) specified, or it can be varied in direct relation to the design of the program. Trades involving sink enhancement projects, for example, might be assigned a greater discount factor than one involving monitored emissions controls or pollution prevention. Another approach might be to determine that certain kinds of actions, for which the uncertainty of results is greater than some threshold "comfort level," would simply not be allowed as part of a trading program. It is probably advisable to include, as an integral part of a trading program, an audit or compliance reconciliation process, so that at least egregious "paper trades" and other problems are caught and corrected. A program of periodic results audits could be used both to adjust source requirements to correct "bad" trades and to make adjustments or improvements to the trading program itself. Without such a final assurance mechanism, the credibility of an international trading program might suffer. Given the potential complications inherent in an international trading program, it might be appropriate to develop an international agency that would, among other things, monitor trading results and implement an agreed-upon compliance assurance regime.

The economic savings from trading approaches will be significant; the principal objective in designing trading programs is to solve the environmental problem at reasonable cost, not to save the most money. In the U.S., trading systems have not produced the scale of savings that had been predicted by the most ardent supporters of such approaches. Undoubtedly, this is in part due to rhetorical exaggeration committed in the act of advocacy. To a large extent, however, it is due to limitations placed on bubbles and other forms of trading in the process of crafting political consensus in support of new programs. Some of these limitations can be seen as necessary to prevent paper trades and other fraudulent abuses; other limitations are more a function of bad design. Like any market, however, there will also be "friction" in emissions trading programs, whether necessary or not.

Despite falling short of their advance billing, U.S. trading programs have nonetheless delivered substantial compliance cost savings. One estimate is that bubbles have saved industry $650 million dollars, and that netting for modifying sources in nonattainment areas have saved $500 million to $12 billion. (Hahn and Hestor) Even if reality for netting falls toward the lower end of estimated range, these are real savings. The lead phase-out program produced significant results as well. The lead banking provision alone saved refiners an estimated $226 million. (Carlin). The tradeable allowance program for reducing acid rain has produced perhaps the greatest savings of all. EPA's Regulatory Impact Analysis of the Agency's implementation regulations estimates that the trading regime will save 40-50 percent of the compliance cost that industry would have incurred under a command-and-control program. The total savings are estimated to equal $700 million to $1 billion annually averaged over the program's life. (ICF Resources)

From theory it is clear that possible cost savings from trading systems increase with the size of the market. The bigger the bubble, the greater the compliance flexibility afforded sources; the greater the flexibility, the greater the potential cost savings. Effective market size is a function of several things, including geographic scope, the variety of types of emissions that can be traded, and the extent to which trading is limited through program rules. From a geographic perspective, global greenhouse gas emissions trading presents huge potential cost savings compared to a nation-by-nation, source-by-source control regime.

However, given the uncertainties (concerning environmental effectiveness) inherent in a global greenhouse trading program, and the importance of ensuring integrity in the compliance aspects of program design, it is my view that program design should take cost savings for granted initially and focus primarily on getting the environmental aspects of the program right. A program designed around environmental integrity will gain credibility over time. Accumulating experience in the implementation of the program will suggest refinements that will increase the effective size of the market by enabling it to function more fluidly. Devoting more attention to maximizing cost savings than to the environmental integrity of the system may result in a program that does not deliver the intended environmental results, leading to criticism and overly-stringent corrections that may effectively cripple the trading system.

Technical innovation is a function of the program's stringency. Accelerated technological innovation is one of the most commonly cited benefits of applying market-based environmental strategies, including tradeable permit systems. Command-and-control systems often are referred to as "technology forcing," because they typically require installation of a narrow range of acceptable technologies. If such command-and-control standards are stringent enough they can also be technology forcing in a second sense -- i.e., by forcing new technological developments. However, most U.S. technology-based standards (and performance standards based on specific technologies) are based on analyses of the feasibility and cost of applying various technologies across broad industry categories. In some cases, this results in close to a lowest-common-denominator standard; seldom does it result in a state-of-the-art requirement that would truly propel new technical advances.

Alternatively, economic incentive approaches may be viewed as "technology facilitating" by creating the conditions and flexibility to facilitate new control and prevention technologies to flower and find a market niche. Because sources are given an economic reason to do better, even considerably better, than the standard, they will try to do so in many innovative ways.

U.S. experience, however, is mixed regarding the degree of innovation spurred by trading programs. The degree and pace of innovation is a function of both the stringency of the underlying standard (the objective) and the flexibility provided in the implementation program (the means toward the objective). The underlying U.S. standards often are not stringent enough to create the need for new technology. There is little evidence of innovation arising from local bubble and offset programs, perhaps because of limited market size. This also appears to be the case for the national-scale acid rain program that, despite an overall 10 million ton SO2 reduction, allows sources to comply with their own limit by fuel switching, using traditional scrubbers, demand side management, and other strategies that do not entail innovation. There is, however, evidence of innovation on the margins in this program. U.S. scrubber manufacturers, for example, are now guaranteeing significantly higher control efficiencies than were available prior to the passage of the CAAA.

The CFC phase-down program provides a counter-example. In this case, the certainty that specific chemicals used in basic industrial and consumer applications would be completely banned over a relatively short time-frame has provided considerable economic motivation to find acceptable substitutes.

Local trading programs developed pursuant to the Economic Incentives Program under the amended Act may give rise to greater innovation than previously seen. This will be due in part to the greater stringency in the emissions standards that will be required for sources in many areas that have to come into attainment. In addition, the CAAA brings into the regulatory net many smaller sources that have not been regulated to date. For many of these sources, new requirements may be very difficult to meet economically without new process, control, and prevention technologies. The use of trading programs may facilitate the necessary innovation in the most cost-effective way. If Los Angeles takes the next step and brings reactive organic gases within the RECLAIM program, significant innovation may result both because of the stringency of the declining baselines and the size of the market involved.

There is a virtue in starting small in designing trading programs. The U.S. has the greatest amount of experience in applying trading programs to air pollution problems. The design and passage of the acid rain program built on nearly 15 years of experience with different types of market-based systems. At the state and local level, even with the "paradigm shift" previously mentioned, trading approaches are innovative enough that many state and local regulators are reluctant to rely on them. Because there is no significant international experience to draw on, the "comfort level" problem is accentuated in the design of international trading programs.

Discussions of incorporating joint implementation into the design of a Second Sulfur Protocol for reducing acid rain in Europe exemplify this situation. Although the UNECE negotiations over national emissions reduction obligations are virtually complete, the parallel discussions regarding design of JI mechanisms is far behind. The absence of any trading experience contributes to the understandable conservatism of the negotiating countries. Current consensus among these countries is leaning toward establishing stringent trading ratios and complementary institutional arrangements that may effectively preclude trading.

A sensible approach to meeting this need for confidence building is to start small in designing an international program and expand the scope of the program as experience accumulates and the confidence level of countries and other stakeholders rises. Swart has advocated taking a phased approach, with the first phase limited to national and bilateral trades, leading to a second phase with a more fluid international market. (Swart) What is called for is a "just do it" philosophy where countries would try various trading programs on their own or in cooperation with others (e.g., through joint implementation arrangements only with neighboring countries) in a conscious experimental approach to the problem. Recognizing that uncertainties increase as the scope of a program increases, starting small and expanding (in terms of nations involved, the chemicals involved, and the degree of freedom in the market) provides an opportunity to fine-tune a program along the way. In the European acid rain context, such an approach is the most that can be expected in the immediate future.

The "start small" strategy is currently being followed in the U.S. in the development of a regional trading program to deal with pervasive ozone pollution in the Northeast. The long-term objective being pursued by the Ozone Transport Commission (OTC) (a multi-state body created by the CAAA to deal with ozone transport problems in the Northeast) is the development of an interstate market for NOx offsets. NOx is increasingly being focused on as an important contributor to the region's ozone problem. Due to the phenomenon of ozone transport, this problem truly is regional. Because it is clear that states in the region will need to impose much more stringent NOx reduction requirements on sources, state air regulators are concerned that it may become extremely difficult for new and modifying sources to find affordable NOx offset credits. Without a sufficient supply of offset credits, growth in the region will be greatly hampered. In addition, OTC members believe that a broader trading market would produce greater economic efficiencies and cost savings and thus contribute to the region's economic well-being.

The OTC members, which include the top environmental and air regulatory officials from the member states, recognize that there is not at this time a consensus to support an interstate NOx trading program. The necessary comfort level in terms of how such a market would work -- what its environmental consequences would be, what it would do to economic growth in individual states -- is simply not there. At the same time, as individual states in the region develop their intra-state trading programs, there is a concern that it may not be possible to integrate incompatible state programs. The solution that the OTC has settled on is to reach agreement on a common set of program elements (including the definition of the commodity being traded, credit calculation procedures, treatment of plant shutdown credits and the property rights issue, intersector trading, and banking procedures) and provide guidance to member states to maximize the degree of consistency among state programs with respect to those critical elements. The hope is that at such future time as states become comfortable thinking about an interstate program, the individual state programs will have enough in common to be easily integrated.

<u>There is a parallel virtue in keeping it simple.</u> Part of starting small is starting simple. One of the most important dimensions of simplicity is the definition of the unit being traded. An international greenhouse gas trading program could be extremely complex, particularly as the number of chemicals being traded grows and as sink enhancement projects are included in the trading scheme. Such a program would be at the opposite end of the complexity spectrum from the U.S. lead phase-out program, for example. Although a narrow definition of the tradeable commodity will reduce the potential for efficiency gains and cost savings, it makes it easier to verify environmental results. Use of some type of global warming potential indexing scheme could help make a broad commodity definition work, the question becomes one of how much confidence to place in such a scheme. Ideally, you do not want any substances in the system for which data cannot be tracked. Another aspect of simplicity concerns the rules of the trading program. The more complex those rules (including the use of indexing), the greater will be the transaction costs that sources will incur. A requirement that national governments must approve individual trades or JI agreements will add considerable transaction costs and discourage

trading.

Even simple systems can be difficult to set up. Advocates of market-based systems often cite administrative simplicity as a strong advantage of such approaches, particularly for government agencies facing declining budgets. While it is true that trading programs can be easier to administer over time, particularly if markets are allowed to operate relatively fluidly, such systems typically require a significant "up front" investment of time and resources to design and initialize. A successful outcome requires that very careful attention be paid to defining the commodity, establishing the rules for trading, developing banking procedures, developing protocols for documenting emissions reductions, and designing a compliance assurance system, among other aspects of a program. Not only do these tasks require investment of time, but they also can require a great deal of technical capability on the part of the implementing organization.

Emissions trading markets need to be facilitated. In general, once a trading program is underway, the less government involvement the better. The U.S. experience with the bubble program clearly shows that transaction costs, timeliness, and ultimately the incentive to trade are all negatively affected by close involvement of government in the trading process. In general terms, the government needs to design a set of rules that strikes the right balance between the desire to encourage trading and the need to ensure the right environmental results, and then stand back and monitor the market's performance. However, it has also been U.S. experience -- particularly at the local level with bubble and offset programs -- that unfamiliarity among sources with how trading markets function can hamper the effectiveness of the market. Government can play a key market facilitation role through establishing centralized clearinghouses for information on who has and who needs tradeable permits. In some cases, governments might want to take the next step and provide a banking or brokerage service to facilitate trades among private parties. At the international level, approval of cross-border trades by national governments may significantly increase transaction costs and thereby have a strongly negative influence on the market. At the same time, there is a positive role to be played by an international institution in serving in a clearinghouse or banking capacity. Because of the greater cost to sources in searching for and linking up with other sources in other countries, this type of clearinghouse/banking facility could greatly reduce sources' transaction costs.

Market certainty and regulatory flexibility must be carefully balanced. Emissions trading presents a classic public policy trade-off in the need to balance the competing objectives of providing certainty to the market and flexibility to ensure achievement of the environmental objective. An absolutist approach to providing certainty treats tradeable permits or banked emissions credits as inviolable "property rights." Under this philosophy, air quality managers lose the ability to make adjustments that can improve the environmental effectiveness of the program. An absolutist approach to ensuring flexibility renders permits and credits essentially valueless because they can be "confiscated" at the whim of program administrators. In short, neither approach is tenable.

It is important to provide a degree of security in the possession of rights or credits, for without such security there is no incentive for sources to participate in the market. It is similarly important to give the regulators flexibility to be able to respond to new information about the science behind the program, or results from a program effectiveness audit, for example, to make changes to the system to ensure that the ultimate environmental objective is met. A typical adjustment would be to change the emissions cap that serves as the baseline for trading. How best to balance these competing needs becomes especially important in programs that include the opportunity to bank emission reduction credits, since such credits are at risk until they are transferred.

In an international tradeable permits system initialized by a national emissions cap, the simplest approach to this problem would be to require that "banked" credits or allowances be discounted by an appropriate amount to reflect reductions in the national cap necessitated by new information. Ideally, it is preferable if the conditions and groundrules for making such adjustments could be spelled out in some detail to provide some measure of predictability to sources. Predictability, after all, is very highly valued by businesses in making market decisions. Alternatively, countries could "grandfather" some or all of the banked credits and make up for these foregone reductions by requiring larger reductions in the allocations of all sources' individual baselines or caps.

6. Conclusion

Accumulating U.S. experience with tradeable permits and other forms of emission trading systems validates proposals that such policy instruments have a constructive role to play in attacking the global warming problem. Indeed, the potential of such strategies to reduce global greenhouse gas emissions at a lower cost than traditional command-and-control approaches is extremely important given the potential for aggressive global warming policies to cause significant economic dislocations. This cost-saving potential increases significantly to the extent that trading approaches are allowed to operate across national borders.

The U.S. has experienced a "paradigm shift" in the evolution of trading programs at the local and national level. This paper has overviewed the plot line of that evolution. The lessons learned during that process, many of which have been summarized here, should have relevance to the design of an international tradeable permits program for reducing greenhouse gas emissions. The objective in that design effort should be to assimilate those lessons and thereby avoid the steepest part of the programmatic learning curve.

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FORESTS TO CAPTURE CARBON: TRADEABLE PERMIT SCHEMES

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1. Introduction

Concern over the state of the world's forests has been a major societal issue for the last two decades. Concerns about excess rates of deforestation have always reflected, to some degree, concerns about local environmental effects such as water quality deterioration, land slides, and so forth associated with deforestation.

In recent years, however, the focus of the concerns has become increasingly global. Two global concerns dominate. First, deforestation may lead to habitat loss and subsequent species losses. Second, deforestation may contribute to the problem of global warming through the release of greenhouse gases, i.e., CO_2 into the atmosphere.

In this paper I will discuss the role of forests in the carbon cycle and suggest some ways that forests can contribute to the mitigation of CO_2 build-up. I might note here that forests contribute to the mitigation of atmospheric CO_2 as stores or inventories of carbon. Maintaining existing forests maintains the carbon in storage. Also, creating new forests adds new inventories to the forest carbon inventory stock. I will discuss how forest carbon sequestration might be promoted with a system of tradeable forest obligations. I will also discuss how carbon sequestration via tree growing might be incorporated into a system of marketable tradeable carbon permits.

2. Opportunities for Carbon Sink Enhancement Through Forestry

To date, most discussion of sink enhancement has been focused upon forests, and specifically afforestation (e.g. CBO 1988; Trexler 1990; OTA 1991) and almost all of the discussion has been directed at carbon sinks. The discussion below will focus on sink enhancement for carbon dioxide through forestry.

A large number of forest sinks exist and many of these have the potential to expand their sequestration of carbon. These include:

1) The world's forest biomass constitutes a major global carbon sink with the potential to increase through either an increase in the biomass of existing forests or through the creation of new "plantation" forests that will sequester carbon. Sedjo and Solomon (1988) estimated that the 2.9 billion tons annually of "excess" atmospheric carbon could be sequestered by approximately 500 million ha of plantation forests. Tree plantations have an advantage over some of the other possibilities that will be discussed since plantation forestry has been extensively practiced in various parts of the world for the last 30-40 years and thus the technology of plantation forestry has been established and refined (Sedjo 1983).

2) Soil carbon exists in forests, grasslands and croplands. Increases in the carbon sequestered in the soils typically occur in forest soils in concert with the maturity of the forest. Prairies, grasslands, and pasture soils also experience carbon buildup under the right conditions (Burke et al. 1989).

3) Ground litter and detrital material in forest ecosystems can also contribute to carbon

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sequestering thereby implying that forest systems may continue to sequester carbon even after net biomass growth essentially ceases (e.g., see Birdsey 1992).

4) Long-lived wood products such as construction material and furniture constitute a terrestrial carbon sink (Row and Phelps 1990).

Of the various potential terrestrial sinks, plantation forests have received the most attention (e.g., Marland 1986, Sedjo 1989, Moulton and Richards 1990, Adams et al.1990, Nordhaus 1990).Other forestry activities, such as improved management and urban forestry, have also received attention (Trexler 1991) although the effects could come more from the cooling effects of shade trees and the reduced air conditioning needs than from their carbon sequestering capacity per se.

The above considerations suggest significant technical opportunities for sink enhancement to sequester carbon through forestry. The most well developed technically is undoubtedly wide-scale tree planting and the establishment of carbon sequestering tree plantations on previously unforested lands.

3. Estimates of the Costs of Carbon "Sink Enhancement"

Although some analysts have suggested that the quantitative significance of forestry options is "very limited" (Nordhaus 1990), a number of studies have suggested that relatively low-cost applications of forest plantations may indeed have the potential to generate a large quantitative effect. For example, Sedjo's (1988) early point estimate implied the cost at $2-$5 per ton, with the lower figure applicable to tropical areas with lands having no alternative uses. More recent and more sophisticated estimates have put the marginal costs in the U.S. as rising from around $5 per ton to over $45 per ton as the total area of tree planting exceeds 100 million ha (Birdsey 1992, Moulton and Richards 1990). Other estimate place the costs of avoiding a ton of carbon dioxide through tree planting at $1.35 to $10.76, with conservation priced at $5.73, fuel switching at $4.48 and carbon scrubbing at $59.41 (Dudek and Le Blanc 1990).

These figures compare with estimates of the costs of preventing the emission of a ton of carbon from the destruction of the tropical forests, which are estimated at $2.30 for Brazil, $8 for the Ivory Coast and $15 for Indonesia (Darmstadter 1990). It should be noted that these costs are quite modest, especially when compared with carbon taxes of $200-$250 per ton that are discussed in some of the literature (Darmstadter 1990, Manne and Richels 1990). This number is based on the estimate that the real costs of a "backstop" technology to reduce carbon emissions is $200-$250/ton and, if imposed as a carbon tax, can be viewed as "society's" estimate of the marginal social benefits of preventing the emission of an additional ton of carbon. Tree planting then is a very low cost way to achieve the end of preventing emissions which generate high social costs. A tree planting approach that can achieve the same carbon effect from one-hundredth to one- tenth the costs is certainly attractive given both the judgement of the social costs of carbon to the economy and the estimate of the cost of utilizing the "backstop" low carbon emitting technology. This level of cost to limit atmospheric carbon is attractive even when compared to the U.S. carbon-emissions tax discussed by the Congressional Budget Office (1990) which begins at a rate of $10/ton in 1991 and rises to $100/ton in 2000 (1988 dollars).

One point that must be stressed is that carbon sink enhancement through forestry cannot be a permanent answer to carbon emissions. Although the world's stock of forest can be increased and in so doing will increase the carbon sequestered in the forest ecosystem thereby diverting it from the atmosphere, the forest cannot be expanded indefinitely. Thus forest expansion can at best buy time, perhaps three to five decades, until the "backstop" non-carbon emitting alternative energy sources become a cost competitive alternative. Such a service should not be belittled, however, since it is well recognized that "quick" technological fixes are typically very high cost and crude, and often generate unforeseen costs and a more careful long-term approach to technological development is to be favored.

4. Mechanisms for Maintaining Forests: A Tradeable Permit Model to Address Problems of Global Deforestation

The Forest Protection and Management Obligations (FPMO) model was developed was designed as a policy vehicle that was designed to internalize the external costs of deforestation by making explicit the opportunity costs of deforestation and other undesirable practices (Sedjo 1991). Such a system is patterned after market-oriented "tradeable permit systems" that have been suggested for dealing with pollution and carbon emission problems. Deforestation rates are socially excessive partially because economic factors and decisionmakers rarely consider the global environmental effects of deforestation, including loss of biodiversity and increased levels of atmospheric CO_2 which are believed to lead to global warming. In addition, high deforestation rates often reflect the attenuation of property rights of forestland owners, both private and governmental. Financial incentives to reduce the rate of deforestation as provided for in the FPMO system, provide a more "level playing field" in which the external costs of deforestation are internalized to the forest owner. Also, by making forestland protection pay, the system provides incentives for owners, private and governmental, to control unauthorized land clearing. For such an approach to work, however, some countries must voluntarily agree to assume financial obligations as part of the establishment of this system.

The Group of Seven in its Houston Declaration in July 1990 called for negotiations "to begin expeditiously and to be completed by 1992 on a global forest convention or agreement to curb deforestation, protect biodiversity, stimulate positive forestry actions, and address threats to the world's forests" (U.N. 1991). The FPMO was a response to the "invitation" of the Houston G7.

The only compelling rationale for broad international action on forests relates to the global public goods produced by the world's forests-- biodiversity and carbon sequestration. Hence, any discussion of forests in this context must relate to these issues.

5. Some Concepts

Forests generate a host of different types of outputs. These may be classified as: a) marketed outputs (private goods), b) local environmental outputs, c) global environmental outputs, and d) global ecological outputs. The outputs that can readily be marketed, commodities such as timber, firewood, nuts, other forest foods including plants, flowers, and so forth, can all be addressed by the usual market incentives and mechanisms. Local environmental outputs can be viewed as classic externalities or "downstream effects," local rules and regulations can be and are developed to allow for the orderly capture of these benefits. Governments commonly intervene to address this issue, e.g., governments often subsidize tree planting or create "protection forests" for watershed protection and erosion control. In so doing they are attempting to create or capture environmental outputs and externalities.

However, for global environmental and ecological outputs, existing markets and individual governmental actions are unlikely to be adequate to address the task. The benefits from the protection of biodiversity (Sedjo 1992) and from the positive impacts on the greenhouse gas problem that come from existing forests are in the form of public goods, which are generally believed to be not readily captured by either a firm or a country. Since no individual country can capture more than a small fraction of the benefits from these global outputs, no single country has the incentive to undertake major investments in protecting forests, the principal benefits of which are global. In economic jargon, the essence of the problem is that the private costs associated with deforestation do not include all of the true social costs. This gives rise to the concept of market failure that is often used to characterize this situation. An alternative, although not inconsistent, interpretation of this problem is that the absence of property rights for the atmosphere and for biodiversity create a common property type of problem (e.g. Sedjo 1992). By either interpretation, given the current system, although individual countries can undertake domestic policies to adjust for this problem at the local level, they are unlikely to be able to fully make the necessary adjustments on a global level. Furthermore, this situation also gives rise to the "free rider problem" whereby, in this case, countries not undertaking the appropriate remedial actions still benefit due to the efforts of others that are undertaking appropriate domestic actions.

The variation in forest ownership patterns across countries often complicates the problem. In many countries, and in most countries of the tropics, much of the large portions of the forest area are in government ownership. Often local residents have rights to certain uses of the land but not to others. In many countries any tree cutting requires government approval. However, because these regulations are difficult to enforce, enforcement is spotty at best. Furthermore, even where forestland ownership clearly resides in private hands, rights to the various outputs vary by country, with rights to game, nuts, berries, passage, and so forth, often being separate from those of land ownership.

Therefore, a mechanism is needed to "internalize" the external costs of forest destruction and deforestation within the countries in which the destruction is occurring. Bearing all the costs directly will be a disincentive to forest destruction and will discourage excessive deforestation, thereby promoting the maintenance of biodiversity and carbon sequestering forest biomass. The approach developed in this study is a global variant of the system of tradeable permits either now being practiced or under active consideration to deal with pollution problems. Such systems internalize the cost of pollution, or forest destruction, to the polluter or forest owner/destroyer. For example, the market value of the tradeable pollution permits makes explicit to the polluter the costs of pollution. In addition, such a system allows the market to adjust and find the least-cost approach to pollution control. A variation of this system which can be applied to promote forest protection and sustainable forest management is developed in this paper.

6. A Tradeable Permit Approach for Forest Protection

Today, tradeable market permit approaches are increasingly being suggested for dealing with sticky environmental problems such as pollution and greenhouse gas emissions. The appeal of a tradeable permit policy is that it internalizes the social costs of pollution to the polluter, thereby providing direct market incentives to reduce pollution. The tradeable feature allows for the reallocation of pollution to its high-value (low- cost) uses, thereby promoting efficiency. A brief review of the essential features of this approach follows:

Tradeable Permits: the Concept Applied to Pollution

Tradeable permit approaches have gained ascendency recently because, by allowing voluntary market responses, they tend to reduce costly regulation and allow market adjustments and thereby meet the pollution standards in a cost-efficient manner. A tradeable permit approach typically caps the level of pollution at a socially acceptable level and then creates and distributes rights (permits) for only that predetermined level. Once created, pollution rights are distributed to various polluters, e.g., firms or countries, based upon some agreed-upon criteria for distribution. Permit holders then have the right to pollute up to the level specified in the permit. Such an approach recognizes, a) that pollution is a cost associated with production, and b) that costs are incurred in the production process and some level of that cost may be worth bearing. By allowing for marketable trading of these rights, the implicit opportunity costs are made explicit. This approach internalizes to the polluter a cost that has usually been borne collectively by society.

In addition, market trading of permits, both a) results in the creation of a market-determined price on pollution thereby creating financial incentives to avoid pollution, and b) allows pollution rights to be reallocated to those to whom the right is most valuable as reflected by their willingness to pay. An important outcome of these features is that market trading encourages the cost-efficient allocation of permits and the subsequent right to pollute to the users who will receive the greatest benefits.

A fully functional system of tradeable permits requires an initial voluntary agreement among nations to define the terms of operation. While within a country the police power of the state can be used to enforce compliance, sovereign countries must voluntarily accept a global system with the following features:

a) a formula that determines the total number of permits and the ways in which permits are created or destroyed;

b) a formula for distributing permits among included countries;

c) a uniform international system for monitoring emissions;

d) a policy to monitor compliance.

Such a system might create a "clearing-house" to facilitate trades among permit buyers and sellers. Alternatively, the market might be expected to develop institutions to provide this function.

Tradeable Permits for Forest Protection and Management

If forest destruction were simply the result of commercial logging, one might determine the level of acceptable logging and then create tradeable rights equal to that amount of logging. However, as noted earlier, it is well recognized that most deforestation, especially in the tropics, is the result of forest clearing to allow for other land uses, especially agriculture. In most cases the felled forest is not utilized but is simply burned, never capturing the timber values. Furthermore, where commercial timber harvests do occur, they are often part of a sustainable management approach that includes forest regeneration allowing many of the timber and non-timber values of the forest to be maintained indefinitely. Thus, a simple marketed permit system to limit commercial logging is inadequate to the complexities of both using and protecting the forest.

Similarly, if the question were merely one of forest cover, the objective could be met simply through widespread tree planting. Although tree planting is often desirable, forest protection and sustainable management consist of more than tree planting. To promote forest protection in such a manner that it protects biodiversity while permitting other socially useful outputs of the forest requires a more sophisticated system than a simple permit system discussed above.

Advantages of a Tradeable Approach

A well functioning tradeable approach would accomplish the following:

a) internalize the costs of deforestation as global externality good;

b) have beneficiaries of global benefits, including industrial countries, bear the costs (user-pay principle);

c) recognize that marketed outputs are also socially valuable and should not be excessively limited;

d) efficiently allocate obligations to protect forests so as to maximize outputs for a given cost.

The features of such a system for global forest protection are developed below.

7. Toward a Workable System for Global Forest Protection and Sustainable Management

As noted, the simple permit system that is designed to place a cap on negative externalities such as pollution, is not adequate to the task of protecting forests. This is true, in part, because forest provide important global public goods, e.g., biodiversity, and forests are not homogeneous with respect to their biodiversity. Since different types of forests provide different types and levels of social values, the returns to forest protection and preservation will vary with the forest type and its condition. Any permit system needs to recognize a hierarchy of types based upon their generation of valuable nonmarket social outputs.

Features of a System of Tradeable Forest Protection and Management Obligations (FPMOs)

Although similar, the permit and obligation approaches are not identical. The permit and obligation systems can be crudely viewed as the inverse of each other. Whereas a pollution permit is an asset, the forest protection obligation is a liability. The permit has positive value and can be sold in the market based upon the market's perception of its value. The FPMO has a negative value in a market and the holder must compensate others to accept the liability based on their perception of the costs of meeting the obligation. Holders of forest protection and management obligations must either, a) fulfill the obligation "on the ground" in a manner acceptable to the monitoring and compliance officials, or b) induce another agent to assume the obligation, presumably in return for a payment. If trading were to occur, the price of the trade would be determined on the basis of the anticipated costs of fulfillment of the obligation (the extent of the liability). An agent would not accept the liability of the obligation unless the payment received equaled the expected cost of meeting the obligation on the ground, plus a normal return. A tradeable global FPMO system would also include a "clearing-house" to facilitate trades among permit buyers and sellers. However, if trading were common, the market could be expected to develop institutions to provide the clearing-house function.

Another major difference between the forest and the pollution, noted and discussed above, is that while pollution tends to be a relatively homogeneous output, e.g., so many tons of sulfur dioxide, forests are multifaceted and therefore the obligation to protect and manage them is much more complex. The forest protection and management obligation is more analogous to the greenhouse gas problem where different gases are compared on the basis of their common unit or index, e.g., radiative forcing capacity, which is heat-trapping ability.

An additional difference from the idealized pollution example is that the initial allocation of the forest obligations permits would be to governments, not profit-maximizing firms. Hence, government behavior may not conform precisely to that expected of firms (e.g., see Bohi and Burtraw 1991).

The heterogeneous nature of the forest to be protected and managed necessitates the development of a relative valuation "index" to relate different forest types, and for different management practices in terms of their contribution to biodiversity and other desired objectives. An illustrative system is developed later in this paper.

Concern among the major world powers about the management and protection of the world's forests has generated a series of discussions from which a global forestry agreement may emerge. This concern is a reflection of evidence that indicates rapid rates of deforestation are occurring in many parts of the world. The case can be made that the current arrangement for managing and protecting forests is inadequate since there are no incentives for the provision of the global public good outputs of the forest, e.g., biodiversity and carbon sequestration. Forest decision makers, be they individuals, firms or countries, do not have an incentive to include in their management decisions considerations of the global public goods provided by the forest.

The tradeable FPMOs model developed in this paper provides a mechanism that internalizes costs of deforestation by making explicit the opportunity costs of deforestation and other undesirable practices. In addition, since the beneficiaries of global forest protection and management include the industrial countries, the distribution of the FPMOs could reflect the "user-pay principle" which suggests that beneficiaries, industrial countries, ought to bear a substantial portion of the costs. However, the tradeable system recognizes that the traditional commercial outputs of the forest, e.g., timber, food items, and plant material, are also socially valuable and does not excessively limit their production. More generally, the tradeable obligation system recognizes that forests are dynamic changing systems and does not attempt to impose inflexible constraints. Finally, the tradeable system allows for the efficient allocation of obligations so as to provide protection and management of forests while maximizing the value of the outputs obtained for a given cost incurred.

Finally, it should be noted that the approach developed in this paper does impact upon issues of both biodiversity and climate. However, this scheme was intentionally designed to be flexible, and therefore compatible with programs that might emerge from the biodiversity and climate conventions.

8. The Relationship Between Sink Enhancement and Tradeable Permits

It should be recognized that a global system of carbon sink enhancement could be introduced either in a world where no system of tradeable permits for carbon existed or as an integrated part of an ongoing system of tradeable carbon permits. The nature of the sink enhancement activities is likely to be quite different in these two contexts.

Concepts: If carbon emissions are viewed as an undesirable "bad" to be dealt with by taxes and rationing through emission rights via tradeable permits, then extension of the logic suggests that sink enhancement can be viewed of as a "good," worthy of a subsidy (negative tax) or perhaps the awarding of newly created emission permits.

More generally, it can be argued that efficiency demands that mitigating actions be permissible since this may be the least-cost way to affect atmospheric carbon levels. Efficiency is served if society can produce products and mitigate the carbon at a lower cost than society is willing to pay for the product. If such activities are recognized as part of the emission rights system, these activities have value that could be captured either via direct payments or through the creation of new emission permits that could be traded in the existing emissions market. Such activities would create new emission permits in the form of an offset to the cost of the sink enhancing.

In this context a sink has both social and market value. Consistency would then require that the destruction of a sink (or the release of carbon from a biotic sink) also would call for the expenditure of emission permits.

Broader Application: Although a full discussion of the operation of the administration of a system of tradeable permits in carbon dioxide is beyond the scope of this paper, it is obvious from the above discussion that a conceptually consistent system of carbon emission permits would also allow sink enhancement as a vehicle for expanding the number of pollution permits, since sink enhancement may be the least costs way to offset atmospheric carbon build-up. Any workable system of tradeable emission permits would require a system of monitoring and compliance to insure that actual emissions did not exceed that allowed by the permits. Although permits would be fully tradeable, monitoring would require accurate accounting to determine current ownership of permits and control for counterfeiting as well as illegal emissions.

The logical extension of a system of carbon taxes and/or emission permits, then, is the provision of carbon sink subsidies in the form of cash or the creation of new and marketable emission permits. The existence of a tradeable rights market could have a profound effect on sink- enhancement activities **if sink-enhancing activities were recognized as offsetting emissions and credit for such were granted**. Furthermore, if specific sink enhancement activities could be converted into additional carbon permits, **sink-enhancing activities would be undertaken voluntarily by the private sector in return for emissions permits.**

In concept, of course, such offsets need not be restricted to tree planting or even land-use changes. For example, if it were demonstrated that environmentally acceptable ocean fertilization were undertaken that would generate additional long-term carbon sequestration, offset credit perhaps in the form of newly created permits might be awarded.

9. Unique Problems in Permit Application to Sink Enhancement

In addition, there are related problems with the application of a system whereby new emission permits are created as the result of sink-enhancing activities. There is the empirical question of determining how much carbon a particular sink-enhancing activity actually sequesters. More critically, many sink-enhancing activities have limited longevity. The one-time sink enhancement may not exist in perpetuity in the absence of further actions. For example, the forest may die, burn, or be converted to agriculture at some future time. By contrast, the one-time carbon emissions that were justified by the offset can be viewed as permanent in the absence of further actions. Modifications in the system to address these problems can, of course, be made. For example, a system of bonding might be introduced in which the bond would be forfeited if the sink were destroyed or seriously compromised. Another example of activity that requires additional expenditure to maintain the enhanced sink might be a rule, e.g., that for every ton of carbon sequestered, an additional permit for one-half a ton would be created.

Given carbon taxes or a market for emission permits, the acceptability of sink enhancement as an offset would generate market behavior for investments in sink-enhancing activities whether or not they also received favorable subsidy or tax treatment as discussed below. However, favorable treatment would be expected to further enhance the financial attractiveness of sink-enhancing activities and thereby result in higher levels of investment in these activities than would be the case with only a permit- driven market.

10. Conclusions

Forests play a large role in the global carbon budget and can have a significant impact in a role as a carbon sink. Forest related activities show considerable promise as a low-cost method of dealing with carbon dioxide emissions. Although such an approach could be in the form of massive governmentally implemented sink enhancing projects, given the plentiful existence of private forestlands, some market mechanism would almost surely be required to ensure that governmental sink enhancement activities such as tree planting, did not simply displace and crowd out private planting activities.

Since atmosphic carbon is a global externality, a meaningful response will almost surely require global participation. Just as with a system of tradeable emission permits, a system to promote global sinks would need widespread participation by countries to overcome a "free rider" problem.

At least two very different global institutional arrangements suggest themselves for promoting carbon sink enhancement. The first would become plausible if an international system of tradeable carbon permits were either functioning or anticipated. Under this circumstance, procedures could be devised for the awarding of additional permits under the condition that a sink enhancing offset had been accomplished. Thus, for example, tradeable credits toward permits could be gained with carbon offsets that met certain criteria. In this context the additional emission permit, tradeable in the market, would in itself be an incentive for sink enhancement.

A second institutional arrangement might involve a international system of forest protection obligations, as discussed above. In this system the wealthy countries agree to bear the financial oblications of protecting certain amounts of forests. Deveoping countries volunarily agree to participate and are compensated for their participation.

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IMPLEMENTATION ISSUES FOR A TRADEABLE PERMIT APPROACH TO CONTROLLING GLOBAL WARMING[1]

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Abstract : Tradeable permit approaches to pollution control have been successful implemented in the United States since 1977 and are now being used in several other countries. One proposed new application of this approach involves its use in controlling global warming. While tradeable permits have enjoyed some considerable success in the various domestic contexts, by no means does that guarantee their success in the international context. In this brief report we present the highlights of our research into how to craft the necessary administrative functions and institutions to support an international tradeable entitlement system for greenhouse gas emissions using the UNCED Convention as our point of departure. Drawing upon the experience gained from both the existing applications of tradeable permits and the monitoring and enforcement of other international agreements, this analysis focuses on the details of establishing and maintaining the certification, monitoring, and enforcement functions associated with a transferable permit system. Special attention is given to assuring that the system serves current purposes while facilitating further development to a more mature, comprehensive system.

1. Introduction

The United Nations Framework Convention on Climate Change, opened for signature in Rio at the Earth Summit during June, 1992, calls for reducing greenhouse gas emissions to 1990 levels by the end of the decade.[2] How can those reductions be achieved? One clue is provided in the Convention itself. Principle 3 under Article 3 states "measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost." One approach which is, in principle, consistent with the cost-effectiveness criterion involves tradeable entitlements.

In principle the case for a tradeable entitlements system is strong.[3] In the short run it offers the possibility of reaching the environmental goals at a lower cost than would be possible if each country were limited to reduction options within its own borders. Because it allows the separation of the financing of control from the implementation of control, it facilitates transboundary cost sharing (an item of particular importance to both the developing countries and the transition economies of Eastern Europe). Tradeable entitlements also facilitate the mobilization of private capital for controlling global warming; private capital is likely to be a critically important component of any effective global warming strategy as long as public

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2 The Convention will enter into force three months after the 50th nation has ratified it. As of September, 1993, 36 nations had deposited instruments of ratification.

3 We only summarize here a few major points. For a complete discussion of the advantages of this approach see United Nations Conference on Trade and Development. 1992. Combating Global Warming: Study on a Global System of Tradable Carbon Emission Entitlements (New York: United Nations).

capital remains insufficient. Finally, and perhaps most importantly, tradeable entitlements facilitate the development and implementation of new methods of controlling global warming. By offering greater flexibility in how targets are achieved (as well as by providing economic incentives for the adoption and use of unconventional approaches), tradeable entitlements significantly lower the long run cost. Lowering long run cost, in turn promotes a greater international acceptance of the idea of limits on greenhouse gases and reduces the difficulties associated with assuring compliance.

How an international tradeable entitlements system might be fashioned from the current situation, however, is not at all obvious. Facilitating immediate progress without jeopardizing a smooth evolution to a more mature, comprehensive system requires careful attention to the implementation details. Beginning with a simple system with the understanding that it could evolve to a more complete system presumes some knowledge about the more complete system. Otherwise the process could well proceed down a path which might ultimately lead in an incompatible, and difficult to change, direction.

The initial steps laid out by the convention were necessarily hesitant. Since the Convention is comprehensive neither in terms of administrative details nor participants, achievement of its objectives depends on an institutional structure which is still being crafted. Appropriately defined institutions and administrative procedures facilitate a natural evolution of this simple system by opening the agreement to more signatories, by facilitating the expansion of coverage to all greenhouse gases, and by providing the foundation for tighter certification, monitoring and enforcement procedures. Recognizing that an international system for controlling greenhouse gases must evolve slowly over time, this report evaluates a particular evolutionary path.

The rest of the report presents the highlights of our analysis of the certification, monitoring, and enforcement functions associated with a transferable entitlement system and the administrative and institutional requirements for their establishment and maintenance.[4] Special attention is given to assuring that the system serves current purposes while facilitating further development to a more mature, comprehensive system.

2. Defining the Evolutionary Stages

To assure a smooth evolution of the trading system each stage must be designed to be compatible with both short term and long term interests. And each stage imposes its own special requirements on the overall design of the system. Our approach is to characterize this evolution by means of three specific stages. In this section we define the stages. In subsequent sections we shall look at the design details appropriate for certification, monitoring, and enforcement in each of the three stages.

2.1 The Joint Implementation Stage

The first stage has already been established by the Framework Convention. It involves a set of nations (listed in Annex I of the convention) which have accepted a goal of stabilizing greenhouse gas emissions at 1990 levels by 2000. Since the laissez-faire outcome would involve increasing emissions, emission reductions will be required to meet the goal. Other nations have subscribed to the general principles of the convention, but not the stabilization goal.

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4 Given the page limits imposed on this paper we can only present highlights. For the evidence lying behind these highlights consult our longer report written for the United Nations Conference on Trade and Development.

Two aspects of this agreement are sufficiently important to the design of a greenhouse gas entitlement system that they deserve emphasis. First, stabilization is stated as a goal, not a requirement. Second, it applies only to the listed nations; other nations are under no equivalent constraint.

As the Annex I nations seek to reduce emissions sufficiently to meet the goal, they have two choices--they can either find the reductions within their own borders or they can seek them in other nations. The possibility for a transborder approach to emission reductions is clearly anticipated in the convention by section 2(a) of Article 4 which reads "these Parties may implement such policies and measures jointly with other parties and may assist other Parties in contributing to the achievement of the objective of the convention and, in particular, that of this subparagraph."

The most natural vehicle for a transborder approach to emission reduction is an offset version of a tradeable entitlement policy. Under this policy a nation could satisfy its emission reduction requirements with a combination of domestic emissions reductions and international offsets.Offsets are emission reduction credits which, once certified, can be transferred across borders.They could be acquired either from other Annex I nations which voluntarily reduce emissions more than required by the stabilization goal or from other nations. Although the joint implementation stage bears little resemblance to an actual greenhouse gas entitlement market[5], it serves the very important purpose of launching the process and providing opportunities for the various supporting administrative institutions to "learn by doing" as they mature in their assigned roles. During this stage, for example, ex ante estimates or emission reductions could be validated by ex post monitoring, using this experience to produce superior ex ante estimates in the future.

2.2 The Initial Entitlement Stage

In the second phase of this process the stabilization goal would be replaced by specific emission requirements for each of the signatory nations. The resulting levels of authorized emissions would then provide a suitable basis for the assignment of actual emission entitlements for carbon dioxide among the signatory nations.[6] Although the normal presumption for Annex I nations would be that they would receive entitlements equal to their 1990 emission levels, other possibilities exist. If, for example, scientific evidence suggests the need for more drastic reductions (as was the case with the ozone depletion gases controlled by the Montreal Protocol), fewer entitlements could be granted. If the problem of global warming is found to be less harmful than originally thought, more entitlements could be granted.

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5 This was reinforced by the August, 1993 meeting in Geneva at which an agreement was reached that, until the year 2000, joint implementation projects should be considered additional to and separate from the commitments already agreed to by the developed nations in the Convention.

6 Although trades in other greenhouse gases would be possible in this stage subject to the certification procedure, we shall focus in this stage on a tradable carbon entitlement, the most likely candidate for the first formal system. Most analysts have noted that sources and gases other than fossil fuel CO_2 are not sufficiently able to be monitored for inclusion in an entitlements system at present. For a review see D.G. Victor, 1992, "Practical aspects of implementing greenhouse taxes: issues for OECD countries," in: OECD,Climate Change: Designing a Practical Tax System (Paris: OECD). Not counting the Clinton administration plan announced in October, 22 of the remaining 23 OECD nations have adopted targets (Turkey has not). All of these except Canada's and Australia's are in terms of carbon emissions only. (The Netherlands has adopted two targets, one for carbon and the other for all greenhouse gases). For a review of all but the U.S. target see International Energy Agency, 1992, Climate Change Policy Initiatives(Paris: OECD).

Because certified entitlements would be freely transferable among signatory nations, the informal and largely experimental trading system of the joint implementation phase would be replaced in the initial entitlement stage with a more formal (and, therefore, a more efficient) version. Organized exchanges would be established to lower transactions costs while a reporting network would provide a public means of accountability. Nonsignatory nations could participate in the process either by signing the agreement (and thereby immediately receiving an authorized level of tradeable entitlements) or by creating offsetting reductions which were certified by an agency designated by the Conference of Parties.

This second stage would offer significant opportunities and incentives for developing nations to join the agreement. In return for their acceptance of ultimately binding limits on greenhouse gas emissions as negotiated with the Conference of Parties,[7] nations could become full participants in the agreement with complete access to the tradeable entitlement market. Full participation in that market would provide access to large amounts of private capital as well as to an efficient means of technology transfer.[8] The alternative, remaining a nonsignatory nation and participating only through the occasion sale of specially created offsets, would offer less flexibility and less access to private capital.[9]

The second stage does not presume any particular domestic strategy for achieving reductions.The reductions could be achieved by traditional command and control regulations, transferable emission permits for domestic sources, or various kinds of "green fees". Combinations of these policies are also possible as long as the resulting emissions do not exceed the amounts authorized by the allocated entitlements.[10]

2.3 The Culmination Stage

The second stage primarily involves trades in carbon entitlements between sources within signatory nations. Developing countries would be allowed to "opt in" by means of the offset certification procedure or they could become a signatory. In any event the market would be limited in terms of both the number of participants and the degree of participation.

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7 The assumption in most discussions of this subject is that developing countries would receive an allocation of entitlements well in excess of current needs. (See, for example, A. Rose and T. Tietenberg 1993. "An International System of Tradable CO_2 Entitlements: Implications for Economic Development." Journal of Environment and Development **2**(1): 1-36. The resulting surplus could be leased to industrialized nations until such time as the local development program created a need for them. The private capital generated by these leases could be used to pursue high priority development goals (as defined by the developing country, not by any international lending agency).

8 Why, some might ask, is private capital necessary when the Global Environmental Facility and an environmental fund (created, but yet to be implemented) within the climate change agreement are prepared to dispense public funds? Private sources of capital seem important for two reasons: (1) public funds are not likely to be sufficient to fill the need and (2) the private capital raised by leasing excess entitlements comes with fewer strings attached.

9 The complete absence of any tradable entitlement system would be the worst possible outcome for developing countries because they would only have access to the public funds provided by international agencies.

10 It could also reserve some proportion, known typically as the growth increment, to accommodate expected future growth. This growth increment could be used to encourage the development of new employment generating activities by reserving entitlements for this purpose.

In the final stage we examine the case in which the entitlements market is completely inclusive in terms of both participation of all nations and coverage of all greenhouse gases. Our objective in defining this stage is to highlight the conditions which would be necessary to achieve this final stage as well as to discuss the evolution of both procedures and institutions which would be necessary to achieve them.

3. The Certification Function

Certification is necessary to assure that the homogeneity of the traded entitlements is maintained while allowing the widest possible participation in the system. By allowing only certified entitlements to be traded, the trading participants and the global community at large can be assured that the entitlement transfers are facilitating, not impeding, the attainment of global warming goals. Furthermore effectively designing and implementing the certification function is the key to the successful evolution of a transferable entitlement system from its earlier phases to a more mature system.

To offer maximum flexibility a transferable entitlement system should have a process which allows limited participation by nonsignatories. This participation is desirable not only as a means of reaching the environmental goals more quickly and more cheaply, but also as a means of providing another channel for the transfer of funds and technical assistance to nonsignatories as they undertake sustainable development activities. Certification provides a vehicle for encouraging participation in the agreement while safeguarding the goals the agreement seeks to attain.

A certification system would be needed, for example, whenever industrialized nations sought to acquire offsetting emission reductions from developing countries which had not accepted any responsibility for limiting emissions under the Convention. By assuring that any newly created entitlements were equivalent to the entitlements authorized by the convention or by subsequent protocols and, in particular, by preventing fraudulent trades (those which appear to result in no degradation or an improvement in the global climate, but which in fact intensify the problem), a certification system can protect the integrity of both the trading process and the agreement on which it is based. The certification process could also be used to eliminate energy substitutions which signatories do not view as desired outcomes of the trading process.[11]

Entitlements to emit carbon in the systems being discussed in this report are of two different types: (1) allocated entitlements and (2) created entitlements. Each creates its own unique certification requirements. In general only certified entitlements can be internationally traded, but the requirements for certification vary with both the type of entitlement and the evolutionary stage of the entitlement system.

Allocated entitlements are received by nations who ratify the Convention once country-specific emission targets have been established. Because the Climate Change Convention specifies an emission goal rather than country-specific emission requirements, no formal system of allocated entitlements exists for the joint implementation phase, even among signatories, until such time as enforceable emission limits are accepted by the signatories.

Transforming the stabilization goal into a requirement would provide one possible legal basis for defining allocated entitlements. Others are certainly possible. Whatever the chosen allocation rule, once the country-specific quantitative emission levels have been internationally validated, carbon entitlements authorizing that level of emission can be allocated to each of the

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11 Some have expressed concern, for example, that a trading system would encourage the substitution of nuclear or hydro power for fossil fuels. Should this concern receive general support, the certification process would be the appropriate institutional arrangement to assure that these substitutions could not be the basis for trades.

signatory nations. Making this allocation is the act which signals the movement from the first to the second stage of the tradeable entitlement evolution.

Allocated entitlements can either be used to justify emissions during the year, banked for future use, or traded to others for their use in meeting their stabilization target. While initially only Annex I nations would be allocated entitlements, other nations could receive allocated entitlements by committing themselves, as signatories, to negotiated emission limits which are sanctioned by the Conference of Parties.

Created entitlements arise from specific actions taken to reduce carbon emissions by sources in nonsignatory nations or to increase the absorption of atmospheric carbon by sources in either signatory or nonsignatory nations.[12] Once they have been certified created entitlements can be traded to signatory nations for use in meeting their stabilization targets. Since nonsignatory nations have no internationally specified targets, trading among nonsignatory nations would presumably be designed to satisfy only domestic goals and would therefore not be subject to the certification process.

3.1 The Certification Authority

The ultimate authority for certification of both types of entitlements would be the Conference of the Parties (CoP) created by Article 7 of the Convention. While the Conference of the Parties would be well-suited for defining the parameters of the certification process and exercising general oversight over that process, it would be ill-suited for dealing with the day-to-day operations of certification. The operational authority for certification can, and should, be delegated to subordinate organizations specifically designed to fulfill that function.

The Convention anticipates the need for creating these subsidiary bodies. Section 2(i) in Article 7 allows the Conference of the Parties to : "Establish such subsidiary bodies as are deemed necessary for the implementation of the convention." Operational authority for running the certification process would be delegated to such a subsidiary body.

For allocated entitlements that subsidiary body would have the power to further delegate some certification authority to specific governmental units within signatory nations or communities of signatory nations, providing certain preconditions had been met. These preconditions would include, inter alia: (1) an identified governmental unit willing and able to assume the responsibility for certification, (2) demonstrated recent compliance with the

Convention by that nation or community of nations, (3) the existence of sufficient enabling legislation to assure adequate powers to carry out its mission, as well as adequate staff and resources, and (4) acceptance of, and willingness to apply, the standard certification criteria. Responsibility for the certification of created entitlements would be retained by the subsidiary body.

3.2 Certifying Allocated Entitlements

Because allocated entitlements are assigned to nations and it is the nations which must ultimately bear the responsibility for assuring compliance with the agreement, the certification of allocated entitlements is designed merely to facilitate that process. Due to the absence of allocated entitlements during joint implementation, all certification during that stage would be handled throughout the created credit mechanism (described below).

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12 Currently joint implementation demonstration projects in Mexico and Poland are being developed under the auspices of the Global Environmental Facility. Whether those projects will result in certifiable offsets is still an open question.

For the other two stages allocated entitlements can be certified for transfer by the nation with political jurisdiction of the location where the seller is located. The purpose of certification would be to assure that any transfer would be compatible with the national compliance plan. Each signatory nation would be required to construct and maintain a national compliance plan. This plan would be designed to assure that actual emissions of greenhouse gases in any year would be no larger than the sum of (1) initially allocated entitlements, (2) acquired created entitlements (either from signatory or nonsignatory nations), and (3) acquired allocated entitlements (from other signatory nations) minus any entitlements transferred to other nations. It would provide an accounting of emissions on one side of the balance sheet and entitlements on the other.

Private sources seeking to transfer an entitlement across the border would be required to: (1) notify the host nation of the request for certification, and (2) satisfy the host nation that the transfer was compatible with the national compliance plan. The second step could normally be accomplished by demonstrating that the entitlement was not needed for compliance (usually by proving that the offsetting reduction had not otherwise been accounted for in the national compliance plan). Once satisfied that the burden of proof has been met, the host nation grants certification and the entitlement can be transferred without restraint.

Because certification takes place before the entitlement is marketed, rather than at the time of the transfer, it provides a convenient means of assuring compliance with the agreement without providing a damper on the vitality of the market process. All certified credits are completely transferable.

For signatory nations certification can take place at the national, rather than the international, level because the entitlement monitoring process provides a check on those individual decisions. Each year the signatory nations would be required to demonstrate a balance between actual emissions and entitlements. At that point any discrepancies would have to be resolved.[13] This approach appropriately places the regulatory burden on the aggregate, rather than on the transaction.

3.3 Certifying Created Entitlements

Created credits pose a rather different problem. Because they are not already part of national compliance plans, they must, at least initially, be certified on a case-by-case basis. To receive certification created entitlements must satisfy three conditions:

- The entitlements must be surplus. The surplus requirement could be met by demonstrating emission reductions below some established benchmark. Since designing that benchmark is probably the linchpin of the entire system, we shall discuss that at some length below.
- The surplus nature of the certified entitlements must be quantifiable. To receive certification tradeable entitlements must demonstrate to the certifying authority's satisfaction that the emission reductions underlying the tradeable entitlements must be real, not just a possibility.
- The reductions lying behind the tradeable entitlements must be enforceable. Easily reversible reductions which are difficult to monitor probably would not satisfy this criterion.

Deciding whether created entitlements are "surplus" requires the existence of a baseline against

13 In the United States Acid Rain Program discrepancies are resolved by canceling an equivalent number of future entitlements corresponding to any excess of actual emissions over dedicated entitlements as well as by imposing a financial penalty.

amount of the reduction which is "excess" can be certified as surplus.

In general the baseline defines the amount of control that should be exercised before additional reductions become "surplus". Any baseline should satisfy several criteria: (1) it should provide a fair basis for allocating the control responsibility, (2) it should not provide inappropriate incentives for emission increases and (3) it should facilitate (or at least not impede) the evolution of the tradeable entitlements system.

Several philosophical approaches for defining the created entitlements baseline are available based either on rules or discretion. Three possible rules include: (1) the "what would have happened otherwise" rule, (2) the marginal external cost rule and (3) the international benchmark rule. We shall consider each of these in turn.

The "what would have happened otherwise" rule allows deviations from expected outcomes to be counted as surplus. For example, the carbon sequestering capability of a forest that is saved from being cut down or the reductions in carbon emissions from building a new energy efficient factory to replace a less energy efficient one might both qualify as a created entitlements under this rule.

The pitfall in using this rule is that the resulting baseline can be manipulated by potential entitlement creators for their own advantage. Since preventing forest destruction could create surplus credits, threatening the destruction of a forest becomes a means of creating an advantageous baseline. Under this rule actions which create more carbon dioxide could become individually rational in the short run as means of creating a favorable baseline. Naturally this type of strategic behavior undermines the achievement of the objectives of the climate convention.

Not all situations, of course, raise this concern. When what would have happened otherwise is clear from historical experience and no evidence of strategic manipulation is apparent, this particular rule could well be applicable.

Strategic manipulation can also be countered by using other rules for baseline definition. Two other rules are not as susceptible to manipulation. The "marginal external cost rule" is a familiar one since it is the rule used by the Global Environmental Facility to dispense funds for projects of global environmental significance. According to the "marginal external cost rule" emission reductions would be surplus if they exceeded levels which would be rational for individual nations to undertake purely in pursuit of their own self-interest. The test is based upon a benefit/cost analysis in which all benefits and costs of reducing emissions are defined purely in terms of the individual country's interests. No transboundary benefits or costs would be included in this particular calculation. The level of control up to and including a level of control which maximizes that nation's net benefits (total benefits minus total costs) from a purely self-interest point of view would be included in the baseline. Any control beyond that would be considered surplus.

The "marginal external cost" rule introduces a few problems of its own. First it takes no account of the ability of whether or not individual countries can afford the level of control which maximizes domestic net benefits. Second, relying on a benefit/cost test would not only make the certification process rather expensive and time-consuming, but it is not clear that current benefit estimation procedures can be relied upon to the extent necessary to satisfy the certification procedure.[14] In many countries, for example, where this rule might be applied, the data necessary to implement these procedures are difficult, if not impossible, to come by at any

14 This point was underscored by a report on the GEF by a group of independent experts who labeled the marginal external cost rule "intellectually quite interesting", but "insufficiently precise" as a basis for lending. Quoted in The Economist (December 4, 1993):85

reasonable cost. Finally, the marginal external cost rule prevents any rent from being transferred to developing countries. All funds they receive are designed to provide external benefits. Using the "what would have happened otherwise" baseline, by way of contrast, could provide developing countries with benefits for them as well as the global community.

A final approach to defining the baseline for created entitlements envisions the application of a predetermined threshold of control responsibility. Once this threshold was reached, additional reductions would be considered surplus. This standard could be defined either in aggregate or source-specific terms to fit the evolutionary stage the program was in at the time.

An aggregate standard would simply specify a level of authorized carbon emissions for the nation as a whole. A source-specific baseline would stipulate how much control would be necessary from an individual source before additional reductions from that source could be certified as tradeable entitlements.

In the joint implementation stage, where offsets are sought from nonsignatory nations, a source-specific baseline would be the easiest to implement because it would only have to be defined for those sources seeking to receive created entitlement certification. Developing a reliable carbon emissions inventory for every source in that country entire country would be impossible and unnecessary at this stage.[15] Yet the certification procedure could provide the impetus for developing a national emissions inventory, which would be a key part of the process of becoming a signatory nation. The created credit certification process would not only provide estimates of actual emissions reductions (possibly transferable to other situations within the country or even to other countries), it would also facilitate the development of both procedures and institutions for measuring and recording compensating emission reductions.

Source-specific baselines could either result from the application of universal standards ("off the shelf") or from a case-by-case discretionary process. Whereas under a universal standards approach the bureaucracy would attempt to define baselines for likely projects in advance in advance, applying those standards to all parties seeking certification as necessary, under a discretionary approach the baseline would be defined on a case-by-case basis as the need arises.[16] Early case-by-case determinations would establish precedents for subsequent decisions. A case-by-case process would prioritize certification determinations by focusing on specific issues as they arise.

A discretionary process would also facilitate the incorporation of greenhouse gases other than carbon dioxide because individual sources could be included as soon as they satisfied the certification criteria. Waiting for all sources of any particular greenhouse gas to fulfill the requirements would no longer be necessary. Once these other greenhouse gases fulfilled the certification requirements, they would be allowed to serve as the basis for offsets on an individual basis without necessitating any wholesale inclusion of all sources of those gases. Providing a window of opportunity for other greenhouse gases would also facilitate the development of new approaches for controlling those gases.[17]

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15 With respect to the Poland and Mexico demonstration projects, the GEF has found that data which would allow the definition of a meaningful detailed national baseline projection do not exist.

16 This is the approach taken by the GEF for the Mexico and Poland Demonstration Projects.

17 Incorporating other gases, however, would require the establishment of procedures for determining their relative contribution to the global warming problem. Ideally it would be possible to develop a table of equivalencies, which would be published and available to all traders in advance. Unfortunately any such table would necessarily represent a simplification of the atmospheric chemistry involved in global warming. In particular since the reactions take place at markedly different rates, the contribution of each gas to global warming is a function of time. Reductions in some gases would have a more immediate impact than

The rigor of the certifying process will vary markedly with the evolutionary stage. During joint implementation it will necessarily be somewhat more experimental. This is desirable not only from the point of view of providing opportunities for "learning by doing", but also because the current legal regime is rather informal. Because stabilization is a goal not a requirement, nations will normally be pursuing joint implementation either for altruistic or for domestic reasons. Entitlements created during this period will be much more important for their demonstration effect than for their consequences for global warming.

That will change once the initial entitlement stage begins. Once signatory nations are allocated entitlements and held to emission limits, assuring the integrity of the certification process will become very important.

The major possible impediment to a smooth transition from one stage to another involves the treatment of created credits, which a nonsignatory nation has either sold or leased to others, once that nation becomes a signatory. For example, if the rule for allocating entitlements to new signatories were based on historical emissions (and all potential signatories were aware of that relationship), an incentive to increase emissions for the purpose of receiving a larger entitlement allocation, once the agreement was signed, would be created.

Basing future entitlement allocations on variables other than historical emissions is one practical solution to the problem, a solution which seems quite compatible with a basic sense of fairness. Most discussions of entitlement allocation envision allocating more entitlements to developing countries than would be justified by historical patterns as a means of accommodating future development.[18]

The remaining question is how existing offsets should be incorporated into later stages. What is the link between created entitlements certified by a nonsignatory and allocated entitlements subsequently received by a newly participating nation?

Once the entitlement allocation for the new signatory has been negotiated (presumably based on some criterion other than historical emissions), already transferred entitlements should be counted against the allocated entitlements. In other words suppose a country has leased or sold 30 tons of CO_2 offsets for five years to another country prior to signing the agreement and receives 1000 tons per year of allocated entitlements following acceptance of the agreement. How should the accounting of these two types of entitlements be handled?

Once the agreement is signed and a specific entitlement allocation received, any outstanding offsets should be counted against that allocation for the years remaining. Consider the effect of adopting this rule in the context of our previous example. For the remainder of the sale or lease agreement the nation in question would have 970 unencumbered entitlements. Once the five years was completed it would have the full 1000.

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others.(For example, a 1 ppm concentration of methane at a point in time contributes 26 times more to global warming than an equivalent amount of CO_2, but the atmospheric lifetime of CO_2, is 10 to 20 times longer.)The practical implication of these chemical reactions for policy is that the relative contribution of any two gases to global warming is not a constant. And the construction of a table of equivalencies presumes that the relative contribution can be expressed as a constant.

18 This can even be justified on efficiency grounds. See Graciela Chichilnisky, Geoffrey Heal and David Starrett, "International Emission Permits: Equity and Efficiency" a Columbia University Working paper, November, 1993.

4. Monitoring

Monitoring serves two primary functions. First, it provides a basis for assessing compliance with the agreement. Assessing compliance is an important initial step in the process of assuring compliance. Second, it provides a basis for deciding whether stronger international actions would be necessary.[19] Since not all nations will participate in the agreement, at least initially, even if the convention were completely successful in achieving the country-specific stabilization goals in signatory nations, global carbon emission stabilization would not result. In order to track progress toward the global objectives specified by the Convention, it is important to keep track of emissions not only in the signatory nations, but, to the extent possible, in the nonsignatory nations as well . Anticipating the use of a tradeable entitlements system may facilitate the development of this capability.

Broadly, monitoring is the process of collecting information: 1) on emissions of controlled greenhouse gases and/or the behaviors that lead to those emissions, for example emissions of CO_2 and/or the burning of different fossil fuels; 2) on the problem that the agreement was designed to solve, for example levels of atmospheric CO_2 and incidence of adverse climatic effects; and, 3) on the extent to which the international agreement has produced policy responses at other levels of governance, for example whether domestic policies have been devised and implemented to meet international agreed targets for CO_2 emissions. Monitoring provides the basis for assessing whether a particular nation, firm or individual is complying with the agreement, whether the problem as a whole is improving, and whether inadequate solutions are due to failures in the agreement itself or in the process of implementation. The extent to which existing agreements are sufficiently monitored varies widely.[20]

Here we focus on the first of these--the monitoring of emissions of controlled greenhouse gases and/or the behaviors that lead to those emissions. An extensive literature has reviewed what is known about the different sources and sinks of greenhouse gases,[21] and, studies have explored the extent to which monitorability of these is compatible with the administrative needs of a system of tradeable entitlements.[22] In practice, direct emissions to the atmosphere are rarely measured; rather, proxies are monitored and then emissions computed on the basis of the proxy using an emission factor. No single proxy may suffice because emission factors may vary with the conditions; under those circumstances, a suite of proxies must be monitored together in order to accurately compute the resulting emissions. The key issue of monitorability devolves to two interrelated questions: what is the monitorability of the proxy? And, how well

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19 As the experience with the Montreal Protocol indicates initial international actions may not be strong enough.

20 For a review of the functions, concepts and evidence related to each of these types of monitoring see J.H. Ausubel and D.G. Victor, 1992, "Verification of international environmental agreements," Annual Review of Energy and the Environment **17**, 1-43.

21 For example, see the review--which includes a review of other reviews--in the 1990 report by IPCC. R.T. Watson, H. Rodhe, H. Oeschger and U. Siegenthaler, 1990. "Greenhouse gases and Aerosols," in: J.T. Houghton, G.J. Jenkins, and J.J. Ephraums, eds., Climate Change: The IPCC Scientific Assessment, New York: Cambridge University Press.

22 For example, D.G. Victor, 1991, "Limits of market-based strategies for slowing global warming: The case of tradeable permits," Policy Sciences **24**, 199-222. For more detail see D.G. Victor, 1990, "Tradeable permits and greenhouse gas reductions: some issues for U.S. negotiators," Global Environmental Policy Project Discussion Paper Series, Energy and Environmental Policy Center, John F. Kennedy School of Government, Harvard University.

do the emission factors estimate actual emissions?

In the case of carbon dioxide emissions due to combustion of fossil fuels there should be few insurmountable problems. At the margin, monitoring costs should be low because the proxy--quantities of fossil fuel disaggregated by type--is already monitored, and the emission factors are well understood. Because the vast majority of fossil fuels are traded commercially and energy is an issue of high political and economic salience, most countries have in place elaborate systems for monitoring flows of energy through the economy. Data systems are especially well developed--with detail to the level of individual refineries or even vendors to final consumers--in settings where sale of fuels is taxed, and thus existing institutions that administer fuel taxes could be used to administer the entitlements system.[23] At the international level, the International Energy Agency (IEA, a quasi-independent arm of OECD) has a regularized system of assessing and harmonizing those national data.[24] These data systems are disaggregated by fuel type, and the carbon emission factors for each of the fuels are well known.[25] In short, it is entirely appropriate--as we have done here and as is the case in most of the literature on tradeable permits for greenhouse gas control--to focus on carbon emissions from fossil fuels in the earlier stages of global warming control.

Any monitoring system must necessarily fit within the context of existing international and domestic institutions. Thus, precedents are important because they form expectations on the types of systems that are economically and politically feasible. And, in an effort to optimize the monitoring system, marginal costs will be lowest where suitable existing institutions and proven designs are utilized. In this spirit, our analysis of past experience with monitoring in both domestic and international settings suggests that the following design principles provide a reasonable basis for creating a politically and economically viable monitoring system:

<u>Rely heavily on self-reporting.</u> Polluters have the most information about their activities and thus can provide it as part of a monitoring system at a cost much lower than if independent monitoring systems were created. Virtually every domestic and international enforcement system is based on self-reporting, and other modes are not economically or politically viable.

<u>Create layers of veracity checks.</u> Systems of self-reporting do offer many risks of deception, although analysts may over-state the extent to which purposefully deceptive self-reporting occurs. Nonetheless, risks of deception do exist, and assuring the integrity of the permit system will require assuring the integrity of self-reporting. At the initial stages of the

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23 We have not addressed many of the details that would have to be settled, especially at the culmination stage where the number of sources is large. For example, at what point is an entitlement considered 'used'--at the point of final vending to consumers (e.g. the gasoline or petrol station) or at more concentrated sources upstream? If markets are efficient, probably it can be shown that the point of application will not matter because prices will adjust throughout the market. But choices here could significantly affect the market. For example, if refiners are state-owned or heavily regulated (which is true in many countries), it might be unwise to make them the linchpin in the tradeable permits system because they might not be sufficiently motivated to buy and sell permits in an economically efficient manner. And, in terms of administration, if existing institutions are to be used then the entitlements system must be tailored to fit with the points of monitoring (and enforcement) of those institutions.

24 This capacity can be used also to assess the national statistical systems for energy in non-OECD countries, and in some cases it has been.

25 Those factors may be adjusted for local fuel types to provide more accurate estimates. We have not addressed whether those factors should be adjusted for other emissions, notably SO_2, which offsets some of the forcing due to CO_2. The exact amount of the offset is debated and depends on many factors, including issues of time horizons discussed later in this section.

entitlement system rather informal veracity checks of self-reporting will be needed, but as the system matures these will need to become increasingly formal and reliable. National governments could provide many (or most) of the domestic veracity checks, provided that those checks are themselves reviewed occasionally at the international level. Veracity checks could be less costly if coupled with policy reviews already envisioned (partially) under the Convention.

Promote transparency of behavior through wide availability of collected data. The assurance function is better fulfilled if data are widely available; veracity-checking is easier if multiple sources of information are available; and, private enforcement is frequently heavily dependent upon the existence of rich database.[26] Further, a monitoring system will produce much data that could be useful in other settings, such as scientific research. Some reluctance to reveal proprietary information is to be expected, but the free flow of information should be the presumption.

Begin certification and monitoring processes promptly. Nations that contemplate establishing tradeable entitlements systems--even if initially not part of an international system--will need guidelines for appropriate processes of certification and monitoring. By developing guidelines early the chances of harmonized procedures in the future--when independent national systems might be merged into an international system--will be higher. Viable and legitimate systems created today, even if they are simple, will become the de facto standard. And, early creation of these institutions will highlight the needed changes in domestic institutions and procedures, allowing more time to make the necessary reforms.

Design monitoring procedures and institutions with future expansion in mind. Although the trading system may "formally" be at an early stage, monitoring systems for later stages need not wait. Notably, the process of examining domestic monitoring procedures will take a long time and could begin now. Initially with volunteer countries, the veracity-checking function could delve deeply into domestic monitoring, with appropriate international sensitivity, to review and assess the compatibility between domestic practice and the evolution of a more extensive international market. Future expansion may include extension to non-carbon sources. If so, markets should be designed to keep the option of a carbon track that evolves to later stages while some or all non-carbon sources remain longer at the offset stage.

5. Enforcement

Once monitoring has uncovered noncomplying behavior an enforcement process is needed to restore compliance. An enforcement process is necessary not only to encourage reluctant compliers, but also to protect the interests of those who voluntarily comply. One of the paradoxes of enforcement is that the best enforcement processes rarely are invoked; their existence may be sufficient to deter noncomplying behavior.

This outcome is particularly likely when the agreement being enforced has broad, deep support among the nations.

An enforcement process can encourage compliance by means of a variety of positive and negative incentives. In contrast with domestic enforcement which relies on a number of tried and true sanctions, international enforcement requires greater creativity and a heavier reliance on persuasion. Fortunately we believe it is possible to build upon existing institutions to craft an enforcement regime which is adequate for current purposes and is capable of evolving in the specific directions needed to support a comprehensive entitlement system. While monitoring provides the base of information upon which suspicions of noncompliance can be lodged,

26 See the review and analysis in: W. Naysnerski and T. Tietenberg, 1992, "Private enforcement of federal environmental law," Land Economics **68**, 28-48.

enforcement is the process of moving from suspicions to penalties.

The life cycle of an enforcement episode consists of several stages: 1) suspicion & flag raising, 2) investigation, 3) clarification and judgment, and 4) penalty. As the process moves along, ultimate sanctions become clearer and the parties frequently settle. Therefore, sanctions are rarely imposed because previous stages in the process transparently lead to adverse consequences--thus the paradox noted earlier that the most effective penalties are rarely (if ever) used. Some penalties occur along the way, such as shame and loss of reputation from negative publicity, and legal fees. The goal of a robust enforcement system is to make ultimate sanctions credible so that threats--which are expensive to carry out--are rarely imposed. Optimal deterrence, which is difficult to achieve within domestic political systems, is even tougher at the international level where the history of enforcement is relatively thin and it is difficult to raise budgets or political authority for enforcement institutions.

These difficulties associated with designing effective enforcement systems based on traditional penalty structures are tempered by strong norms in the international system in favor of complying with international law as well as strong pressures--in the form of reputation and reciprocity--in favor of joining legitimate international treaties. Thus states remain parties of treaties even when their narrow obligations under the treaty are inconvenient.[27] Fear of being exposed as a violator of one's agreements--and as a violator of international law in general--leads to strong predisposition towards compliance within government bureaucracies, through state leaders' reputations, and with the public. Some persuasive evidence suggest that despite this weak formal enforcement, compliance with international agreements is actually quite high in general.[28] The use of sanctions is rare in part because compliance is high and in part because nations are ultimately reluctant to use force.

Much of international law presumes that enforcement will be based upon public opinion and normative pressure to comply--transparency is important because it makes violations apparent, and the fear of detection promotes compliance. The international system is marked by reluctance to enforce treaties and by inflexibility within treaties and international institutions to take swift and regularized enforcement actions. Few examples of regular enforcement procedures have been built into international agreements, and international institutions that perform enforcement functions are limited in their power. Those systems that do exist are based heavily on self-reporting, with some room for independent information. NGOs, where they are regularly and actively involved, have gained credibility and played some roles in identifying violations (e.g. IUCN under CITES and industry associations under the Whaling Convention), and secretariats can help. But, the ultimate authority lies with the parties.

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27 For example, Japan has remained within the Whaling Convention and portions of CITES even when the obligations of those wildlife agreements strongly clashed with Japanese practice.

28 See, for example, the often quoted statement "Almost all nations observe almost all principles of international law and almost all of their obligations almost all of the time" in L. Henkin, How Nations Behave, 2nd ed., New York: Columbia University Press. However, the evidence for this point is thin--it has been quoted extensively because it supports claims by many international law and international relations scholars that international norms and obligations matter and thus their research program studying the use and effectiveness of, e.g., international agreements and norms is not irrelevant. For a seminar study of compliance in decentralized settings, including the international system, see O. Young, 1979, Compliance and Public Authority, Baltimore: Johns Hopkins University Press. For the major recent analysis of compliance with international agreements see A. Chayes and A.H. Chayes, 1993, "On Compliance," International Organization **47**, 175-205.

5.1 Design Principles

Enforcement is the most noticeable gulf between pure theorists of international collaboration, who argue that tough collective action problems can be solved only if states submit to tough enforcement, and many international law scholars, who argue that the need for such enforcement is overstated because compliance can be (and is) high despite the absence of tough enforcement. Both could be right if we note that international agreements frequently are not solutions to collective action problems--agreements are negotiated so that they conform with underlying interests and are aligned in favor of compliance. Truly collaborative agreements are rare. And, for salient issues in world affairs--such as compliance with a major arms control agreement--fear of adverse publicity may be a sufficient enforcement instrument. The challenge for a tradeable entitlements system is that as permit prices increase, incentives to defect will be strong. At the same time, as the permit system evolves the number of actors in the market will increase, making it unlikely that traditional modes of international enforcement--such as public opinion and normative pressure to obey the law--will be sufficient. Traditional international enforcement instruments are ill-suited to handle large-scale defections when the number of emitters and permit holders is measured in the thousands (or more).

But, the problem is not catastrophic. Based on extending current examples from international and domestic settings, the following design principles can provide the basis for an economically and politically viable enforcement system; many are in the same spirit as the design principles for monitoring systems:

<u>Rely heavily on domestic enforcement, especially by existing institutions.</u> A wide variety of domestic enforcement systems should be expected because there are many histories and cultures, and enforcement instruments will vary with these. The international system must accommodate this, and in practice that must be done by allowing the major enforcement activities to occur at the domestic level through familiar institutions.

<u>Set international standards for domestic enforcement.</u> Although diversity must be expected, some international standards will be needed. At a minimum, agreed acceptable levels of noncompliance will be essential to assuring that property rights are more or less stable across different markets.[29] Failure to do so would result in loss of confidence in the value of internationally traded permits and substantial thinning of the market. Such standards may not be needed at the earliest, offset and initial entitlement stages when the mode of domestic implementation is irrelevant because trading is entirely between governments and it is governmental responsibility to assure that total emissions (and net trading of entitlements) meet the agreed targets. But, standards should be devised and tested at the earliest stages--and form an early part of the institutions and expectations that arise under this market--because stability and effectiveness here will be essential for later evolution into the culmination stage. These standards will have significant political and economic implications, and the broad features of the standards must be negotiated rather than set by technicians. A logical body for this early work would be the "Subsidiary Body on Implementation" established under the Convention, or some independent body created by the CoP and charged with implementing a permits system.

<u>Perform veracity checks and international adjustments through agreed procedures.</u> As with monitoring, compliance with international standards for domestic enforcement will fundamentally be assessed by self-reporting, but those reports must be subject to layers of veracity checks. Without this capacity operating on a regular basis with established guidelines for how parties must address failed checks, the market may destabilize on fears of incomplete domestic enforcement.

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29 As is done with International Atomic Energy Agency (IAEA) safeguards, it may prove helpful to set guidelines for acceptable levels of noncompliance within domestic systems, say 10% or 20%, so that tolerance of the system and enforcement goals are clear.

Ensure proper operation of dispute resolution procedures. Similarly, procedures that create a path for regular dispute resolution will be needed. Disputes are an opportunity to learn, and long term harmonization of domestic implementation will require a capacity to address implementation problems as they arise. The current experience with the GATT is a starting point, and the draft text for the completion of the Uruguay round includes even better procedures. The parties must break the mold of ineffective dispute resolution within environmental treaties if a system such as this one--with major economic implications--is to operate smoothly.

Disputes will be prone to escalation because enforcement affects permit prices which in turn affect the costs of production (notably through energy costs) which in turn affect international competitiveness. Thus most disputes, even over seemingly technical issues, could destabilize into unproductive divisive debates over economic competition and welfare. Agreed procedures could help chart the way and keep disputes productively focused on the issues at hand. Indeed, disputes can be very helpful in promoting learning. And, the parties should expect to encounter many implementation problems, if only because implementation will be difficult and the parties must learn how to do it in their particular domestic setting.[30]

Push early adoption of institutions and procedures. The system will evolve if lead countries take the initiative and show the way. The international system of organizations and diplomacy is not well-suited to forging the path, but it can help by working with leaders to establish institutions and procedures before they are needed. (OECD does this frequently, and as a result OECD helps to set the agenda and pace for collective action on issues such as harmonization of chemical standards and trade in hazardous waste.) An endless supply of important details must be addressed, and early experience can help ensure that bad choices do not undermine later, broader markets once they are underway.

However, leadership may require assumption of some (perhaps substantial) risk. For example, if a country (or group of countries) decides to implement a domestic market system--as a way to show that the culmination stage is viable--then it must bear the risk that actual emissions will be higher than its target due to initial difficulties with the market. Similarly, countries decide to bear the risks of stable exchange rates by creating target systems supported by central banks, sometimes at enormous cost.

Transparency. The most important function of penalties is as a deterrent, and thus transparency is important so that it is clear that noncompliance will be detected and that detection will lead to penalties. For reputable actors, a transparent system may be all that (or most of what) is needed because fear of losing reputation will be a strong deterrent. Especially for private enforcement, which is probably very sensitive to incentives, a rich and accessible base of information would be very helpful.

6. Conclusions

The successful implementation of a transferable entitlement system requires the existence of a supporting set of institutions and procedures as well as the necessary resources and information to allow them to run effectively. The amount of sophistication demanded of those institutions and procedures depends crucially on the nature of the transferable entitlement system.

In this paper we have identified three stages of evolution that a transferable entitlements system might experience, moving from the current joint implementation stage to a culmination stage

30 It might be interesting to speculate on whether veracity checks for monitoring and enforcement that promote harmonization of domestic systems might contribute, more broadly, to processes of political harmonization.

which would incorporate rather complete markets involving several different gases and complete participation by all public and private sources. While it would be possible to undertake actions in earlier stages which would preclude the effective evolution of this system, we have also found that each stage can be designed in such a way to fulfill immediate objectives while facilitating the maturation of the system.

Starting with a rather simple system, the approach taken by the Climate Change Convention, was in our view not merely expedient, it was sound policy. The offset system allows the process to begin without overwhelming the supporting institutions.

Precedents can be set on a case-by-case basis at a more leisurely pace than would have otherwise have been possible. Procedures can be refined on the few initial trades and subsequently generalized as the system evolves. Data can be developed and reporting frameworks harmonized. Staffs and nations can become comfortable with the overall approach. The transferable entitlement system and the institutions that support it can mature together.

We have also examined the three key functions performed by this supporting institutional structure: certification, monitoring and enforcement. Certification is designed to offer great flexibility in creating credits while assuring that the overall objectives of controlling global warming are not jeopardized by that flexibility. Monitoring serves two primary functions. First, it provides a basis for assessing compliance with the agreement. Assessing compliance is an important initial step in the process of assuring compliance. Second, it provides a basis for deciding whether stronger international actions would be necessary. An enforcement process is necessary not only to encourage reluctant compliers, but also to protect the interests of those who voluntarily comply.

Although the basic criteria for certification are invariant with respect to the type of entitlements, the burden imposed by those requirements depends on the nature of the entitlements; it is much larger for created entitlements than for allocated entitlements.

An important issue to be addressed in the certification process for created entitlements is how the baseline is defined. Of the three possible baselines we have addressed in this report-- (1) the "what would have happened otherwise" rule, (2) the marginal external cost rule and (3) the international benchmark rule-- a discretionary version of the international benchmark rule seems to be the most workable.

The process of certification depends on the creation of a new subsidiary body within the Conference of Parties to oversee the daily operations, an eventuality anticipated by the framers of the Convention. Sharing clearly specified responsibilities with national bodies should allow this process to proceed rather smoothly from existing arrangements.

Our review suggests that a workable monitoring system can be designed which relies heavily on self-reporting, which involves layers of veracity checks, which promotes transparency of behavior through wide availability of collected data, and which is flexible enough to respond to changes in circumstances. Monitoring will of necessity be the shared responsibilities of international and national public authorities with private organizations such as environmental nongovernmental organizations playing a very limited augmenting role.

Designing enforcement systems at the international level is difficult because international institutions are typically weak and international treaties rest on the assent of their parties. Fortunately, however, strong norms in the international system in favor of complying with international law as well as strong pressures--in the form of reputation and reciprocity--in favor of joining legitimate international treaties make the task easier than it would be in a more hostile environment. Fear of being exposed as a violator of one's agreements--and as a violator of international law in general--leads to strong predisposition towards compliance within government bureaucracies, through state leaders' reputations, and with the public. Some persuasive evidence suggest that despite this weak formal enforcement, compliance with international agreements is actually quite high in general and we believe this experience is relevant for enforcing transferable entitlements.

Yet inducing compliance is certainly not easy. Traditional international enforcement instruments are ill-suited to fine-tuned enforcement when the number of emitters and permit holders is measured in the thousands (or more). Even at early stages, where trading is formally limited to national governments, it is unlikely that public opinion will be sufficient to preserve the integrity of the market--claims of permit shortfalls are unlikely to mobilize public outrage or superpower action to the degree that human rights, whaling and oil pollution have been able to.

But, the problem is not catastrophic. An economically and politically viable enforcement system can be crafted if: (1) it relies heavily on domestic enforcement, especially by existing institutions, (2) it establishes international standards for domestic enforcement, (3) it incorporates veracity checks and international adjustments through agreed upon procedures, (4) it establishes proper channels and procedures for dispute resolution, and (5) the principle of transparency is effectively incorporated. The establishment of such a system would certainly be facilitated if leading nations or groups of nations took the initiative in crafting a feasible system and in agreeing to support it once it was established. The current Framework Convention offers sufficient flexibility--in the form of the Conference of the Parties (CoP) and the possibility for further protocols--to allow the first steps in developing the enforcement functions envisioned here.

Discussant's Comments

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This is a stimulating paper, but it is also preliminary and is deficient in some respects. For example, although the paper emphasizes the importance of time, no account is taken of technical progress. Interestingly, had the paper considered the availability of a "backstop" technology, this would have offered a convenient device for reaching a steady state.

Let us, however, focus discussion by recasting the model in a form which is easy to understand and familiar: the prisoners' dilemma game. A version of this famous game is shown in Figure 1. There are two countries, I and II. Each may choose to abate or to pollute. The payoffs which each country receives depend on what action it chooses and what action the other country chooses. In the Figure, the number on the left in each cell is I's payoff and the number on the right is II's payoff.

Now, suppose each player must choose an action, that in doing so each player knows that the "game" will be played only once, and that each player prefers a larger payoff to a smaller one (without any regard to the payoff received by the other country). When player I chooses an action, it considers how its payoff depends on the action chosen by player II. Suppose II chooses "abate". Then I receives a payoff of 5 if it abates and pollute(=6) if it pollutes. pollute is bigger than 5, and so I will choose pollute, given that II chooses abate. Now suppose II chooses "pollute". Then I receives -1 if it abates and 0 if it pollutes. 0 is bigger than -1, and so I will choose pollute given that II chooses pollute. In other words, I will pollute whatever player II does. Since the game is symmetric, we know that II will also choose pollute. Then, both players will choose pollute and receive a payoff of zero.

Dr. Brian Fisher's model is similar to this one except: (i) his model consists of more than two countries; (ii) countries are different (not symmetric) in his model; (iii) the choice of emission levels is continuous in his model but binary in the prisoners' dilemma; (iv) the game is played more than once; and (v) he payoffs at date t depend on the solutions to previous plays of the game.

While this prisoners' dilemma game is different from Dr. Brian Fisher's, there are also similarities. Note that in the prisoners' dilemma, both players choose "pollute" but both players would receive higher payoffs if they both chose "abate". Also, the total payoff is greatest when both parties abate (5+5=10). In Dr. Brian Fisher's model, the noncooperative outcome is similar to the outcome (pollute, pollute), and the full cooperative outcome is similar to the outcome (abate, abate). The gain to cooperation is the difference between the aggregate payoffs in these two outcomes, 10-0=10. In Dr. Brian Fisher's model, this difference is shown in Table pollute as $43,990 billion.

The major omission in Dr. Brian Fisher's model is that he does not determine whether or how the full cooperative outcome can be sustained. As we have seen, the equilibrium to the prisoners' dilemma game is (pollute, pollute), yielding an aggregate payoff of 0. To sustain the better outcome (abate, abate), free riding must be deterred. One way of doing this is by allowing each player to "punish" the other if it chooses "pollute" rather than "abate". Punishment is possible in Dr. Brian Fisher's model because his game is played repeatedly. If a player cheats in period t, the other can punish this player in period t+1. It is possible that such punishments can sustain cooperation, and Dr. Brian Fisher may wish to consider this possibility.

Figure 1

II

I	Abate	Pollute
Abate	5, 5	-1, 6
Pollute	6, -1	0, 0

Discussant's Comments

Noriyuki Goto
Kanazawa University

I would like to thank both speakers for the interesting and informative reports that contained many constructive proposals. I would make a commentary discussion on the two points with my questions to the speakers.

First of all, thanks to the nice review of the U.S. experiences by Mr. Harper, we can be assured that a tradeable permits system might work well as a mechanism provided that certain conditions were satisfied. From the review, we notice that in almost all cases the approach was taken after the legislation or the legal agreement of a clearly specified target plan which would have been attained through rigorous national and political debates. I am inclined to share the view that the clear statement of the goal and the legislation, which virtually excludes a free-riding and non-participation in a domestic context, are essential presumptions to the well-functioning of the system. If these conditions were satisfied, then we can see the process as an economically rational response to the constraint. In an international context, however, it is anticipated that the maximum efforts as well as huge costs would have to be devoted to establishing these conditions, which might also take very long time. Although such system as a joint implementation could be employed as a first step, its hasty introduction seems to be dangerous to the construction of a sound international framework that may affect a long-term global control scenario. For example, it is highly probable, as is often argued, that hesitant countries attempt to use the system to escape from making the best efforts to reduce the emissions. The U.S. examples also suggest that it might discourage technological innovations that are expected to play a significant role and are economically efficient in a long-term perspective because they are apparently costly and risky investments in the short run that private sectors would hesitate to conduct.

Here, my question to Mr. Harper is how and to what extent the possibility of introducing a tradeable permits system in the future affected the legislation process in the U.S. experiences, or more precisely whether or not it actually promoted the legal establishment of a stringent environmental policy particularly in the early stages.

I would like to proceed to the second point. Although I cannot say I am well prepared for the detailed technical discussions on the dynamic game approach presented by Dr. Fisher, the qualitative results derived there are mostly understandable and conform to my intuition. Above all, it is demonstrated that a global cooperation could realize a high degree of economic efficiency, to which a significant contribution of a tradeable permits system might be possible. Here, let me look at this from a slightly different angle. Although in many occasions tradeable permits issues seem to be discussed focusing solely on the system itself, I would like to pay attention to the consistency of the system with other international control framework. In yesterday's sessions, we had constructive discussions on a tax control policy. Taxes are widely recognized as a most effective economic instrument in the reduction of greenhouse gas emissions. I totally agree with this. My personal view is that the introduction of a certain taxation scheme would be easier to be agreed internationally and be realized earlier than a tradeable permits system, even if the tax rate is quite mild in the early stages. Although I cannot predict what kind of tax agreement will be attained, typically there can be two types of international framework. One is that an equal tax rate is accepted among countries, which might be desirable in terms of fairness in trading as well as an emissions leakage, and the other is that the tax rate is determined by each country so as to attain a specified quantity reduction target. According to the UNCED convention framework agreed at the Earth Summit in Rio, the latter may be closer to the actual political environment. In the latter, however, such compensation as an import tariff based on the differences of tax rate among countries might be employed to maintain the international trading competitiveness as it is. Let us briefly examine whether a tradeable permits system can be well integrated into the international taxation framework. At first sight, a tradeable permits system does not seem to be logically consistent with the uniform tax rate regime because permits trading is essentially an instrument for the quantity control. On the other hand, the system appears to be consistent with the latter taxation regime. A country that is required to impose higher tax rate due to higher marginal abatement costs is willing to buy emissions right in return for lowering the tax rate, and vice versa. In Dr. Fisher's model, this might be almost equivalent to the movement from unilateral actions to a global cooperation. Looking at the dual side of the mechanism, therefore, the tradeable permits can be considered to be a tool to equate the tax rate among member countries. Now, we could say that the system is not only consistent with but also a mechanism to help approach to the uniform tax rate regime, which is the most desirable outcome in terms of cost-effectiveness at least theoretically.

Here, however, the purpose of my discussion is not to show such consistency that is rather trivial. My question is the following: If the logic is right, then could we not design a different control scheme that leads to a desirable goal, based on the same idea as a tradeable permits system but is easier to implement? In my mind is the integration of a uniform tax rate and tax revenue reallocation system in which all or part of the tax revenues are collected in a newly established international institution and are reallocated based on the cost-effectiveness by bidding among all countries that express their intention, clearly state the plan, and demonstrate the capability based partly upon the past performances to reduce emissions by themselves in return for the drawing right of the fund, which I call "emissions reduction initiatives (ERI)". The global tax rate should be continuously adjusted, according to the increases in the scientific knowledge and the environmental status quo. It seems to me that this scheme could simplify several complexities associated with a tradeable permits system while maintaining basically the same concept. In addition, we could rely on the positive willingness of each country rather than a hesitant compliance or a complicated negotiation on the side payments as the principal driving-force to support the system.

Discussant's Comments

Jin-Gyu Oh
Korea Energy Economics Institute

I enjoyed reading Dr. Sedjo's paper dealing with forests as carbon sinks in tradeable permits schemes. His paper provides a nice overview of the various issues involved and motivates me to say that more attention should be paid to forests when we discuss policy instruments for climate change.

In the case of tradeable emission permits, the precondition is that actors are agreed on the emission target's schemes or emission permits. The analogy for forestry is the agreement on the absorption target or absorption liability. Given the current understanding on forests as carbon sinks, the quantification of absorption liability at the national level seems to be a daunting task. Getting agreement on an initial allocation of absorption targets among countries is therefore likely to be more difficult. Hence, rather than creating a separate tradeable absorption market for forest obligations, tradeable forest options could well function as part of the tradeable emission permit system, which is relatively well understood and defined. Forest options can be utilized in terms of a created entitlement as discussed in Tietenberg's paper. Forest offset schemes can be practical options especially in the Joint Implementation step. As part of tradeable emission permits systems, the forest option would be among the first to be utilized since the level of marginal costs are very low compared to other options as indicated in Dr. Sedjo's paper.

When he discusses subsidies on forest and agriculture competing for land, it seems to me that it would make more sense if the subsidy on energy production or consumption is removed and converted to an afforestation subsidy, rather than from agriculture to forestry. This is because a decisive influence on the demand for agricultural land is not likely to be the climate change issue, even though agriculture is quite a sensitive sector to climate change. Removing a subsidy on agriculture on the sole grounds of converting land to forest seems to be politically infeasible in many countries. If we view sources and sinks in a comprehensive manner, the priority for removing subsidies would be those in the energy sector. One of the main goals in trying to minimize climatic change is to ensure agricultural production sufficient to alleviate poverty in developing countries. It is articulated in the objective of the Climate Convention, article 2, which reads "The ultimate objective of this Convention ... is to achieve ...stabilization of greenhouse gas concentrations in the atmosphere at a level.... Such a level should be achieved within a time frame sufficient ... to ensure that food production is not threatened ..." Of course, there is a need for sustainable agricultural practices which must be pursued regardless of the subsidy issue.

Finally, there are much more difficult issues in tradeable forest schemes such as the initial allocation, determination of a baseline, uncertainty, imperfect information, strategic behavior, monitoring, institutions and sovereignty. It seems to me that conservation of biodiversity is also a critical aspect of forest policy which should be brought into the discussion of carbon sinks.

Discussant's Comments

Matthias Mors
European Commission

Both papers presented in this session offer very stimulating reading and present their arguments very convincingly. In particular, Prof. Tietenberg's paper makes a very valuable contribution to the discussion by adopting an evolutionary approach and by explicitly distinguishing certification, monitoring and enforcement of emission entitlement. The following brief comments and questions merely reflect the caution of someone who is concerned about practical policy implementation in a region of the world with almost no practical experience with tradable emission permits.

The first comment concerns what is called stage I in the Tietenberg/Victor paper, namely the present situation of legally non-binding national emission stabilization goals. It is argued in the paper that this stage could be the training ground for administrative institutions supporting a later entitlement market. However, one can have doubts as to whether in the case of non-binding goals, the economic incentives for setting up administrative institutions for organizing offsets between countries are sufficient.

Secondly, there is the questions of who is going to trade entitlement in stage II (binding national emission targets), private sector agents or governments/nations. It is argued in the paper that at this stage of an international tradable permit scheme the choice of policy instruments at the national level is still open. However, if this is the case, one could easily imagine a situation in which taxes are used as a policy instrument at the national level. In such a situation it might be worthwhile to explore in more detail the administrative implications and costs of also allowing entitlement trade by individual private entities, as these entities are likely to request being exempted from the application of national policy instruments.

Thirdly, there are a number of issues related to the certification process. To begin with, one can doubt whether it is desirable to charge the certification process with eliminating "undesirable" energy substitutions as is foreseen in the Tietenberg/Victor paper. Instead, there might be a benefit of leaving such normative questions out of the certification process and leave them to the political process and institutions. In addition, as the certification / monitoring / enforcement process is likely to be of considerable importance for the credibility of the entire entitlement trading scheme, it would be worthwhile to have at least a rough idea of the likely administrative costs of such a process.

The fourth comment concerns the issue of the amount of permit trading or, put differently, the question of the efficiency of permit markets. A survey of the experience with tradable permit schemes in the United States as well as experience at the international level (e.g. in the context of the Montreal Protocol) seems to lead to the conclusion that, often, there has been less trading than originally expected by economists. The possible explanation for this are very high transaction costs. If this is the case, this would have important implications for the choice between emission taxes and tradable emission permits.

This latter point implies that more attention should be given to the comparison between a quantity-based (permits) and a price-based (taxes) approach. In addition to considerations of uncertainty with respect to global climate change, there seem to be other arguments in favor of an international agreement on the joint introduction of carbon/energy taxes. In particular, such an agreement would almost immediately ensure cost-effectiveness at the international as well as at the national level. However, if this were case, this would have important repercussions for the entire IPCC/INC approach, which at present is almost entirely quantity oriented.

Rapporteur's Summary

Erik Haites
Technical Support Unit, WG III, IPCC

The first half

The session featured papers by Dr. Brian Fisher on "A Dynamic Game Approach to Greenhouse Policy" and by Mr. Stephen Harper summarizing the "Lessons from U.S. Experience" with tradable permits.

Prof. Barrett used the prisoners' dilemma to illustrate the problem being tackled by Dr. Fisher. The problem is how to secure cooperation when everyone benefits through cooperative action, but without knowing the actions of others each party has an incentive to act selfishly with the result that everyone suffers.

The prisoners' dilemma deals with this problem for two parties where each makes one irrevocable decision. Dr. Fisher analyzed the problems for a number (10 to 15) of countries where each can vary its actions continuously and commitments are renegotiated frequently over time.

To secure cooperation, Dr. Fisher finds that side payments from some countries to others benefit everyone.

Prof. Goto found Dr. Fisher's results intuitionally understandable, but felt that internationally coordinated carbon taxes might be easier to negotiate and implement than a tradable permit system. Some participants, also questioned the feasibility of implementing a tradable permit system and adjusting allowable emissions, relative to a system of coordinated taxes. Others felt that given the uncertainties associated with climate change, reducing the uncertainties associated with the cost of control (through a carbon tax) is preferable to reducing the uncertainties associated with the level of emissions (via tradable permits).

As a result of his review of the U.S. experience with tradable permits, Mr. Harper advises that it is prudent to proceed cautiously with implementation rather than to try to create an ideal system. Some participants questioned how a tradable permit system could be implemented and enforced internationally among sovereign countries, given that countries have not yet negotiated emissions limits.

In the discussion it was pointed out tradable permits provide a means of transferring resources to developing countries without requiring developed country governments to raise taxes. Difficulties such as compliance and adjustments to emissions limits, it was noted, apply equally to other instruments as well. Similarly, the challenges of securing international cooperation are a feature of every policy regime.

In their final summaries, the speakers advocated starting with a simple tradable permit system and improving it over time. The tradable permit system needs to be structured to promote international cooperation. With experience the uncertainties surrounding permit prices will be reduced.

Even if a tradable permit system is not implemented, analysis of this mechanism can yield useful insights into how best to secure international cooperation to address climate change.

The second half

The session featured a presentation by Dr. Sedjo on tradable forest management obligations and by Prof. Tietenberg on enforcement on international tradable permits.

Dr. Oh, in his discussion of Dr. Sedjo's paper, questioned the cost estimates of carbon sequestration through reforestation, other possible benefits associated with forest management, and possible conflicts between forestry and agriculture. Other participants also questioned the cost estimates and the geographic regions to which they apply. Dr. Sedjo replied that the cost estimates apply broadly, but that other experts are developing improved cost estimates.
He also advocated creating a "level playing field" for forestry and agriculture by eliminating distortionary subsidies for either or both forestry and agriculture and recognizing non-market benefits such as biodiversity.

Prof. Tietenberg argued that the key aspects of a tradable permit system are certification of permits, monitoring of compliance, and enforcement. He argued that workable provisions can be developed for each of these aspects, but that this will probably occur gradually over time. Dr. Mors questioned the magnitude of administration costs for a tradable permit system. He also noted that the certification process is critical.

Prof. Tietenberg noted that a great deal can be learned from joint implementation and small scale international trading. Over time the system can be expanded to include more countries, more gases, more sources, and permits created through carbon sequestration. National level trading, he noted, does not restrict the choice of domestic policies to manage greenhouse gas emissions. A carbon tax or other policies can be used to manage emissions domestically. Government can then trade permits as necessary to fulfill their international obligations.

Other participants noted that getting agreement on national entitlements is a key requirement for a full scale emissions trading system and that this could prove very difficult. Changing these entitlement in response to new scientific information related to climate change may also prove difficult. The possibility that large countries might dominate the emission permit market was also raised as a concern.

The initial allocation of entitlement will need to be settled through international negotiation. The initial allocation is likely to award surplus permits to developing countries as a means of transferring resources to those countries. Other international environmental agreements typically adjust entitlement on a proportional basis when necessary.

The tradable permit system can be designed to minimize transaction costs and to minimize the market power of large countries. Carbon sequestration through reforestation can be integrated with a tradable permit system, but this is not essential.

4. Other Economic Instuments

ON THE FEASIBILITY OF JOINT IMPLEMENTATION OF CARBON EMISSIONS REDUCTIONS[1]

Peter Bohm
Stockholm University

Abstract: The Framework Convention on Climate Change allows Parties, jointly with other Parties, to contribute to the objectives of the Convention. In this paper, at least some industrial (Annex-I) countries (ICs) are assumed to make binding commitments to limit their carbon emissions, whereas developing (non-Annex-I) countries (DCs) are not. An attempt is made to clarify the general implications of Joint Implementation (JI) between ICs, on the one hand, and between ICs and DCs, on the other. The first type of JI is found to contain all the preconditions for an internationally efficient tradeable-emissions-quota system for IC signatories. The second type is altogether different and unlikely to play an important role for improving the efficiency of the actions taken by the ICs. The fundamental reason for this difference is that while monitoring of emissions reductions is achieved at essentially no extra cost at all in the one case, it is complicated and costly in the other.

Introduction

Joint Implementation (JI), as this term is used here, is a mechanism for helping parties to the Framework Convention on Climate Change (FCCC) meet their (unilaterally or otherwise imposed) net emission limits by financing greenhouse gas reductions in other countries[2]. Here, where the discussion is limited to net carbon emissions, an attempt is made to provide an overview of the potential benefits as well as rawbacks of this system in a long-term perspective. To fix ideas, however, this perspective is assumed here to be applicable to the period covered by the FCCC, i.e., the period up to the year 2000.

The main conclusions are as follows:

(1) JI between those industrial country (IC) signatories[3], which make binding commitments to limit their emissions, does not seem to give rise to any serious implementation problems with respect to carbon emissions and could potentially perform as a tradeable emission-quota system for these signatories. To the extent that marginal abatement costs differ significantly between the ICs involved, JI can provide an important opportunity for improving the efficiency of emissions reductions, already by the year 2000, the FCCC target year.

(2) For the time being, the same conclusion cannot be drawn concerning increases in carbon sequestration. Until biomass volumes of individual countries can be monitored (by satellite inspection) and have been monitored for a base year, the effects of JI have to be estimated on an individual-project basis, which is the case for all JI operations between ICs and developing countries (DCs) as long as the latter countries have not made any commitments to limit their emissions, say, to agreed estimates of baseline emission levels for the near future.

(3) The extent of JI operations between an IC and a DC, which can be credited to the IC as

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1 Part of the work presented here was commissioned by the Ad Hoc Committee on Climate Change Strategies of the Nordic Council of Ministers. Comments by Asbjörn Aaheim, Olle Björk, Scott Barrett, Dan Dudek, Karl Gîran Mäler, Per Molander and Astri Muren on an earlier draft are gratefully acknowledged.

2 See, in particular, Article 4.2 (a) and (b).

3 The FCCC distinguishes between Annex I countries, i.e., industrial countries and East European and former Soviet Union countries in transition to market economies, and other, non-Annex-I, countries. For simplicity, we call these two groups industrial countries and developing countries, respectively. It can be noted here that a "Party not included in Annex I may ... notify the Depositary that it intends to be bound by /Article 4.2/ (a) and (b) ...". Thus, in this respect, a developing country could assume the role of an Annex-I country. This case is not explicitly observed in what follows.

part of its emissions target fulfillment, will be severely limited by problems of estimating the projects' counterfactual nationwide baselines.

(4) Undertaking JI projects between ICs and DCs in the near future -- probably because the sponsoring country would want to undertake demonstration projects while accepting to exceed it reduction targets (which is what a large number of FCCC parties now seem to prefer) -- will provide some further information about the extent to which it will prove possible to identify generally acceptable rules of thumb for estimating the net emissions reductions and net sequestration increases of various types of JI contracts. For several reasons, however, the volume of such demonstration projects may be quite limited.

(5) A clearinghouse version of IC/DC JI operations, where all DC projects are screened and aggregated before they are offered as anonymous emissions reduction units to ICs at a market-clearing unit price, seems to have several advantages over bilateral operations.

Section 1 gives a definition of JI to be used here. The effects of various types of JI operations under ideal circumstances (perfect foresight) are discussed in Section 2. The rest of the paper is devoted to a discussion of IC/DC JI projects. In Section 3, the problems of ex ante estimations and the monitoring of net emissions reductions under uncertainty are discussed. The implications of incentives distorted by uncertainty are the topic of Section 4. Section 5 presents some implications of a small supply of JI projects. The question of whether JI promotes or impedes a tradeable quota system including DCs is discussed in Section 6. Some political aspects of JI are observed in Section 7. Section 8 investigates the possibilities for additional information about JI project effects in real-world applications. A summary is given in the final section.

1. Defining JI

As yet, there is no formal definition of the criteria for JI as the concept is used in the FCCC. The concept will eventually be defined by the Conference of the Parties (FCCC, Article 4.2 (d)). However, it will be assumed here that JI includes implementation undertaken jointly by two or more IC signatories to stay within their joint 1990 emission levels by the year 2000. Several parties to the convention, e.g. the USA (see statements of delegations to the International Negotiating Committee (INC)) have explicitly interpreted JI as including, in principle, also transactions between ICs and DCs. In fact, IC/DC JI has generally been seen to offer the most important long-term opportunities for efficiency gains. Therefore, most of the discussion in what follows refers to this kind of JI.

In principle, JI may refer to any source or sink of any greenhouse gas. So far, much the discussion of JI projects has concerned both sources and sinks of CO_2. However, some parties seem to regard sink augmenting projects (primarily increased forest cover) as not yet suitable for inclusion (e.g. the EC positions in Denmark's note to the INC) while others (e.g. the USA) seem to regard such projects, e.g. reforestation, as among the most important ones. So far, such projects seem to have been the dominating kind in actual practice, especially when U.S. firms have been involved. Both carbon emissions source and sink types of projects will be discussed here.[4]

In its most general form, JI can be a transaction between a government or private firm, on the one hand, and a government or private firm, on the other (see e.g., the Environmental Defense Fund). In the case where a party is a private firm, the JI transaction would still have to involve the firm's government so that the credits for the emissions reductions accomplished by JI operations can be properly registered. The registration of international emissions reduction transfers would also require the participation of some international body, such as the Global Environmental Facility (GEF).

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4 Occasionally, as long as misunderstandings are unlikely to arise, the term "carbon emissions reductions" will also cover "carbon sequestration increases".

The GEF administers the financing of technology shifts in DCs which would reduce their greenhouse gas emissions. This activity can be seen as a complement to JI operations. The GEF has also been involved in JI demonstration operations (co-funded by Norway). In principle, for JI projects as well as GEF projects, funding should cover only the agreed "full incremental cost" of the technology shift or net emissions reduction (concerning JI, see FCCC, Article 4.3). In this paper, no distinction is made -- because a distinction seems neither possible nor necessary to make -- between the agreed "price" and the "full incremental cost" of a project undertaken by the seller country, with a certain amount of emissions reduction credits accruing to the buyer country.[5]

2. The Benefits of (various categories of) JI under Perfect Foresight

JI has been presented as a step towards (1) promoting global cost efficiency, (2) making it easier for individual nations to accept more ambitious abatement goals and (3) increasing the chances of more general international abatement agreements.[6] One way in which global efficiency would increase is that the "carbon leakage" issue could pose less of a problem to the extent that JI would imply a shift towards an equalization of carbon emissions abatement costs between ICs committed to a binding emissions constraint, on the one hand, and DCs that are not, on the other (Barrett, 1993b; Jones). Countries that engage in unilateral carbon emissions reductions would otherwise risk importing carbon-intensive products from other countries where no or less stringent emissions reductions are taken or risk having their carbon-intensive firms move to such countries, hence "carbon leakage".

On closer inspection, it seems difficult to apply this description to JI as whole. In fact, JI between IC signatories may, as we shall see, be presented in even more positive terms. On the other hand, JI between ICs and DCs has serious implementation problems that may threaten its presumed role as an important policy instrument. Thus, for example, its role as a remedy to the "carbon leakage" problem is likely to be small.

To begin with, we discuss JI for the analytically less complicated case of perfect foresight.

2.1. JI between developed FCCC signatories

Consider two ICs that have made firm and binding commitments (while others may not) to keep their carbon emissions as well as their forest cover at 1990 levels by the year 2000.[7] Let us concentrate on the emissions from fossil fuel combustion. In the absence of economically worthwhile techniques for carbon removal from stacks or tailpipes, these emissions can be perfectly measured by the consumption of fossil fuel.[8]

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5 On the lack of a need to estimate "incremental costs" of JI projects, see Johnson, 1993. -- What is here called buyer country and seller country in JI transactions is sometimes called sponsoring country and host country, respectively.

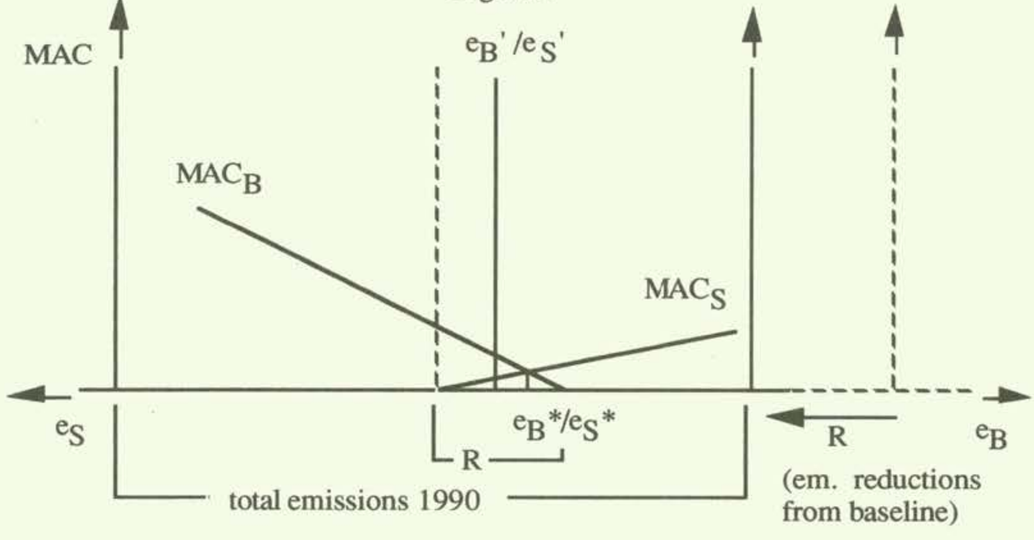
6 See, in particular, Hanisch (1991), Hanisch et al. (1992), Barrett (1993 a, b) and Jones (1993).

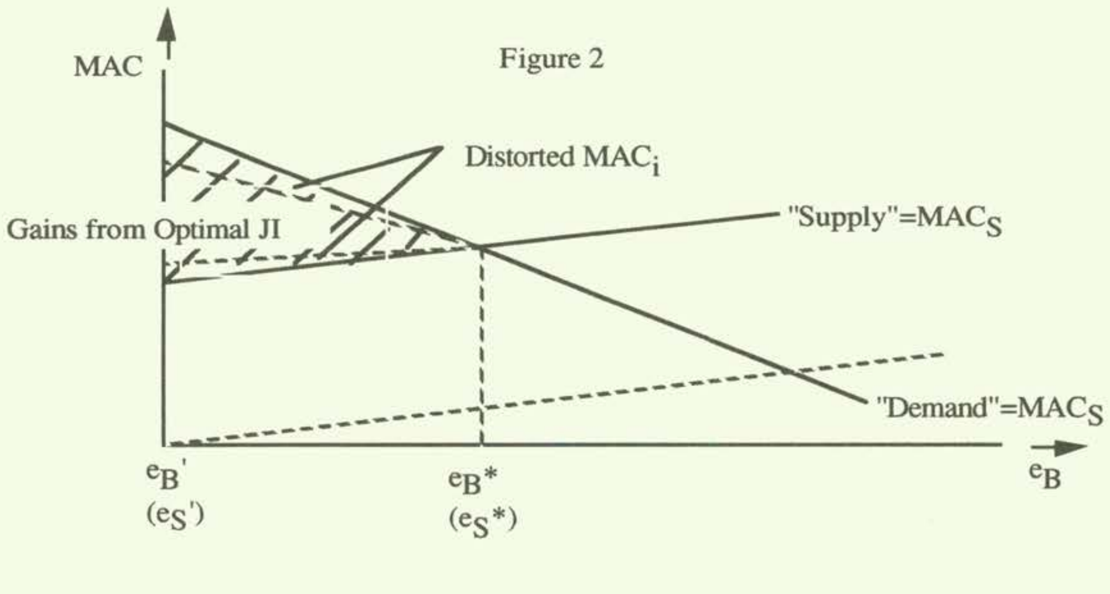
7 JI can hardly have any role to play, during the 1990s, for IC signatories that have not committed themselves, by the year 2000, at the latest, to a binding emission target (at least equal to that mentioned in the FCCC). It may be noted that some ICs have made commitments as of now that do not require them to stay within the 1990 emission levels by the year 2000. Their target year and/or reference year differ from these dates.

8 The FCCC target year 2000 seems to be the first instance where the reported magnitude of national carbon emissions can be embarrassing to an IC and if so, perhaps, the first time there are incentives for countries to distort such estimates. It should be noted here that the wording of the FCCC indicates that national (greenhouse gas) emissions are assumed to be possible to estimate even under such circumstances.

The base in Fig. 1 shows total emissions of the two countries, B and S, by the year 2000; the wider base including the dashed lines to the right shows the sum of the two countries' baseline or business-as-usual emissions for the year 2000, while the smaller base portrays the total emissions for the year 1990, e_B' plus e_S'. The marginal abatement costs (MAC) are shown by the two curves. The least-cost emission levels <u>if these two countries</u> would jointly implement their emission control policies are e_B^* and e_S^*, where marginal abatement costs are equal. Hence, the only procedure needed here would be to measure fossil fuel use during the period (say, the year) for the two countries, where the sum would be required to equal the sum of their emissions values for 1990. No attention needs to be paid to the policy or project details of the shift in the emissions from autarchy (e_B', e_S') to the optimum (e_B^*, e_S^*). Still, if need be in the context of the FCCC, the JI transactions may be formally attached to a set of particular projects or policies such as hydropower stations or the introduction of a carbon tax.

Figure 1





The curves in Fig. 1, which are taken to reveal least marginal costs, are reproduced as the bold curves in Fig. 2. The latter diagram highlights the trade scenario for the two countries. The shaded area is the maximum total gain from JI, which is divided between the two as in negotiations between bilateral monopolies. This represents the potentially optimal case of joint implementation between two ICs.[9] In the negotiation process, parties are likely to misrepresent their MAC curves in order to try to collect a larger share of the maximum gain. Such a case is illustrated by the two dashed curves inside the shaded area, where the seller country S has incentives to exaggerate its abatement costs and the buyer country B to underreport its abatement costs. Another possible bargaining situation may be one where the buyer is expected to accept that a "reasonable" profit mark-up (in percent) is added to total project (or policy) costs. If it proves difficult for the seller to misrepresent cost, because the buyer is a competent evaluator of the additional policy actions or projects undertaken by the seller to reduce its emissions, it may pay the seller to chose an inefficient and hence more expensive policy (or project) design. If so, this bargaining process would tend to reduce the gains from JI.

If three or more ICs have made similar binding commitments and if all of them wanted to cooperate, the outcome could be even better for each of them than in the bilateral case just discussed. Take the extreme case where all (or, to avoid imperfect competition, at least enough) IC signatories accomplish joint implementation by introducing a market for emissions-reduction units, exactly as in a tradeable emission quota (TQ) system (Bohm, 1990; UNCTAD, 1992). The two curves in Fig. 2 can now be taken to portray aggregate demand from all (who turn out to be) buyers and aggregate supply from all sellers, respectively. If the market performs sufficiently close to a perfectly competitive one, the market price for quota units would be given by the equilibrium point and emissions in each of all these countries would be at their efficient levels as defined for this group of countries.

This outcome would seem to represent the ideal version of JI among FCCC signatories that have made binding commitments to limit their emissions. Note also that for this case as well as the bilateral case initially discussed:

- there are no intricate problems of finding and agreeing on initial allocations, which is amajor potential stumbling block for agreements on general TQ systems, since in this case the initial allocations are given by the actual 1990 emission levels,
- there is no need to identify what (individual project) emissions would have been in the absence of JI, as is required for the type of JI to be discussed below, and
- there are no monitoring problems other than those which exist when a signatory country has committed itself to staying within the given (1990) emission limit.

2.2 JI between developed and developing countries

Bilateral JI. If a DC had committed itself to keeping its emissions below a certain binding level, the preceding discussion would have been valid also for this country.[10] Now, take the more interesting case of a non-Annex I country that has not made such a commitment. This is the case that has been most widely discussed in the literature and also the one for which there now exists a number of potential JI project (undertaken by the USA, Norway, Germany and

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9 For there to be a strictly positive gain, it would need to be known that the sum of the emission levels to which the parties have committed themselves does not exceed the sum of their baseline emissions. A case where this condition may not be met is where the JI seller country is an Annex-I country in transition to a market economy that would have reduced its emissions anyway and would have reduced its emissions more than the buyer country would need to reduce its emissions.

10 On the choice of emission commitments for low-income countries that would keep them at least compensated for making such commitments, see Bohm and Larsen, forthcoming and Bohm, 1993.

the Netherlands, see e.g. the Environmental Defense Fund). This is the case to be highlighted in the rest of this paper.

Let us assume for the time being that the net emissions reduction from a certain measure or project is calculable and known with certainty. The starting point for a discussion of a potential JI operation in country S, now a DC, financed by country B, an IC, is given by the dashed line to the left in Fig. 1, showing the emissions by S and B prior to the operation being undertaken. The minimum MAC_S (which sets out from zero) are now shown by the lower dashed curve in Fig. 2.

Whereas JI between countries committed to fixed emission levels can concern any type of measures, since the buyer country simply buys emissions reductions from the seller country, JI with an uncommitted country must concern a specific project.[11] Although it may be feasible, in theory, to "buy" an introduction (or increase) of, say, a domestic carbon tax in country S, the effect on emissions cannot be calculated unless all other policy parameters, directly or indirectly influencing carbon emissions, are fully controlled by the JI contract. This is ruled out as being unrealistic here.

A JI project may refer to the reduction of emissions from a specific emission source or an increase in a specific carbon sink.[12] Moreover, by allowing private firms in a buyer country to develop projects in cooperation with firms or the government in a seller country an additional set of efficient projects may be identified. Thus, the involvement of private firms may lead to the market providing a significant part of the technology transfer, which DCs are eager to obtain. (See Jones, 1993; U.S. delegation to the INC., 1993)

Potential JI projects are shown by specific segments of the MAC_S curve in Fig. 3, where for simplicity, all projects -- 1, 2, etc. -- have the same net emissions reduction effects. This yields a menu or supply of JI projects from country S as shown by S^{JI}. The demand curve shows the demand from one IC. Although the projects are taken to be indivisible, this is for the time being assumed not to create any problem from the buyer's point of view. The payment made by country B for each project is the result of bilateral negotiations and may exceed the true incremental cost and thus give rise to extra profits accruing to the seller firms. If, for simplicity, prices are taken to equal incremental costs for the case shown in Fig. 3, country B would like to finance projects 1 to 5. This then shows a case of efficient JI operations, where the IC cannot find any less expensive projects elsewhere and where the costs (to firms in country S) are minimized for each project.

If there are many ICs competing for the projects offered by one country S, prices are likely to go up. Similarly, if there is competition mainly on the supply side, say, many DCs offering projects to one country B interested in only one project, prices will tend to approach the true incremental costs. Competition in the latter case is particularly likely to keep incremental project costs at a minimum, as has been assumed here.

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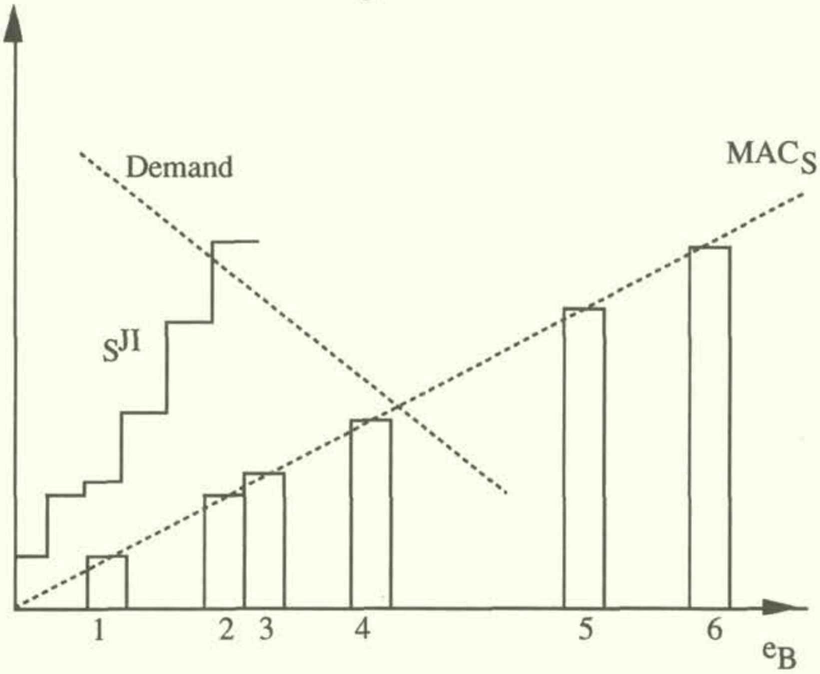
11 For a discussion of this case see Jones, 1993.

12 For examples of potential categories of JI projects, see Dudek et al., 1993 b.

Figure 3



<u>Multilateral JI.</u> Assume now that there are a large number of buyer and seller countries, a number large enough for a perfect market to be established. One way in which this market may operate is to channel all projects through a <u>clearinghouse</u>, allowed to be an active buyer cooperative on the JI market, say, the GEF.[13] The clearinghouse here is thus something more than an institution that evaluates and, if relevant, credits the buyer country with a certain emissions reduction in another country; the clearinghouse here collects and screens all JI offers from DC (non-Annex-I) sellers and lets the aggregate supply of reduction units meet the demand from IC signatories. An equilibrium market price may now be established for perfectly divisible emissions reduction units. The creation of this market has several efficiency and distributional implications:

(a) If the market price is received in full by seller countries, it will now definitely be in their interests to keep MAC$_S$ at a minimum. (This, as we saw above, may not be so for the bilateral monopoly situation discussed in connection with the case in Fig.3.) If, however,the clearinghouse negotiates the price for each individual project, a surplus would arise in the clearinghouse. (For example, if the GEF is the clearinghouse, the GEF may receive funds for its own -- JI or technology-transfer -- operations.) If so, the incentives to keep MAC$_S$ down are no longer obvious.

(b) Buyer countries would no longer be connected with specific JI projects; this has a number of possible implications. One advantage, already hinted at, is that project size will no longer constitute an implementation problem, since buyer countries now purchase reduction units instead of reductions from individual projects. A possible disadvantage is that private firms in buyer countries may no longer to the same extent be involved in developing new and more efficient projects with firms in a seller country, which the first-mentioned firms might want to finance. This, however, may be turned into an advantage if the creation of a market price for emissions reduction units introduces the option for private IC firms to help develop profitable JI projects in DCs as a separate and independent business proposition. This would allow firms to engage in project development joint ventures and be buyers of emissions reduction units as two completely separate activities,to the extent they want to participate in both. For the same reason, they may now chose to participate in only one of the two activities,

13 For arguments in favor of using the GEF as JI coordinator, see Barrett, 1993 a, b. For a more critical view, see Environmental Defense Fund, 1993.

a choice that may not exist to the same extent in the case of bilateral JI operations.

As we will see below, additional differences between the bilateral and the multilateral/ clearinghouse case arise when there is uncertainty about the emissions reduction effects of JI projects. Moreover, we will see in Section 6 that, while multilateral JI among IC signatories may automatically, albeit gradually, emerge as a TQ system, multilateral JI with DCs as sellers of emissions reductions is institutionally quite different from a TQ system and may actually reduce the prospects for a future TQ system, where also DCs participate.

3. Estimating Net Emissions Reductions Under Uncertainty

The assumption of perfect foresight in the preceding discussion did not require that one party knows the other party's costs for a given emissions reduction. Uncertainty about the other party's true reservation prices does not influence the outcome, only the income distribution between sellers and buyers in bilateral JI, as long as all projects, where true buyer reservation prices exceed true seller reservation prices, are carried out.

Introducing uncertainty about net emissions reductions of individual projects, we should note that this is unlikely to affect the long-term outcome of JI between parties who are committed to certain emission levels (e.g. keeping joint emissions in the year 2000 below joint 1990 emissions.) Even if JI between two IC signatories were initially conducted on a project basis and the countries agreed that a certain net emissions reduction would be attained by the project(s), it could hardly be compatible with the FCCC that their emission levels exceed their joint 1990 emission levels by the year 2000. Therefore, it must be up to the individual parties of this type to trade emissions under JI as if they were under a TQ system and to prove to the Parties of the FCCC that their joint emissions (carbon content of their fossil fuel use) are sufficiently low to meet their joint commitments (on this point, see Johnson, 1993).[14] As long as these operations are not supported by a well-developed market mechanism, complications may arise, e.g., when one IC wants to trade with two or more ICs, so that three or more countries would have to agree to aggregate their emission levels. Thus, before a true TQ system could evolve among a set of ICs, IC JI may take the form of bilateral transactions between pairs of ICs.

By contrast, uncertainty about net emissions reductions of individual JI projects, where the seller is not committed to a specific emission level, is likely to have a significant influence on the outcome of JI. This is the issue to be dealt with now. Two problems connected with uncertainty can be distinguished:

(a) Uncertainty about the project's firmwide actual net emissions in the future. That these emissions may deviate from predicted levels is not taken to be a complication for the estimation of emissions reduction credits, since such firmwide net emissions are normally required to be determined by ex post monitoring (see e.g. Environmental Defense Fund). But this uncertainty will constitute a problem for an investor in the buyer country and reduce the attraction of JI projects. It has therefore been proposed that an insurance system be developed to alleviate the negative consequences of this problem (see e.g., Barrett, 1993 a). We may note here that the clearinghouse arrangement just mentioned would more or less automatically create such an insurance in that no individual buyer would be connected to any particular project, only to the overall outcome for all the contracted JI projects. If there is no systematic distortion in the predicted project emission levels, this insurance problem would indeed be taken care of automatically. However, as we shall discuss later, distortion incentives exist and might differ between project types and between seller countries, which would complicate the introduction of a smooth insurance system.

(b) Uncertainty about what changes the project would give rise to within the project firm and in the surrounding area, nation or even world. Here, ex post monitoring is of little help, since

14 As of now, this observation does not carry over to the case of carbon sequestration projects traded between ICs, due to monitoring problems.

the task now is to measure what happens as compared to what would have happened. Since the latter counterfactual case is unobservable, the changes will also be unobservable. This baseline estimation problem is discussed in the remainder of this section.

Assume that actual emissions (in the year 2000) from, say, a fuel substitution project (from more to less carbon-intensive fuels) or actual emission absorptions from a reforestation project are perfectly monitored. This eliminates uncertainty about actual emissions (at some possibly significant level of monitoring costs). A prerequisite for calculating project net emissions is that the global baseline without the project can be estimated at reasonable costs and with at least some reasonable approximation.[15]

Take, first, a case where baseline estimation may present only a minor problem. An example may be provided by a coal-fired heating plant that has operated at a constant output level in a DC for a number of years and is almost certain to be replaced by a similar plant x years from now. Replacing this plant now by a gas-fired plant with the same capacity and service quality would allow a calculation of the net emissions reductions for the firm, especially if carbon emissions from he reconstruction work itself were negligible. This would also be the relevant (approximate) estimate for the world as a whole, if coal and gas prices as well as other prices or effects relevant for emission-related activities were unaffected by the project. However, since -- for transaction-costs reasons[16] -- typical JI projects would not be insignificantly small, such price changes or other effects with relevant repercussions may very well arise. For example, local coal prices may go down and spur new coal-using activities. Thus, even in the case where calculated firmwide net effects are almost certain, the nationwide effects are not and, if so, they may to a significant extent fall short of the firmwide effects. (We abstract here and in the following from effects on emissions in other countries (carbon leakage). One reason is that such effects would also seem to confront international measures to reduce emissions other than making JI an acceptable policy option. Thus, we take the net nationwide, not the net worldwide, effects to be the relevant measure here.)

It may be noted here that the experience from Norway's and the GEF's JI demonstration projects in Mexico (replacing ordinary light bulbs with energy-efficient lamps) and Poland (boiler coal-to-gas conversion), two seemingly uncomplicated projects from the point of view of overall baseline estimation, is that it has been "very difficult" to estimate the "net abatement effect" and that the baseline or "counterfactual is not clearly defined or perhaps definable" (Anderson, 1993).

At the other extreme we may consider the more complicated case of a sink-enhancing reforestation project. This type of project is representative of a number of existing projects that have been suggested to qualify, in principle, as officially recognizable JI projects (Environmental Defense Fund). Let us assume that actual annual net absorption from the reforested area is monitored, say, by self-reporting and official sample inspections. Thus, inefficient design of the tree planting activity, poor plantings and other similar negative "surprises" are not taken to pose problems for the monitoring of the net effects (although certainly for the two parties engaged in the project). However, estimating the baseline scenario will be complicated by the fact that the reforestation project -- at least, to the extent it has a market value -- could nevertheless have been undertaken now or a couple of years from now. Or, carbon sequestration of the natural vegetation growth on the project land would have to be estimated, which may not be as simple as it sounds. Moreover, if the land, labor and

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15 For a review of possible JI project types and their baseline estimation requirements, see Dudek et al., 1993 (a).

16 In the literature, there seems to be general agreement that the estimation problems discussed here would be considerable and that, hence, also the administrative estimation costs would be considerable. If so, an assumption about the economies of scale of these computations (which would have to be convincing to the outside world) could be made, saying that these costs would be smaller for a large project than for an equally large sum of small projects.

domestic capital inputs that were planned to be used in the project were instead used for other purposes (which eventually is likely, of course), what would the net carbon emissions be in that case?

Furthermore, a significant reforestation project offering forest products some years from now would influence the profitability of other reforestation projects considered by the market in neighboring areas. If, as a result, such other projects were not undertaken now, the total net effect on carbon sequestration would be further reduced. To make the computations even more complicated, if different reforestation projects used different production techniques, emissions caused by land clearing operations, etc. may have to be estimated for the JI project as well as the baseline scenario.

Thus, in general, JI projects lead to firmwide net emissions reductions (or net sequestration increases) as well as to indirect emissions (sequestration) changes, most probably emissions increases (sequestration reductions), in the rest of the nation. The total net effects of significant JI projects may, as has been argued here, deviate significantly from the firmwide net effects.[17]

What has been said here amounts to saying that transaction costs (in particular, nationwide baseline estimation costs) will be considerable for large JI projects in DCs. This will tend to reduce the number of large projects suitable for JI. The transaction costs for infinitesimally small "projects"(where, say, a household reduces its fossil-fuel consumption), i.e., "projects" likely to form a significant part of the market response to the fossil-fuel price increases induced by a TQ system, are, of course, much smaller. But, as noted in passing above, it goes without saying that the transaction costs would be too high for such projects to be part of a JI system. Hence, on two accounts, projects for IC/DC JI will tend to be limited as compared to the IC JI case. (For reasons stated above, the baseline estimation problems do not occur for JI between ICs with binding emission commitments.)

If it were "known" that a project would never have been undertaken in the absence of JI, it would be significantly easier to estimate the net emissions reductions effects. However, limiting JI projects to such projects would not only further limit the extent of JI, but also risk limiting JI operations to projects that are far from being profitable now, hence to high-cost projects only. Thus, as compared to low-cost emissions reduction projects that would be the first, and perhaps only, projects to be undertaken, say, under a TQ system with the same emissions reduction effect for the two countries involved, this strategy for selecting JI projects would imply an efficiency loss.

Similarly, if attempts to estimate true nationwide net emissions effects of (large) JI projects were replaced by the simpler and less costly estimates of a lower bound to these effects, this again means that JI operations would tend to include mainly high-cost (per unit of emissions reductions) projects. Not only would this imply that an efficiency loss is embodied in the JI system, this loss would also tend to make the projects less attractive to investors in buyer countries and less likely to prove helpful for governments of such countries that are looking for alternatives to the high marginal-cost portion of their domestic emissions reduction options.

If the risks of overstating the nationwide emissions reductions of JI projects would tend to increase over time, because of the increasing risks of overstating emissions in the baseline scenario over time, a proposal suggested by the EC may be used as a rough remedy (see EC-positions in Denmark's note to the INC). The proposal amounts to a time limitation on the credits attributed to a JI project.[18] Thus, credits could be awarded as a decreasing share of estimated emissions reductions over time and even be set at zero after some given period of

17 Should IC/DC JI in practice be such that projects are accepted in spite of a credible risk that their baseline estimations tend to overstate true emissions in the baseline case then, of course, this kind of JI would lead to an increase in global emissions.

18 See also Merkus, 1992, Vellinga et al., 1992 and Jones, 1993.

time. While a rule of thumb of this kind would reduce the implications of overestimates of the net emissions effects wherever such overestimates exist, it would, of course, introduce a bias against projects with long gestation periods or with long-term emissions reduction effects. In addition, it would be another mechanism through which the number of attractive JI projects will be reduced.

To sum up, uncertainty concerning the overall net emissions reductions of JI projects in DCs (without a commitment to a binding emission level) creates significant estimation problems. These problems would reduce the number of practicable JI projects directly as well as indirectly via higher transactions costs. It remains to be seen whether the "demonstration projects", which are undertaken now and in the future, will identify any generally acceptable rules of thumb for estimating the indirect project effects relative to the unobservable nationwide baseline. A factor that will make this work particularly complicated is the counterproductive incentives that JI creates and to which we now turn.

4. Incentive Effects of JI

Opening up possibilities for JI with DCs means that both private firms and governments in buyer as well as seller countries will be encouraged to search for profitable JI projects and develop new projects suitable for JI. However, some of the implications of these incentives may prove to be incompatible with the objectives of JI.

Let us first consider the case of a clearinghouse for JI projects offered by firms or governments in DCs. Projects which (happen to) have firmwide emissions reduction (or sequestration increasing) effects and which would be carried out in the absence of the JI institution may now be advanced as projects which need JI funding in order to be realized. Such projects may even be particularly attractive to the buyer community (represented by the clearinghouse), since they are likely to appear as low-cost options (in spite of the fact that they, in fact, are priced above real implementation costs).

Furthermore, JI may even give rise to new projects that, in the process, imply increases in emissions as compared to what the emissions would have been in the absence of potential JI funding. An obvious case in point, should sequestration projects be formally accepted as JI projects[19], is where additional forest land is harvested or burnt down, solely because it is believed that the land area could later be sold as a JI reforestation project. A remedy here might be to exclude from acceptable JI all forest areas that have been harvested or burnt down after JI became known and established as a real-world business proposition. Of course, this step would also hit those land areas which, in the absence of JI, would have been harvested or ruined by forest fires and which, therefore, should have been eligible for JI. If so, this remedy would tend to further limit the feasible set of desirable JI projects.

In addition to the incentives to create "false" JI projects other incentives exist for exaggerating the net effects of "real" JI projects. The party -- government and/or firm --implementing a JI project in the seller country stands a better chance of having the project accepted for outside funding and of getting paid more if it can convince the buyer community that the (nationwide) emissions reduction effects are larger than in fact is likely to be the case.

Shifting now to the case without a clearinghouse, that is, to the case of bilateral JI, there is the risk that also the buyer firm and/or government may want to -- or may unintentionally -- distort the performance of JI projects in the same direction as that mentioned for the seller country. Even if net emission effects are measured ex post, it is still quite likely that these measurements could be carried out in more than one way and would involve some more or less subjective estimates. If so, given the existing incentives, there are risks that the effects will be systematically overvalued. These risks are particularly high, of course, when it

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19 The incentive problems dealt with here are probably part of the reason why the EC holds the position that "/u/ntil the Conference of the Parties has laid down criteria for determination of sinks this should not be included in the concept of joint implementation" (see EC-positions in Denmark's note to the INC).

comes to estimating the baseline scenario for which there is no monitoring option available.

The fact that both parties to a bilateral JI project have common interests when supplying information about the net emission or sequestration effects of the project (and leaving out information about possible negative indirect effects) makes these misrepresentation risks particularly serious. This is so not only because of the overvaluation risks per se. The existing risks, even where no systematic distortion in fact takes place, may cause other parties in an international emissions reduction agreement simply to disbelieve some of the project evaluations, especially if they feel that applications of the JI institution are to their disadvantage. Thus, countries which, for one reason or another, have not used JI projects for meeting the emission limits to which they have committed themselves or (believe they) have used less questionable JI projects for reaching their emission limits, may not accept the estimates of the net contributions of certain projects funded by others.

The existence of the distorting incentives now mentioned will, of course, come as no surprise to those involved in designing criteria for JI. The main problem of these incentives is likely to be that they may rule out a vast number of potential projects by making the criteria sufficiently stringent. That is, the round of "demonstration projects" that may be evaluated in the years to come could well result in a significant devaluation of the potential for JI, especially bilateral JI, as compared to what may originally have been believed to be feasible.

5. Implications of a Small Supply of Acceptable JI Projects

We have seen that a sustainable JI system which involves (seller) countries without a binding emission commitment would have to meet stringent criteria. The need for stringent criteria is also one of the most oft-stated points in policy declarations made so far by various governments (see INC, 1993). Above, we have identified several reasons why the DCs' supply of projects that pass stringent JI criteria would be small. The following question may now be raised: What are the likely consequences for the functioning of the JI system if the project supply remains small, aside from the obvious implication that JI between ICs and DCs might then not play any significant role in reducing global carbon emissions?

First, a small number of JI contracts may partly be explained by high transaction costs for making them meet the JI criteria. But, in addition, a small number of JI operations would also be a reason for high transaction costs, assuming economies of scale in the handling and development of administrative practices for such operations. If so, the small size of the market would be reinforced by this factor.

Second, a quite different -- and perhaps more important -- factor that could turn out to work in the opposite direction, is that, for a small-scale international IC/DC JI system, the criteria for acceptable JI projects may not be so stringent after all. In particular, the requirements of making detailed estimates of the projects' nationwide net emission effects may be looser, once the JI system plays only a small role for international emissions reductions. If JI had a significant role to play, enforcement of the requirements would be more stringent. The implication of this hypothesis would then be that JI operations may tend to be small but not "too" small.

6. Does JI Promote or Impede Development towards a Global TQ System?

As was shown above, the development of JI is likely to be quite different for JI between ICs that have made binding emission commitments, and IC/DC JI, where the DCs are taken not to have subjected themselves to any (binding) emission commitments. In the first case, we have seen that the real objects of trade would be units of emissions reductions below the seller's emission limit, whereas in the second case trade would have to be on a project basis. Thus, while the first case would (eventually) amount to a version of a TQ system, the question arises as to whether, in the second case, the existence of JI will have any effect on the prospects of a more comprehensive TQ system including also the DCs.

It has been argued that JI operations in general, essentially by using the same mechanism as in a TQ system, viz. having low abatement-cost countries sell abatement services to high abatement-cost countries, could develop into a TQ system including also the seller countries in the second case (Barrett, 1993 a,b; Jones, 1993). To investigate this argument, let us assume that, for the time being, acceptable initial quota allocations for DCs in such a more comprehensive TQ system would equal an internationally agreed estimate of their expected emissions for the relevant target year. Then, to the extent that JI operations have preceded the introduction of a TQ system and have led to lower emissions in the DC, the initial allocation to this country would be lower. In Fig. 4, MAC_S shows the position of the DC's marginal abatement cost curve in the case of no preceding IC/DC JI operations. If some JI projects relevant for the target year (projects 1, 2 and 3 in Fig. 4) have been carried out and the estimated net emissions reduction effects of these projects (equal to the sum of the bases of the bars representing these projects) have been credited to JI buyer countries, the lower part of the cost curve would have been shifted to the right by a corresponding amount (see MAC_S'). The dashed line indicates the redistribution of emissions between the two parties as a result of the JI operations. The DC would now gain less from joining the TQ treaty. The gain, which in the absence of any preceding JI operations would equal the triangle below the quota unit price, would be reduced by the market value of the projects' net emissions reductions minus the costs of these projects (see the shaded areas in Fig. 4).[20] If the DC's willingness to join the TQ treaty depends on the expected benefits from joining, the DC may now decline to cooperate.[21]

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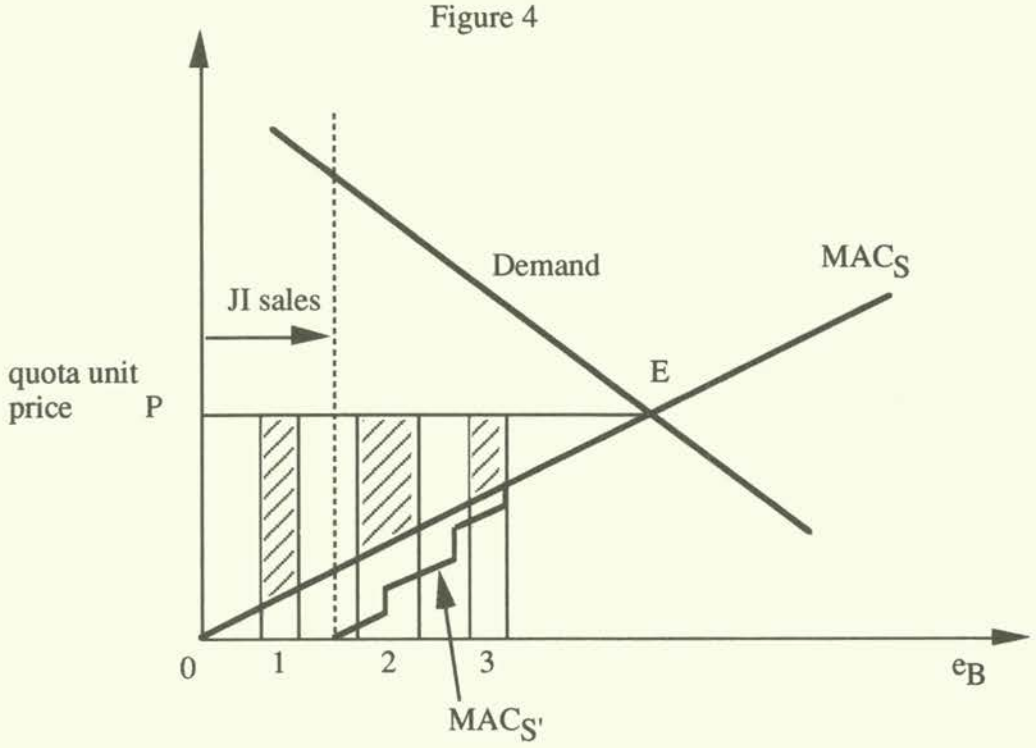
20 The prices at which the JI projects were initially sold may have been larger or smaller than those implied by the quota unit prices; the reduced gain from joining the treaty is, of course, independent of what the actual JI prices were.

21 Here, initial allocations to the DCs in a TQ treaty were assumed to equal (or, more generally, be tied to) the baseline emissions for the target year, which would be smaller if preceded by JI operations. If, instead, allocations were tied to the emission level for a past year such as 1990, hence independent of whatever JI operations have been undertaken, the DCs would now receive a higher gain from joining the TQ system (by an amount equal to the difference between MAC_S and MAC_S') if JI operations had preceded the TQ treaty than if it had not. This follows from the fact that the DCs would now be paid once more for the emissions reductions of the JI projects. Moreover, this allocation principle means that no net emissions reductions would have been accomplished by the JI operations, since these operations allowed IC emissions to be larger now than without JI. Thus with this allocation principle, JI preceding the TQ system would only have increased global emissions, other things equal. To avoid this outcome, allocations offered to DCs must take account of the emissions reductions paid for through JI and credited to others. One version of such a principle was used above.

Figure 4



Here, again, the implications of JI operations will tend to hinge on the scope of these operations. The larger the scope and thus the more important the role of JI for DCs, the larger will be the capacity of JI to stop DCs from being attracted to a TQ system. In other words, the more (less) effective the JI system, the larger (smaller) these obstacles to a TQ system including the DCs.

The implications of a TQ system are straightforward as long as this system is limited to emissions from fossil fuel combustion. Including also carbon sequestration projects in a TQ system would, of course, create the same type of baseline estimation problems that were earlier shown to be so problematic for JI projects. If so, the preceding would be like comparing "apples and pears", i.e., JI operations involving both sources and sinks and a TQ system concerning only sources of carbon emissions. This lack of comparability vanishes, however, if changes in total national carbon sequestration could be gauged sufficiently accurately by satellite monitoring of the nation's biomass.[22] Needless to say, the satellite monitoring option would not help solve the problem of estimating the nationwide net sequestration effects of IC/DC JI projects.

7. Political Aspects of JI

Opening up possibilities for JI operations can produce and have produced reactions or consequences of a more political nature, which in turn could influence the extent and performance of JI in actual practice. Some tentative comments on these aspects will be given here.

(1) The value of JI has been questioned from a DC point of view.[23] One type of reactions roughly amounts to saying that the risks for climate change are essentially the result of historical actions taken by the ICs and should therefore be taken care of, first of all, by them alone. This view may be questioned with reference to two additional aspects: (a) that some DCs are likely to be particularly hard hit by climate change and therefore should be

22 For a detailed proposal for such a monitoring system, see Dudek and LeBlanc, 1992.

23 See, among others, Parikh, 1993, and Reddy, 1993; for a somewhat different view, see Pachauri.

interested in cooperation that increases the efficiency and effectiveness of international climate change policy; and (b) that DCs would make -- at least, short-term -- gains from sales of emissions reductions.

Another type of DC reaction, which relates to point (b), is that undertaking projects which reduce the use of fossil fuel may -- if JI were carried out on a large scale -- threaten the long-term industrialization process in these countries. This stand would obviously refer to DC participation in TQ systems as well as in JI.

Moreover, JI and possibly also TQ systems can be questioned in terms of fears that purchases of emissions reductions at prices that would be judged as advantageous to DCs might be used by ICs as a reason for reducing their aid to DCs (the aid additionality problem). Although there does not seem to be any simple solution to this problem, the suggestion mentioned earlier may be repeated here, that JI could be reserved for ICs that remain "with at least 0.7 % of GDP in official development assistance (ODA)" (EC position according to the Denmark's delegation, INC).

If a large number of DCs remain hesitant to participate in JI or TQ systems, e.g., for reasons now given, it would simply mean that the prospects of JI or a broad TQ system become dimmer.

(2) It may be necessary to evaluate the implications of private firms in ICs as a potential special-interest group in connection with <u>bilateral JI</u>. Assume that a JI project is a joint venture between a DC firm and an IC firm, both of which make some resource commitments in the project. Assume, moreover, that the IC firm is interested in bilateral JI, because it wants to alert its government to its ability and willingness to finance carbon emissions reduction projects in other countries. This may, however, be only part of the story. Another reason might be connected with the choice of project technology, which could tie the DC firm to future deliveries of goods or services from the IC firm or its business partners. If so, the DC firm would not be at liberty in the future to choose another technology and another, and less costly, supplier of such (or similar) goods and services. This would constitute an efficiency problem only, or at least, when the DC firm (or government), for the reasons stated, does not pay sufficient attention to the future real or potential consequences that these ties would represent.

This story may seem far-fetched. It may, however, represent an example of cases where mixed interests could arise in connection with bilateral JI. It would not seem to arise as easily when JI is channeled through a clearinghouse (or, for that matter, when DCs participate as sellers in a TQ system). If, as was briefly discussed in Section 2.2, an IC firm now would participate both as a buyer of emissions reduction units (on domestic "political" grounds, say) and as a participant in a joint-venture project called forth by the fact that emissions reductions projects now have become profitable business propositions, it is because the IC firm happens to be involved in these two, now separate, activities. Thus, far-fetched or not, the story points at possible efficiency problems arising from the lack of separation of two "markets" in the case of bilateral JI.

The bottomline here is that JI -- and bilateral JI, in particular -- may be both politically sensitive and politically complicated matters that call for close scrutiny by political scientists as well as for applications of JI in actual practice before a more well-founded evaluation of this policy instrument is possible. This last-mentioned need for JI "demonstration projects" is further discussed in the next section.

8. The Feasibility of Learning More about JI in Actual Practice

Given the potentially serious estimation problems with using JI over a wide set of different projects in DCs, the practical value of JI can hardly be evaluated unless a large number of pilot projects have been tested in actual practice. Several delegations to the INC as well as proponents of JI (see, e.g., Dudek <u>et al</u>., 1993 b) have stressed the need for such tests. The differences between project types and between individual seller countries, and the many possible differences between individual projects of a given type in a given DC, imply that, if possible, a large number of such pilot projects would need to be carried out.Some INC delegations have stated that JI will hardly be ready for formal use in the FCCC context in the near future. The U.S. delegation has been more optimistic on this point, buthasalso emphasized that the U.S. plans to stay within the 1990 emission levels by the year 2000 "with domestic actions alone" and would support JI operations only as efforts to attain emissions reductions in addition to those "required" (U.S. delegation, INC). The present EC position is similar and states that JI "should not be used to fulfill the commitment of stabilization but only for the following reductions after the year 2000" (Danish delegation, INC).

One way to interpret these declarations may be that, for the time being, IC/DC JI projects with IC government support will be started mainly or perhaps only on account of the information they could provide about JI in actual practice. This limitation of the value of JI projects may make many ICs hesitate to give such support. Furthermore, given that the trend in many countries to limit or even reduce government expenditure will continue at least over the next couple of years, the risk is that government financed JI projects will be carried out at the expense of ordinary assistance to DCs, at least for countries with ODA now exceeding 0.7 % of GDP. Confronted with this real risk which, as we have seen, some DCs already feel they will encounter, their willingness to engage in JI operations may dwindle.

If estimating baseline scenarios and nationwide net effects constitutes the dominant problem for practicable JI, the question is whether this problem could at all be "solved" in the near future, especially if there are several circumstances which discourage JI operations and hence, limit the experience that can be obtained. Moreover, if some, but not all, committed ICs will have serious difficulties in staying within their 1990 emission levels towards the end of this decade and if JI operations with DCs are not sufficiently feasible or attractive, they may want to rely more on JI with other ICs committed to binding emission limits. This could be another reason why few JI projects with DCs will be started.

Thus, if the extent of "experimental" JI activities will be limited, it will be particularly important that the test program is efficiently organized. If some international cooperation in selecting JI projects proves feasible, this selection would need to be determined according to criteria for an "optimal" test program. Two brief comments on what these criteria might be can be made here.

First, there is the choice between trying to get information from all kinds of different potential projects and trying to get more secure information about a limited subset of project types. What has been said about the likely scope of JI in the near future suggests that the latter may be the best choice. Second, regardless of which of these two approaches is found to be the most promising one, it would seem important to select individual projects with a maximal information value. Two factors which are likely to increase the information value are low expected baseline estimation problems and high expected emissions-reduction volumes for the type of JI projects selected.

9. Concluding Comments

(a) The effects of JI among those ICs which have accepted to keep carbon emissions at their 1990 levels will (have to) be monitored by their joint emissions (as measured by their joint fossil fuel use) in the year 2000. Each seller country will be accountable for the amount of emissions reductions sold and hence be required to keep domestic emissions below its emission target level by this amount. Since the real object of trade is units of such emissions reductions, the kind of action taken by the seller country is of no concern here. This means that, in principle, IC JI meets the requirements of a tradeable emission quota system. Since, by assumption, some ICs have accepted the FCCC emission targets, this form of TQ would be relieved of the problem of negotiating inital emission allocations. To what extent and at what pace the efficiency potentials of a TQ system could materialize would depend on a number of factors such as the extent to which the ICs would want to be engaged in such operations at an early stage, the extent to which market institutions will be created by international cooperation and how various risks for imperfect market operations in TQ systems are handled.

(b) Actions to increase carbon sequestration in ICs can be included in this JI/TQ system if (when) national biomass volumes, and their effects on the capacity of carbon sinks, can be monitored -- and have been monitored for some base year.

(c) Otherwise, if used for crediting emissions reductions to the buyer countries to help them stay within their emission commitments, such carbon sequestration actions as well as all IC/DC JI operations will have to be conducted on a project basis (as long as the DC involved has not committed itself to some emission limit). Given the high marginal domestic abatement costs for ICs with stringent emission targets, such countries will most likely demand proof that projects undertaken by individual ICs are not registered for overestimated nationwide net abatement effects. If IC/DC JI occurs to a modest extent only, i.e., if such JI does not emerge as a significant international policy instrument, this demand may be relaxed.

(d) Since the nationwide net abatement effects of many JI projects can be expected to be extremely difficult to estimate and acceptable lower bounds to these estimates may therefore be low, the volume of IC/DC JI operations may be quite limited. Thus, projects, which would have been attractive under perfect foresight, may no longer be so. Transaction costs, which may be particularly high when the volume of JI operations is small, will tend to make this volume even smaller.

(e) If the volume of IC/DC JI operations is not too small, a clearinghouse version would seem to be preferable to strictly bilateral operations, since (1) the price for each individual project need not be negotiated, (2) incentives to distort project net abatement effects will be smaller, and (3) risks for individual buyers will be smaller. Technology transfers from individual IC firms could remain high under this version, if such firms continue to engage in profitable emissions reductions projects in DCs, now as an activity separate from buying emissions reductions from JI projects.

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"JOINT IMPLEMENTATION" AS A POLICY INSTRUMENT FOR RESPONDING TO CLIMATE CHANGE

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1. Introduction

The adequacy of the policy response to any problem, including that of climate change, should be judged against the objectives it is trying to achieve. In the case of climate change, we can look to the recently-signed Framework Convention on Climate Change (FCCC) for some insight into these objectives.

Clearly, a key priority of the countries who signed the FCCC was environmental. The primary objective of the agreement (Article 2) is stated in explicitly environmental terms -- "... stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". In the language of program evaluators, this indicates that the signatories were primarily concerned about the *environmental effectiveness* goal. The same Article also suggests a desire to achieve *economic efficiency* and *social equity* goals, by expressing a wish "... to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." This is because economic efficiency in its broadest sense is synonymous with sustainable development, and because sustainable development can only occur if certain broad standards of social equity are respected.

The same three policy objectives of environmental effectiveness, economic efficiency and social equity are strengthened in the Principles that follow (Article 3). The equity objective is elaborated in Principles 1 and 2, where the ideas of inter-generational fairness; differentiated burdens for different countries, depending on individual capabilities; and the responsibility for developed country Parties to take the lead in combating climate change are introduced. Principle 3 mentions the need for precautionary measures (environmental objective) and cost-effectiveness (economic efficiency objective). Principle 3 also refers explicitly to "cooperative efforts" between Parties for addressing climate change. Principles 4 and 5 focus on sustainable development, pointing to the potential contribution of free trade in achieving that goal.

In short, whatever policy instrument(s) are used to respond to climate change will have to deliver some environmental improvements, some degree of economic efficiency and be perceived as being somewhat equitable in their distributive consequences. The point is that all three of these objectives are valid, and that achieving any one of them may involve tradeoffs with the others. It is also important to recognise that no single instrument is likely to be able to deliver on all objectives at the same time. It will rarely be a question of "either instrument *a* or instrument *b*", but one of "how much of each?".

Several possible ways of achieving the Convention's objectives are suggested in the FCCC itself. But we should not necessarily look to the FCCC for detailed guidance on instruments. It is, after all, only a *framework* Convention. Most of the commonly-discussed potential instruments are being reviewed at this Workshop, but the focus of this paper is on one particular instrument -- joint implementation.

Although the principle of joint implementation is embodied within the FCCC, we do not yet know what joint implementation will actually mean when it is applied in practice. The Conference of the Parties (COP) will consider this matter at its first meeting, which should help to reduce some of this uncertainty.

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1 The opinions expressed in this paper are those of the author, and do not necessarily reflect the views of either the OECD Secretariat or any of its Member countries.

For the moment, all we can say is that joint implementation seems to have been introduced into the FCCC negotiations mainly because of its potential contribution to the goal of economic efficiency, or more exactly, to that of cost-effectiveness. Objectives other than cost-effectiveness, especially those of institution and capacity-building, as well as of technology transfer, also seem to have been in the minds of the negotiators [2], but it is the role of joint implementation in promoting cost effectiveness that has gained the most attention since the signing of FCCC. In the climate change context, cost-effectiveness can be broadly defined as minimising the global costs of achieving a given level of emission abatement. Conversely, cost-effectiveness would allow a higher level of abatement for a given cost.

In principle, there are several different ways that cost-effective abatement could be achieved at the global level, such as an international tradeable emission permit system or a global carbon tax, coupled with international redistribution of the tax revenues. Until the COP actually defines criteria for joint implementation, we cannot be sure that the joint implementation system that eventually emerges will not contain provisions for a full-fledged tradeable permit or tax/redistribution system. We can say, however, that the negotiating history of the FCCC seems unlikely to result in joint implementation being defined in this way. This is because the level of international co-ordination necessary for successful application of these approaches seems unlikely to exist in the near term. For the purposes of this paper, therefore, it is assumed that joint implementation will ultimately involve "project investments", wherein countries facing *higher* abatement costs would invest (or would encourage investments) in greenhouse gas emission abatement or sink enhancement projects in countries facing *lower* abatement costs.

Three basic possibilities exist for making these investments. First, countries could "pool" their resources in an investment fund, from which disbursements would then be made, as some countries have already effectively begun to do by investing in the Global Environment Facility (GEF). Second, investment arrangements could be made directly between countries on a bilateral or multilateral basis. Several OECD countries are already beginning to experiment with such arrangements on that basis. Third, investments could be carried out directly by the private sector, in order to meet emission constraints imposed by national governments (or perhaps even to meet objectives that are unrelated to direct national government interests). Several examples already exist of private companies attempting to create "offsets" by investing in net emission abatement activities in other countries. All three of these approaches seem, *a priori*, to be appropriate ways of applying the joint implementation concept, since the FCCC does not explicitly specify the level of the economy at which joint implementation cooperation should occur. For simplicity, this paper concentrates on the bilateral (i.e. government-to-government) approach, but this should not be interpreted as an endorsement of this particular approach over any other.

The paper begins with some observations about how joint implementation is treated in the FCCC itself. Because the idea of joint implementation is actually proposed within the FCCC, this is a logical place to start. Joint implementation is then discussed from the point of view of the three fundamental objectives of the FCCC mentioned above -- environment, economy, and equity.

Before proceeding, it is useful to consider what the specific objectives of this paper are, and (perhaps more importantly) what they are not. The joint implementation concept is in its early stages of development at the international level. For this reason, the objective of this paper *is not* to suggest specific operational criteria for joint implementation. Nor is it to *promote* the use of joint implementation in preference to any other potential policy response. Nor is it to suggest

2 Given the fluidity of the current discussions about joint implementation, much of the reference material used to prepare this paper is still only available in unpublished form, and cannot be directly cited or quoted. In such cases, references have been formulated in more general terms (e.g. "Some observers have suggested..."). Unpublished material on which no citation restrictions exist are also listed in the References at the end of the paper.

that individual countries or groups of countries *will* take any particular position in the international negotiations about joint implementation that are about to occur. As noted above, all of these issues are of concern to the political arena, as represented by the COP. The paper simply attempts to review the joint implementation concept from several different perspectives, in order to shed light on the most important problems and opportunities that might be generated from trying to use this instrument in actual practice. This "review and assessment" role is entirely within the mandate of the IPCC, and therefore, of this Workshop. In economic jargon, the paper's objective is *positive*, rather than *normative*.

2. Joint Implementation and the FCCC

Although it would not be appropriate here to attempt a full legal interpretation of the FCCC, it is useful to broadly review the main passages of the Convention that relate to joint implementation, and to try to indicate the different interpretations that are presently causing some of the debate at the political level. The first reference that seems to relate to joint implementation is Article 3, Paragraph 3, which specifies that "... Efforts to address climate change may be carried out *cooperatively* by interested Parties" (emphasis added). Located in the Principles section of the Convention, this sentence : (i) seems to provide an intellectual basis for joint implementation itself; and (ii) may allow *any* interested Parties to participate in cooperative activities (i.e. "cooperative" activities do not appear to be limited to any particular sub-group of Parties). Article 4, Paragraphs 1(c) and 1(d) also seem to support the view that all Parties are required to participate in "cooperative activities", given that these clauses appear in the "General Commitments" part of the agreement.

Under Article 4, Para. 2(a), each Annex I Party "... shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting *its* anthropogenic emissions of greenhouse gases and protecting and enhancing *its* greenhouse gas sinks and reservoirs ... These Parties may implement such policies and measures *jointly* with other Parties and may assist other Parties in contributing to the achievement of the objective of the Convention ..." (emphases added). This is the section of the FCCC that has been interpreted as providing the strongest endorsement of the joint implementation concept. Several things are worth noting about this Paragraph.

First, it applies only to Annex I Parties. Non-Annex I Parties are clearly not implicated in this particular commitment. Second, it talks about the adoption of *national* policies and measures to limit *its* (i.e. each Annex I Party's) emissions of greenhouse gases or to promote/protect *its* sinks. This may imply that *international* policies and measures are excluded from the commitment and, therefore, that emission reductions outside of the Annex I Party's territory are *not* contemplated here. On the other hand, the Paragraph also indicates that Annex I Parties can implement their (national) policies *jointly with other Parties*, implying that international programmes *would* be acceptable. Third, note that the commitment here relates only to *emissions* of greenhouse gases -- not to their *concentrations*. This is unlike the Objective statement, which is expressed in terms of concentrations. And fourth, both emission control and sink protection/enhancement policies seem to have been envisaged by the signatories as being acceptable for joint implementation.

Thus, one interpretation of Article 4, Paragraph 2(a) could be that Annex I Parties are committed to adopting national policies and measures for reducing *their own* emissions of greenhouse gases, and that non-Annex I Parties can participate in this process if they wish, so long as the policies and measures relate to emission reductions *in the Annex I countries only*. Another interpretation could be that Annex I countries are committed to adopt national policies and measures to limit emissions, but that all that is required is that these policies and measures demonstrate leadership on the part of Annex I countries. No particular emission reduction objective would be implied in this interpretation, the result being that *any* form of joint cooperation could be envisaged under this Paragraph. The main area of debate seems to be over whether Annex I countries might be able to obtain "credit" for joint implementation projects undertaken in an non-Annex I country, but paid for by an Annex I country. The answer to this question probably depends on how strong the abatement commitment contained in Paragraph 2(a) is interpreted to be.

Article 4, Paragraph 2(b) discusses the commitment of Annex I countries to prepare national communications, containing information on the policies and measures referred to in Paragraph 2(a), "... with the aim of returning *individually or jointly* to their *1990 levels* of these anthropogenic emissions..." (emphases added). Note that this is the only place in the Convention that refers to 1990 levels of emissions. Note also a few other significant aspects of this statement: (i) it does not talk about emission *stabilisation*, in the sense that it does not require the 1990 emission levels to be maintained after they have been reached; (ii) it is the aim of the *communications* [not of the *policies and measures* in Paragraph 2(a)] to return to 1990 levels; (iii) there is no direct linkage between 1990 levels of emissions and "the end of the present decade", as is often assumed; and (iv) even if the goal of this Paragraph *were* to encourage Annex I countries to stabilise emissions at 1990 levels by the year 2000, the "individually or jointly" phrase seems to limit the individual responsibility of particular nations for achieving such a target.

In its only direct reference to joint implementation, the FCCC also requires the COP to " ... take decisions regarding criteria for joint implementation at its first meeting" [Article 4, Paragraph 2(d)]. This is in recognition of the fact that joint implementation is imprecisely defined in the Convention itself, and that some agreement will be required among the Parties before it can actually be used in practice. To help prepare the ground for the COP, the INC took up the issue of joint implementation at its August 1993 Meeting in Geneva. Most of the discussion at that meeting centred around the different interpretations of the FCCC, some of which are reviewed in this paper. The INC Secretariat has now been asked to prepare a list of possible operational criteria for joint implementation, taking into account the views expressed by countries at INC-8. It is expected that this list will be presented for discussion at INC-9 in February 1994.

It is also worth mentioning one other reference to joint implementation that is *not* contained in the FCCC, and is somewhat conspicuous by its absence. Article 4, Paragraphs 3, 4, and 5 generally outline the responsibility of Annex I countries to provide "...new and additional financial resources to meet the full agreed incremental costs of developing country Parties..." Of all of the various reasons given in Paragraphs 3, 4 and 5 for making such transfers, none relates directly to joint implementation in particular, or even to Paragraph 2 in general. This could be interpreted as either : (i) recognition that joint implementation investments involving developing countries *were not* anticipated under the Convention (in which case, no transfers would be required); or (ii) implicit acceptance that joint implementation arrangements *could* be negotiated with developing countries (in which case, any transfers would simply reflect normal business transactions, and would not need to be specially mandated within the FCCC).

Note also that Paragraphs 3,4, and 5 only refer to financial transfers from Annex II countries to developing countries. Potential transfers to countries included in Annex I but not in Annex II (i.e. economies in transition) are not mentioned.

3. Joint Implementation and Environmental Effectiveness

There are three basic questions that will ultimately confront proponents of joint implementation concerning the criterion of environmental effectiveness :

- Would joint implementation investments lead to actual reductions in global greenhouse gas emissions?
- How can we be sure that joint implementation projects promote emission reductions that are "additional" to what would otherwise have occurred?
- What impact would joint implementation have on the path of long-term technological development?

Joint implementation and emission reductions

Although the long-term goal of the FCCC is to reduce atmospheric concentrations of greenhouse gases, it should be pointed out that the FCCC itself probably expects global concentrations to actually *increase* for some time to come. One reason for this is that, even if all current emissions could somehow be eliminated, concentrations would continue to rise because of physical lags in the dose-response relationship. More importantly from a policy perspective, however, is the possibility that emissions in developing countries will have to continue to rise for some time, regardless of what happens in Annex I countries. The Preamble (tiret 3) notes "...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." Article 4, Paragraph 7 also refers to the fact "...that economic and social development and poverty eradication are the first and over-riding priorities of the developing country Parties." Both of these statements suggest that *increasing* emissions in developing countries are at least possible. In short, it could be argued that the FCCC does not presume (although there is clearly the hope) that increases in non-Annex I emissions will be offset by reductions in Annex I emissions. If this is so, it may be reasonable to judge the environmental effectiveness of joint implementation projects not on the basis of whether they achieve net *absolute* emission reductions at the global level, but on whether they are perceived as having improved the chances that long term global emissions will decline. *Consequently, a joint implementation investment that achieves emission reductions in one country, only to increase them in another, would not necessarily be inconsistent with the FCCC.* For example, it may be argued that the increased emissions in the second country serve to increase incomes in that country, thereby shortening the delay before it will be able/willing to begin contributing to global emission reductions itself.

Another important way to look at this point is that, even if all that is achieved by joint implementation is that reported emissions are reduced in Annex I countries and increased in non-Annex I countries, this may be all the existing FCCC actually calls for. It may be desirable for reported emissions to decline in both groups of countries, but the non-Annex I countries do not appear to have agreed to such an idea in the FCCC. Viewed in this way, one could argue that any interpretation of the FCCC that required countries which host joint implementation projects (non-Annex I countries, in this example) to demonstrate absolute emission reductions would actually be *inconsistent* with the terms of the FCCC. Furthermore, requiring them to accept either an absolute or a relative (i.e. a "baseline-adjusted") emission reduction condition before making a joint implementation investment on their soil could, in this light, be seen as an infringement on their sovereign right to decide when to make such a commitment themselves.

The "baseline" issue

The preceding discussion also has significant implications for the so-called future "baseline scenario" problem. Under the FCCC, the Annex I countries have agreed to work toward emission reduction and sink enhancement. Some will even argue that they have even agreed to stabilise emissions at 1990 levels by the year 2000. Assume for a moment that this latter (i.e. broader) interpretation has, in fact, been accepted by all Annex I countries. In that case, the abatement goal for Annex I countries would at least have been stated in terms of actual historical emissions, not in terms of future emission scenarios. What the developed countries might do in the future would not be especially relevant to the FCCC. All that would matter is that their emissions stabilise at 1990 levels by the year 2000, and the performance of their policies and measures could be judged against this particular standard.

In countries that had *not* accepted any quantified abatement target (the non-Annex I countries, in this case), there would be a problem. Without some idea of the "baseline" that would have existed in the absence of the policy, it would now be impossible to directly judge either the environmental effectiveness of that policy, or its contribution to economic efficiency. To give a concrete example, an investment in preserving a forest in a developing country would not reduce any emissions at all, if the developing country never had any intention of harvesting the forest in the first place. Nor would it improve global economic efficiency to pay a country to do something that it would have done anyway. In theory, therefore, an argument could be made for either attempting to develop "future baseline" scenarios for recipient countries, or even for excluding non-Annex I countries from joint implementation projects altogether, on the grounds that measuring a "counter-positive" result is impossible. Several countries already seem to be taking one or both of these positions in the INC discussions.

On the other hand, if we assume that non-Annex I countries *should* be included in the joint implementation activities countenanced under the FCCC, estimating the "future emission scenario" will be very contentious. It is difficult to imagine being able to credibly model the future emission behaviour of even one country, let alone of several. Moreover, even if this could be done for one point in time, any prediction would probably be outdated as soon as it was negotiated.

There is no easy way around this problem, but one practical approach might be to begin by assessing individual investments on a "project-by-project" basis, rather than attempting to develop a national emission baseline, making as realistic assumptions about future conditions facing both investor and recipient countries as possible. Under this approach, the "general equilibrium" effects of joint implementation projects would essentially be ignored; simplifying assumptions about future conditions made; and the project's impacts on emissions "qualitatively judged", rather than "precisely quantified". Most importantly, the starting point for such an analysis would be *existing conditions*. All likely changes from today's situation would assessed in the decision-making process, but the range of effects considered would be limited to those which could reasonably be expected to result from the project itself. A post-project audit process could be set up to broadly monitor the subsequent behaviour of both investor and invested nations, and "moral suasion" (i.e. national and international public opinion) used to bring pressure to bear on excessive claims by either side.

The main effect of this approach would be that joint implementation investments would be based on conditions *as they are today* in both Annex I and non-Annex I countries. The baseline issue would diminish in importance, but we would have traded this problem for an inability to directly attribute environmental and economic improvements to individual joint implementation projects. Over the long term, of course, the environmental effectiveness of all policy responses, in all countries taken together, *will* be measurable. Either emissions will decline or they will not, so an indirect measure of the environmental effectiveness of joint implementation activities will eventually be available. Ex post analysis (i.e. "hindsight) may also be able to provide us with some idea of the degree to which joint implementation investments have contributed to global cost-effectiveness. Unfortunately, these indicators will not be available ex ante; nor will it be possible to allocate the environmental improvements to the individual project level in a cost accounting sense.

Does this matter? If the COP has in mind a "tight" emission target, coupled with individual responsibility for individual countries, the allocation of economic and environmental improvements to individual projects takes on extra importance. Under such a system, we might visualise countries seeking official "credit" under the FCCC for their joint implementation investments. To obtain credit, countries would have to "prove" that their joint implementation instruments were efficient and effective. To do this, they would have to compare a "future baseline" with and without the joint implementation project. Once "approved" by the FCCC, the joint implementation activity would have to be monitored and controlled by some agent authorised to do so.

However, another model may also be reasonable. Assume here that countries have only "loose" commitments to abate (i.e. that, collectively, they are uneasy about taking on quantified emission abatement targets). In this model, the important thing would be to encourage countries to do things that result in both emission reductions and economic improvements over the long term. It would not be necessary to "prove" these improvements exante, or even to monitor their impacts in detail expost. Nor would it be necessary to formally "credit" them to individual countries in an accounting sense. The emphasis would be on moving forward from the existing situation, and on developing long term international cooperation. All that would be important would be to satisfy the Parties that there was a reasonable chance that individual joint implementation projects would actually contribute to improvements over the long term.

Using this model, two key results would be obtained : (i) the "baseline scenario" problem would be reduced. This may be less elegant in theory, but more appropriate in practice; and (ii) a "project level" approach, rather than a "general equilibrium" one would reduce the complexity of measuring the potential impacts of joint implementation projects. Two additional observations are in order here. First, if it is accepted that a joint implementation investment need not lead to immediate absolute reductions in emissions in host countries (as discussed above), then measuring future emission baselines becomes less important in those countries anyway. And second, the "past baseline" problem would also be reduced, in the sense that actions that had already been taken in countries to reduce their emissions could be ignored (in effect, countries would *not* have to be given credit for any abatement action they had already taken by the time the joint implementation system became operational). This point is more fully developed in the section below dealing with "burden-sharing".

Technology issues

Technological innovation is likely to be a key element of the policy response to a long term problem like climate change. It is therefore fair to ask whether joint implementation is likely to contribute to the right kind of technological change, and whether the pace of this change is likely to be speeded up or reduced as a result of joint implementation projects.

One view suggests that joint implementation will *inhibit* technological development. This argument runs along the following lines: technological improvements result primarily from regulatory pressures. Such pressures now exist in the case of climate change, since all developed countries have accepted an "emissions cap" under the FCCC. If joint implementation were permitted to occur beyond the boundaries of the developed countries, this pressure would be reduced, thereby contributing to a reduced rate of technological development within the developed countries. This would also reduce opportunities for developing countries to acquire this new technology, which would otherwise permit them to "leap-frog" over inefficient technologies. This is because the focus of the developed countries would be on selling their "old" (i.e. existing) technologies, rather than on creating new ones. In sum, joint implementation would have a negative influence on technological growth, and therefore, on the policy response to climate change.

Several problems seem to exist with this reasoning. To begin with, as explained earlier, the developed countries may *not* have accepted an overall cap on their emissions. It may be environmentally desirable for them to do so, but it can be argued that they have simply not yet done it. *If* governments were to agree to stringent environmental targets, it *may* be reasonable to assume that technological development would respond to that pressure (although many would argue that there are limits to the ability of technology to solve all of the world's environmental problems). Until governments agree to do so, it might be assuming too much to conclude that joint implementation would automatically inhibit technological development.

Second, even if it were desirable for new technologies to "leap-frog" over old ones, especially in developing countries, the penetration of new technologies into a country will not always be supply-driven. Penetration will also depend on economic and cultural factors, which may have little to do with the level of emission constraints. The existence of a direct correlation between higher domestic abatement targets and greater rates of technological development and penetration is a matter for empirical study, not for assumption.

Third, even if "technological leap-frogging" does not occur, there could still be *some* technological advancement in developing countries as a result of joint implementation projects. We should note that an improved technology can be better than the existing situation, even if the improvement is less than what might be considered "optimal". Even the application of a conventional technology today may be better than waiting until tomorrow for a yet-to-be-defined "leap-frogged" technology. Related to this argument is the observation that technologies designed to respond to pollution problems in developed countries might not always be appropriate to developing country situations. In such cases, applying "old" technologies might actually be the best way forward for the developing countries. Furthermore, by helping to expand the market for existing technologies, it could be argued that joint implementation would actually *enhance* the chances that new technologies will actually penetrate to countries where they can contribute to emission reductions.

And finally, we should also keep in mind that the transfer of existing technologies to developing countries may not need to result in absolute emission reductions in those countries, for reasons discussed earlier. This will make it even harder to judge what the "optimal" path of technological development actually is. In a sense, the argument that joint implementation inhibits technological development is caught by the same problem that proponents of "future baseline scenarios" are. It is difficult to prove a counter-positive in both situations. What really matters is not the technological development that *might otherwise* have occurred, but the technological development that *actually* occurs.

4. Joint Implementation and Economic Efficiency

The concept of economic efficiency as applied to the problem of climate change has two main dimensions. First, there is the issue of how much abatement would be appropriate. In classical economic terms, the answer to this question depends on a comparison between the impacts of climate change (i.e. the benefits of doing something about the problem), and the costs of any policy response. The second issue is how to achieve whatever level of abatement is decided upon at least cost. This is the question of "cost-effectiveness". Joint implementation, as usually envisaged, is not related to the question of how much abatement is needed, although it seems intuitive that governments will eventually accept higher levels of abatement if the costs of that abatement can be kept down. However, the main objective of joint implementation *is* to promote cost-effectiveness. Theoretically, it is possible to achieve cost-effectiveness at *any* level of abatement, even a loosely-defined one. Obviously, the more clearly the abatement target is defined, the easier it will be to *measure* the cost-effectiveness of policies designed to achieve that target, but the fact that the emission target is only loosely-defined does not change the basic economic need to reduce costs.

Since improved cost-effectiveness is the main reason usually advanced in support of joint implementation, it is useful to examine this claim. In theory, the cost savings from using joint implementation as part of the policy response could be very large. For example, Barrett (1992) has estimated that the costs of achieving the European Union's CO_2 stabilisation target using joint implementation could be as much as *50 times* less expensive than if each Member state were to stabilise its emissions individually. Similarly, one global emission stabilisation scenario examined by Burniaux *et al.* (1992) suggested that global abatement costs could be halved using joint implementation principles (from 2 per cent of real world income, down to 1 per cent).

Given that the developed countries would likely have to bear a high proportion of any emission abatement costs, many of these countries would appear to have a direct interest in applying joint implementation principles to the abatement problem. Some developed countries also stand to benefit from a joint implementation approach in at least two other ways. First, the export potential of their (generally) more advanced pollution control technologies might increase. Second, the global commitment to reducing emission loads could increase, ultimately reducing the impacts of climate change on *their* economies.

What about the economic benefits of joint implementation as seen from the perspective of the developing countries? Three types of incentives seem to exist for these countries: (i) local benefits from the resource transfers received for the environmental "service" they would be providing to the developed nations (these would include infrastructure improvements, employment gains, reductions in other air pollutants, and so on); (ii) they would have better access to more developed pollution control or avoidance technologies (e.g. energy efficiency technologies); and (iii) they would have a reduced exposure to climate change itself, as a result of a presumably greater level of global abatement than would have occurred without joint implementation.

If joint implementation could generate all of the above-noted economic benefits, why is there any hesitation to use the tool? Perhaps it is because there is a suspicion that these theoretical cost-savings might not actually materialise in practice. Several of the assumptions underlying this theory are therefore examined below in more detail.

Are "no-regrets" policies available domestically?

Some have argued that there are plenty of "zero-cost" (or at least "low cost" options available to countries in their domestic situations. For example, the U.S. National Academy of Sciences (1991) recently concluded that about one-third of existing US greenhouse gas emissions could be reduced at little or no economic cost. If this is true, there would be no point in countries investing in joint implementation projects elsewhere, since their abatement costs would be minimised by abating their own emissions. This view has considerable support in the economic community, and its political attraction is obvious.

Countering this perspective, however, are the notions that: (i) if such cost savings are really available, they will tend to exploited first anyway -- joint implementation would only enter the picture after all "low cost" domestic projects had been implemented; (ii) the countries which have been the most supportive of joint implementation during the INC process have tended to be the same countries which already have higher levels of greenhouse gas emission efficiencies. This suggests that the number of "low cost" domestic options may be limited in some countries; and (iii) if "no regrets" options exist in one country, they are likely to exist in others. If "better" *no-regrets* options (i.e. options with even higher pay-offs) happen to exist internationally than at home, cost-effectiveness principles would still require that a joint implementation investment be made in the "lowest cost" country. In other words, the existence of "no-regrets" options does not, in itself, negate the theoretical attractiveness of joint implementation.

Are abatement costs really lower in developing countries?

A second key assumption is that the costs of abatement will actually be lower in other countries than they are domestically. Chichilnisky (1994) has argued that this assumption should be proven by empirical analysis before it is accepted. Her argument is that this issue is particularly important because of the "free rider" problem. In the provision of public goods (e.g. in emission abatement), "free riders" tend to argue that "the other" party should provide the goods, because it "would cost that party less to do so". Seen in this light, joint implementation might simply be an exhibition of "free-riding" behaviour on the part of its proponents. Countering this argument are the notions that: (i) one is more likely to find "low cost" options if the scope of the search can be expanded, rather than limiting the search to only domestic opportunities; and (ii) countries which have already experimented with joint implementation investments in developing countries seem to be satisfied that the cost-saving potential of these investments is, indeed, real.

Does joint implementation include all costs?

Opponents of joint implementation also tend to argue that the real cost savings will be lower than expected, because some important categories of costs will inevitably not be included in the investment decision. The two most often discussed of these categories are "subsidies" and "capacity building". There are a host of policies in most countries that distort market signals in ways that are not necessarily economically efficient, outright subsidies being the most obvious example. Clearly, the removal of these distortions from the cost comparison is required if joint implementation projects are to be compared on the basis of a "level playing field". Similarly, it is not enough for joint implementation investors to simply make capital investments in host countries, without ensuring that the recipients have the necessary technical, infrastructural, and operational capacities to ensure that the investment actually delivers the anticipated benefits. When costing joint implementation projects, therefore, investors should be encouraged to include these "capacity building" costs into their decisions. On the other hand, the assumption that countries would *not* include all relevant costs in their computations is equivalent to assuming that they are not competent as sovereign states. Since host countries would have an interest in including all real costs, and investing countries would have an interest in not paying for any "non-real" costs, it could be argued that the existence of these competitive interests would ultimately lead to a suitable (i.e. cost-effective) result.

Private or public sector joint implementation?

There has been some discussion of whether joint implementation activities should be permitted under the FCCC between governments, or whether the private sector should also be allowed to play a role. The first point to make here is that the FCCC may not be in a position to "permit" anything. It can establish the criteria under which activities can be judged "acceptable" to the Conference of the Parties, but it is difficult to see how the FCCC could (or would want to) prevent two economic agents from entering into contracts with each other for any reason they chose. Second, it is reasonable to assume that the more actors involved in joint implementation activities, the more chance there will be that acceptable cost-saving projects will be uncovered and exploited. This tends to support the view that undue limitations on private sector involvement should be avoided. Two other advantages of a private sector approach are that: (i) the joint implementation investments would be made "off budget" from the point of view of the governments involved -- not an unimportant consideration in the current climate of increasing national deficits; and (ii) the private sector may be better at delivering technology-based environmental improvements involving large numbers of producers and consumers than the public sector. Nevertheless, it is *countries* that have signed the FCCC, and it is countries that will be expected to report on its implementation. One way of reconciling this difference might be to countenance private sector joint implementation investments under the FCCC, but using a reporting framework that is established at the national level, and coordinated at the international level by the COP. The National Communications process envisaged by the FCCC [Article 4 paragraph 2(b)] might be a useful way of achieving this coordination.

Transaction costs

The higher the transaction costs associated with joint implementation, the more the other economic benefits associated with the tool will be dissipated. Very little evidence exists yet in this area, given the paucity of actual joint implementation projects in existence. However, one can look to previous experience with tradeable permits for some guidance here. For example, Dwyer (1992) has suggested that transaction costs could be in the order of 10-30 per cent of the total cost for administering the emission permit trading programme in the South Coast (California) Air Quality Management District. Admittedly, transaction costs will vary according to the level of "administrative intrusion" that is built into the design of the programme, but 10-30 per cent of a large number is still a lot of money. Barrett (1992) also points out that a joint implementation approach to abatement would likely generate even higher costs than a tradeable permit program because: (i) the computation of costs would have to be done on a case-by-case basis; and (ii) individual contracts would have to be negotiated, monitored and enforced. He also points out, however, that using "clearing-house" mechanisms to help locate suitable projects would tend to reduce these transaction costs. This is why several proponents of joint implementation have explicitly called for these mechanisms as part of any joint implementation approach. Some observers have also suggested that, in an attempt to keep transaction costs down, developed countries might impose capital-intensive, supply-side, abatement options on developing countries, rather than perhaps more effective demand-side policies, to the long run detriment of developing country interests. Clearly, more work needs to be done in this area, both to determine the likely transaction costs associated with joint implementation, and to suggest how these costs might be reduced.

Market power

Economic theory suggests that the concentration of market power tends to lead to sub-optimum levels of production and/or consumption. In a joint implementation context, there is a possibility that countries with the most economic power (generally assumed to be the Annex I countries) might be available to exploit their position, to the disadvantage of other countries. Although this may be true in theory, it should be recalled that there are 36 countries listed in Annex I. Each of these countries differs considerably in virtually every category of economic activity from the others. The differences are even greater if one considers the 154 signatories as a group. On the surface at least, there would seem to be ample room for achieving reasonably competitive conditions among participants in joint implementation projects.

The need to equalize marginal costs

The basic economic principle underlying joint implementation (and other economic instruments, for that matter) as policy tools is that, until the marginal costs of abatement have been equalised across all
countries, further investments in joint implementation projects would lead to an improvement in global social welfare (Pareto Optimality). This assumption has recently been questioned by some authors, on two grounds (see Chichilnisky, 1994). First, it is argued that joint implementation projects would likely involve large fixed costs, possibly associated with *declining* marginal costs (i.e. economies of scale). In such situations, *allocations based on marginal costs* may not lead to as efficient a result as those based on *average* costs.

Chichinisky also argues that, in situations where public goods that are produced by each consumer (the actual case for greenhouse abatement), an efficient allocation would require that the marginal cost of abatement in each country be inversely proportional to that country's marginal utility of consumption of all other private goods. If this is so, countries with high marginal utilities of consumption (typically the low-income countries) *should be expected* to have lower marginal costs of abatement. Extinguishing these low marginal cost would therefore *not* be efficient in economic terms. Although this conclusion can apply to any market-based policy instrument, it does have important ramifications for joint implementation, especially in the context of the debate about whether or not joint implementation should include the non-Annex I countries.

Comprehensiveness

Other things being equal, the more comprehensive the coverage of joint implementation, the more economic benefits we might expect to flow from its use. Comprehensiveness can be thought of in terms of *space* (the number of countries to which joint implementation could projects could apply); *time* (the time period covered by joint implementation projects); *type of activity* (sink enhancement; abatement; demand- or supply-side projects); or *scope* (the number of gases eligible for inclusion in joint implementation projects). It would appear that the upcoming negotiations will have to address each of these parameters. For example, there has already been some discussion in the INC about which countries should be able to participate in joint implementation activities, and around what time period. In principle, there is no economic reason for excluding some countries, some gases, or some types of investments from joint implementation activities. There may be technical reasons for doing so (e.g. high transaction costs; difficulties in measuring emissions of certain gases; etc.), but these can be decided on a case-by-case basis. There may also be political reasons for doing so (see next section), but these should not be rationalised on economic efficiency grounds.

5. Joint Implementation and Burden-sharing

There are four basic questions that arise when thinking about the potential impacts of joint implementation on the sharing of the emission reduction burden within the international community:

- Should the scope or the timing of joint implementation be limited in order to achieve burden-sharing objectives?
- How to deal with the "cream-skimming" issue?
- Would joint implementation distort investment priorities in host countries?
- How can host countries be certain that joint implementation activities would not simply displace existing aid arrangements?

Should joint implementation be limited in either scope or time?

Much of the international discussion about burden-sharing has centred around the view that the developed countries are responsible for most of the historic emissions of greenhouse gases; that they have already used up the assimilative capacity of the earth's atmosphere for these gases; that they are in the best position to solve a problem that they created anyway; and that they are also likely to benefit the most from efforts to reduce climate change. This view suggests that it would be more equitable for the developing countries to first clean up the environmental problems that they themselves created (such as traffic pollution), only moving on later to the problems that the developed countries created (such as global warming). In the meantime, the developed countries should proceed with the necessary abatement of greenhouse gas emissions *themselves*, and that the developed countries should not expect the developing countries to help them "buy their way out" of their abatement responsibilities with joint implementation. This argument has been used to suggest that joint implementation activities should be limited to Annex I countries, especially until the year 2000, by which time the Annex I countries will have been expected to stabilise their emissions at 1990 levels.

Countering this argument are the ideas that: (i) the climate change being addressed by the FCCC is related to future emissions, not to *past* ones. Since emissions from the developing countries are expected to grow at a faster rate in future than those in the developed countries, it seems reasonable to look for ways to reduce the former as well as the latter; (ii) it is also possible that the Annex I countries have *not* agreed to stabilise their emissions at 1990 levels by the year 2000 (see earlier discussion). In this case, it would be inequitable *to the Annex I countries* to impose such a constraint on them; and (iii) if emission reductions can be achieved at lower costs in developing countries than in developed ones (the premise of joint implementation), *both* groups of countries would be in a position to benefit from efforts to control emissions in developing countries.

It has also been suggested that, for equity reasons, there should be some limitations placed on the amount of emission abatement that could be carried out through joint implementation in an individual country. Perhaps the Annex I countries could be prohibited from obtaining credit under the FCCC for more than a certain maximum percentage of their own emissions, or of their emission abatement requirements. Perhaps the joint implementation regime might require a sharing of the emission credits between investor and host nations. Or perhaps the developed countries could be required to work through a "clearing-house", buying the right to undertake a joint implementation project from that body at a pre-administered price that reflects some burden-sharing criterion.

Although such arrangements may eventually be negotiated by the COP, a few observations can be offered about these ideas. First, we do not yet know how much joint implementation is likely to occur in the Annex I countries, even under a totally unregulated abatement regime. The amount of joint implementation that countries choose to indulge in will depend to some extent on the relative costs and benefits of abatement that they face. It will also depend on political constraints. After all, it seems unlikely that voters in all countries will support investments being made in projects offshore that could be made at home. This is likely to be true even where the economic cost of the offshore investments is less than that of domestic options, especially where there are secondary local environmental benefits that could result from investments made at home. On balance (although this has not yet been extensively studied), it seems likely that joint implementation activities will be inherently limited as a proportion of total abatement *in any event*. If this is so, the need for the COP to "legislate" the maximum proportions of Annex I emissions or abatement objectives that can use joint implementation under the FCCC would be reduced.

Several observers have also pointed to a potential conflict between joint implementation and control over land use, especially in the developing countries. For example, joint implementation projects involving reforestation might generate long-term and significant constrictions on land use in host countries. Partly to minimise any potential infringements on national sovereignty, it has been suggested that sink enhancement projects should *not* be encouraged under a joint implementation system.

However, it is difficult to see how the *actual* reduction of sovereignty (which *would* occur if the decision to accept the investment were taken out of the hands of the host country) would be any worse than the *potential* loss of sovereignty (which *might* occur if the host country failed to negotiate good enough terms in the joint implementation contract). Furthermore, early evidence from "pilot" joint implementation projects seems to suggest that suitable ways of avoiding this risk can be found, even in land-intensive joint implementation activities.

Another point is that joint implementation has more potential applications than just in a developing-developed country context. Because the FCCC makes several statements about the respective roles and responsibilities of developing and developed countries, there has been a tendency to view joint implementation from this particular perspective, and to discuss its relative merits on that basis alone. Several other possibilities also exist, even if the COP were to decide that joint implementation is not applicable to the non-Annex I countries. For example, the Annex I group itself contains two groups of countries which might form the basis for future joint implementation activities -- the OECD countries and the countries in transition to a market economy. The wording of the FCCC also opens up the possibility of regional economic integration organisations (such as the European Union) cooperating to achieve common objectives, so it may be reasonable to think about joint implementation activities being undertaken at *that* level. If one also thinks about burden-sharing at the sub-national level, it is also possible to imagine joint implementation projects helping to reduce relative abatement burdens across *economic sectors* (fossil fuel enterprises may have higher abatement costs than hydroelectric enterprises, etc.), or across *income classes* (climate response policies may be more or less regressive in their impacts on different groups of consumers). It will probably be important to look for opportunities to improve the sharing of burdens at each of these levels, and joint implementation may be able to contribute to this search. And finally, we should also remember that burden-sharing has a long term perspective as well as a short-term one, implying that the relative burdens that exist today may be quite different from those that will exist tomorrow. Current policies to share these burdens should be flexible enough to allow for these changes over time, even though it will often be short-term considerations that shape political decisions.

The "cream-skimming" problem

The fear has also been expressed by some that joint implementation would only serve to "pick off" the cheapest abatement options available in host countries, thereby discouraging these countries from eventually taking on abatement commitments of their own. This is because they would presumably be at a higher level on their abatement cost curve than they would have been without the joint implementation project. Underlying this view is the (equity-based) idea that it is unfair for the developed countries to get credit for "cheap" abatement that they are responsible for in any event, leaving the developing countries to pay a higher price at a later date, when they begin abating themselves. Not only would this be unfair, it would also retard progress toward the achievement of the FCCC's objectives by delaying the date when developing countries might begin to abate too.

The problem with this view is that it does not seem to fit very well with previous experience in negotiating the FCCC. During the negotiations, there were significant differences of opinion about the level of abatement commitment that should be taken on, even within the Annex I group. This difference of opinion reflected different views on a whole suite of subjects --

costs, benefits, past responsibilities, institutional histories, cultures, etc. Despite these differences, the Annex I countries were able to agree, as a group, that they should demonstrate leadership in attacking the climate change problem. In one sense, the future position of the developing country would be somewhat the same as that of an Annex I country today that has already implemented more abatement measures than its other Annex I partners. And yet, these countries have seen fit to sign the FCCC, despite their relatively higher marginal cost position. In another sense, the future position of the developing country would be even better than the present-day Annex I country, because the all joint implementation projects implemented in the interim would have been financed directly by other countries.

One could also argue that, by increasing the scope of abatement activity, joint implementation might actually *increase* the likelihood that countries will want to take on "Annex I-type" responsibilities in the future. Certainly, it is possible to think of some Annex I countries which seem more comfortable with arrangements that involve commitment-sharing arrangements like joint implementation than they would be with the idea of "strong" national abatement targets. This would imply that joint implementation might actually make it more -- not less -- attractive to be included in the Annex I group.

Therefore, it is not obvious that developing countries will *necessarily* be worse off with joint implementation than without it, even where "cream-skimming" seems to be at work. Nor is it obvious that the participation of developing countries in joint implementation activities today will automatically inhibit their willingness to take on "Annex I-type" abatement commitments tomorrow.

Even if this *were* the case, one solution to the problem might be to simply agree amongst the Parties that any future emission target involving the developing countries would be no lower than the levels of emissions in those countries whenever joint implementation began to be operative. This would avoid the developing countries being "economically penalised" for having accepted joint implementation projects on their soil. However, if emissions in developing countries are likely to *grow* in the medium term (see earlier discussion), such a limitation might not mean very much.

The issue of national sovereignty is also relevant here. Assume that "cream-skimming" is indeed a problem. Would it then also be reasonable to assume that the countries in which the "cream-skimming" takes place are not able to account for this, and to either negotiate an abatement commitment at a future date that is acceptable to their voters at that time, or to simply refuse the joint implementation project in the first place?

The "additionality" problem

Another often-heard argument is that it would be inequitable for existing aid and development monies to be simply transferred into climate change control programs. If it were possible for investor countries to reduce their overseas development assistance (ODA), for example, in order to pay for joint implementation investments abroad, the host countries would not necessarily gain from the joint implementation activity. This is why much of the discussion has emphasised that any funds available for joint implementation should be "new and incremental".

Several points can be made about this view. First, it is very important to distinguish between joint implementation investments and "aid". A joint implementation investment should result from a mutual desire on the part of two equal partners to an agreement. There is no sense of a "gift" in joint implementation, and it would be inappropriate to think of it in this way. Second, it will ultimately be impossible to distinguish between new and old funds ("a Franc is a Franc"). This problem is intuitively the same are the baseline issue that was discussed earlier. As in the "baseline" case, it may be best not to try to be too precise in our definition of "additionality". The best approach may be to try to ensure that existing levels of ODA are simply maintained, and that joint implementation activities are viewed as being "extra" to these levels.

There have also been suggestions that the developed countries should agree to a common minimum level of ODA, which would serve as a "sill" below which joint implementation activities would not be credited under the FCCC. The problem with such an approach is that it might be perceived as an attempt to achive ODA objectives that have nothing to do with joint implementation, or with climate change for that matter. In the end, Annex I countries will likely want to retain sovereignty over how much ODA they provide, and to whom. These countries might argue that it is not within the jurisdiction of the FCCC to attempt to arbitrate in this area.

On the other hand, the COP may be able to agree on broad principles of the relationship between ODA and joint implementation investments, and it is conceivable that such an agreement would help to reassure the developing countries that joint implementation would result in "new and additional" resources being available to them in the future.

Distortion of investment priorities?

A perception exists that joint implementation investments might distort the investment priorities of developing countries, which have many important social priorities other than climate change (poverty, education, etc. -- see earlier discussion). This would occur because of economic pressure applied from the developed countries.

Countering this is the view that *any* significant policy response to climate change *should* cause shifts in production and consumption patterns. The question is not so much whether change is required, but whether the change should occur in the developed or the developing countries (or both). Compared to a "no regrets" policy, joint implementation would probably engender changes in investment patterns in *developed* countries. These changes might not be as large as what might be expected from the application of national stabilisation targets in developed countries, but (as suggested earlier) stabilisation in individual countries may simply be too costly in political or economic terms for developed countries to achieve. As a result, they might decide to interpret the FCCC "narrowly", and to reduce their level of abatement. Therefore, we might expect joint implementation to lead to *some* changes in producer/consumer behaviour in developed countries, but we cannot say *a priori* that these changes would be more, or less, than what would have resulted if a joint implementation approach had not been used.

Conversely, in *developing* countries, joint implementation seems likely to result in higher levels of abatement than could be achieved in the absence of joint implementation. This is simply because, *without* joint implementation-type compensation, the developing countries may not abate very much. *With* joint implementation, some distortion of investment priorities in developing countries *would* be involved, but these distortions would presumably be compensated by the investing Parties. It is not obvious why such an arrangement would be especially one-sided in favour of the developed country, unless the argument were that the developing countries are not responsible for taking *any* action to reduce their emissions of greenhouse gases. However, by virtue of Article 4, Paragraph 1 of the FCCC, this argument seems difficult to support.

Another point is that joint implementation projects would, by definition, involve at least two Parties. If one Party decided that climate change was not a priority, all it would have to do to focus on another priority would be to simply not participate in the joint implementation activity. If it *did* decide to participate, the priorities of both parties to the joint implementation agreement would clearly be somewhat altered. This is, after all, in the nature of *all* agreements. Furthermore, it could be argued that it would be a violation of the sovereignty of both nations to assume *a priori* that they cannot negotiate a suitable joint implementation agreement for themselves. Viewed in this way, imposing more constrictions on a country's behaviour than have been agreed to in the international discussions would also be inequitable. On balance, "distorted" investment priorities may not only be desirable in themselves, both types of countries may actually benefit from them.

6. Conclusion

The preceding discussions point to the existence of two basic models for applying the joint implementation concept (see Table 1). The first of these might be called the "accounting/adversarial" model. This model tends to see the FCCC as establishing a clear emission stabilisation objective among Annex I countries. Based on this goal. it also visualises a strong accounting framework for "abatement credits", coupled with an assumption that the economic and environmental performance of individual projects will have to be monitored and controlled on a regular basis. The concepts of accountability, numerical precision, and international justice are dominant in this model.

The second model might be called the "sovereignty/cooperative" model. Here, the underlying assumption is that the FCCC is a loose amalgam of (essentially political) statements about the modalities of future cooperation among the Parties. Under this regime, strict accounting for "credits" would *not* be envisaged, and the priority would be placed on the gradual development of mutual trust and common perspectives among the Parties, using individual joint implementation projects to do so. The emphasis would be placed on speeding up the flow of resources destined to fund joint implementation investments as a way of involving more countries in the abatement effort.

The "accounting/adversarial" model might lead to higher levels of environmental and economic performance, if ways could be found to actually implement it in practice. The "sovereignty/cooperative" model seems to offer opportunities for solving some of these practical problems, but probably sacrifices some environmental effectiveness and some economic efficiency in doing so. As stated earlier, the purpose of this paper is *not* to advocate one view over the other. However, the actual joint implementation system that is eventually constructed will probably differ, according to the particular model one accepts, and it is reasonable to conclude that the Conference of the Parties *will* have to face this choice before it can generate the criteria necessary to make that system operational.

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TRADABLE ABSORPTION OBLIGATIONS

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Abstract : The Tradeable Absorption Obligation (TAO) is a novel instrument under which emitters of pollution are required to take physical steps to reduce the stock of pollution, or (hence "Tradeable") to contract for that to be done. Its comparative static properties are different from those of traditional instruments - emissions tax, tradeable emissions permit (TEP) - and therefore, under the conditions assumed for the proof of the least cost theorem (Baumol and Oates, 1971) it is inefficient. However, the least cost theorem has been misapplied in relation to greenhouse gas pollution, for which market conditions are different from those assumed in the proof of the theorem and are such that, under appropriate technological assumptions, the TAO is lower cost. Aside from such efficiency considerations, the TAO carries a number of political-economy advantages in responding to greenhouse gas pollution, in particular its effectiveness in securing the diffusion of sustainable energy technologies; in promoting 'joint implementation' and technology transfer through the actions of firms in the market, mobilising the skills of energy firm managers; *in* resolving the problem of incremental cost; in avoiding the punitive aura of new taxation; in circumventing sovereignty issues; and in its potentially beneficial impacts on development and trade.

1. Preliminaries

1.1 Introduction

One obvious task, in presenting a novel economic instrument, is to respond to those who will ask "what is wrong with the existing 'traditional' economic instruments: emissions taxes and TEP's?". We shall come to that in Section 3 below, in the context of an appreciation of the scientific nature of greenhouse gas pollution and a critique of the economics profession's mainstream approach to the economics of climate change, summarised in Section 2. But first we explain how the Tradeable Absorption Obligation (TAO) works and, using a simple demand and supply diagram, distinguish it sharply from the two traditional instruments - which, it has been argued (Hoel, 1991), are broadly equivalent in comparative static terms. In order to make use of the simple diagram we will claim approximate equivalence between the TAO and a Dedicated Carbon Tax (DCT). Section 4 will discuss the substantial political-economy advantages of the TAO.

The TAO is designed to drive GREENS (standing for Global Redevelopment with Energy Environment Sustainability) the rather simple low cost response strategy advanced in "*Responding to Global Warming: the Technology, Economics and Politics of Sustainable Energy*" (Read, 1994, January). Thus it should be emphasised that the TAO is not advanced as an economic instrument suited to responding to every type of pollution problem (although that does not mean that its application is necessarily limited to the single problem of greenhouse gas pollution). The TAO is a custom built instrument designed to deal with the special problems presented by the technological and geo-political aspects[1] of a trans-national stock pollution problem where an absorption technology is available.

1.2 How the Tradeable Absorption Obligation works

Under the Tradeable Absorption Obligation energy sellers, at the wholesale level, are required to absorb some proportion (the "per-centage TAO") of the carbon that is emitted when their product is used by the purchaser, or to contract with other firms to carry out this obligation. The tradeability of the obligation, i.e. that it can be discharged by third party contractors or their sub-contractors in exchange for money, means that the marginal cost per ton of carbon

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1 See Read 1992b for a discussion of the geo-political aspects of GREENS but note that suggestions for relating GREENS to the Third World Debt problem are handled somewhat differently in Read, 1994, January, Chapter 8.

emitted is the same for all emitters that incur the same per-centage TAO, thus achieving a first order necessary condition for economic efficiency. This remains the case whether or not different per-centage TAO's apply in different places on equity grounds (ability to pay and/or responsibility for the problem) as could result from using the TAO to achieve the different commitments of Annex 1 countries and other countries under the FCCC.

In the absence of any other low cost technology for the purpose, the obligation to absorb carbon is equivalent to an obligation to grow biomass (either for carbon storage as standing timber - hereafter 'sequestration' - or for harvesting as fuel, typically as fuel-wood - hereafter 'recycling'). This obligation is incurred at the time the pre-cursor fuel is sold wholesale (i.e., with inventory hold-up for fossil fuels rather brief at the retail and consumer level, approximately when it is burned) and the costs incurred in producing the biomass are unavoidable from the perspective of the energy firm which is obliged to produce it, or to contract for it to be produced.

Accordingly, as far as the energy firm or contractor is concerned, the biomass, when it has been grown, is a free good in the sense of zero opportunity cost (since, with the quantities involved an order of magnitude greater than conventional demands for forest products, it is valueless except as fuel). Given a choice between energy product supply based on zero opportunity cost fuel-wood as raw material or positive opportunity cost fossil fuel, energy firms will choose fuel-wood in order to minimise avoidable costs (unless the biomass is produced in remote locations, with high transportation costs, in which case the sequestration option will be more attractive). But to say that the fuel-wood has zero opportunity cost does not mean that it costs nothing to use it, since doing so incurs a further TAO (to grow more fuel-wood to absorb the carbon dioxide emitted when the first batch of fuel-wood is burned, thus ensuring the continued recycling of atmospheric carbon). However, burning fossil fuels involves both the cost of the TAO and the avoidable resource cost of extraction.

Additionally, the obligation may be interpreted as a net absorption obligation (net TAO) in the sense that it may be discharged - subject to possibly formidable problems of measurement and accountability - by paying for a third party's emissions to be reduced, pari passu with paying for a third party contractor's absorption to be increased. In principle this equalises the marginal cost of energy efficiency measures for reducing emissions and the marginal cost of increasing absorption, on a global basis, whether or not the burden of paying for the TAO is equitably shared by consumers in different countries.

For instance, under the current commitment of OECD countries to stabilize net emissions at the 1990 level by the year 2000, no burden falls on non-OECD countries although a firm in, say, Leeds, may choose to discharge a net TAO by growing trees for sequestration, say in Nigeria, or by up-grading a power station in China - or by coppicing poplars to fuel a gas-turbine power station in Yorkshire, i.e. recycling, for that matter. But given the superior conditions for biomass production in hot wet climates near the equator, absorption, paid for by cost minimising firms will tend to migrate towards such regions, thus providing a supply of renewable fuel raw material to meet the rapid growth in energy demands that is forecast for newly developing countries. And, given the low efficiency of much energy using plant in the developing countries, net absorption (i.e. emissions reductions) can be expected to occur mainly in such countries, paid for by cost minimising firms in the course of discharging TAO's incurred mainly in developed countries.

1.3 Demand and supply analysis

Demand and supply analysis cannot capture the lag between initial emission and subsequent absorption which leads to the zero opportunity cost result mentioned above, and the analysis therefore relates to a steady state which persists for the duration of the sequestration or recycling activity. Since the sequestration cycle is essentially very long term, such a steady state is obviously an abstraction from what is fundamentally a dynamic problem, and the demand and supply analysis is offered in order to provide a simple comparison between the TAO and the traditional instruments. Also, in order to facilitate the comparison, we make the claim that the TAO is broadly comparative static equivalent to a dedicated carbon tax (DCT), that is to say a carbon tax of which the revenue is devoted wholly to the two absorption activities (sequestration or recycling).

Even within the limitations of comparative statics, exact comparative static equivalence depends upon assumptions as to who captures producer surplus (that is to say the area above the marginal cost curve and below the price level in the standard diagram) or upon equivalent assumptions regarding price formation in the markets involved. Whatever the success of different actors in this rent seeking game[2], it is convenient to assume the same out-turn regardless of whether the funds are channelled through government under the DCT, or flow directly from fuel wholesalers to suppliers of absorption services under the TAO. With that proviso we consider supply and demand for absorption services under traditional instruments in both the case of sequestration (left Figure 1a) and of recycling (right Figure 2a) below and under the DCT/TAO in corresponding Figures 1b and 2b further below:

Figure 1a

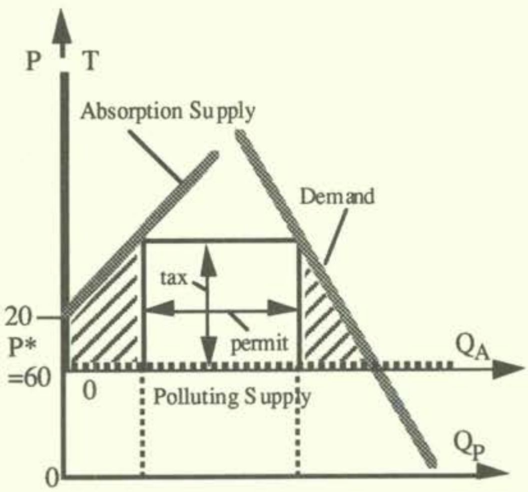
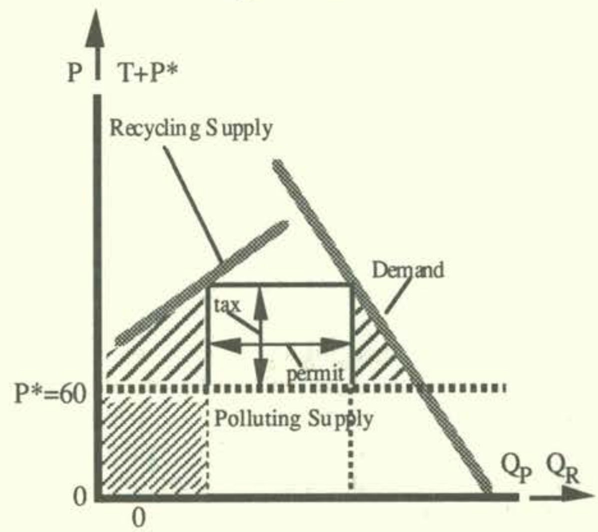


Figure 2a



In these Figures, the supply of polluting activity is, for convenience and without much loss of generality, assumed to be infinitely elastic at price P* = 60 (dollars per quantity of fuel containing 1 tonne of carbon). The incidence of a carbon tax thus raises the price to the consumer, with no change in the price received by the producer. This causes a reduction in demand and induces the supply of carbon absorbing activity. Sequestration is shown with lower costs at low outputs ($20 per ton of carbon initially, cf $80 per ton of carbon with recycling) since recycling involves harvesting costs and the cost of transportation to market. But recycling is more elastic in supply, since it requires less land. Also it provides a cost offset in substituting for output from the fossil fuel extraction industry.

In Figures 1a and 2a the quantity of TEP's issued is such that their price rises to the same amount as the alternative tax. The broad equivalence of the two traditional instruments is apparent from noting that the same price increase results for a given reduction in net emissions whichever of the two instruments is used. Thus the introduction of TEP's at the existing level of emissions, and `grandfathering' them to existing suppliers, is the same as introducing a carbon tax at zero level. And the intention to progressively restrict such `grandfathered' TEP's to lower and lower proportions of unrestricted demand is equivalent to progressively increasing a carbon tax from its initial zero level and handing over the tax revenues to existing suppliers.

2 This outcome depends on questions of industrial organisation and strategic behaviour in the markets for land, for absorption activity and for energy products, questions which constitute a field for future research.

Note that in all four Figures the reduction in emissions is drawn (roughly to scale) to be 50 per cent, whether brought about by tax, TEP, or DCT/TAO, and providing we are targeting net emissions[3].

Figure 1b

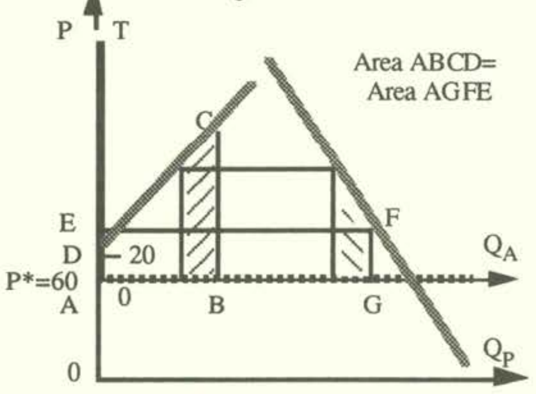
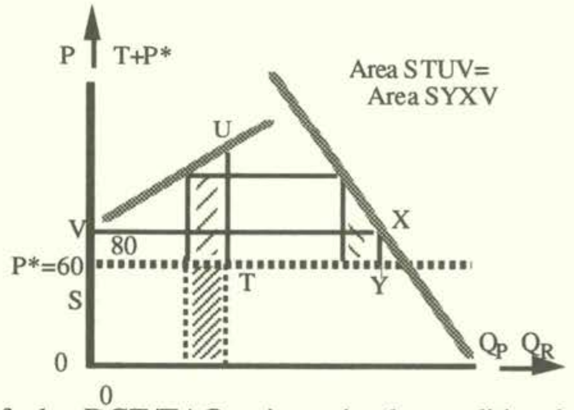


Figure 2b



In the lower diagrams, the additional cost of the DCT/TAO, vis-a-vis the traditional instruments, is shown shaded in the SW-NE direction[4], with partially compensating benefits shown shaded in the NW-SE direction. The key point to note in relation to the discussion of Section 3 below is that, although the DCT is clearly inefficient in the pollution emitting market under consideration in the demand and supply analysis, the price increase that results, for the same 50 per cent reduction in net emissions, is lower for the DCT/TAO than with the traditional instruments.

2. Background

2.1 Scientific appreciation

The scientific context leading to the GREENS concept and the TAO comprises:

i) a concern that the possible impact of rising levels of greenhouse gases will come to be seen in terms of the threat of adverse climate surprise, rather than of gradual global warming;

ii) a critique of economists' widespread deployment, grounded in mainstream cost-benefit analysis, of a marginalist response to potential incremental damage;

iii) an awareness, in the context of the FCCC's call for cost effective precautionary measures to avoid possible irreversibilities, of a potential need for urgent action (over decades rather than centuries);

iv) a perception that, in the event such action requires control of the <u>level</u> of greenhouse gases, (rather than simply a reduction in the rate of emissions, as largely considered by mainstream economists) that absorption of carbon dioxide by the production of biomass is the only available low cost technology for achieving such a result;

v) an appreciation that the storage of such biomass as standing timber (carbon sequestering) eventually involves unacceptable conflicts with demands for land to produce food and fibres, with a consequential need to dispose of the biomass produced by subsequent absorption;

vi) the conclusion that, with conventional markets for timber products saturated by the quantities of biomass that need to be produced to achieve the control at iv) above, the only means of disposal are either to bury it underground or its use as fuel in lieu of fossil fuels, with the latter (carbon recycling) usually preferable.

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3 i.e. providing that absorption is permitted as an offset against gross emissions - a proviso that is by no means universally accepted, despite the mention of sinks *pari passu* with sources in the FCCC.

4 Using the 'points of the compass' notation for direction (SW = South-West, etc).

This context led (vide Read, 1994, January) to:

vii) the adoption of a decision-theoretic methodology based, in the context of scientific uncertainty, on a risk-averse criterion applied to a measure of policy regret (Chapter 3);

viii) hence the development of the GREENS concept in broad terms (Chapters 4,7,8,9): the approach adopted is to regard carbon dioxide absorption (for either the sequestering or recycling of atmospheric carbon) as a technology with highly elastic supply characteristics which is capable, for several decades - maybe to 2100 - of filling the GAP between

A the net emissions which would result from commercial energy utilisation (after account has been taken of rising efficiency in energy utilisation and management and of increased supplies from ambient energy sources, such as windpower, passive solar techniques, etc.) and

B what is allowable, if the target (set by advances in scientific understanding of the maximum permissible net emissions for unacceptable risks of humanly induced climate surprise to be avoided) is to be met.

ix) the initial statement of the TAO (Chapter 7);

x) the formulation of a simple modelling framework for costing the implementation of GREENS (Read, 1991). This suggested that the cost of a programme in New Zealand, beginning at a low percentage TAO in the mid-1990's, and ramped up to a 75 percentage TAO over two decades (sufficient if emulated globally to <u>stabilise</u> CO_2 <u>levels</u> by 2020) would average about 11 percent of relevant fuel raw material purchase and processing costs over the period, peaking at 17 percent half way through, with eventual land requirements of 7 percent of New Zealand's farmland. Consideration of the burden of macro-economic adjustment outside the energy sector, (employing the simple technique for making use of others' estimates of such costs which is proposed in Read, 1992) could double these costs, still leading to a result which is an order of magnitude less costly and an order of magnitude quicker than is yielded by mainstream 'top down' analyses.

2.2 Reassessment of the economics of climate change

Advocating this approach led to a reappraisal of the mainstream analysis of the economics of climate change, as it has developed since the major OECD Conference held in Rome in 1990 (Read, 1993a). The gist of this reappraisal is that, while the economics profession has rightly stressed the need to embed the energy sector impacts of measures taken to mitigate the impact of potential climate change within an over-all model of the economy (a global model for a global problem, thus yielding what has come to be called the 'top-down' approach) the performance of this ideal has suffered various defects which spring from the application of old analyses to a new problem. In particular, inappropriate global models have been employed, and environmental economics theory derived from the study of local, flow pollution problems has been applied to a global, stock pollution problem.

In relation to the global models, the impact of the previous sudden and unexpected adverse supply shocks to a full employment situation is different from a gradual and rationally expected policy-induced shift towards a marginally more expensive supply system, particularly one where new demands on production can be substantially met from currently under-employed resources in the subsistence sector of developing economies (where the lowest cost opportunities for growing biomass exist). Additional sources of error arose from an initial failure to take account of the benefit from 'recycling' carbon tax revenue to reduce current distortionary patterns of taxation; from a failure to appreciate that a stock pollution problem can be addressed, in terms of <u>net</u> emissions, by increased absorption as well as by reduced emissions; and from reliance for data on econometric studies of past economic behaviour.

At the micro-economic level, there was a consequential failure to incorporate into the analysis a variety of economising and ambient energy technologies (wind-power, etc.) that have not been commercially exploited whilst environmental costs have remained externalised; and there was a mis-application of the Baumol-Oates 'least cost theorem' (which, in relation to local pollution problems, has been used to justify the application of efficient, market-oriented, pollution taxes in lieu of traditional regulatory measures for protecting the environment).

The proof of the theorem relies upon assumptions which imply that the pollution tax will have no effect on the level of market demands for the type of goods produced by the polluting firms. Such firms are assumed to reduce their output while other, non-polluting, firms increase output at the margin, with no impact on prices (Baumol, 1993). Clearly this is a very different situation from one in which the need to take account of the cost of adjustments in the rest of the macro-economy - in response to energy price increases brought about by a carbon tax or other policy measure - is advanced as a major criticism of engineers' 'bottom-up' estimates of the cost of mitigation.

3. Efficiency Aspects

3.1 Misapplication of the least cost theorem

In Baumol and Oates, 1971, it is shown that a desired reduction in emissions can be achieved at least cost by means of a tax, or uniform charge per quantum of pollution emitted, imposed upon firms that emit the type of pollution that it is desired to control. The proof of the theorem relies upon a crucial assumption, that cost minimising polluting firms purchase their inputs in perfectly competitive markets. The essence of the proof is that first order conditions - for a set of polluting firms, purchasing inputs as just assumed, to achieve a given reduction of total emissions at minimum cost - are met if the marginal cost of further reduction is the same for all firms. It then follows that, if a tax is imposed on pollution that is equal to this marginal cost, then each of the firms will be induced to produce at their respective levels of output which will together yield the required reduction in emissions at least cost. For a given level of demand, the collective reduction in output of the polluting firms is implicitly replaced by increased output from non-polluting firms.

This proof must relate to a polluting industry that is fully vertically integrated, or otherwise devoid of sales from one polluting firm to another or, if not, it relates to a polluting industry that sells on a perfectly competitive market. Otherwise the assumption that inputs are purchased in perfectly competitive markets does not hold. Read, 1993, demonstrates that first order conditions for least cost emissions reduction do not hold under a uniform emissions tax if one polluting firm sells to another in a market which is not perfectly competitive. That such a situation is relevant to greenhouse gas pollution is immediately evident from consideration of the position of OPEC in the global market for oil, or, in many countries, from the position of electricity utilities in relation to coal suppliers.

Another feature of the proof, undamaging to its application in the circumstances implied by its assumptions, is the absence of a characterisation of the product market. It is undamaging in those circumstances because, with product market price unaffected by the re-allocation of output from polluting firms to (many) non-polluting firms, nothing happens to demand for the product. Read, 1993, continues with a demonstration - for a particular set of own and cross price demand elasticities for gas and electricity reported for the USA (Joskow and Baughman, 1976) and for particular assumptions regarding the production technology in the two industries - that first order conditions for least cost emissions reduction are not met by a uniform tax on emissions. The technologies assumed are constant proportion (Leontief) production functions, so chosen in order to eliminate opportunities for choice of factor proportions and to demonstrate effects that arise purely from demand side choices.

3.2 Implications for the use of economic instruments in relation to greenhouse gas pollution

The analytics of the problem are closely akin to those of an older problem, that is to say the efficient distribution of a tax burden across a set of firms or industries or, in the case of publicly owned industries, the efficient allocation of a financial obligation to the treasury or other source of funds. Like the earlier problem, it leads to quite complex rules if an efficient outcome is to be achieved (Turvey, 1971, Chapter 3). Without the need to consider such complexities, two conclusions arise in the present context.

The first conclusion is that some instrument such as the TAO, other than a uniform pollution charge or tax (or other than a comparative static equivalent TEP scheme) cannot necessarily be assumed to be inefficient (or less efficient than such a tax or TEP scheme) when the field of application is one in which demand effects or vertically non-integrated structures occur, as they manifestly do in relation to proposals for a tax on greenhouse gas emissions.

Of course this is not to suggest that economic instruments that lead to price changes and which have impacts on the pattern of demand cannot result in an efficient outcome. It is to be expected that some efficient set of pollution taxes exists and can be discovered by application of the complex rules mentioned above, different taxes on different products in different markets, such that a desired or target reduction in emissions will result at least cost. But that is a far cry from the direct application of a uniform charge or tax, to which environmental economists are attuned by reference to the least cost theorem .

However, such a set of taxes, different taxes in different markets, is at least imaginable: if a firm deals in two markets - industrial and domestic electricity supply for instance - it is imaginable that different taxes in each market would be passed through to consumers more or less in line with the intentions of policy. But with TEP's it becomes harder to see. Maybe different quantities of permits could be grandfathered in respect of different industries, but with the permits then traded at a price, firms with strategic motivations might frustrate policy objectives by buying or selling permits and allocating their total quantum of permits (grandfathered issue plus or minus the amount traded) differently from the intention of policy.

But grandfathering is a politically oriented device, introduced in the USA to achieve the form of an emissions permit scheme without the effect of a tax. Given the political sensitivity of the USA to new taxes, such an expedient may have been necessary. But its perpetuation, as the quantum of permits is reduced in proportion to total unrestricted emissions, in the pursuit of significant emissions reductions, is (as mentioned in Section 1.3) to hand over the equivalent of increasing pollution tax revenues to the firms that are already in the market.

Also, it is to create the potential for a significant barrier to entry by new firms, some of which may wish to deploy technological advances yielding sharp reductions in emissions per unit output. Whether or not such a direction is acceptable to the regulatory process, or to anti-trust administrators, or to customers, grandfathering is clearly not conducive to a dynamically efficient policy in which the technological transformation of a polluting industry is aimed for through progressively increasing the level of some economic instrument.

So we leave aside the question of grandfathering, and consider an arrangement in which TEP's are auctioned, with the proceeds going to towards a reduction of other, distortionary, taxation. This is the arrangement that is portrayed in Figures 1a and 2a, with the tax equivalent price increase actually occurring (and without the possibility that prices will be held low to deter the entry of non-polluting suppliers - e.g. ambient energy sources such as windmills if we are thinking of electricity production - and without the possibility that non-market methods will be employed by the `grandfathers' to allocate output).

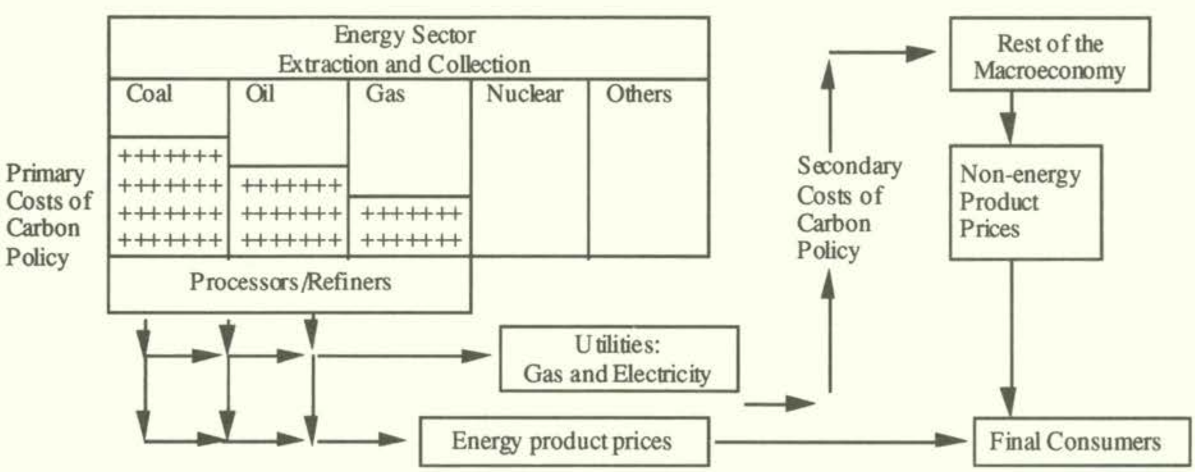
With an auction of TEP's, a price per permitted unit of emission (equivalent to the emissions tax as per Figures 1a and 2a) is established. But such a single price cannot be equivalent to the efficient set of emissions taxes discussed above. To achieve the same result there would have to be different classes of TEP's for different sectors of demand for the different kinds of output which give rise to pollution in the course of their production. For instance TEP's for the supply of electricity to bulk industrial users, TEP's for the supply of coal to households, etc. A moments consideration reveals that such an arrangement would be unsatisfactory since we would in some cases, and in some countries, be contemplating an auction with only one bidder, and in many other cases an auction with an extremely small number of bidders.

Thus the second conclusion to be drawn from this discussion is that, where pollution control *measures have an impact on demands for the good or goods of which the production gives rise to the pollution, and where the good or goods are sold to more than one sector of demand, an efficient pattern of emissions taxes may be feasible but an efficient scheme of TEP's is not likely to be.*

Finally we may note that, in respect of the difficulties raised for traditional instruments in Read, 1993, and summarised above, the TAO is on a par with emissions taxes. To the extent that it is possible to devise an efficient pattern of emissions taxes, it is possible to devise a pattern of TAO's which impose different burdens on the supply of different goods to different sectors of demand and hence to achieve an efficient pattern of reductions in demand in different markets. The difficulties of trading on thin markets, noted above in relation to trades in TEP's, do not arise in the markets for the discharge of net TAO's. A net TAO can be discharged in a global market for sequestering opportunities, a global market for recycling opportunities or in a global market of opportunities for raising the efficiency of energy conversion processes. Each of these markets can be expected to broadly fulfil the conditions for perfect competition.

3.3 Macroeconomic adjustment costs.

These microeconomic considerations bypass the concern that has been expressed by 'top-down' modellers. This is that estimates of the cost of curbing greenhouse gas emissions should be made within a comprehensive modelling framework that takes account of the repercussions of policy measures throughout the macroeconomy as a whole, generally using a computable general equilibrium model. The nature of the problem is captured by a simple flow diagram[5] in which our focus on the greenhouse gas pollution problem is maintained by identifying the energy sector as the primary source of pollution, as follows:



Evidently it is the price increase of energy sector products which stimulates the process of adjustment outside the energy sector and which constitutes the transmission mechanism of policy designed to curb energy consumption - leading to demand effects and secondary adjustment costs in the economy as a whole. This is what led to the mention of a 'key point' in the last sentence of Section 1.3 above.

Comparison studies of the various global modelling exercises that have been done to estimate the 'top-down' cost of emissions reduction policies (Dean and Hoeller, 1992) show broad consistency of result after allowance is made for the failure to 'recycle' tax revenues in some of the earlier exercises. By combining graphical representations of reductions in GDP (as a

5 This diagram broadly follows the presentation by the OECD's Peter Sturm to the seminar of the IPCC's WG3, held during its meeting in Montreal in May 1993.

measure of cost) against emissions reduction, and emissions reduction against carbon tax, it is possible to derive an approximately linear relationship between the level of carbon tax and the total cost to the economy of imposing the tax (Read, 1992a). It is shown in Read, 1992, how subtraction of the primary sector costs implicit in these models from their total cost estimates yields a measure of the secondary adjustment costs (that is to say the costs which are not taken into account in `bottom up' models of the primary energy market) as a function of the policy induced energy price increase (which we have identified above as the transmission mechanism for these secondary adjustment costs).

The purpose of making such a subtraction and obtaining a broad measure of secondary market adjustment costs as a function of the primary market price increase, is to enable the contribution of 'bottom-up' practitioners to be corrected for the omission of secondary costs and hence to become policy-relevant information. A further benefit of this approach is that it facilitates an understanding of the impacts of different economic instruments in circumstances where the critical assumption in the proof of the least cost theorem, the absence of demand effects, does not hold. Thus, with a lower primary market price increase, as indicated by comparison of Figures 1b and 2b with Figures 1a and 2a, the DCT/TAO leads to a saving in secondary costs which may be set against the increase in primary costs in the energy market itself, which was also noted in making the 'key point' in Section 1.3.

Thus the third conclusion is that, where costs and benefits arise in secondary markets that are not represented in the demand and supply diagram for the primary market(s) in which polluting production takes place, it cannot be assumed that the efficient level of offsetting activity will be induced by the incentives that arise as a consequence of taxes in the primary market(s), even when such taxes are set according to a pattern which is efficient in terms of the considerations discussed in the foregoing Section 3.2.

3.4 Technology dependency and optimality

The practical importance of the last conclusion is technology dependent. For instance it is shown in Read, 1992, that the DCT/TAO is lower cost than carbon tax with offsets (and/or the equivalent TEP scheme) in the case of 'longstop'[6] sequestering and recycling technologies having finitely elastic supply, but not in the case of a high cost infinitely elastic backstop technology, such as nuclear power. If the non-emitting sustainable technology is sufficiently high cost it is obviously counter-productive to dedicate tax revenues to subsidising it. Additionally, it is shown in Read, 1992, that the cost advantage of one instrument over the other may depend on the level of emissions reduction that is sought.

These considerations are not restricted to situations where a sequestering or recycling technology is available, as in Figures 1 and 2. The diagrams would be equally valid if, in the spirit of `net absorption', the supply curve represented the supply of opportunities for reducing third parties' emissions, or indeed, the supply of ambient energy technology opportunities, such as sites for placing wind generators. The key point is that, where demand effects give rise to costs outside the primary market, it is beneficial to subsidise more (net) absorption activities than result from the incentive to firms within the primary market through simply permitting offsets against the emissions tax or TEP scheme (Figures 1a and 2a).

And logically, if benefits apart from pollution abatement arise outside the primary market, as a side effect of a pollution tax, then the level of pollution tax (dedicated or otherwise) can beneficially be increased relative to the level(s) that would be efficient out of regard only for the pollution externality. These remarks add up to no more than the trite observation that, in setting taxes and subsidies in response to pollution externalities arising from activity in a primary market, regard needs to be had to all effects of the policy measures external to that

6 In cricket the longstop fielder changes from time to time, as must the choice of finitely elastic 'longstop' technology (as costs rise with growth in the market) whereas in baseball the backstop screen lasts for the duration of the game, as will the choice of a perfectly elastic backstop (disregarding the possibility that technological progress may yield a cheaper backstop).

market, not just the pollution externality.

Trite as may be, this point makes it clear that only by co-incidence will a dedicated tax (or set of taxes in different markets) on the one hand, or a simple tax (or taxes) with offsets on the other, be efficient. There is a continuum of possible combinations of tax on pollution and subsidy on pollution offsetting activity and somewhere on that continuum will be found the efficient combination. Such a combination can be implemented either by a tax and subsidy or by a TAO with topping-up tax or `bottoming-down' subsidy.

Consideration of Figures 1 and 2 above suggests that, with finitely elastic linear supply and demand functions, emissions reduction varies linearly with the levels of tax on emissions and of subsidy on absorption and/or recycling. However, costs in the primary sector are quadratic functions of the two levels while secondary costs are characterised in Read, 1992, as linear with the price increase passed through to the macroeconomy (although there is some indication, in Dean and Hoeller, op cit, of non-linearity at low levels of price increase). An optimal, minimum cost, combination of tax and subsidy may be derived by solving the constrained minimisation problem:

$$\text{Min } C = aT + bT^2 + cS + dS^2, \text{ s.t. } NER = eT + fS,$$

where lower case letters represent parameters of the model and C is cost, T is the tax on emissions, S is the subsidy on absorption or recycling and NER is the net emissions reduction required by policy. The variety of solutions to this problem under different technological assumptions and other specifications is under continuing research.

4. Political Economy

4.1 Technology diffusion and the role of firms

In the context of the scientific appreciation of Section 2.1 above, especially items (iv) to (vi), the TAO was originally conceived[7] as an instrument to drive the rate of uptake of sequestering and recycling technologies, and the rate of market penetration of biomass based energy products. The need for the TAO was seen as arising from the absence of developed operational models to explain technology diffusion, although those working in the Schumpeterian tradition have descriptions which suggest that innovations may remain dormant until precipitated by the evolution of an invention or development which completes a technological cluster of symbiotic advances (Freeman, 1988).

Indeed, the `top-down/bottom-up' debate reflects uncertainty as regards the rate of technological diffusion and/or market penetration of various energy conservation and renewable fuel and energy technologies which are believed to have low or even negative costs of implementation. In this partial vacuum of analytic capability, old fashioned command and control measures are advocated, or non-price market support measures that aim to repair informational or financial market failures. Such advocacy is addressed to the uncertainty of response to price mechanisms in relation to the process of technological change.

However, the TAO has a command and control aspect which yields a policy determined rate of market penetration - a TAO that is ramped up at 5 per cent per annum over a two decade period beginning in 1995 would see all the carbon that is emitted in the year 2015 absorbed. How quickly after 2015 depends upon the fuel firms' choices between slow absorption, rapid recycling, or third party emissions reduction under the `net absorption' approach. The choice facing firms may be influenced by the `rules of the game' associated with the monitoring and accountability aspects of enforcing the FCCC. Thus, with land constraints looming on a planning horizon beyond the time frame of commercial decisions, a lesser subsidy on slowly absorbing sequestration, or a penalty on profligate land use - thus inducing the faster diffusion

[7] Its likely (technology dependent) efficiency advantages discussed in the preceding Section came serendipitously.

of more rapidly absorbing (and/or more land conserving) recycling technology - could form part of the `rules of the game' (see Chapter 9 in Read, 1994, January, for a discussion of how the institutions envisaged in the FCCC could operate).

With the TAO obliging sellers of carbonaceous fuel to absorb the greenhouse gas emitted when their product is sold (and hence to become owners of biomass fuel which they sell in preference to incurring the additional cost of mining fossil fuels) the fuel industry is weaned off its `mother's milk' onto a sustainable biomass diet. Thus the diffusion of sustainable energy technology is forced at a rate determined by the rate of increase of the percentage TAO.

Under the TAO, the implementation of such diffusion rests with managements in the energy industries (which cannot use the instrument as a potential barrier to entry, as with TEP schemes - Morch von der Fehr, 1991). It is a feature of the TAO (per contra the equivalent DCT) that - instead of facing fossil fuel firms with a demand to hand over tax revenues which will then be disbursed to subsidise renewable fuel firms, effectively requiring fossil fuel firms to act as agents in their own extinction - the firms are enlisted to themselves organise their own weaning process, thus providing managerial continuity in the transition from unsustainable fossil fuels onto a sustainable fuel system.

And, it may be noted - in the context of the debates roused in the USA by the introduction of an energy tax, and the general political difficulty of new taxes or raised taxes - the TAO imposes no tax burden. Instead, the TAO is an expression of the traditional and much less controversial role of government in relation to business, that is to say its role as protector of the public from dangers that may arise from unregulated commerciality. Seen in terms of a requirement on fuel firms to protect the public from a danger that arises from the firms' product, it results in a cost on the business of fuel supply which is of a kind that it is traditional for governments to impose on firms (e.g. the costs of safety testing pharmaceuticals or the costs of making automobiles safer to drive).

4.2 Subsidiarity - the role of governments and the FCCC

The FCCC embodies, as a response to the shared but different responsibility and capability of its different parties, a commitment that developed (Annex 1) countries will carry the cost of response. However, as has been pointed out, effective action on this basis involves international transfers on the scale of hundreds of billions of dollars. This is a scale which is unimaginable on a government-to-government basis, being orders of magnitude greater than the traditional scale of aid transfers (Schelling, 1992). However, the commercial fuel industries have been handling international cash flows of this order as a routine matter for decades. Indeed, if we regard the difference between price and marginal cost of oil as an OPEC imposed tax or royalty, consumers at the gasoline pump are already inured to paying for such transnational transfers.

Apart from rendering imaginable a scale of transfer that would otherwise be unimaginable, arrangements which place the management of the process of transition to sustainable energy technology in the hands of firms are appropriate in terms of the subsidiarity principle. Under this jurisprudential doctrine responsibility for commercial activity is placed at the level of the firm, leaving the higher levels of decision - government, and, beyond that, international collective action - to take a regulatory and supervisory role. Apart from such grounds of principle, this carries the political advantage that non-fulfilment of obligations becomes the default of firms, which are subject to national laws and penalties, rather than the responsibility of sovereign nations, which are only weakly subject to international sanctions, and where allegations of default may impugn national honour.

4.3 Joint implementation and incremental cost

Placing the implementation of the technological transformation in the hands of energy industry management effectively casts energy firms in the role of intermediaries for the programme of Joint Implementation (between developed and developing countries) which is envisaged to follow from the FCCC. The prospect of a developed country and a developing country combining to Jointly Implement the developed country's commitment (say to stabilise its net emissions at the 1990 level through, for instance, paying for afforestation in the developing country) with the accompanying need for inter-governmental negotiation and potential for diplomatic misunderstanding and political conflict - does not arise.

Instead a firm (from a developed country which has agreed at the Conference of Parties on a policy for achieving its FCCC commitment by a percentage TAO of, say, 10%) finds itself with a need to absorb 100,000 tons of carbon, having sold 1m tons. The firm then simply shops around until it finds the best site for doing it, given the conditions that the sovereign government imposes (including questions of ownership of the biomass produced and, maybe, of sub-contracting to a local firm) and given the general 'rules of the game' agreed by the technical committee of the CoP and monitored by the CoP's extension workers in the various countries that welcome such developments.

Insofar as they opt to discharge a TAO in terms of the net TAO approach, by modernising old and inefficient plant in developing countries, the Earth Summit objective of technology transfer is also advanced. This possibility provides a simple market solution to the burgeoning problems presented by the concept of incremental cost with which officials of the Global Environment Facility are grappling. If it is official funds that are involved, with Joint Implementation achieved through government to government negotiation and different national conceptions of public accountability, a can of worms is opened by the prospect of trying to measure what is the incremental cost of a project. Consider a project to supply electricity efficiently to rural consumers and reduce the need for kerosine compared with the baseline projection. Without the GEF, would the electrification take place at all? when it is in place to one village, what is the baseline for its extension to the next? Who provides the baseline projection for kerosine demand, and when, and with what strategic motivations?

With an energy firm attempting to discharge a TAO the position is different. It is engaged in a commercial negotiation and in the end will come to a price. If it can discharge the TAO at a lower price elsewhere then it will do so, with a market in 'net TAO discharge opportunities' establishing itself, with intermediation by a network of professional experts (energy technologists, legal interpreters of the `rules of the game', monitors and extension workers, etc) acting commercially rather than within a diplomatic framework. Such a market will not be perfect, but at least it will be workable, with the incremental cost (that is to say the cost of the sustainable project in excess of the commercial value of its output in the location it is placed) reflected in the lowest price that the energy firm can negotiate for discharging its TAO, with the burden carried by its customers in the developed country where the TAO was incurred - appropriately under the `polluter pays' principle.

4.4 The development process, trade and the GATT

The macroeconomic impact of gradual and foreseeable price increases under GREENS, mainly reflecting increased wage payments in low income developing countries, is quite different from the impact of the sudden price increases imposed by OPEC in the 1970's. That yielded large rent increases to owners of oil reserves and led to a flood of investment funds in capital markets facing recession, with outlets in ill-considered commercially financed development projects leading to the `Third World Debt' problem and to the financial market difficulties of the 1980's.

Given the spending propensity of low income wage earners, GREENS yields matching increases in demand and supply and the prospect of multiplier enhanced growth in developing countries, with later prospects of increased demands for exports from developed countries (for which the hard currency requirements would be derived from developing countries' 'invisible exports' of greenhouse gas absorption services, and transmitted from fuel consumers in developed countries through the TAO mechanism). Of course there are well known dangers from uncontrolled plantation developments in traditional societies, possibly subsisting on fragile ecologies, and these need to find a response in terms of the `rules of the game' and the monitoring and field extension services provided by the institutions of the FCCC. The control framework on transnational corporations managing the business - as envisaged in the Chapter 9 mentioned above - arises through writing the 'rules of the game' into the contractual documents of the TAO's in the country of issue, with default information transmitted through the extension and monitoring service of the Conference of Parties to the FCCC, and recourse to contract enforcement processes in the developed countries where the corporations make their sales, and where they have substantial commercial standing at stake.

Apart from these macroeconomic and developmental aspects, biomass fuels increase demand for land based production yielding (a) alternative income to developed country rural communities threatened by over-production of food in relation to demands backed by cash and (b) increased cash demands for food from third world wage earners taken off the reserve army of under- and unemployed rural subsistence farmers. These alternative sources of farm income may be expected to yield beneficial side effects from reduced resistance to the liberalisation of trade in agricultural products, and smoother GATT negotiations after the Uruguay round.

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THE WASTE PROBLEM AND ECONOMIC POLICY INSTRUMENTS[1,2]
-The Deposit- Refund System and Assignment of User Fees for Waste-

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1. Introduction

Reduction of the amount of waste products being generated has now become a social requirement and, here in Japan, experiments with a number of arrangements are being carried out by local governments (which have responsibility for waste disposal) through the implementation of waste reduction plans, as well as by citizens' groups and corporations. Social consensus has yet to emerge, however, on the extent to which waste reduction should be undertaken or what instruments and systems should be used. Thus, because there is no agreement on efficient and equitable waste reduction, local governments often have a difficult time coming up with workable arrangements for waste reduction in spite of the growing recognition of their necessity. Also, because, of a socio-economic system of waste reduction and for recycling is not yet in place, citizens' groups' efforts at cooperative collection frequently run into problems as do recycling schemes managed by private enterprise. The research outlined in this paper then focuses on the problem of the selection of specific economic instruments (within the broader spectrum of policy instruments) for waste reduction and recycling, and aims to clarify issues and options in their application.

In recent years particularly in the industrialized nations, at least in principle economic instruments in environmental policy have been gaining acceptance. The desirability of economic instruments, it has been stressed, lies in their ability to modify the behavior of firms and individuals through the price mechanism. The basic idea behind their use is the efficient correction of market failures but , in order to effectively realize their capabilities, there is a need to place such economic instruments within a systematically considered overall program of waste management.

Much diversity is contained within the simple expression, "economic instrument". Even with the seemingly narrow range of existing or planned countermeasures for packaging waste there is quite a variety, as evidenced by Table 1. In addition, there are many economic instruments not listed which bear indirectly on waste management. Here, however, from among the policy instruments with direct influence on waste management, we will be primarily concerned with the assignment of user fees for waste and the Deposit-Refund System (DRS hereafter).

2. The Deposit-Refund System

DRS incorporates two elements: first, deposits on certain kinds of transactions such as purchases of particular commodities and second subsidies of (refunds for) particular forms of behavior with respect to consequences of the initial transactions[3]. As an environmental policy instrument DRS is being applied to products that could cause environmental damage.

DRS is often understood as a combination of tax and subsidy. That is, by matching the deposit with the social cost entailed by the item, the social cost is internalized, meaning that 1) a strong incentive is created for the consumer to return the product and 2) a strong incentive is created

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1 This parer was prepared for IPCC Working Group III Tsukuba workshop on Policy Instruments and Their Implications, January 1994, Tsukuba, Japan.

2 This research was supported by a "Specially Promoted Research" grant in-aid for a project entitled, "On the Economic Feasibility of Sustainable Development," provided by the Japanese Ministry of Education. All opinions belong solely to the author, without implication of endorsement by any funding agency.

3 Bohm, P, Deposit-Refund Systems, Resources for the Future, 1981

for the producer to consider social cost in choice of product.

In the case of the problem of empty cans DRS would be applied as follows [4]. The "tax" putts the price of the canned beverage to its socially proper price from a market level below that price. Meanwhile, the "subsidy" is paid in exchange for the effort and costs of collection to whomever makes such expenditures. This can be explained by means of Figure 1, where the Y-axis indicates the number of canned beverages and the X-axis denotes price. *OP* is the market price of the beverage and curve *DD* ' is a certain consumer demand curve. Thus in the absence of any policy, the consumer drinks *OE*, abandoning the cans. Curve *PB* represents the marginal cost of can collection (the additional cost associated with collection of another can) for the consumer. This increases with each can collected since the additional cost of transportation, as well as physical and mental exertion tend to rise with number of cans collected.

If a deposit equal to *PT* is added to the price of the beverage, as long as the consumer's collection cost remains below the amount of the deposit, s/he will collect empty cans and turn them in exchange for the return of the deposit. When collection costs exceed the deposit, s/he will choose to forfeit the deposit, as this is cheaper than collection. Consequently, in the portion of the figure where the number of cans is less than point *H* (the intersection of curve *PB* and line *TA*) for this consumer the cost of the beverage is the sum of the market price and the marginal cost of can collection; in the portion above point *H*, it is the sum of the market price and the deposit. This means that the supply curve for canned beverages is the bent curve *PHA*.

Thus the intersection *K* of the demand curve *DD* and the supply curve *PHA* indicates that, given a deposit of *PT*, this consumer will reduce purchases of canned beverages by *EF* (compared with the pre-tax level), and will be left with *OF* cans. Of this number, s/he will collect *OG* and throw away *GH* forfeiting area *HJLK* in undefended deposits as a tax on pollution. The deposit system as a tax, then reduces the number of discarded cans by encouraging the consumer to 1) reduce the number of canned beverages purchased in the first place and 2) collect the empty cans.

In Figure 1, when the amount of the deposit is increased, line *TA* shifts upward, shortening segment *HK* and indicating a reduction in the number of discarded cans. When the deposit is raised such that line *TA* rises above point *R* (the intersection of the demand curve and the marginal cost of can collection), the number of cans discarded given that deposit will be zero; with such a high tax, it would be "cheaper" for the consumer to return all the empty cans.

In this manner, a tax on discarded cans in the form of a deposit system automatically tends to align individual utility maximizing behavior in the part of each consumer with socially rational behavior effectively realizing the goal of the policy.

However, the amount of the deposit should not necessarily be made equal to the marginal external costs. DRS can come about either spontaneously without policy intervention or it can be legally mandated, even though, in the case of spontaneous development, as in the case of DRS for bottles, the costs of replacing bottles that cannot be re-used are offset in a policy-like way by deposit receipts.

But the amount of the deposit in spontaneously-developed DRS for bottles does not represent the marginal external cost of re-used bottles. This particular DRS exists not for social reasons but due to the fact that it is cheaper to re-use bottles than to use new ones. When due to consumer behavior it becomes impossible to re-use a bottle, it is rational to have the consumer pay the cost differential, which is collected as a deposit.

Let us consider this as applied in the form of environmental policy in the case of beverage cans. Here the equivalent of the differential between new and re-used bottles is the cost difference

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4 Shibata, H. and Shibata, A, *Public Economics* Toyo Keizai Shimposha, 1988, pp132-136 (in Japanese).

between cans made of new material and recycled cans. However, the difference between the former and the latter is the same as for bottles, we would expect to have seen spontaneous development of a deposit system without intervention. Thus using the same logic as for bottles it is not rational to apply the deposit system. The reason to apply this system to cans is because of the external costs accompanying their use [5].

That is, if
(cost of cans from new material - cost of recycled cans) < 0, and
(external costs - cost of cans from new material -cost of recycled cans) > 0, then
it is rational to introduce a DRS with a deposit equal to the latter.

In order to establish conditions for the practical success of such a system, let us consider the problem from the standpoint of cost-benefit analysis. The net social benefit of DRS can be expressed by the following formula[6].

$$NB(DRS) = B_{WS} + B_{LS} + B_{PS} - C_R - C_C \qquad (1)$$

in which,

B_{WS}: the social benefit that can be obtained from reductions in the costs of collection and/or disposal of waste

B_{LS}: the social benefit that can be obtained from reductions in the amount of litter
BLS = bpc + bag
bpc: the amount saved in litter pick-up costs
bag: amenity derived from decreased littering

B_{PS}: reductions in necessary beverage container industry inputs

C_R: social costs resulting from increased inputs necessary for container storage and transport

C_C: social costs resuiting from extra time spent by copsumers returning empty containers

DRS introduction will definitely reduce the costs associated with litter and disposal but because running the system will entail large costs as well expected net social benefit will differ case by case[7]. As has been confirmed by much actual DRS experience, the rate of return does not change very much in relation to the size of the deposit. More important determinants of the rate of return are the number of return/collection points, ease of return/collection and consumer knowledge concerning these. Governments can, through regulation, determine the number and type of return/collection points and consequently the rate of return and recycling. Of course, the higher the number of such locations the higher will be the total costs of the system.

In actual cases, when DRS collection rates have been low these have been increased by raising the deposit and establishing a specific return rate target. The fact that such a rate can be established and accepted by society indicates that it provides a corresponding benefit. In other words, as in Formula (1), B_{LS} is large. Specifically, when the costs of litter are very high or it includes very undesirable properties the concentration effect of proper disposal is also high. And, regardless of marginal costs in cases where conservation of resources is necessary, there is a basis for the establishment of a specific goal for the rate of return.

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5 Oka, T. "Lessons from Experience with Economic Instruments for Environmental Protection in OECD Countries", Waste Management Research, Vol.4, No.3, 1993, pp.192-198 (in Japanese).

6 Pearce D.W. and Turner R.K. "Market-based Approaches to Solid Waste Management," Resources, Conservation, and Recycling. Vol.8, No.2, 1993, pp.63-90.

7 Department of Trade and Industry, Department of the Environment, Deposit/Refund Systems for Beverage Containers and Batteries, 1991, London, HMSO

3. Assignment of User Fees for Waste, and the Role of Public Policy[8]

Local waste collection services contribute to the quality living conditions and public sanitation, thus acquiring external effects that are strongly public and conversely not very market-oriented. However, with the exclusionary social norms which specify that only certain people are permitted to discard waste in specific locations or when there is a requirement that only special trash bags be used the establishment of the exclusionary principle in waste collection services is possible. Alternatively, under given waste collection conditions where, if one person puts out too much waste, another person's waste may be left uncollected, there will be a kind of rivalry leading to a certain measure of market character.

As reduction of the amount of general waste has become a social issue, debate concerning the assignment of user fees for waste has become more vigorous. Because general waste generated by companies is considered industrial waste, local governments are at least entitled to collect the costs of disposal. As for household waste, following the May 1993 declaration of support for waste disposal user fees by the National Mayor's Conference, the number of municipalities and citizens' groups advocating such fees has been on the increase.

It is quite natural with the establishment of a certain level of market characteristics in the collection of waste, to consider pricing as an instrument in its reduction. User fee theory as applied to waste collection services holds that price will be an effective disincentive and will reduce the amount of waste generated. At the same time user fee theory makes no distinction between the person who makes efforts to reduce waste and the person who lives a waste generating lifestyle and contains implicit criticism of the current system that provides waste disposal as a public service.

In other words, waste collection/disposal user fee theory is essentially a problem of suppressing activities and products that increase waste, supporting the construction of arrangements which encourage waste reduction and/or recycling-type activities and products while simultaneously focusing on the type of waste disposal service provided and on its payment.

These are problems fully deserving of attention. But, are the disincentive effects expected by fee theory apparent? Of course, in cases where special trash bags have been required (not a direct charge for disposal, but nevertheless a system linking cost to the amount of waste), effective decreases in the amount of waste is observable as in the experience of Date City in Hokkaido. Date's waste collection was mixed through 1988, but in July of 1989 the municipality introduced a system of specialized separate collection for burnable, non-burnable, and bulk waste. Average waste generated per person per day fell from its 1988 level of 778g to 565g in 1989, 501g in 1990, recording a slight rise to 510g in 1991.

There is a tendency to interpret these figures simply to mean that user tees result in waste reductions. While such a relationship is very important the process involved in the reduction is also of great significance. Assuming that introduction of user fees was responsible for the decline in waste levels we might well ask what kind(s) of waste decreased and how citizens achieved these reductions. Knowing the answers to these questions would not merely illuminate the mechanism involved, but would also enable such waste reduction know-how to be transmitted around the country.

Unfortunately, investigative work on these topics is not yet sufficient but research in Date indicates that household incinerators and composers have largely reduced collection and disposal of burnable waste. This research also shows that, in the absence of alternative methods of disposal user fees seem to have little effect on waste reduction.

There are a number of interesting points here. With user fees in Date, the citizens had a ready

8 Ueta. K. "Haikibutsu no genryoka/recycle to shakai-keizai shisutemu" | "Waste Reduction/Recycling and the Socio-Economic System" | *Urban. Policy.* No.74, 1994, pp.111-120 (in Japanese).

alternative in the form of home disposal. 70% of Date's citizens live in detached houses, and opportunities for such disposal is much greater than in an urban area. As it turns out 50% of the citizenship undertakes home disposal.

The proportionate figure in a highly urbanized location could be expected to be significantly lower. Widespread use of home incinerators would cause other environmental problems and would thus be intolerable. There is the possibility that user fees in the absence of viable alternatives would merely invite illegal dumping. It is a mistake, then, to blithely assume that user fees will yield progress in waste reduction. However, a socio-economic system that will reduce waste and address the problems raised by user fee theory must be constructed. Assuming that user fees are to be introduced in congested urban areas in order to reduce waste methods of actually bringing about the reductions must be prepared. Concerning the most voluminous type of household waste, containers and packaging, for example, businesses could be required to take back such materials or convenient collection depots could be established. Additionally, unless businesses are required to meet recycling targets or reach goals for the use of recycled materials and otherwise encouraged to re-use and recycle real reductions in waste may not be guaranteed. If waste reduction and recycling are to be helped along the physical and administrative infrastructure must be set up. The role of public policy is not merely to set up such infrastructure but to push forward the design of the necessary socio-economic system(s).

4. Conclusion

Of the items that deserve consideration in the introduction of economic instruments as policy measures in the reduction of waste, the first is the formation of a social consensus on the necessity and effects of waste reduction as a policy goal. Next there is a need for full discussion, based on citizen participation, of efficient, equitable and fair policy instruments, or a workable mix thereof. To facilitate the choice of such policy goals and instruments, we must, through social consultation among citizens, businesses and government, come up with an overarching for a socio-economic system that will allow waste reduction and recycling[9].

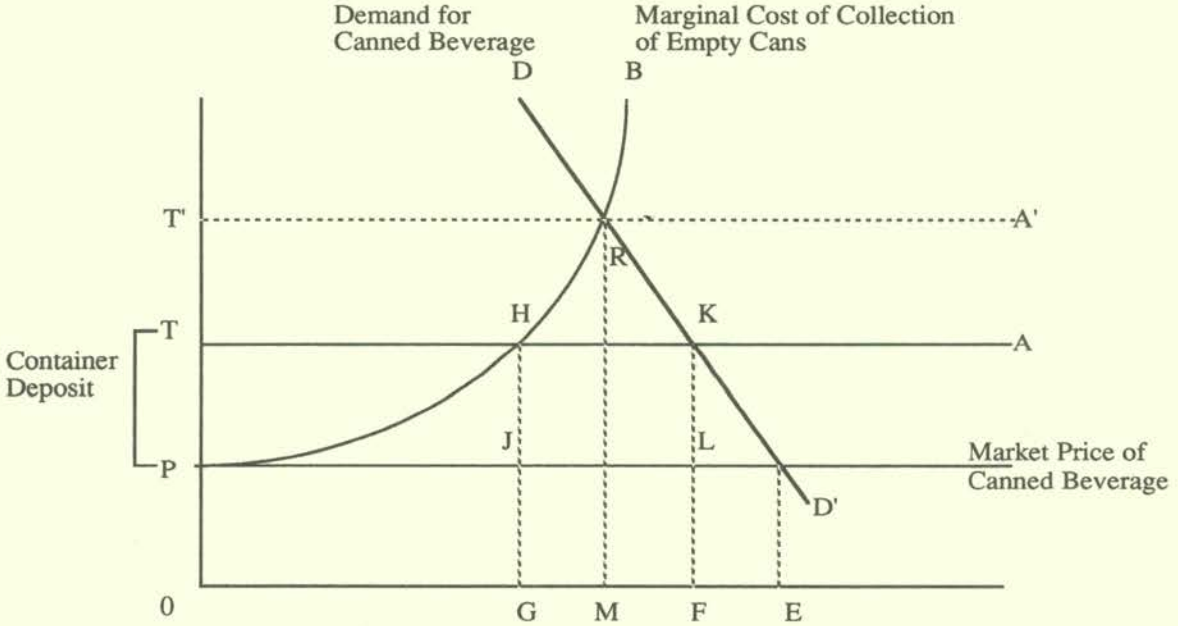

Figure 1 Representative Consumer Behavior with Regard to Empty Cans, Given a Deposit-Refund System
source: Shibata, H. et al, Public Economics, p.134

9 Ueta, K, Economics of Recycling for Solid Waste Management, Yuhikaku, 1992. (in Japanese)

Table 1 Examples of the Use of Economic Instruments in the Management of Packaging Waste[1]

Country[2]	Type of economic instrument[3]	Application: in use (u): under study / proposed (p)
Austria	deposit-refund	refillable plastic beverage containers (p)
Belgium	waste charges (incentive)	MSW (u)
Canada	deposit-refund	beer and soft drinks containers
	waste charge	non-refillable containers
Denmark	deposit-refund	refillable beer and soft drinks containers
	product charge	beverage containers, pesticides in small containers (u)
	waste charge (incentive)	various packaging products
Finland	product charge	non-returnable beverage (carbonated)container(u)
	deposit-refund	refillable beverage (carbonated) containers (u)
France	waste charge (incentive)	MSW (p)
Germany	deposit-refund	plastic beverage containers (u) extension to other packaging (p)[4]
Italy	product charge	non-biodegradable plastic bags (u)
Japan	deposit-refund	refillable beer containers waste charge MSW
Netherlands	waste charge (incentive)	MSW (p)
	product charge	non-recyclable packaging (p);
	deposit-refund	products with short life PVCs (p) products containing aluminum and long life-cycle PVC (p)
Norway	product charge	disposable carbonated drinks containers (u)
	deposit-refund	refillable beverage containers (u)
Portugal	deposit-refund	metal cans (p)
Sweden	product charge	beverage containers (u)
	deposit-refund	aluminum cans (u)
	waste charge (incentive)	not specified (p)
Switzerland	product charge	disposable beverage containers (p)
United Kingdom	recycling credits	MSW (u)
USA	deposit-refund	beverage containers (u)
	marketable permits	newsprint (p)

1 Source: Correction from Peace and Turner, 1993

2 Some instruments apply at state, province or regional level only.

3 User charges for collection and treatment of MSW are applied in almost all industrialized countries: taxes on the use of virgin materials have been implemented in Denmark and have been proposed in the context of sand and gravel resources in Finland.

4 A "Dual System" has been introduced (1991), it involves mandatory take-back requirements throughout the supply chain which can only be replaced by industry established separate waste collection and recovery systems (outside of normal municipal system). The Dual System would be financed by a "Green Spot" approval systems, where verification and approval of a package's recyclability will have to be obtained. A payment (user charge) and partly recycling per package is imposed, depending on weight and material to cover the costs of collection, crude separation.

Discussant's Comments

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I have two things I would like to say in relation to the papers presented in this session. The first is a comment and a question about joint implementation of CO_2 abatement projects, and the second is a question concerns the deposit-refund system. My speciality is policy studies, so my questions come from the viewpoint of policy development and implementation.

My first comment has already been suggested indirectly by Prof. Bohm, Dr. Jones, Prof. Tietemberg, and in some of yesterday's discussions, but it is a point that I want to emphasise.

In fact, I was somewhat frustrated by yesterday's discussion of tradable permits, because we haven't yet successfully clarified the initial policy scenario to implement an actual international tradable permit system. I think that the joint implementation system, which is now being discussed, is the most important chance, and may be the only chance, to implement an international tradable permit system. So in order to explain my thoughts on this matter, I would like to use a very rough chart of the relationships between tradable permits, joint implementation systems and other similar concepts, if we want to have a comprehensive tradable permit system.

The chart shows a hierarchy of tradable permits at the international level. I consider that joint implementation has a good chance of being changed into multilateral joint implementation, that is a 'clearing house' approach, and then further developed into international tradable permits or a tradable absorption obligation system. Then they could be finally developed into the most desirable format for a comprehensive system for international tradable permits. Such opinions have already been expressed by Prof Tietemberg, and most researchers think that there is a relationship between joint implementation and tradable permits.

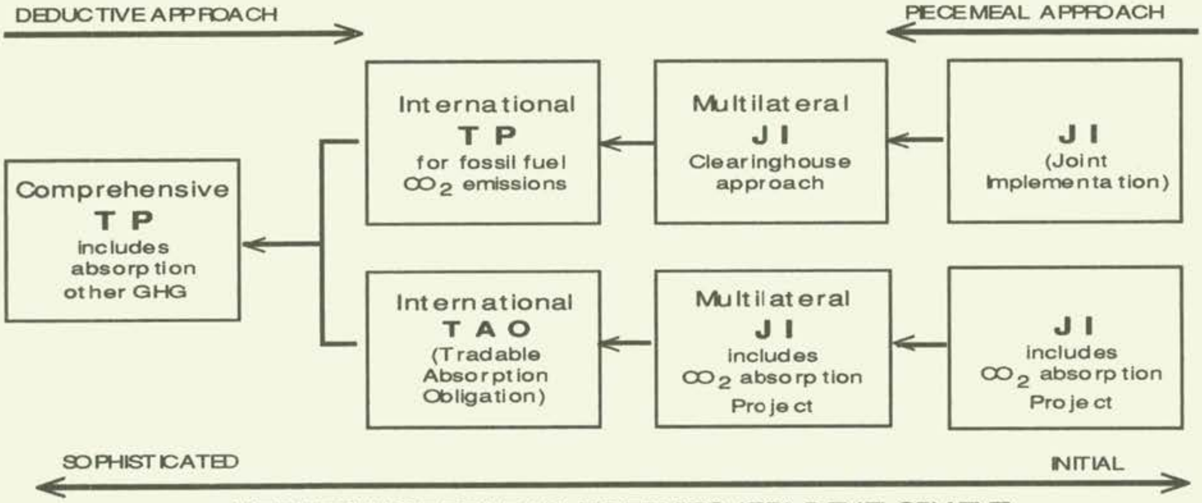
But the problem as I see it, is that most of the discussion on joint implementation has taken a piecemeal approach, by which I mean how to use the most practical and feasible approach at that time. On the other hand, the tradable permits discussion has tended to focus on the deductive approach, which begins from the most desirable and simple theoretical final system, and then works backwards to determine how to reach this position in the "real world". However, for me, these two approaches have not yet been linked or integrated. I consider that the research into tradable permits should take account of joint implementation system from the beginning, while joint implementation systems should be designed to increase the opportunity for development of a desirable tradable permit system.

If such a strategy is adopted for joint implementation design, the result will be different to that without such a guiding strategy. For example, following this strategy, a joint implementation system must be first designed and implemented as a system for use in developed countries, because developed countries will have a CO_2 emission limit as an objective and the total limit within a developed country will be determined, and the concept of an international credit system for CO_2 will already be accepted. So it will be much easier to be developed into a comprehensive global tradable permit system. On the other hand, joint implementation between a developing and a developed country will perhaps have a greater cost effectiveness than implementation between two developed countries. But in such a case, a developing country potential to emit CO_2 is unlimited, 80 the concept of a CO_2 credit system is irrelevant to it.

Thus, if the development of an international tradable permits system for CO_2, and perhaps other GHGs, is accepted as a final objective, then we need to determine what criteria to apply when designing the initial joint implementation system 80 that countries will be able to easily modify policies etc to enable them to advance towards this goal.

The question that I would like to pose here then is "What should be the structure of the basic Joint Implementation system and the intermediate stages that will allow the international community to achieve this objective of comprehensive tradeable permits system ?" I'm afraid I can't provide an answer to this problem, but I am very interested to hear your comments and ideas, as I think this is fundamental to the problem we are all trying to address at this meeting.

I also have a question for Prof. Ueta. I understand the importance of recycling waste products for reducing CO_2 emissions in Japan. But for foreign researchers, the Japanese situation may be a little difficult to understand. So, I would like to ask you why Japan has come to put so much emphasis on recycling in its global warming abatement policies at this time.



HIERARCHY OF TRADABLE PERMITS (TP) DEVELOPMENT AT INTERNATIONAL LEVEL

Discussant's Comments

Ted Hanisch
Co-Vice-Chair IPCC / WG III

All the papers in this session circles around how one can achieve some cost-effectiveness across borders, given the global character of the problem of climate change. We know that marginal abatement costs vary among parties to the IPCC. The costs have been calculated to vary as much as by a factor of 5 or even 10 in some cases.

It may be obvious to economists and other experts gathered here that cost effectiveness is important. It was not so when the Intergovernmental Negotiating Committee started to negotiate the climate convention in Washington back in 1990.

It took some efforts to create a general understanding of the economic complexity of abating climate change. A number of delegates thought it was not much more than solving the ozone problem.

Also, when promoting the mechanism for joint implementation (JI), the government of Norway was eager to create a mechanism for creating new and additional funds that would produce a clear interest for developing countries to participate actively in the global effort. Joint implementation in this effect creates a win-win game, where industrial countries get credit and developing countries get investments of modernization, often with additional environmental and economic benefits.

The money provided for joint implementation is not ODA, i.e. confessional aid, but investment in the interest of industrial countries. It will therefore be additional to ODA, thoroughly needed, since little growth in ODA is expected to come along with the Climate Convention.

Let me now mention briefly what is the difference between joint implementation and tradeable emission rights as discussed yesterday.

The Convention only recognizes governments as nations. Governments do not trade with each other they negotiate. Joint implementation is a negotiated system producing some of the same benefits as a system of tradeable permits. It allows one industrial country to meet some of its obligation by action taken jointly with another party, whether industrial country, or not. Tradable permits is not recognized by the convention.

I note that Bohm and Jones discuss whether J.I. was meant to cover cooperation between industrial and developing countries. I think that was and is reflecting clear. As a matter of fact some DC's insisted that the mechanism should be restricted to this, but that was not agreed, mostly because some european countries, notably Germany were looking for cooperation with eastern and central european countries.

To Professor Bohm, who once again has produced a very valuable paper, I have one question. He is specifically concerned with the leakage problem. I can see the problem theoretically, but the convention can generally only function if governments seriously intend to do something about climate change. Why should one think that they would like to spend money on projects through JI that are not contributing?

A clearing house could contribute to the quality of JI. We already have the clearing house as the Global Environment Facility (GEF) is the financial mechanism of the FCCC. Two pilot projects co-funded by Norway is now being implemented by GEF in Poland and Mexico. Later one can foresee that the GEF develop a portfolio of projects into which governments can try a share, may be funded by their own industries. This would reduce transaction costs for investors, and also reduce risk, as it is generalized. Bilateral arrangements will require more proof by investors may be closer review by other parties. Here we can look at GATT for practical ways of mutual control and conflict resolution.

I was not altogether surprised when I found that I could support almost all of the paper by Tom Jones. He seems to cover almost all the dimension in the current debate of JI. Maybe he is sometimes to kind worrying about all possible problems as he tries to integrate all viewpoints.

In relation to the possibility that JI could inhibit technical change, I was somewhat taken aback by the question he raises, ever though it is hard to argue against it on practical terms.

The question is : do I hear Tom Jones of the OECD contemplating or considering whether one should avoid seeking cost effectiveness across borders in the short term of abating climate change, based on a fear that it would inhibit technical change?

Peter Read's paper contains a number of arguments with which I have difficulties or problems.

As far as I can understand, he proposes an obligation for all wholesale petroleum or carbon fuel dealers to sequester or recycle carbon up to a given proportion of its total sale. As far as I can see this will work as a tax on fossil fuel most, only that it is earmarked for sequestration, and the contracts for sequestrations can be traded. I have one question;

- How come that an earmarked tax is more cost-effective than another system like JI, where sequestration is one of various options to choose on a cost-benefit basis?

I have taken the liberty of being rather outspoken at this meeting, because it is likely to be my last in the work of IPCC/INC. I would like to say that we have come at since 1988, only 5 years. But also I am somewhat worried about further progress. If industrial countries had intended to take really firm action in the near future, then we would have seen more intense interest in how this could be achieved most effectively. Less time and effort would have been spent on what weaknesses in the mechanism of joint implementation possibly show up 10 or 20 years from now, as compared to a perfect solution.

Rapporteur's Summary

Lee Solsbery
International Energy Agency
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Following the presentations by the speakers, the following key points were brought out in the discussion :

Joint implementation may be the best, if not the only, chance to transition measure; however, most discussion so far of joint implementation and tradable permit has not fully explored this look.

One limitation is that the FCCC only recognizes governments. Not private firms, and governments do not "trade", they negotiate.

The key issue is cost-effectiveness across borders; marginal abatement costs can vary among countries by a factor of 5 to 10; therefore the problem of burden-sharing is real.

A clearinghouse could contribute to this, and there already is one of a sort--the GEF--which could even sell shares in projects and spread risk among participants.

If FCCC signatories are not talking about cost-effective responses and joint implementation, then one must wonder how serious they are about taking meaningful action in the near-term.

In discussing and responding to the problem of "leakage", we should not seek perfection. Rather, we should be realistic about the real-world potentials for response measures and consider their net benefits.

To allow joint implementation to gain support and begin to function in a manner which establishes an effective track record, we should not over-complicate the proposal or place too much emphasis on theoretical, aspects. Setting too high a standard at the beginning could be counter-productive.

Nevertheless, there are basic issues which must be resolved at the beginning for a joint implementation program to function, e.g., how to avoid parties to a joint implementation project over-stating the credits through collusion, especially when they have a monopoly on project information.

Concerns regarding the above points included:

- taxes are still more efficient so shouldn't we be promoting them more than joint implementation?
- isn't there a possibility that increased donations to GEF and emphasis on GEF as a clearinghouse could reduce or distort existing aid flows to developing countries ?
- evolution of j.i. into tradable permits is still problematic and linkage is not yet clear.
- Prof. Read clarified the basic point of his paper, namely, that his objective is to minimize the economic cost of a carbon tax by dedicating the revenues to absorption and thereby reducing the amount of tax needed to achieve goal.

5. Regulatory Instruments & Administrative Guidance

THE ROLE OF REGULATION IN DUTCH CLIMATE CHANGE POLICY

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1. Introduction

This paper discusses the role of regulation in Dutch climate change policy as it affects energy conservation efforts. Policy measures in the areas of transport and waste are not addressed. The paper goes into some detail about the relationship between energy taxes, voluntary agreements, environmental permits and general administrative orders in the Dutch situation. While the paper focuses primarily on regulation as an instrument of energy conservation policy, an attempt is made to put it into the broader context of a multi-instrument, cohesive, and mutually reinforcing policy mix. The role of the energy distribution sector is also discussed briefly. The paper concludes that regulation is a very useful tool in the context of energy conservation policy, reinforcing and complementing both voluntary agreements and taxes.

2. Development of Climate Change Policy in the Netherlands

The roots of Dutch climate change policies can be found in the first National Environmental Policy Plan (NMP), issued in 1989. The Government set a target of stabilizing CO_2 emissions in the Netherlands at their 1989/1990 level in the year 2000. Shortly thereafter, during the formation of a new national government, a political commitment was made to an even farther reaching CO_2 target. This new target - which was set down in the National Environmental Policy Plan Plus (NMP-plus) and sent to Parliament in 1990 - is to reduce CO_2 emissions by 3 to 5% in 2000 relative to 1989/1990.

In 1990, when the new target was adopted, it appeared likely that the target could be achieved with the traditional instruments of energy conservation policy (along with contributions from the transport and waste sectors as well as some fuel switching). The measures to be taken were set out in the first Memorandum on Energy Conservation (NEB) in 1990. Projections of energy price development made at that time assumed a continuing rise in world oil prices throughout the 1990's, growing by 65% in real guilders between 1990 and 2000. Prices at this level would have boosted the effectiveness of such traditional policy instruments as subsidies, standards for insulation and appliance energy consumption, research and development and public education and awareness building. Given this expectation about rising prices, the Government was reasonably confident that the package of measures announced in the NMP-plus and the NEB would be sufficient to reach the goal of reducing CO_2 emissions by 3 to 5%. However, just to be on the safe side, the Government also began to prepare for the eventuality that the then-existing package of measures might prove to be inadequate for attaining the -3/-5 target, or that more far reaching targets might be agreed to in international fora. These preparations took the form of research into the possibilities of deploying regulatory instruments geared to decreasing CO_2 emissions (such as making use of the environmental permitting system or issuing general administrative orders) and the possibilities of imposing regulatory charges on energy use.

During the four years that have passed since the NMP-plus was issued, our perception of energy price development has changed radically. Where in 1989 our forecasts assumed that real world oil prices would rise substantially during the 1990's, we now find ourselves with world oil prices at their lowest level since the early 1970's. The most recent official projections made for policy-development purposes in the Netherlands assume that real energy prices will remain more or less constant between 1990 and 2000 and that economic growth will be modest. Under these conditions, application of existing policy instruments will have to be intensified and additional policy instruments will have to be deployed in order to attain even the 3% emission reduction target for CO_2.

In December 1993, the Government issued the second National Environmental Policy Plan (NMP 2) and the second Memorandum on Energy Conservation (VNEB), indicating among other things how policy efforts in the area of climate change will be enhanced. Targets for energy efficiency improvements were set for different sectors, including households (23%), non-residential buildings (23%) industry (19%), agriculture (26%), transport (10%) and power stations (26%). The overall efficiency improvement (including renewables) will lead to energy consumption of 2865 PJ in 2000 (550 PJ less than what it would have been without the policy measures; slightly more than what it was in 1990). Energy efficiency (including renewables) will be responsible for roughly two thirds of the CO_2 reduction needed, with the remainder coming from transport, recycling, reduced coal use, afforestation and structural changes. This paper addresses only the energy efficiency measures.

3. Regulation as Part of a Package of Policy Instruments

The instruments to be intensified as a result of NMP 2 and VNEB include voluntary agreements with (industrial and non-industrial) energy users and the energy distribution companies. The new instruments are regulatory charges, requirements attached to environmental permits and regulation by means of general administrative orders.

Not only will application of the aforementioned instruments be intensified, but the more traditional instruments of energy conservation policy will also continue to be used. These traditional approaches include such things as subsidies, efficiency standards for appliances, insulation standards for houses and other buildings, accelerated depreciation of investments in innovative energy conservation technologies and so forth. Public information and awareness building will also continue to be very important elements in the package of policy instruments. It is crucial for the success of our policy efforts - including regulations - that there be a constituency for far reaching measures. The public at large as well as the specific target groups of policy must be convinced that the climate change issue is not just a "storm in a teacup" but a real risk deserving serious attention. The policy world needs support from the scientific world in estimating the probabilities that certain effects will occur. Industry in particular is accustomed to developing strategies and taking decisions on the basis of information about probabilities and risk. The presentation of the climate change problem in terms of "uncertainty" as such does not provide a sufficient basis for a risk assessment in a company. Without more information about probabilities they will be very reluctant to go beyond the "No Regret" measures to which they have already committed themselves.

The elaboration of the instruments mentioned above - regulatory charges, voluntary agreements, permits and general administrative orders - will follow the same two general precepts which underly existing energy conservation policies in the Netherlands. First, policy instruments must be tailor made for the situations in which they are applied. Differences in the nature and size of the target groups being addressed have to be taken into account and instruments must be fine tuned for situation-specific circumstances. And second, the package of policy instruments should be a cohesive whole, containing individual elements which reinforce and complement one another in such a way that the effect of the whole is more than the sum of the parts.

Section 4 of this paper deals with the relationship between taxes and regulation followed by a discussion of the relationship between voluntary agreements and regulation in section 5. Because the energy distribution sector can provide effective support to government policies aimed at inducing or encouraging energy conservation, it is also worth considering their role in a cohesive policy package in somewhat greater detail. Therefore Section 6 of this paper describes briefly the efforts being made by the distribution sector in the Netherlands.

4. Carbon/Energy Taxes Versus Direct Regulation

The question of the role of economic instruments in environmental policy is fuel for a debate which has been going on for many years and which shows no sign of cooling down any time soon. It is an especially "hot topic" in the context of climate change policy, where there are many persuasive advocates of carbon/energy taxes as the single most important instrument available to policy-makers. The strengths of taxes as an instrument of energy conservation policy have been dealt with exhaustively in the literature. As an instrument which makes use of market forces taxes can be expected to generate least cost solutions. They also make it possible to reach and influence the behavior of millions of energy producers and consumers with a relatively small effort on the part of the government.

The hitch, of course, is that in order to avoid/prevent unacceptably high costs in terms of economic adjustment carbon/energy taxes must either be introduced worldwide, or they must be accompanied by measures in the area of trade policy, or there must be some sort of special treatment for exposed, energy-intensive sectors of industry. Taxing the total energy use of energy-intensive companies in the absence of trade policy measures puts a burden on them that is disproportional to the incentive effects generated by the tax. Energy use is inherent to their operations and accounts for a large share of production costs. If a tax is levied on this unavoidable use of energy, and if this tax cannot be passed on in prices, it will erode profit margins without generating any additional environmental benefit. Over the longer term these companies will either cease operations or they will relocate to areas where they are not subject to tax - neither of which is a politically acceptable possibility. Taxation, then, is clearly *not* the preferred policy instrument (at least not in the current political situation) for inducing energy conservation in large, energy-intensive companies. Voluntary agreements, regulations in the form of permits, or some other form of administrative guidance all offer alternatives to taxation. In the Netherlands, the numbers involved are small enough that a case-by-case approach is possible. (About 65 of the hundreds of thousands of companies account for 20% of total non-feedstock, non-transport energy use in the Netherlands.)

Regulation in the form of individual permits is not a viable option for households, small businesses and other non-residential buildings, however. The numbers involved (more than 7 million in the Netherlands) make not only the granting of permit applications but also enforcement of individual regulations impractical. For these target groups taxation offers more potential. Taxation of smaller scale energy consumers also has the advantage that it increases demand for the energy conservation expertise present in the energy distribution sector, providing this sector with greater opportunities to furnish energy conservation services and thereby contribute to lessening the impact of the tax on energy consumers.

In the second National Environmental Policy Plan (NMP2) the Government announced that it will be undertaking preparations for the introduction of an (additional) tax on small scale energy use in the Netherlands. While EU-wide energy taxation continues to be greatly preferred, progress in this area is extremely slow. It is not certain when, if ever, the EU Member States will decide to introduce the carbon/energy tax proposed by the Commission in 1992. Therefore the Dutch Government is undertaking the (technical) preparations needed to make unilateral introduction of a tax on small scale energy use possible in the Netherlands in the course of 1995, should the EU fail to reach a decision during 1994. The actual decision as to whether to go ahead with the tax will be left to the new Government which will be formed following the general elections in May 1994. Such a tax, if introduced, would augment, not replace, the regulatory and administrative policy instruments which are described in greater detail in the following sections.

5. Voluntary Agreements Versus Direct Regulation

As noted earlier in this paper, a relatively small number of energy-intensive companies account for a large share of total primary energy consumption in the Netherlands. Their contribution to reducing CO_2 emissions is taking the form of improvements in energy efficiency. Precisely how these improvements will be realized has been set out in a series of voluntary agreements with the sectors concerned. The Dutch Minister of Economic Affairs has currently signed agreements with 16 branches of industry and is engaged in discussions with 11 others. Agreements have also been signed with the greenhouse horticulture sector and with the social rental sector and discussions are ongoing with the health, education, commercial services, retail and agricultural sectors. The intention is to cover about 80-90% of industrial energy use with the instrument of voluntary agreements.

Important provisions of the agreements include first of all the target for energy efficiency improvements, which is fixed on the basis of an in-depth study of potential. An intermediate target for the year 1995 is included along with the target for the year 2000 (generally a 20% improvement in energy efficiency for the sector as a whole). The measures to be taken by both the industry involved and the Ministry are also set down in the agreement as are provisions relating to monitoring and reporting of activities. These provisions are absolutely esssential. They make it possible to monitor progress and where necessary adjust activities to ensure that the targets are being met. This adjustment process is facilitated by elements in the agreement which provide for regular consultations between the parties involved. There are also provisions relating to how the agreement may be altered or terminated.

Individual companies within a sector participate in the agreement by signing an "entry letter". Entry into the agreement commits the company to drawing up a corporate energy plan elaborating possibilities for conservation. The number of companies participating in the agreement differs by sector. What is important is that the target be reached by the *sector as a whole*, so one individual company may be able to do less than the average company or vice versa. This is one of the greatest strengths of agreements as an instrument of policy: the possibility they offer for a flexible approach adjusted to the needs of the individual industrial sectors.

As noted above, part of the follow-up to NMP-plus included research into the possibilities offered by environmental permits and general administrative orders as regulatory instruments for encouraging energy conservation. This research became even more relevant with the entry into force in March 1993 of provisions in the Environmental Protection Act (EnvPro) empowering the permitting authorities (municipalities and provinces) to attach requirements relating to energy use to environmental permits and empowering central government to set rules for categories of establishments in general administrative orders.

The new provisions of the EnvPro Act mean that the competent authorities must evaluate whether it is necessary in the interest of environmental protection to set rules relating to energy conservation. They are not obligated to set such rules; they are empowered to do so where deemed necessary to protect the environment. An important principle to be applied when it is decided that rules should be set, is the so-called ALARA principle - As Low As Reasonably Achievable. The rules to be set should ensure that any residual damage to the environment is as low as reasonably achievable. The rules must also be formulated in such a way that they allow as much flexibility as possible. For this reason the EnvPro Act emphasizes the use of performance standards, rather than technology standards.

The Act distinguishes two types of regulations: permits and general administrative orders. Permits are granted to individual establishments by municipalities or provinces and are the instrument of choice when the characteristics of the establishment in question are so individual that the regulations must be more or less custom made.

Central government may issue general administrative orders covering large homogeneous groups of establishments. Standard requirements are drawn up for these groups. Local authorities must see to it that the requirements are met, but may not set any additional requirements. The general administrative order takes the place of the environmental permit for the establishments falling under it. There are 26 general administrative orders, covering most commercial establishments.

Given the benefits and effectiveness of voluntary agreements, the question that inevitably rises is: why include requirements relating to energy conservation in a permit or general administrative order? Why regulate if it is possible to address problems on a voluntary basis? Isn't this a case of overkill? An implicit answer to this question can be found in the NMP 2 and the VNEB, in which the Government noted that regulation and voluntary agreements are two instruments which can be used to *supplement and reinforce* one another and still retain flexibility.

The fact that permits and general administrative orders are available to governmental authorities as an instrument of policy makes it impossible for companies to "free ride" on the voluntary agreements. "Free riders" (firms that refuse to participate in an agreement or which do not participate in good faith) would enjoy a competitive advantage relative to companies who participate whole heartedly and live up to their commitments. The existence of the regulatory instrument ensures that all companies are dealt with on equal terms and prevents companies from refusing to participate in agreements out of fear that their competitors will refuse to participate. In cases where the execution of a voluntary agreement benefits from having as many participants as possible from a given sector, the existence of the regulatory instrument stimulates companies to participate in good faith, thereby increasing the effectiveness of the agreement.

On the other hand, permits and general administrative orders cannot be used to regulate every topic that can be addressed in voluntary agreements. The agreements can go beyond purely technical measures and also detail good housekeeping measures and energy management as means of achieving the target. Both of these things require behavioral changes which could theoretically be specified as permit requirements, but which would be difficult to enforce. Enforceability is an extremely important criterion for credible rules. It is for precisely this reason that general administrative orders are limited to purely technical, relatively self-evident measures. Compared to such regulations, a voluntary agreement executed in good faith will generate a better result. The bottom line is that companies which enter and fully execute a voluntary agreement will often do more in terms of conserving energy than they could have been required to do had they been subjected to regulations.

In order to realize in practice the intended synergy between regulations and agreements it is necessary to elaborate the relationship between the two in a certain way. The studies carried out following publication of the NMP-plus - the so-called PEM project - were set up to this end. The PEM project was launched in mid-1991 under the direction of a steering committee comprised of the ministries most directly concerned (Environment and Economic Affairs), the permitting authorities and representatives of private industry. The project examined different types of regulations. The most useful option identified was based on the possibility of mandating the company to draw up an energy conservation plan. The plan is then evaluated against a given criterion. For example, if the company in question participates in an agreement, then the plan is checked to be sure that the contribution to the overall sector target is reasonable and that the plan is based on the criteria agreed to. The pay back period of the investments contained in the plan is one of the more important of these criteria. If the company is question does *not* participate in an agreement, then the energy conservation plan is evaluated against the ALARA principle. The permit may subsequently require that the energy conservation plan or parts of it, drawn up by the company itself, be executed. The results of the PEM project as regards permitting, on the one hand, and general administrative orders on the other are described in the following paragraphs.

•Permits

Based on experience with four experimental permits drafted during the PEM project, the Ministries of Environment and Economic Affairs are currently putting the last finishing touches on a circular letter addressed to the permitting authorities advising them how to deal with energy aspects in permits for establishments that *do* participate in voluntary agreements as well as for establishments that *do not*. The essential difference between the two sorts of permits is that permits for participating establishments will impose fewer requirements than those for non-participating establishments and that participating establishments will be able to prepare an acceptable permit application with a lot less work than non-participating establishments. The competent authorities will also be less rigorous in evaluating permit applications from participating establishments. This distinction will also be made in applying the ALARA principle. The energy conservation agreement will be the major factor in permitting participating establishments, while non-participants will be subject to a thorough individual ALARA assessment.

We are already beginning to see the first effects of this proposed difference in the permitting approach. The refinery sector, which in the past showed no interest in participating in a voluntary agreement regarding energy conservation, has made moves in that direction. The reason for this change in attitude is presumably that the sector hopes to avoid lengthy individual negotiations with the permitting authorities by taking the initiative now to draft an agreement.

•*General administrative orders*

Studies carried out in the context of the PEM project also looked at the technical possibilites for including energy conservation in two existing general administrative orders, namely those covering the horeca sector and retail outlets. The studies concluded that such possibilities do indeed exist.

During the coming years central government will continue to examine the desirability and possibility of including energy conservation in existing and new general administrative orders. Possibilities offered by pieces of legislation other than the Environmental Protection Act, such as the Appliance Energy Conservation Act and the Housing Act, will also be assessed. These initiatives should be seen as part of on-going efforts to optimize the multi-instrument energy conservation policy mix.

6. Role of the Energy Distribution Sector

The energy distribution sector consists of the companies which distribute gas and electricity to industrial, commercial, governmental and residential customers. This sector has a statutory responsibility to promte efficient energy consumption in the Netherlands. It has accepted the challenge of contributing to a cleaner environment, notably with regard to reductions in emissions of greenhouse gases and acidifying gases. In order to meet this challenge, the sector has drawn up a collective plan of action, the Environmental Action Plan, which focuses on energy conservation and alternative methods of power generation. The sector expects to be able to reduce CO_2 emissions by something on the order of 18 Mtonnes in 2000 with a financial effort of HGL 400-450 million per year. The distribution companies, collectively and individually, are undertaking four kinds of activities in executing the plan. These can be described in general terms as: first, furnishing their customers with information and advice about possibilities for saving energy. Second, providing prior financing and leasing arrangements for their customers who want to acquire energy efficient equipment. Third, administering subsidy schemes and incentive arrangements for such things as insulation and high efficiency boilers in homes, energy saving lightbulbs in homes and large-scale energy efficient lighting projects in non-residential buildings. And fourth, stimulating investments in additional wind power facilities and cogeneration, with support from central government. It is expected that decentrally generated electricity will provide about one third of total supply in 2000. Cogeneration installations will furnish the lion's share of the decentrally generated kilowatt hours.

Optimizing the involvement of the energy distribution sector can be a very significant element in the energy conservation policy mix. It is important to take advantage of the expertise present in the sector and of the existing relationship between distribution companies and their customers. This relationship provides access to millions of small-scale consumers of energy who would otherwise be much more difficult to reach with information and services. The process of drawing up and executing the Environmental Action Plan, moreover, contributes to internalization of environmental awareness in the energy distribution sector, which after all is a key link between supply and demand in the energy market.

7. Conclusions

An effective policy approach to the climate change problem requires that a variety of policy instruments be applied. Taxes, voluntary agreements and regulations all have their own individual strengths and weaknesses. By using them in combination it is possible to compensate their individual weaknesses and enhance their individual strengths such that the total effect is more than the sum of the parts.

Not each instrument is equally applicable to each of the target groups of energy conservation policy. Applying all four of them to all the target groups would result in overkill which would not be compatible with the Least Regrets approach. It is therefore important to consider which instruments are most suitable for which target groups and how certain combinations can serve to mutually reinforce and complement each other.

For large, energy-intensive companies voluntary agreements offer an efficient and effective way of encouraging energy conservation. The existence of a regulatory instrument in the form of environmental permits for individual establishments enhances the effectiveness of the voluntary agreement by stimulating participation and ensuring that participating companies do so in good faith. Non-participating companies are in any case subject to regulation.

Agreements may also be used effectively for smaller scale commercial establishments. In this case, however, general administrative orders rather than individual permits supply the regulatory support since the numbers involved are simply too great to make individual regulation feasible. Taxes targetted on small-scale energy users as well as activities on the part of energy distribution companies serve to reinforce the effectiveness of the agreements and general administrative orders.

In order to encourage energy conservation in households, taxes offer a very efficient policy instrument. When supported by activities on the part of energy distribution companies, the conservation effect of the taxes can be optimized.

NON-ECONOMIC INSTRUMENTS: REGULATION AND STANDARDS, ADMINISTRATIVE GUIDANCE, AND ACTION PLANS AND PROGRAMS

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Abstract: Markets are not always perfect and they do not necessarily ensure economically optimum solution of environmental problems. In reality, political decisions are not always made, nor public consensus reached in accordance with economic efficiency and effectiveness criteria. Here, non-economic criteria such as social equity, fairness, administrative feasibility and social acceptability are as important as economic ones. According to the situation in which the nation is placed, government might be advised to adopt "non-economic" instruments which are practically feasible and socially acceptable and which can be applied either independently or in combination with market-based economic instruments. Non-economic instruments, however, do not simply mean "command and control" approaches. Traditional dichotomy of economic instruments vs. regulation should be reexamined. Whether the instruments may be economic or regulatory, they would have limited applicability to the management of the global environment. A variety of new "soft-instruments" such as administrative guidance, planning, information and education could be used in addition to the traditional instruments. From this viewpoint, this report explores the role of government initiative and intervention based on non-economic instruments and discusses their possibilities and limitations. It takes up policy instruments such as "regulation and standards," "administrative guidance" and "action plans and programs," while reviewing the application of these instruments in Japan and other countries.

1. Introduction

There might be different views about the extent to which the interventionist government policy such as regulation, standards and administrative guidance will prove effective in environmental policy and how it can be successfully applied to the management of the global environment.

While acknowledging the need of government intervention for correcting market failures, economists would favor the market-based measures. Some of them maintain a view that economic activities which are as much as possible free from government regulation, relying upon "invisible hands" of markets will provide an economically optimum allocation of resources. They advocate the minimization of government role and call for spontaneous, voluntary actions of businesses.

Although "the least cost solution" is economically desirable, real markets do not necessarily ensure such solution as they are not perfect due to insufficient information, lack of scientific knowledge and difficulty in eliminating "free riding." In view of such imperfect nature of markets, government initiative and intervention, especially for inducing businesses and citizens to take environment-friendly actions as well as for promoting scientific research and technology development, are desired for global environmental management.

In reality, political decisions are not always made, nor public consensus reached in accordance with the economic efficiency and effectiveness criteria. Here, non-economic criteria such as social equity, fairness, administrative feasibility and social acceptability are as important as economic ones. Thus, depending upon the situation in which the nation is placed, government might be advised to adopt non-economic measures which are practically feasible and socially acceptable. They can be used independently or in combination with market-based instruments.

It should be noted, however, that "non-economic" instruments do not simply mean "command and control" approaches. Traditional dichotomy of economic vs. regulatory instruments has to be reexamined. Whether the instruments may be economic or regulatory, they would have limited applicability to the management of the global environment. Instead, a variety of new "soft-instruments" such as administrative guidance, planning, information and education must be more widely and effectively used in addition to the traditional instruments.

This report explores the role of government initiative and intervention based on non-economic instruments and discusses their possibilities and limitations, while reviewing the use of these instruments in Japan and other countries. Firstly, it takes up traditional policy instruments such as "regulation and standards" and "administrative guidance." Then it focuses its attention to the role of "action plans and programs," especially those prepared at local level for promoting collective and cooperative actions of government, citizens and businesses

Fig.1 demonstrates the responsibilities of government, businesses and citizens and the role of various policy instruments that could be mobilized for arresting climatic change.

2. Regulation and Standards

2.1 Economic vs. Regulatory Instruments

An objective of environmental policies in general is to achieve certain environmental targets which are determined in terms of the concentration or total amount of pollutants in air, water and soil. Regulatory and economic instruments have been applied either independently or in combination with each other to achieve these targets.

Traditional discussions about the choice between regulatory and economic instruments in environmental policy also apply to the management of the global environment. Global climatic change, however, has some distinctive peculiarities with respect to the framework and foundations of policies addressed to it. Firstly, carbon dioxide and many other greenhouse gases themselves are not harmful substances to human health. Moreover, there are controversies about the possible consequences of the climate change. Secondly, it is practically difficult to eliminate "free riding" with respect to the actions to limit the emission of greenhouse gases (GHGs). The benefit of avoided damage as well as the damage itself will be incurred to all human beings indiscriminately, whether they take actions or not. This problem is closely related to the administrative feasibility of enforcing emission standards of GHGs. Furthermore, there exist no authentic international institutions that are authorized to implement any binding standards internationally agreed upon and conduct monitoring and inspection of the compliance with such standards.

The framework convention(1) was concluded, but any rigid schemes of international burden sharing and nation by nation targets for controlling CO_2 and other GHGs emissions were not agreed upon(2).

The above arguments seem to suggest the advantages of using economic instruments such as environmental taxes and charges and tradable permits rather than regulatory measures as instruments addressing the global climate. Meanwhile, OECD recommends more consistent and extensive use of economic instruments in environmental policy(3) by its member governments. At present, however, there is no definite prospect that internationally harmonized economic measures will be simultaneously introduced in the United States, Europe, Japan and other countries very soon. Instead, in accordance with the nation's political and economic situation, government may have to choose non-economic measures which do not necessarily aim at the regulation of GHG emissions but which will have favorable impacts on their control.

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1 The United Nations Framework Convention on Climatic Change.

2 Except for CFCs subject to the Montreal protocol.

3 OECD: "Guidelines for the Application of Economic Instruments in Environmental Policy (Environment Committee Meeting at Ministerial Level, Background Paper No.1, 30th-31st January, 1991)

A typical example of non-economic measures is the regulation on energy conservation. Here, energy demand of factories and households is regulated and poorly insulated houses are required to be made more efficient with stricter building codes. Regulatory standards and labeling code for improving automobile and appliance efficiency and packaging directives that require reuse of materials should also be considered.

2.2 Regulation and Standards for Energy Conservation

Enforcement of regulation and standards will bind business activities and citizens' life and they must have clear legal ground justifying their need. There remain a certain level of uncertainties about the question whether perceived threats to the integrity of the global environment from climatic change is only theoretical or not. Due to this very peculiarity of global warming issues, it is not easy to find rational grounds for government to set regulatory standards to limit directly the emission of carbon dioxide (CO_2) and other greenhouse gases, and no countries so far have introduced such standards.

On the other hand, countries were hit by the oil price shock in the 1970s, and the rational use of oil and other energy resources now takes an important position among national policy objectives. Standards for energy conservation performance of factories and plants as well as for energy efficiency of machines and appliances have been introduced and they can serve as proximity to the regulation of CO_2 emissions. Examples of such regulation are the energy conservation targets set forth by the Energy Conservation Law in Japan and the corporate average fuel economy (CAFE) standards for automobiles introduced in the United States.

Among various greenhouse gases, reduction of carbon dioxide (CO_2) emissions is especially important. As CO_2 can not readily be removed, it is necessary to restrict the overall energy use or to shift away from carbon based fuels. Fig.2 demonstrates the procedure and criteria for choosing certain policy instruments from a set of available tools. Fig.3 elaborates the scope of various standards for improving energy efficiency. It also demonstrates the role of other policy instruments that can be used in close connection with regulatory measures. The standards do not only include those for rationalizing the use of fossil fuels but also "passive" measures such as the code of insulation for houses and buildings.

2.3 Regulation on Energy Conservation in Japan

On the basis of the Energy Conservation Law,(4) Japan enforced energy conservation standards requiring factories and businesses to make an effort to conserve energy. The old law, however, was not strong enough to control business activities. Then global warming issues brought about a new impetus to encourage energy conservation efforts in various sectors. Thus, in March 1993, a pair of laws, i.e., the "Energy Supply and Demand Structure Advancement Law" and the "Energy Conservation and Recycling Support Law,"(5) were enacted.

Energy Supply and Demand Structure Advancement Law laid down the amendments of three energy-related laws. Among others, the Energy Conservation Law was amended and the old energy conservation targets were divided into seven areas including the recovery of discharged heat, prevention of electric current losses, and effective combustion of fuel. The standards define detailed steps that businesses are required to follow, including the mixture of fuel and air and boiler exhaust heat temperatures. The Ministry of International Trade and Industry (MITI) encourages and guides businesses to follow the reinforced regulations. Those failing to meet the lowest targets would be penalized while those clearing new, stricter targets would be given

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4 The Law Concerning the Rational Use of Energy.

5 The Provisional Law for Promoting Business Activities Related to the Rationalization of the Use of Energy and Etc. and the Utilization of Recycled Resources

tax incentives and other financial benefit.[6] MITI plans to ask some 3,200 key energy consuming factories and businesses, which would be designated as "special business entities," to take part in its effort and report fuel and electricity consumption to MITI. If the ministry determines that the energy conservation efforts of designated factories and businesses are inadequate, it could order them to comply with MITI's conservation targets. To enforce compliance, the ministry would be able to publish the names of firms that fail to report the information and impose other sanctions.

The law also provides that if imported equipment does not meet MITI conservation targets, the ministry could order importers to make revisions to meet the targets.

Energy Conservation and Recycling Support Law, which aims to facilitate the enforcement of the Energy Conservation Law and promote the recycling of material, calls for creating a low-interest loan and interest-rate subsidiary program. In another measure, a tax credit would be extended to factories that prepare conservation programs set by MITI. The factories would also be eligible for a 30 percent accelerated depreciation of assets. The law also provides energy conservation targets for buildings. Moreover, the same law calls for a loan and interest subsidiary program for businesses that introduce equipment and facilities for recycling products, develop environmental protection technology, and replace chlorofluorocarbons with less damaging alternatives.

Thus the current Japanese system is a combination of regulatory and financial instruments as summarized in Fig.4 and Table 1. From a practical point of view, combination of regulatory and financial assistance measures is advantageous for encouraging the actions of businesses and other entities to which the regulation is applied.

Effectiveness of regulatory measures is strongly dependent upon the administrative feasibility of monitoring and inspection of compliance with the standards or targets. Administrative feasibility will depend upon the capability of existing administrative systems such as information and report requirement to factories and air pollution monitoring and inspection. In this regard, Japan's industrial and environmental policies have established an effective network connecting government and businesses, which ensures the enforcement of standards and implementation of administrative guidance.

2.4 Regulation of Automobile Fuel Economy and Traffic Control

In most industrialized countries, transportation sector shares approximately a quarter to one third of the nation's total energy requirement. Improvement of the vehicle fuel efficiency, and traffic avoidance and the reduction of the miles traveled by passengers and freight by expanding public transportation networks will be a policy priority for controlling CO_2 emissions.

A viable tool for improving the vehicle fuel efficiency is the enforcement of fuel economy regulation. In 1975, following a sharp increase of world oil prices, the United States passed the Energy Policy and Conservation Act establishing mandatory fuel economy standards for automobiles and light trucks (CAFE or "corporate average fuel economy" standards). Beginning at 18 MPG (miles per gallon) [7] in 1978, the passenger car standards increased to 27.5 MPG[8] by 1985.

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6 Companies that introduce energy conservation systems that can meet the targets (a moderate cut in energy use) would be granted a tax credit and interest subsidies, among other preferential measures.

7 Approximately 7.6 km/L

8 Approximately 11.6 km/L

Some argue that the vehicle fuel improvements are the natural response of the marketplace to rising fuel prices and that the regulation has little effect, while others claim that the market is unlikely to respond strongly to gasoline price changes. In the United States, since gasoline prices increased and the standards were enacted at about the same time, the relative importance of the regulations versus the market response to higher prices is not obvious. A statistical analysis,(9) however, indicated that the standards were at least twice as important as market trends in fuel prices, and may have completely replaced fuel price trends as a bias for long-range planning about MPG.

In Japan, according to the Energy Conservation Law, fuel economy targets for vehicles was set in 1979,(10) and they remained unchanged until the revision made in 1992.(11)

Fuel economy of newly registered passenger cars in Japan showed a notable improvement in 1973-1984.(12) In addition to the increased fuel prices and the national targets, the U.S. fuel economy regulation must have influenced the decision-making of Japanese car manufacturers in this period. Then the fuel economy turned to a slight decline after 1984.(13) This took place in parallel with the lowered domestic gasoline prices(14) and the increased size of automobiles. Thus, as exhibited in Fig.5, the change in fuel economy seems to have responded to the change in domestic oil prices although the correlation is not necessarily a causality.

In today's society, automobiles are closely linked to our daily lives. Emphasis on convenience is one major factor causing the increase of passenger and freight traffic. Increasing dissemination of home delivery and just in time systems exemplify some of its examples. A recent survey conducted in Japan shows that people would not change their behaviors regarding the use of automobiles even if there were a considerable increase in gasoline price.(15)

With respect to traffic control, municipalities in many countries have enforced regulation such

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9 D. L. Greene, "CAFE or Price? : An Analysis of the Effects of Federal Fuel Economy Regulations and Gasoline Price on New Car MPG, 1978-89", The Energy Journal, Vol. 11, No. 3, pp.37-57.

10 The target year for achievement was 1985. The targets are not mandatory standards, but car manufacturers are requested to make their best efforts to meet the targets by the designated target year.

11 The target values to be achieved by the year 2000 were set according to the size of vehicles. For small-sized vehicles (in between 827.5 kg and 1515.5 kg in weight) , the target value is 13.0 km/L, while that for large-sized vehicles (heavier than 1515.5 kg) being 9.1 km/L.

12 The average fuel economy of newly registered passenger cars in Japan was improved from 9.6 km/L in 1973 to 12.8 km/L in 1984 according to the standard test mode of the country ("10 mode" test).

13 The average fuel economy was declined from its peak record 12.8 km/L attained in 1984 to 11.5 km/L in 1990. For small-sized vehicles (in between 827.5kg and 1265.5kg in weight), for example, the target set in 1979 was 12.5 km/L and it was achieved in 1985. Thereafter, however, the value declined to 11.9 km/L, which was not compliant with the target.

14 The decrease in domestic gasoline prices was a result of the lowered international oil prices and it was further amplified by the rapid evaluation of the Japanese currency.

15 According to a questionnaire survey conducted by the author (December 1993, for residents in Tokyo, Osaka, Fukuoka and other cities) , about more than 30 % of the respondents replied that they would not change their behaviors of using cars even if gasoline prices were raised by more than 50 %.

as "park and ride system," "car pooling" and "car number control." They also have programs to establish a mass transit system and introduce economic instruments such as "road pricing." In Japan, some cities have regulatory programs for automobile air pollution control, and such programs generally have a favorable impact on the traffic reduction.

2.5 Regulation of Green House Gases Other Than CO_2

For CFCs, regulatory measures have been prescribed according to the Montreal protocol. They might not only include the ban of the production and use of CFCs but also measures to encourage their recycling as well as the ban of their export to non-signatory countries of the protocol.

For methane, regulation could be applied to natural gas pipelines to prevent leakage during transportation.

Japan will reduce CFC consumption by 75 percent in 1994 and totally ban the use by the end of 1995. MITI plans to impose a total ban on domestic production and consumption of hydrochlorofluorocarbons, which are CFC alternatives, by the year 2020.

MITI is also discussing with home electric appliance manufactures the feasibility of installing CFC recovery equipment at their affiliated retailers. MITI also is holding consultations on the plan to recover CFC-12 from refrigerators with municipal governments. Currently, when households dispose of broken refrigerators, the first step is to call municipality sanitation departments for pickup, and the departments transport the refrigerators to dump sites. If CFC recovery is mandated, the departments then must alert retailers to recover the gas before disposal. At present, however, such mandatory measures have not been taken. Instead, some municipalities have started a program to enforce the recovery of CFCs from publicly owned buses and other vehicles.

2.6 Complementary Regulatory Measures: Packaging and Labeling

Legislation such as packaging and labeling requirements and eco-audit would facilitate the compliance with standards if they are applied in combination with energy efficiency standards of appliances and products as well as other measures including the regulation of CFCs.

Packaging legislation will impose an obligation on companies to accept recycled packaging materials. If such legislation is enforced, production companies may fulfill the requirement by setting up a new mechanism such as a fund for the collection of recycled packages. Through encouraging the rational use of materials, it may contribute to the reduction of energy required in production processes. It may also reduce the energy consumption pertinent to the collection and treatment of wasted materials. However, there are opposite views about the question whether or not the recycling of materials will truly result in the reduction of total energy consumption in the society.

Labeling legislation will require manufacturers to indicate the energy efficiency of appliances and products. It will affect the purchasing behaviors of consumers, and thereby facilitate the development and dissemination of products favorable for the protection of the environment. In June 1993, the European Community Commission released its criteria for products seeking the environmentally friendly "eco-label." Energy usage is one of the main criteria that would be used for giving the eco-label to electric appliances such as washing machines and dishwashers.

Evaluation of the energy efficiency of appliances and products would be a far reaching exercise if it plans to analyze the energy requirement and greenhouse gas emissions throughout their total "life cycle" from cradle to grave, covering all phases of production, distribution, use and disposal. Therefore, labeling legislation could be linked to the criteria of "life cycle assessment (LCA)" of the environmental impacts of products and "eco-audit" of businesses. In this regard, there are several international exercises taking place.

The international Chamber of Commerce, based on its Charter on Sustainable Development, plans to draw up self-regulatory guidelines for the implementation of good management practices in areas such as environmental reporting, eco-audits and product labeling.

The International Standard Organization (ISO) and the International Electric Committee are currently drafting environmental assessment guidelines that will require businesses to evaluate their production systems, operations and manufacturing processes. In Japan, the Ministry of International Trade and Industry plans to propose Japan's benchmark standards which are similar to ISO standards. Meanwhile, Keidanren (the Federation of Economic Organizations) plans to form an environment supervisory panel to discuss this issue.

2.7 Trade and International Implication of Standards

In today's globalized economy, one of the greatest problem of regulation and standards is that they may serve as non-tariff barriers which obstruct the free trade and cause distortions in international allocation of resources. Environmental regulation on factories and plants may induce the shifting of production bases to countries where standards are less stringent. This might cause a kind of "carbon leakage" from industrialized countries to developing world.

However, trade liberalization and the protection of the environment should not be considered as mutually conflicting objectives. They call for greater integration of environmental and trade policies at the national level as well as for parallel efforts to promote international cooperation on the basis of multilateral rules.

Some countries are endowed with abundant energy resources while others are not. From a national viewpoint, therefore, countries like Japan must enforce tougher energy policy encouraging energy saving and conservation and the development of new energy sources. In such cases, they need appropriate domestic measures that will compensate the financial burden of their businesses. Such measures could be ensured by subsidies and other preferential financial programs provided by the government. Here, questions may arise about the exemption of such measures from the rule of PPP (Polluters Pays Principle).

Regulation of CFCs also poses some trade problems. Japan, for example, exports about 10 percent of its CFC production, mainly to Asian nations for cleaning electric and precision parts in their high-tech industries. Ban of the export of CFCs to non-signature countries of the Montreal protocol as well as restriction on the import of some products manufactured in these countries might be a matter of political concern.

2.8 Deregulation Necessitated for Energy Conservation and Environmental Protection

In many fields, skewed economic incentives and outdated regulatory structures have encouraged business activities which are not favorable for energy conservation and environmental protection.

In Japan, electricity generation at dispersed plants such as waste incineration factories and households is regulated by the Electric Utilites Law. Ensuring the stable supply of electricity is a major objective of the law, and it provides various control measures against the activities of electric utilities industry. On the other hand, it protects the utilities industry by controlling the new entry into the business. For encouraging the development of small-scale dispersed power plants and the use of solar energy by means of photovoltaic and fuel cells, regulation on the connection between the utilities' electricity system and dispersed, small scale plants was relaxed to some extent. Overall, however, a further reform of the existing legislation could be envisaged.

In many countries, existing regulation encouraged the building of large power plants, where nearly two-thirds of a fuel's energy content is vented to the atmosphere as waste heat. Relaxation of the existing regulation on the construction of power plants would encourage the return to more efficient cogeneration plants, which use waste industrial stream to produce electricity, and district heating plants.

In some cases, new policy objectives such as energy conservation and CO_2 emission control might cause conflicts with the existing environmental requirements. In Japanese cities, the building of cogeneration plants was restricted by air pollution control policy. Regarding automobile vehicles, the use of diesel-engined vehicles has been promoted for energy efficiency reasons, but they are causing air pollution problems in large metropolitan areas in Japan. Contradictory objectives such as energy efficiency improvement and air pollution control should be and could be solved by technologies rather than by merely abandoning the existing regulation.(16)

3. Administrative Guidance in Industrial Policy and Voluntary Actions of Businesses

3.1 Role of Administrative Guidance in Environmental Policy

In most countries, a large portion (40-70 percent) of CO_2 is emitted from industrial facilities including electric power plants and manufacturing factories. In Japan, it is roughly estimated that a dominant part (80-90 percent) of CO_2 emission from those industrial facilities is accounted for about 3,000 specific plants and factories.

Thus, if it is administratively feasible, regulation and guidance to these larger plants and factories would prove effective by inducing them to take stronger actions for energy conservation and CO_2 emission reduction. Japan's industrial pollution control policy has been based on a similar idea and approach, and it made a great success in the control of traditional pollutants.

New energy conservation program of MITI also takes a similar approach. Such methods, however, can be applied only when there exists an effective industrial policy based on administrative guidance practices, reporting systems and human networks of government authorities and business officials.

3. 2 Advantages and Limitations of Administrative Guidance

Administrative guidance has both positive and negative aspects. It has an advantage that it can be flexibly used while avoiding a rigid application of the law. It sometimes pushes businesses to take stronger actions than those required by laws. It can provide semi-official guidelines to businesses even when relevant legislation does not exist. It may, however, opt to rely on the effort of specific sectors or firms that have greater technical potential and financial capacity. On the other hand, it may protect smaller firms and weak industrial sectors, thereby causing economic inefficiency. Moreover, it might prove inefficient due to the bureaucratic sectoral policies and conflicts among different ministries and departments. For example, Japan's MITI can exert its influence upon manufacturing and electric and gas utilities industries, but its role is not so influential to other sectors such as transportation and construction.

Furthermore, the fundamental limitation of the traditional administrative guidance is that its structures are producer-oriented and it can not handle consumers' behaviors and actions. It is not practically feasible to exert administrative guidance to unspecified individuals. Some new mechanisms such as local authorities' initiative that encourages the participation of citizens and a variety of non-governmental organizations must be put into force.

In addition, Japan's interventionist industrial policy has been internationally criticized as an unfair practice due to its protectionism and lack of transparency. Administrative guidance and

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16 For gasoline-engined vehicles, compatibility between fuel economy and exhaust gas control was achieved by technology.

industrial policy played a positive role for Japan's economic development. It was a proper policy when Japanese industries were in their infant years. Today, however, there is a growing view that government should minimize its intervention in private business activities.

3.3 Government Control vs. Voluntary Actions of Businesses

Businesses in general would like to avoid government regulation and intervention. Instead, they would prefer to take measures based on their own initiative rather than under government control.

In April 1991, the Federation of Economic Associations or *Keidanren*, one the most influential business associations in Japan and one of the largest in the world, published its Global Environmental Charter, including eleven-point guidelines for corporate action. For energy conservation, it states that "companies shall actively work to implement effective and rational measures to conserve energy and other resources ever when such environmental problems have not been fully elucidated by science." In October 1991, *Keizai Doyukai*, a society of influential business leaders in Japan, issued "Recommendations on Measures to Apprehend Global Warming - Tasks to Undertake Now for the Sake of Future Generations." They do not only include recommendations addressed to private corporations but also those to the government and to the general public. These business actions have been in parallel with international business initiatives such as the eco-audit program of International Chamber of Commerce (ICC) and "Changing Course" report prepared by the Business Council for Sustainable Development (BCSD).

In November 1992, three advisory panels(17) of MITI prepared a joint report on a new government initiative that seeks to promote environmental protection, economic growth and energy conservation. The initiative was made up of 14 proposals, which essentially was a repackaging of policies and measures already in place or about to be enforced.(18) Following these proposals, MITI advised that businesses should prepare "voluntary plans" for protecting the global environment. In February 1993, Environment Agency also published a report on the environment-friendly corporate actions, which also intended to serve as guidelines to businesses.

Businesses felt such government initiative to be something obtrusive and nonessential, and some business leaders expressed their displeasure with it. On the other hand, it provided a timely back up to environmental divisions and officials of business firms, encouraging them to take a leading role inside the respective institutions.

In summary, there is a conflict for leadership between the government and businesses. Businesses would emphasize their own initiative such as "response care program" and "self-regulatory guidelines." However, others may question whether capitalistic business activities can be compatible with environmental protection. Businesses must live up to their promises while the credibility of their actions should be judged not by the industry but by those affected by their activities. A certain mechanism such as eco-audit which ensures public access to business information would be indispensable in order to assure the credibility of businesses' environmental programs.

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17 They are the Industrial Structural Council, the Advisory Committee for Energy, and the Industrial Technology Council.

18 The proposals included new measures to promote highly energy-efficient investment and setting targets for higher energy efficiency of consumer goods, office equipment, and automobiles. Another proposal was to build new systems for effective district energy use and to promote local cogeneration plants. It should be noted that the enactment and amendment of energy-related laws in March 1993 were done according to the proposals.

4. Action Plans and Programs for Promoting Collective and Cooperative Actions of Government, Businesses and Citizens

4.1 Role of Action Plans and Programs in Decentralized Approches

Most governments of the industrialized nations have already published a national action plan or program for stabilizing the global warming, setting forth certain national targets regarding CO_2 and other greenhouse gas emissions. Such national targets are generally taken as international commitments of the nation. Legally speaking, however, such plans and programs are mere guidelines illustrating general policy directions and possible technical and other solutions. In order to implement the national action program and achieve the stabilization goal, a wide variety of extensive and long-term measures to guide citizens and businesses are essential.

Consultation and consensus-building among diverse entities are especially needed, but such tasks are difficult to be carried out by a sole effort of the central government. Here, 'decentralized approaches' based on the initiatives of local government authorities, in particular, could play a principal role for promoting the participation and collaboration of citizens, businesses and NGOs. Preparation of action plans and programs at local level will be an effective tool for local authorities to work for this. Of course, non-governmental organizations can also play a similar role.[19] What is likely to emerge is a greater attempt by citizens and industry to participate in the process of planning and drafting of action plans and programs. They should work toward improved consultation and communication rather than standing aside and criticizing the actions of other entities. Fig.6 illustrates the role of such action plans and programs.

In Japan, a number of prefectures and municipalities have already prepared or will draft a local action plan or program for arresting global warming. The Environment Agency prepared guidelines for helping local governments to work on this. In preparing such a plan and program, local authorities usually makes an estimation of CO_2 and other greenhouse gas emissions in their jurisdiction, and conduct a survey on the awareness and attitudes of citizens and businesses to global warming issues. Then potential reduction of CO_2 emissions is examined by assuming various policy options. Here, analysis is made on the possibilities of taking various measures such as changing the citizens' lifestyles, introducing new energy technologies and enforcing traffic management and control programs. Throughout this process, local authorities can make consultations with citizens and businesses for building a consensus on the measures to be put in the program.

Many Japanese businesses have an idea that industry's existence is closely bound to the global environment as well as to the community it is located. They hope to keep a cooperative relation with the residents and local governments. Although they are sometimes nervous about the initiative of the central government, they are generally supportive of the actions of local governments.

Meanwhile, Agenda 21[20] stipulates that each local authority should enter into a dialogue with its citizens and private enterprises and adopt "a local agenda 21." It points out the importance for local authorities to learn from citizens and businesses and other various organizations through consultation and consensus-building. In Japan, several prefectural governments[21] have already published their local agenda 21, in which measures for stabilizing global warming

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19 An example of such NGOs' action plans is "Sustainable Netherlands" presented by Friends of the Earth Netherlands, which gives one of its priorities to the reduction of CO_2 emissions.

20 It has a special chapter on local authorities' initiatives in support of Agenda 21 (Chapter 28).

21 Japan is divided into 47 prefectures.

assumes an important position. Thus, local agenda 21 might provide a framework embracing action plans and programs addressed to climatic change.

Number of Japanese municipalities(22) have also prepared special programs for the control of traffic pollution. Reduction of air pollutants such as nitrogen dioxide is the major objective of these programs, and they generally include various measures to rationalize the use of automobiles by restructuring the existing transportation system. Thus they would play an important role for reducing CO_2 emissions from automobiles.

4.2 International Initiative of Municipalities

Most of the people in the industrial world live and work in cities and it is cities where most energy is used. It is especially vital, in this period of rapid urbanization, to re-examine the overall structure of cities in which intensive economic activities are carried out by using a large amount of energy. ICLEI (international Council of Local Environmental Initiatives) encourages municipalities to take a leading role for building more energy efficient cities. The mayors of 60 cities in 20 different countries endorsed an environmental initiative ("the Cities for Climatic Protection" Campaign) which is designed to curb the dangers associated with global warming through a reduction in carbon dioxide emissions and broader energy efficiency.

The cities' campaign to curb climatic change contains four specific components. Firstly, the Energy Building Initiative seeks to reduce CO_2 emissions from municipal buildings by 20 percent over 10 years. Then, the Green Fleet Initiative seeks a 20 percent cut in CO_2 emissions from police, mass transit, and other city vehicles over a 10 year period. Moreover, the Energy Collaborative Initiative encourages regional groups of cities to study common environmental problems, exchange data and cooperatively act on the problems. Lastly, the Energy Partners Initiative encourages cities in developed nations share their knowledge and technologies for energy management with developing nations

The outstanding feature of such municipalities' effort is that they are already attempting to cut CO_2 emissions and curb energy usage, working on targets which the framework convention fail to mention. Thus cities have started their own little 20 percent club. National and provincial or state-level governments should support municipalities in meeting their goals as they pick up the slack left by higher-level governments.

There are a variety of attempts already undertaken by municipalities.(23) Under Toronto's Audit-Retrofit Program, the city has chosen 268 buildings to be retrofitted with high efficiency lighting systems and occupancy sensors which turn off lights automatically. Amsterdam has focused on reducing greenhouse gases through a citywide referendum to cut CO_2 emissions by 20 percent. It has also developed a campaign which discourages the use of automobiles. The campaign offers mass transit alternatives to commuters and encourages car pooling. In Minneapolis, an attempt is made to reduce CO_2 emissions through a major building weatherization program. The city is also encouraging a reduction in automobile emissions through inducements for car pooling and through the construction of a light rail transit system for commuters.

4.3 Public Information and Education for Consensus-Building

Today, a wider range of activities of industries and citizens have complex and far reaching implications for global climatic change. Here technology alone can not provide an ultimate

22 Tokyo metropolis and large cities designated by government that have almost same administrative status as prefectures. These cities approximately have a population greater than 700 thousands.

23 The Bureau of National Affairs (Washington, D.C.): "International Environmental Reporter", p. 86, February 10, 1993

solution. Our social systems and values must incur a change so that the environment-friendly actions of citizens and firms will be spontaneously facilitated. Incorporating such new value systems into people's daily lives will fundamentally change the way they live in. Environmental consciousness must also be effectively incorporated into business decision-making and performances.

In such a new paradigm of environmental policy, regulatory measures and traditional administrative guidance which has been addressed to industrial activities alone, or to some specific industry sectors such as manufacturing, prove ineffective. Public information and education by various methods will play an essential role for encouraging the involvement of a wider range of citizens and businesses(24) based on their improved knowledge and awareness about global environmental issues. Action plans and programs must embrace measures for promoting improved environmental education at all levels and a restructuring of corporate decision.

Thus the exercise of making an action plan and program will provide opportunities for government, citizens, businesses and all other entities concerned to work together on the basis of improved information.

5. Concluding Remarks

Role of government for applying non-economic instruments to the management of global climate is discussed. Non-economic instruments, however, do not simply mean command-and-control methods, but they include a variety of "soft" approaches. They should be used to remedy the failures of markets or to make markets work more efficiently. Here, it should always be kept in mind that improper government interventions might cause failures even worse than those intrinsic to the markets.

Regulation and standards would be an effective tool if they are properly designed and used in combination with economic instruments.

Traditional methods of administrative guidance in industrial policy would be effective as far as their targets are limited to specific plants and factories. However, they must be made more transparent, and their limited applicability should be noted. On the other hand, businesses are emphasizing voluntary and self-regulatory attempts based on their own initiatives which are as much as possible free from government control. For their efforts, a certain mechanism such as eco-audit should be properly designed and enforced in order to assure their credibility.

In advanced industrial nations, the focus of environmental efforts is being shifted from production to consumption phase, where the role of consumers, citizens and households would become increasingly important for energy conservation and CO_2 emission reduction. The use of consumer-oriented tools such as public information and education should be more emphasized. Legislation on labeling, packaging and recycling would also play an important role for changing the attitudes and behaviors of citizens and businesses through encouraging the rational use of energy and other resources.

Decentralized approaches based on local authorities' initiatives should be more emphasized for promoting cooperative and collective actions of government, citizens and businesses. Preparation of a local action plan and program as well as local agenda 21 would provide an effective means for encouraging the local authorities to work in this direction. Public information and education should be an integral part of such attempts at local level.

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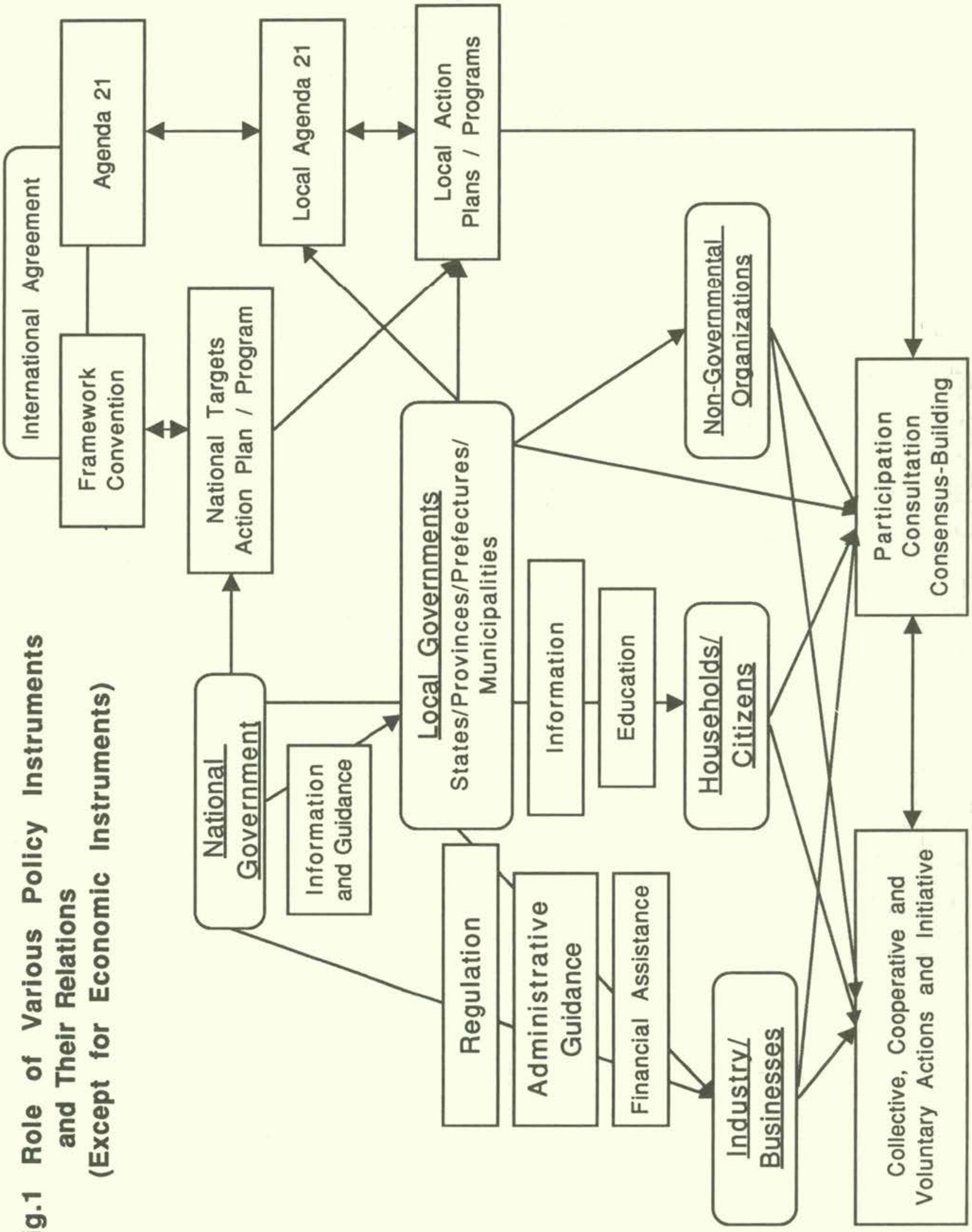
24 The role of non-manufacturing industries such as service (including construction, wholesale and retail, and other various businesses) and transportation sectors is increasing as end-users of energy.

Table 1 Legislation for Energy Conservation in Japan

	Measures to Reinforce the Energy Conservation Effort *	Measures to Support the Energy Conservation Effort **
Factories	(a) Energy conservation targets (set by government) (b) Measures to ensure the compliance with the government-set targets by designated factories -Duty of periodic reporting to MITI -Guidance and command by MITI to factories which can not achieve the targets -Penalties (publish the names of non-compliant factories, impose a fine)	Financial assistance to designated enterprises -Low interest loan and interest-rate subsidiary program (4.05%) - Debt guarantee by a special fund -Special tax system for promoting energy conservation investment (7% tax-credit, or 30% accelerated depreciation of assets)
Buildings	(a) Energy conservation targets (set by government) (b) Equipment for which the rational use of energy should be promoted (air-conditioning, hot water supply, lighting and etc.) (c) Measures to ensure the compliance with the government-set targets by designated constructors	Financial assistance to designated enterprises -Low interest loan and interest-rate subsidiary program (4.25%) - Debt guarantee by a special fund
Machines and Appliances (including automobiles)	(a) Energy conservation targets (set by government) (b) Labeling of energy consumption efficiency	-----
Technology Development	-----	(a) Subsidies to the development of energy conservation technology (b) Financial assistance to designated enterprises -Low interest loan and interest-rate subsidiary program (4.1%) -Special tax system for promoting energy conservation investment (6% tax-credit)
Area-wide Energy Conservation	-----	Area-wide energy conservation type supply system -Low interest loans by the Japan Development Bank - Debt guarantee by a special fund

* Measures Based on Energy Supply and Demand Structure Advancement Law
** Measures Based on Energy Conservation and Recycling Support Law

Fig.1 Role of Various Policy Instruments and Their Relations (Except for Economic Instruments)



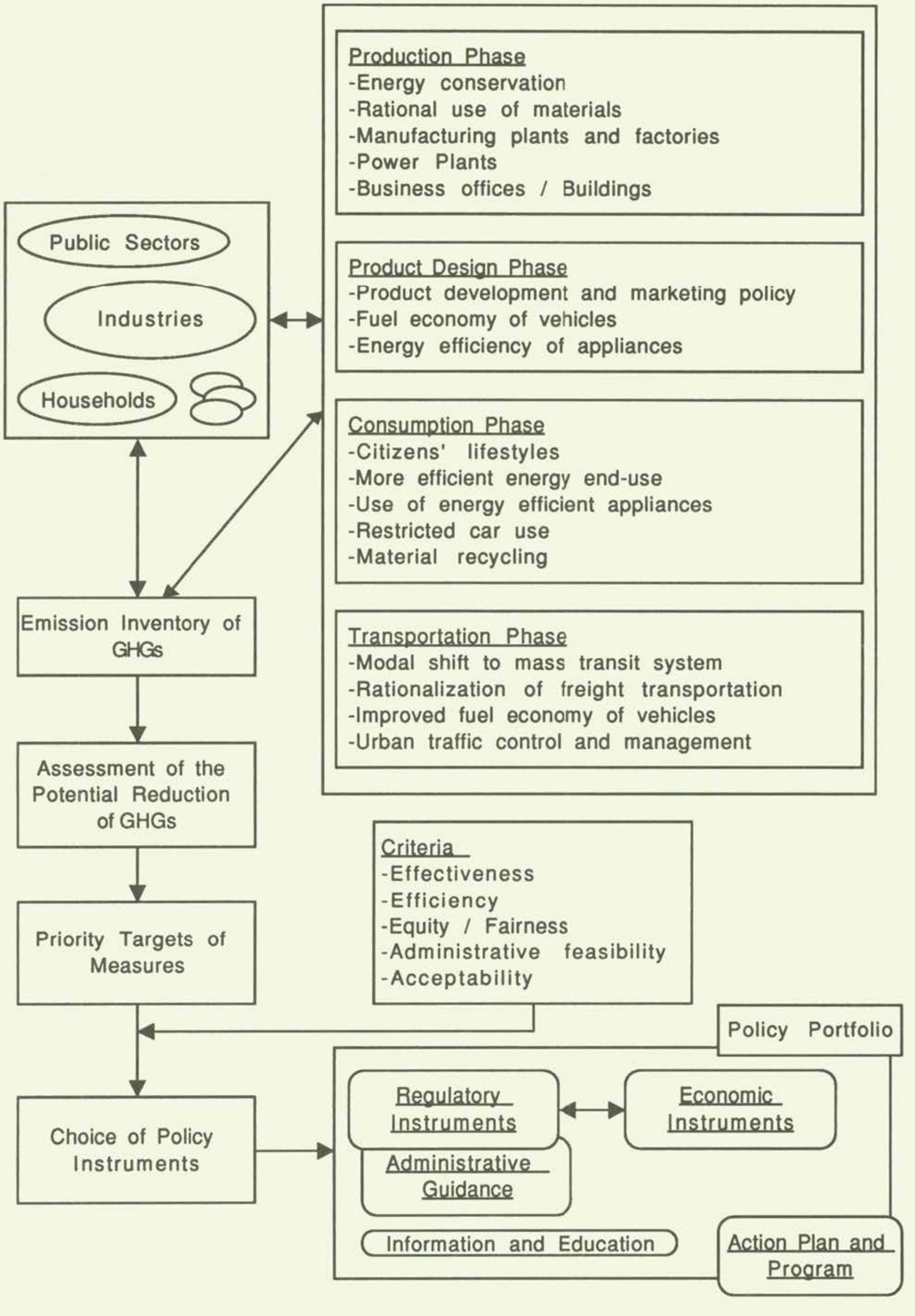


Fig.2 Scheme of Selecting Policy Instruments

Fig.3 Role of Regulatory Instruments and Their Relations with Other Policy Tools

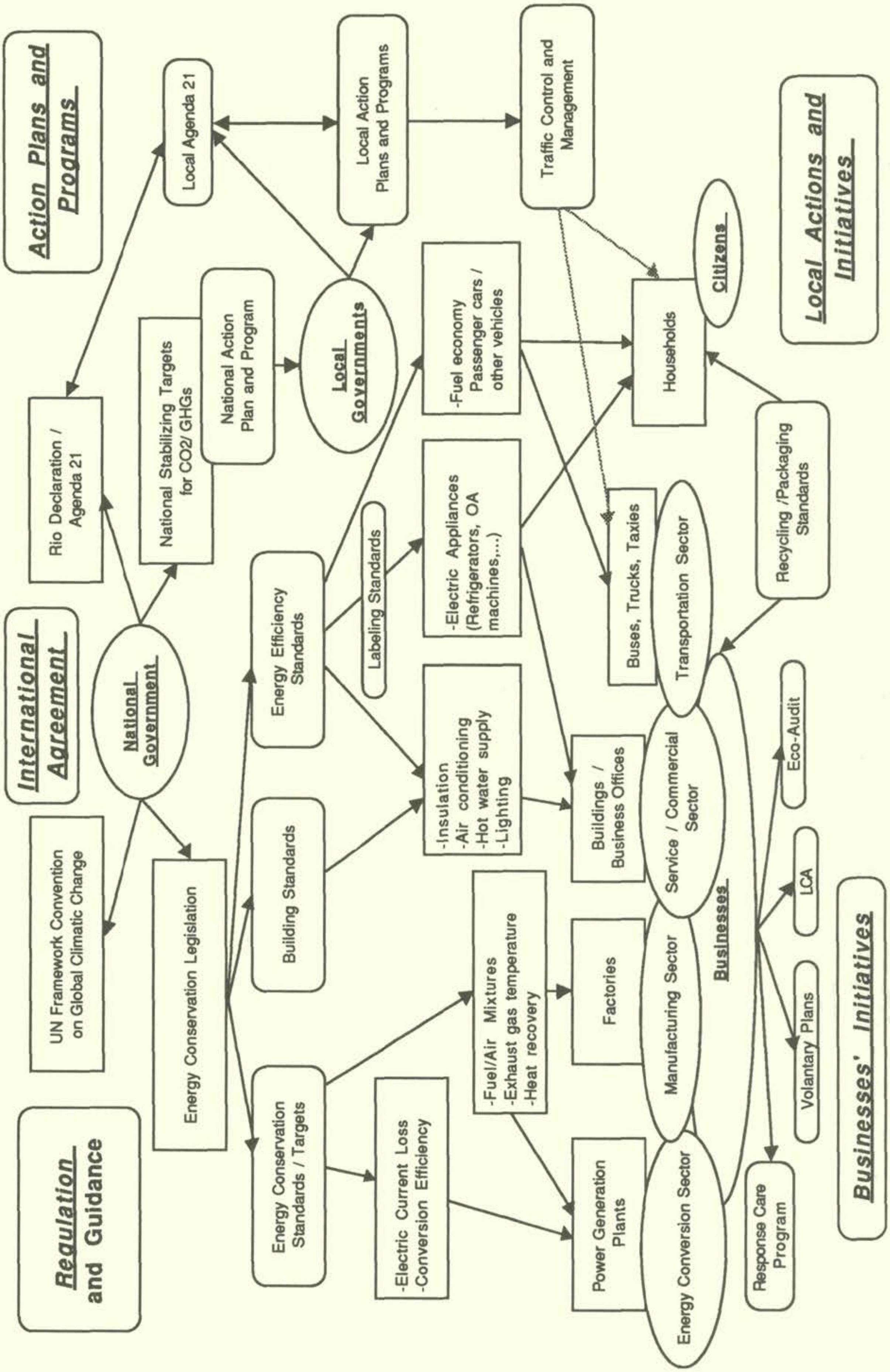


Fig. 4 The Scheme of Japanese Energy Conservation Law

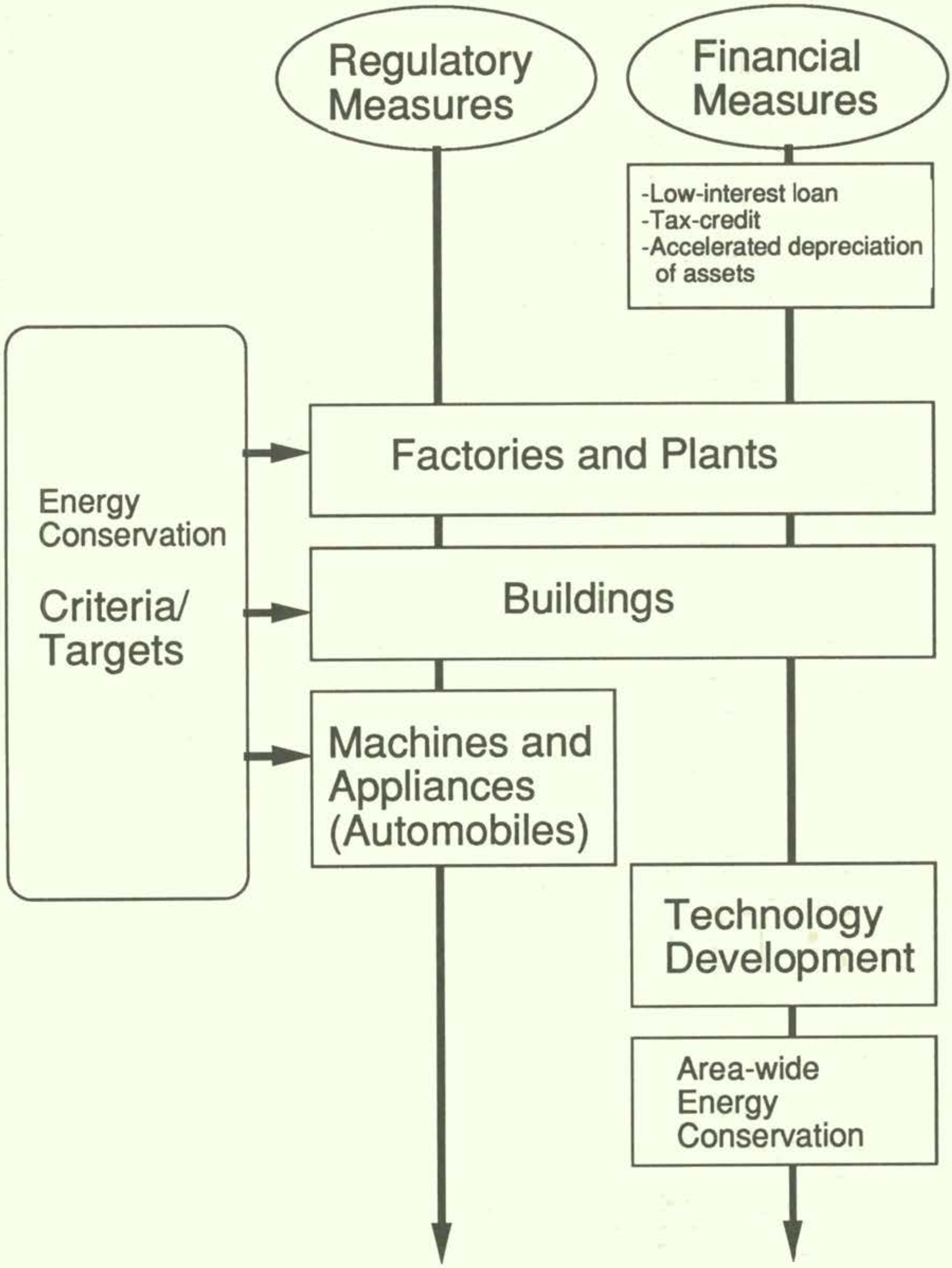
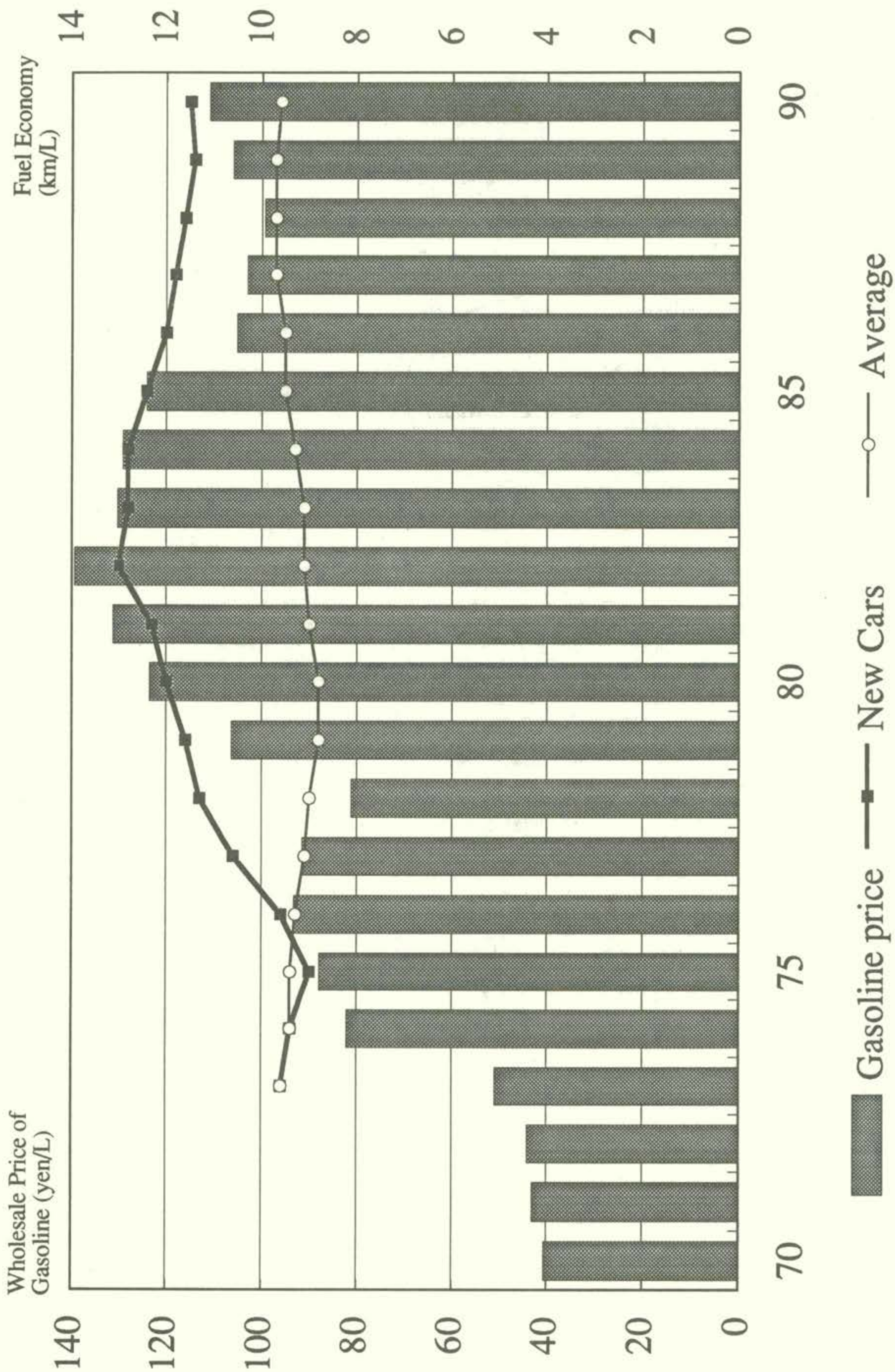


Fig. 5 Changes in Gasoline Price and Fuel Economy of Passenger Cars in Japan



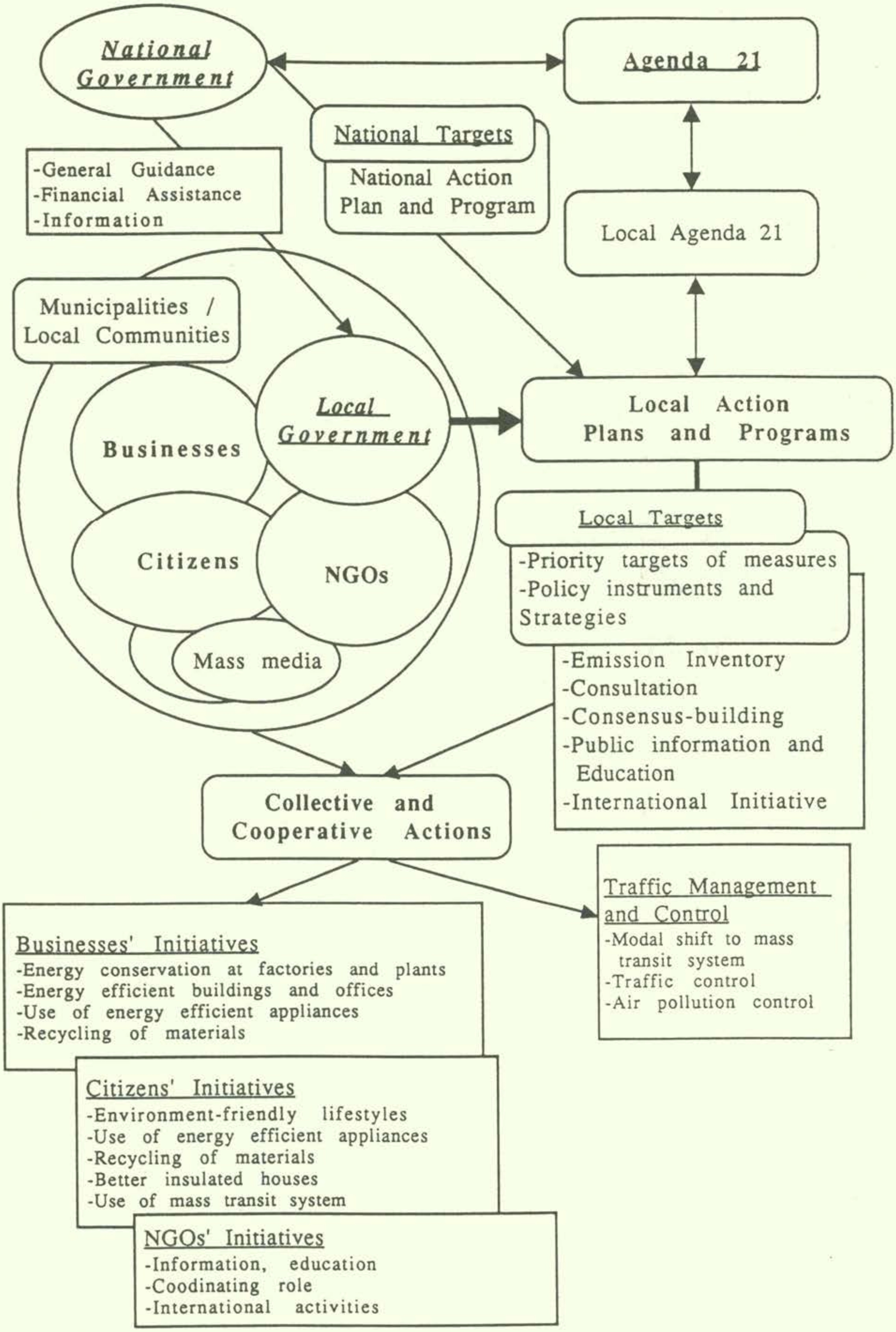


Fig.6 Role of Action Plans and Programs

Discussant's Comments

Lee Solsbery
International Energy Agency
OECD

Both authors have shared with the group very useful treatments of innovative regulatory approaches in their respective countries--Netherlands and Japan--which present two different, but not dissimilar, models for consideration. At the outset, I think we should recognize our two presenters' courage for coming before this audience--full of economists--for whom the mere mention of regulation is often synonymous with gross economic inefficiency and bad command-and-control policies left over from a by-gone era of environmental regulation. Of course, neither speaker advocated that sort of outmoded regulatory approach. They both acknowledged the important role of economic instruments and price signals working in conjunction with the programs they described. At the same time, Mr. Lenstra discusses the limits of carbon taxes when they are not implemented on an international basis and explains how voluntary agreements, regulation by permit and administrative guidance all offer alternatives to taxation. Prof. Imura notes the imperfections of markets in delivering certain results.

Both authors discuss the differences among end-use sectors in their "uptake" of economic signals versus regulatory guidance and, most important of all, the critical role of social acceptance and active, direct cooperation with market participants to realize results. In short, the practical importance of developing a constituency for far-reaching policy measures cannot be over-emphasized. Measurability and enforceability are also critical to the success of any new policy initiative, including regulatory or administrative guidance and voluntary agreements.

Prof. Imura explained how the Japanese system is a combination of regulatory and economic instruments, and he, too, emphasized that the effectiveness of regulatory measures is strongly dependent upon the feasibility and success of monitoring and enforcement. Mr. Lenstra noted that economic instruments are better suited than voluntary agreements in the residential/commercial and transport sectors. It is interesting to note the similarities in the two papers from two OECD countries as diverse as the Netherlands and Japan, although it must be said that both countries have a similar close relationship between government and industry which lends itself very well to the success of the measures they describe.

The IEA has just completed a scoping study on voluntary agreements, and I would like to show a few summary slides which draw some observations from that study (see three tables attached). IEA Ministers, in their latest communique, noted that a mix of measures should be considered in responses to climate change and that mix will vary among nations according to their circumstances.

In conclusion, let me try to make several specific, and I hope practical, observations to stimulate further discussion. First, I am struck by the empirical nature of the papers in this session and the concrete points they bring out on the implementation side of the issue; e.g., the importance of acceptance by stakeholder and consumers, the relatively manageable number of large emitters involved (65 firms in the Netherlands and 3,000 plants in Japan) and the established track record associated with the initiatives described. Second, I think this group should compare, contrast and reconcile in its deliberations the issues raised in this session versus those raised in yesterday's discussion which focussed heavily on long-term projections and the macro-economic modelling of policy measures leading to the standard conclusion that maximum efficiency is always achieved by economic instruments. Everyone here is familiar with this conclusion, and we in the IEA/OECD certainly subscribe to the economic tenets which lead to that conclusion.

However, I think we should not lose sight of the process actually under way in the INC negotiations and in the preparation of national communications by Annex I countries under the

FCCC. Very few OECD countries have, so far, enacted new economic instruments in this area and I would be surprised to see them do so in the eight months which remain before those plans must be submitted. Instead, it appears likely that a majority of Annex I countries will rely heavily in these plans upon the sort of measures described by our two speakers this morning. So, if that is the case, shouldn't WG III in its report on policy instruments not only make the case for the optional solution under macro-economic models, but also address the potential for mitigating emissions under the regulatory approaches discussed here? If not, do we risk a "disconnect" between theoretical analysis and political realities? Can we usefully shed light on this problem by focussing upon the top-down versus bottom-up modelling issue on by reviewing the role of consumer behavior in more detail? My role as a discussant here is to provoke discussion, so I pose these questions in a blunt and simplified manner for precisely that purpose.

Tables

Voluntary Agreements in Selected OECD Countries

	Transport (Car Fuel Consump.)	Appliance Standards and Labelling	Building Standards	Home Energy Labelling	Industry	Energy Supply Companies	Monitoring Energy Consump. and Emissions Reductions
Canada	X		X		X		
Germany		X					
France						X	
Finland					X		
Ireland		X			X		
Netherlands					X	X	
Norway					X		
U.K.		X		X	X		
U.S.A.	X	X			X	X	X

Why Voluntary Agreements?

- Increased flexibility to achieve objectives
- Results can be achieved relatively fast
- Lower administration and enforcement costs for government
- Objectives can go beyond what would be possible by regulations
- Companies trying to develop a 'Green' image
- Industry knows that if objectives are not met harsher policy instruments can be used
- Increased trust amongst partners
- Many areas do not lend themselves well to regulation

Difficulties Relating to the Use of Voluntary Agreements

- Lack of formal sanctions
- Lack of transparency - Need for monitoring
- Needs high participation rates to be effective
- Hard to reach agreements on an international level (eg European Union)

Discussant's Comments

Eiji Hosoda
Keio University

The purpose of this paper is to explore "the role of government initiative and intervention based on non-economic instruments and discuss their possibilities and limitations." Such instruments as "regulation and standards", "administrative guidance", and "action plan and programme" are taken up and examined respectively.

Recently, market oriented methods to control environmental quality are recommended. They are considered to be more effective than and preferable to direct control by government from the viewpoint of allocation efficiency. Although this is true, we must be very careful on this point. As the author, Prof. Imura, suggests, applicability of those methods are subject to many constraints, such as imperfect knowledge, free-riding, public acceptability of the purpose and so on.

Faced with such constraints, Prof. Imura has shown that government control or initiative is more acceptable and effective than economic instruments in some cases. One of the examples is the Regulation on Energy Conservation. This was not implemented to reduce CO_2 emissions, but fulfil energy savings. After the two oil crises, such a regulation to save energy has been socially justified and accepted. The regulation has indirectly fulfilled the purpose of curtailing the CO_2 emissions.

The dynamic aspect of regulatory measures should not be forgotten. Contrary to economists' beliefs, such measures may bring about technical progress : The Japanese automobile industry succeeded in the improvement of energy efficiency after the regulation of exhaust gas of automobile was introduced. As a consequence, the emission of CO_2 from automobiles was reduced through the improvement of fuel efficiency.

Another point is, as emphasized by Prof. Imura, that the combination of regulatory measures and economic instruments is necessary. They should be complementary to each other. Indeed, such a combination has been adopted by MITI, as exemplified in this paper.

Although I agree with the general thrust of this paper, I would like to make a few additional remarks in order.

(1) Administration cost may be an important factor in deciding-whether regulatory measures are adopted or not. A certain amount of information may have to be obtained at great cost. Conflicts among government sectors (ministries) in the decision making process also causes costs. Furthermore, these costs may not be evaluated properly.

(2) Regulatory measures often mean concentration of information in government sectors, and bureaucrats may enjoy the increase in their political clout. Thus, it is quite probable that rent-seeking activities will be encouraged. To offset these demerits, decentralized methods need to be jointly implemented.

(3) Regulatory measures in other countries may not be as effective as in Japan. Great amounts of information and power have been accumulated in the Japanese bureaucracy. The power of Japanese bureaucrats makes private sectors dependent upon the government sectors in certain respects. MITI's guidance is very powerful, as demonstrated in this paper. I am suspicious if these types of measures are effective in countries where bureaucratic power is not so strong.

(4) The roles of businesses and citizens are also emphasized in this paper. As the author suggests, cooperative actions by businesses, citizens, and government, including local municipalities are important. Recently, those cooperative actions are often called partnership. To create a real partnership among those sectors, mutual recognition and respect among them is necessary. In Japan, however, strong bureaucratic power has prevented the growth of initiative actions by the private sectors. For instance, most of Japanese NGO's and NPO's (Non-profit organizations) are poorly funded and virtually powerless. The government, as well as businesses, should encourage the institutional and financial development of NGO's and NPO's.

Rapporteur's Summary

L. Solsbery, IEA/OECD
H. Asano, University of Tokyo
C. J. Jepma, University of Gnoningen

Prof. Hosoda's main comments on both papers were that in the papers many of the advantages of regulatory measures based on dialogue between government and private sector have been spelled out, but less so on some of the other aspects. In this respect he mentioned the administrative costs involved with executing the various measures, and those involved with decision-making within the government, as well as those costs involved with rent-seeking, that may result due to the fact that such policies often focus on a specific set of policies/industries only. In addition he wondered to what extent the Japan's case with its own strong interrelationship between government and industry can be used as an example for illustrating the scope for applying similar approaches in other countries. Finally, he stressed the fact that any policies based on partnership relations can only be effectively applied if there exists a genuine mutual recognition between the parties involved.

Discussion

A participant remarked that both papers related to experiences with regulatory versus voluntary measures in OECD-countries (The Netherlands and Japan) and wondered if and to what extent the experiences in both countries might provide useful information for application in developing countries. Mr. Benuvides (Min. of Foreign Affairs, Peru) indicated in this respect that the Peruvian government is in the process of setting up a system of regulatory measures based on extensive dialogue and negotiation between government and the private sector. He considered the experiences with voluntary arrangements in the two Western countries useful information. A question was being asked about the transparency of approaches such as the voluntary agreements-cum-permits/administrative orders system of the Netherlands. In this respect Mr. Lenstra remarked that the Netherlands' system of permits/administrative orders as recently set out in the Environmental protection. Act is supplementary to the voluntary agreements system; and is fully transparent everybody can check whether or not plants comply with the principles set out in the permit system. Mr. Haites wondered why not special attention was given in the regulatory measures discussed to the transportation sector. Mr. Lenstra remarked that the Netherlands government's environmental policy vis-a-vis this sector is mobility-oriented (on voluntary bases), not technology-oriented, because the latter policy aspect is handled at the EC-level.

A participant referred to the criterion of cost-effectiveness as expressed in the Framework Convention Act. 3, and argued that, unlike regulatory measures, voluntary measures cannot be properly assessed on the basis of the cost-effectiveness criterion. Precisely because the costs of applying regulatory measures will differ among industries, voluntary measures most likely will do so much less. This creates the problem that voluntary measures may do insufficient justice to the above criterion. Any movement away from regulatory measures towards voluntary measures - as for instance, might be inferred from the remarks about deregulation and voluntary policies in the Asano's paper - therefore has to be appraised very carefully.

In responding to this, it was argued that voluntary agreements may be the only feasible alternative if the political willingness to apply regulatory measures, such as taxes, is absent. The administrative costs involved with these schemes are fairly small because common use can be made of the already existing institutions, and mainly deal with the transmission of information.

However, in this respect another participant expressed his concern about finding the proper mix of regulatory and voluntary policies, and indicated that according to his view, one first of all should focus on increasing the efficiency of regulatory measures rather than increasingly relying on voluntary measures.

6. Forestry, Public Awareness & Environmental Auditing

I THINK THAT I SHALL NEVER SEE... A LOVELY FORESTRY POLICY: LAND USE PROGRAMS FOR CONSERVATION OF FORESTS

Steve Rayner and Kenneth Richards
Pacific Northwest Laboratory[1]
Battelle Memorial Institute

Abstract: This paper describes a suite of instruments that are commonly employed to implement a given policy. These are initially applied to a relatively simple case--a tree planting program in the U.S.--to demonstrate the difficulties involved in implementing a carbon sequestration program, even in a well-developed market economy. The choice of policy instruments and program design is more difficult with other forest technologies in the U.S. than for the simple tree planting case. We also examine problems that arise where economies may bear less resemblance to the ideal market economy than in the U.S. In those settings the choice of policy instrument must be sensitive to non-market considerations that are often missed in conventional policy and cost analysis. We conclude that although economic incentives appear to be attractive options for simple cases of tree planting on marginal lands, regulation, information programs, RD&D (Reaerch, Development and Demonstration) instruments, and direct government investments also have a role to play in implementing forestry policies to reduce greenhouse gas emissions. The actual selection of policy instruments may depend as much upon the inherent preferences of particular institutions-private sector, environmentalist, and regulatory -- as upon judgments of relative economic efficiency.

Introduction

Forestry programs are frequently invoked as having potential for mitigation of greenhouse gas emissions (National Academy of Sciences 1991). Most studies have attempted to quantify the potential impact of forest programs on carbon uptake and on the potential costs of such programs. In this paper we will attempt rather to focus on the institutional issues of the implementation of forestry programs for carbon sequestration. In particular we explore the challenges for implementing forest programs that are:

- of increasing technological complexity; and
- in settings that depart significantly from the idealized conditions of economic models.

We start in section 1 by examining a suite of instruments that are commonly employed to implement a given policy. Section 2 examines a relatively simple case - a tree planting program in the U.S. - and demonstrates that there are significant difficulties involved in implementing a carbon sequestration program even in a well-developed market economy. Section 3 focuses on other technologies in the U.S. and why the choice of policy instruments and program design is more difficult than for the simple tree planting case. Section 4 considers implementation of forestry policies in other countries where the economies may bear less resemblance to the ideal market economy than the U.S. In those settings the choice of policy instruments must be very sensitive to nonmarket considerations that are often missed in conventional policy and cost analysis.

1. Policy Instruments

A wide array of instruments exists for translation of climate policy goals into action at the national and local levels. Various combinations of these would be available for any government seeking to implement forestry programs. Such instruments may be grouped broadly under five headings: economic incentives; regulation; information; research, development, and demonstration (RD&D) programs, and direct government provisions of goods and services (DOE 1989).

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[1] Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute under contract DE-AC06-76RL0 1830.

Regulation is defined as legislation or rules, supported by sanctions, that are designed to limit the discretion that may be exercised by public and private decision makers. Such legal and administrative means are exemplified by rigorous effluent emission standards with large effective penalties. Efficient regulation depends on good data according to which performance standards or emissions limits can be fixed for a technology or environmental discharge. The major benefits of regulatory programs when the costs of obtaining the appropriate level of information are very high for a large number of dispersed decision makers. Under these circumstances the regulator is able to reduce information costs to decision makers in the form of standards. However, regulations may be administratively quite costly and inflexible. For example, certain restrictive standards, particularly those that specify the technological means to achieve environmental ends, may hinder the progress of new technologies. Rules restricting clear cutting activities and requiring replanting following timber harvest are examples of direct regulation of forestry activity.

Economic incentives can be used to correct the undesired side effects that may arise from the behavior of private agents in pursuit of private objectives. These kinds of policy generally are designed to ensure that consumers and producers face the true costs of their decisions, but allow them a high level of discretion about how to deal with those costs. Economic incentives include any tax, fee, loan, subsidy (including directed government purchases), or rule change (such as creating a property right in marketable emissions allowances) that is designed to alter the consumption of a good or activity by changing its price relative to the prices of other items that consumers might choose freely.

The major instruments affecting prices are emission fees and subsidies, tradeable emission rights, and deposit-refund systems. Emission fees put a price on pollution and confront the emitter with the full cost of his or her actions. This has considerable political appeal as well as widely recognized properties of economic efficiency. However, uncertainty about costs of damages, emission control costs, and effectiveness of such a system to influence decisions reduces the attractiveness of emission fees. Additionally, the concept of paying to pollute may be unacceptable to an array of environmental advocates, while the sudden rearrangement of property rights may be highly objectionable to manufacturing interests.

The U.S. commonly employs subsidies and cost sharing mechanisms to encourage landowners to establish or replant forest stands. Carbon offset arrangements by which a landowner would be awarded marketable CO_2 emissions allowances in return for carbon sequestration activities are often discussed in the context of the greenhouse effect.

Information is a commodity that is especially subject to problems of market failure. With much information, once it is produced, it is very difficult for the producer to capture its full value. Consequently, the markets for some types of information can fail to exist, or can function poorly. As a result economic agents often are forced to make decisions with far less information than could be available to them if information markets worked better. Government can influence private sector actors to alter their behavior by improving the information available to them. Four major types of informational programs are advertising, education, moral suasion (jawboning), and signalling. These programs are more effective when combined with other types of incentives, e.g., with economic incentive, regulatory, or RD&D programs. They can improve the effectiveness of those other programs by strengthening or creating informational markets that are weak or nonexistent.

Information programs can intervene at a number of points to various ends. Government may wish to increase the volume of information available or the rate at which it moves from producers to final users; it may wish to bolster memory capacity or facilitate learning, both altering the effective stock of knowledge; and it also may want to influence evaluative activities by improving information feedback loops. The U.S. Forest Service commonly uses education and advertising mechanisms to encourage owners of underproductive forest land to modify their practices to improve timber yields.

Research, development and demonstration (RD&D) programs offer another set of instruments for policy implementation. It is difficult, if not impossible, for an individual or firm undertaking basic research to appropriate the full benefits derived from it. Consequently, private agents well tend to undertake less basic research that is desirable from a society-wide perspective. Applied research, on the other hand, sometimes suffers from a common-property problem associated with the possible capture of a valuable patent by the first party to develop all invention or innovation. In these common-property situations, there is a tendency for too much research to be undertaken by multiple private parties, with the society-wide benefits from the eventual discovery being dissipated in competitive research to get the patent rights.

Demonstrations can suffer from high risks associated with expensive projects that may or may not be capable of commercialization and from attendant free-rider problems. Once the technology is demonstrated successfully agents who did not share in the costs and risks of the demonstration usually can use it, at least at a license fee which may fail to capture the full social value of the new technology. A major goal of RD&D strategies is to reduce risk and uncertainty, including: technological uncertainty, cost uncertainty, demand uncertainty, institutional uncertainty, and uncertainty about external and indirect effects of the technology on, for example, health, safety, and the environment. In the forestry context, RD&D activities include yield studies, developing fast growing hybrid species field tests of alternative management methods, and development of biomass fuel systems.

Direct government provision of goods and services may be appropriate in the case of public goods, such as air quality, that cannot be provided by the private sector. Generally, when uncertainties regarding the character and level of goods and services needed make it impossible to develop full contracts between the government and private sectors, government production may be the only viable alternative. Examples of government production of forestry services are the National Park System and the U.S. Forest lands.

These very brief summaries and examples of implementation instruments indicate that each has characteristics that might be more or less attractive to important constituencies in U.S. society. Private sector institutions seem to favor implementation policies that maximize the discretion of individual decision makers and firms. We may therefore suppose that they will favor carrots rather than sticks. Positive economic incentives, such as subsidies and tax breaks are likely to be favorably received. Government support for RD&D, for example into biomass energy, also could be popular with this constituency, especially if private firms can enjoy proprietary control over innovations. On the other hand, the private sector may be suspicious of informational programs that hint at moral suasion, or jawboning.

At the other extreme, environmentalists, especially deep ecologists, may emphasize sticks rather than carrots. Because of concern about *regulatory capture,* environmental groups are likely to favor command and control regulation, uniformly applied without the exercise of discretion by regulators or regulated firms and individuals. Economic incentives may be acceptable, especially if linked to regulation. However, systems such as emissions permits are likely to be frowned upon as licenses to pollute. Information programs, particularly those designed to expose weaknesses in the compliance records of firms, also may be well received by environmentalists if information can be used as a stick to beat slow bureaucracies or sly entrepreneurs.

Regulatory agencies, on the other hand, are likely to see themselves caught between a rock and a hard place. Their orderly instincts may incline them towards the predictability and ease of monitoring associated with command and control regulation. However, their need to reconcile their own agendas with those of the firms and individuals they must regulate may lead them to favor a combination of economic incentives backed up by regulation. In any case, regulators are often sympathetic to demands from market constituencies for the exercise of discretion in the application of regulatory rules. Regulators' ability to exercise such discretion (for example grandfathering activities of firms that were practiced prior to regulatory rule making) is likely to be restrained in proportion to the strength of environmentalist objectors. Information is likely to be favored by regulators to the extent that it facilitates their own regulatory tasks. However, they may tend towards skepticism as to the usefulness of public information programs. In summary, we may expect regulators to favor policy instruments that combine carrots and sticks according to pressures from the other two constituencies.

These observations about institutional preferences for implementation measures are summarized in Figure 1 which defines a triangular policy space within which any mix of instruments can be located. Of course, institutional preference alone will not determine which implementation instrument will be selected. However, these disaggregated preferences are entirely ignored by the homogenizing individual self-interest assumptions of neo-classical economics.

The Reagan-Bush decade has signalled a preference for economic instruments for a wide variety of environmental policies, in contrast to the regulatory approach of the Carter years. It has been predicted that the Clinton-Gore era will see an increasing emphasis on information and RD&D as environmental policy instruments, especially in collaboration with the private sector (Rayner 1993). If the provisions of the President's Climate Change Action Plan (Clinton and Gore 1993) are any guide to the future of U.S. environmental policy implementation, this prediction is well on the way to fulfillment.

2. The Simple Case: Tree Planting in the United States

Most economic models employed to examine the effects of greenhouse gas policies concentrate on the energy sector. In these models fossil energy fuels are treated as commodities that are traded and consumed in reliable and predictable ways. Each of these commodities are fungible and, especially for stationary energy uses, are highly substitutable for one another. They are widely traded in well-established markets where information is plentiful and prices are responsive to fairly uniform trading opportunities.

In contrast, modeling the effects of forestry policy on carbon dioxide emissions and carbon sequestration is a more difficult task. Three considerations - scientific, behavioral and programmatic uncertainty - create a very complex modeling problem. In some cases the uncertainty applies even to the direction of expected change in both the costs of carbon sequestration and the potential accomplishments. These conditions are more properly characterized as *indeterminacy,* which exacerbates the challenges of designing and implementing appropriate policy options.

2.1 Scientific Uncertainty

Several factors combine to determine the ultimate carbon yield of a given tree planting project in the U.S. These factors include the species planted, previous uses of the land, region of the country, soil type, planting practices, density of planting, management regime, and ultimate use (if any) of the timber. Although the U.S. has one of the most comprehensive databases on forestry planting, management, and yield figures, there is still little agreement regarding the appropriate yield figures to use in either analysis or regulation of carbon sequestration programs. The most often cited figures are those provided by Birdsey. These have been modified and updated over the post four years to reflect additional research (Birdsey 1990, 1992). However, in policy analysis work many estimates of expected carbon yield vary significantly from the Birdsey figures. In his highly cited work, Nordhaus (1990) uses figures that are much lower than those of Birdsey. Others have suggested that the appropriate yield figures may be a factor of four higher than Birdsey's.

2.2 Behavioral Uncertainty

The land and timber markets in the U.S. are perhaps closer to the economists ideal market than elsewhere in the world, and even here it is difficult to predict how downers will respond to various carbon sequestration programs. First, the rental rate (or purchase price - depending upon the nature of the program) is difficult to predict in a program that involves removing large quantities of land from agricultural production and planting it with a crop that has a rotation length of 25 to 70 years. For example, the rental rates under USDA's Conservation Reserve

Program (CRP) are considerably higher than those observed in private market transactions (Moulton and Richards 1990). This may be due to the long-term nature of the commitment (10 to 15 years) or due to the fact that contracting with the Federal government is an inherently risky transaction.

Second, if land rental rates for relatively small quantities of land (less than 17 million hectares in the case of the CRP) are difficult to predict, the rental rates for large quantities of land (70 million hectares or more for a large scale carbon sequestration program in the U.S.) are even more difficult to estimate. The marginal cost of agricultural land is expected to go up as more land is removed from production. Ricllards et.al. (1993a) have tried to capture this effect by employing a factor for the price elasticity of demand for agricultural land. However, there are no reliable estimates of this factor. Adams et.al. (1991) have attempted to capture these non-marginal effects through use of an agricultural sector optimization model that measures land costs in terms of losses in producer and consumer surplus. Both studies indicate that the costs of carbon capture rise steeply as large quantities of land are removed from agricultural production. However, neither provides estimates upon which a cautious decision maker would rely.

Third, little is understood about the rates at which farm land could be converted to forest land. This is similar to the technology dissemination and market diffusion problem that faces advocates of new technologies. Even if we could accurately predict the costs and prices of converting agricultural land to forest lands, we would be ill-advised to rely upon such a strategy if the program could not be implemented at a reasonable pace.

Fourth, once land is in production, there may be significant moral hazard problems associated with keeping it in production. The government has a choice of how to design its reward structure. At one extreme, it could make all of its payments to land owners at the commencement of the landowner's sequestration project. At the other extreme, it could make payments only for the amount of carbon stored significantly delaying the flow of payments. The government may be inclined to follow the first approach because the latter approach - delaying the payments - may prove to be a significant disincentive to landowners. However, paying for the carbon sequestration in advance may lead landowners to reduce their management efforts, thereby reducing yields.

Finally, implementation of a large-scale carbon sequestration program may lead owners of existing timberland to change their management behavior. If they see the subsidized planting of new forest land as a potential source of competition for the eventual supply of raw timber, they may be induced to change plans to increase their holdings of forest acreage, to harvest earlier than they otherwise would have, and to avoid replanting recently harvested areas.

2.3 Programmatic Uncertainty

Behavioral uncertainty is compounded by programmatic uncertainty, which may involve either the carbon sequestration program itself or other land-use programs. While it is common to cast economic policy instruments in general categories such as taxes and subsidies or marketable permits and offsets, there are some significant constraints facing the government's use of these tools. Congress has had a difficult time committing to any long term tax or subsidy program (Doernberg and McChesney 1982). Similarly, the government's ability to establish long-term contracts may be hampered by its general immunity, under the doctrine of sovereign immunity, to certain types of contractual damages (Krent 1992). These observations are important in light of the role that risk plays in the landowners' decision to establish carbon sequestration activities. Richards et al (1993b) have shown that as much as 80% of the cost savings associated with inclusion of carbon sink options in a program to stabilize U.S. carbon dioxide is lost if the landowners required rate of return on investments rises from 5% to 20%. The higher rate of return might be required, for example, if landowners viewed participation in the program as highly risky due to Congress' inability to make a credible commitment to a series of subsidies or contractual payments.

Estimation of accomplishments of a large-scale carbon sequestration program may also be complicated by other land-use regulations and programs. For example, the agricultural subsidy programs in the U.S. may in fact be a competitor with a program to convert agricultural land to forest land, providing an alternative form of income for less productive land. This need not be the case, however. Restructuring the agricultural programs, such as an expanded CRP program, could provide positive incentives for establishment of tree plantations even in the absence of an explicit carbon sequestration program.

2.4 Effect on Choice of Policy Instrument

Simple cost analysis indicates that conversion of economically marginal and environmentally sensitive agricultural land may be one of the least expensive ways to significantly reduce net greenhouse gas emissions in the U.S. (Moulton and Richards 1990, Richards et al 1993b). However, these analyses are based upon sets of assumptions regarding the implementation mechanisms (generally government subsidies), landowner expectations, and reliability of the scientific data. In fact, the important policy implementation decisions are less apt to relate to the choice among economic incentives - taxes and subsidies versus tradeable allowances and offsets - than to some very specific design choices. For example, major restrictions on the harvest of timber from subsidized plantations will raise the level of subsidy required to induce landowners to enroll. On the other hand, lack of restrictions may cause counter productive activities by owners of productive activity.

If the government faces significant legal constraints and information hurdles (scientific uncertainty and monitoring) it may seek to provide the carbon sequestration services directly by buying the inputs to production - land, labor, seedlings, and management. However, this approach still faces several difficulties. First, the uncertainty regarding accomplishments remains. Second, while the transaction between the government and the private sector along with some of the need for monitoring have been eliminated, these have simply been replaced by an internal agency monitoring problem. Third, the current political climate in the U.S. is inimical to direct government action of this sort.

Thus, implementation of a large-scale carbon sequestration tree planting program faces significant uncertainties - scientific, behavioral, and programmatic. The government can address these through research, contractual restrictions, monitoring, and development of mechanisms for committing to long-term programs. However, reducing any of these uncertainties is costly and will reduce the cost effectiveness of carbon sequestration policies. The nature of the programmatic and political uncertainty inherent in development of a carbon sequestration program suggests that models that examine only general policy instruments - taxes and subsidies, allowances and offsets - may not capture some important factors that will determine the effects of the program.

3. Implementation Challenges from Technological Complexity

Section 2 focused on the simplest forest technology - planting trees on marginal land. Implementation challenges increase as the desired forest technology increases in complexity. In this section we examine four additional approaches to capturing carbon and reducing emissions that illustrate significantly greater complexity and concomitant challenges for implementation. These are:

- agroforestry;
- urban trees;
- forest management; and
- biomass for energy.

3.1 Agroforestry

Agroforestry represents a syntheses of silvicultural and agricultural practices. Generally, agroforestry practices requires less energy and chemical input per unit output than annual monoculture crop approaches, but may require more land and labor. The advantage from a greenhouse gas emissions standpoint is that agroforestry systems store more carbon in the soil and biomass than annually tilled crops and may reduce CO_2 emissions from fossil fuel use.

From a policy instrument perspectives, agroforestry presents all of the difficulties of conversion of agricultural land, and then some. Not only are the scientific uncertainties every bit as great, the activity itself is less well defined. There are as many agroforestry methods as there are sites on which crops can be grown. There is no standard agroforestry practice. This suggests that measurement of carbon sequestration accomplishments - a necessary prerequisite to either a carbon subsidy or emissions offset approach - is at least very costly. It may be possible to subsidize activities that are likely to lead to carbon sequestration and emissions reductions, but assessing the cost effectiveness of such programs would be difficult.

For two decades, the U.S. Department of Agriculture's Soil Conservation Service (SCS) encouraged American farmers to modify their annual tillage practices, and move toward low-till and no-till approaches. Through their local representatives and extension agents the SCS has also encouraged reductions in chemical and energy use, with substantial success. This approach, which involves a combination of demonstration projects, education and moral suasion, may be adopted to encourage agroforestry and additional alternative agricultural practices that have beneficial effects on carbon sequestration and greenhouse gas emissions.

3.2 Urban Trees

Planting trees in an urban environment may have a much larger impact on greenhouse gas emissions than just sequestration of carbon through photosynthesis. This is due to the modifying effect that they can have on the *urban heat island* effect, especially in warm mid- and low-latitude cities (Taha et al 1988). Dramatic differences have been documented in the cooling energy use of homes on landscaped and unlandscaped sites, indicating that properly placed trees and shrubs call reduce daily air conditioning electricity use by as much as 50% (Parker 1981). The precise time frame within which such an option will reach its full potential will depend on the species planted and its growth patterns, but it is inevitably a medium- to long-term strategy.

Advocates consider planting trees in urban areas to be an inexpensive means of conserving energy, perhaps as low as 0.3-1.3 cents per pound of carbon compared with 2.5 cents per pound for efficient appliances and 10 cents per pound for efficient cars (Akbari et al 1988). However, there is really very little experience with urban tree planting programs of this sort and the scientific, behavioral, and programmatic uncertainties associated with planting trees on marginal land apply. In addition there are problems with planting large numbers of urban trees, including conflicts with infrastructure above and below ground (electric powerlines and water, gas, and sewage pipes) for which damage estimates are not included in planting costs. Monitoring the effectiveness of urban tree planting programs presents further obstacles to any economic instrument. Modifications to local zoning ordinances to take advantage of urban trees in new development may be a plausible instrument, although regional variations in climate, geography, and demography would seem to preclude the development of efficient Federal standards. The best the Federal Government is likely to be able to do is to require states to account for urban forestry effects on energy demand in formulating zoning laws as a condition of receiving Federal funds.

3.3 Forest Management

Forests, whether newly created or existing, are managed resources. It is questionable whether any terrestrial ecosystem is truly unmanaged, although there is a huge variation in the intensity of management. Even the Amazonian rain forest is lightly managed by indigenous peoples at very low densities. Patterns of harvesting game and uncultivated forest products are forms of resource management that ha~re all but disappeared in the U.S., although they remain important in other parts of the world. We distinguish three management strategies:

- mining the forest;
- conserving the forest; and
- preserving the forest.

Mining the forest is the opposite of the simple case of tree planting discussed above. It is the removal of forest and conversion of forest lands to other uses such as agriculture, industry, human settlement, or degraded wasteland. Mining the forest was probably the dominant mode of forest management in the U.S. two centuries ago. Over the past two hundred years, forest management has shifted to the resource concentration mode and even to forest preservation. The overall stocks of U.S. forest land have show a net increase throughout the 20th centuries. However, wide uncertainty remains about the carbon intensity of those forest stocks.

Conserving the forest is essentially rational management to ensure continued supplies of forest resources for human use, Such uses may include recreation as well as extraction of timber. Depending on a variety of factors, the instruments of conservation include various combinations of regulatory and economic instruments. However, these instruments may prove to be highly controversial. The U.S. has recently experienced increasing scrutiny of the use of public lands for timber production, not only in old growth forests. Furthermore, from a carbon sequestration perspective the effects of forest conservation programs are quite uncertain. Better management of forests to increase return on investment does not necessarily lead to net increases in carbon sequestration. This is because maximizing economic yields of usable timber products does not maximize the storage of carbon which may occur in low-value species of trees, in understory, and in litter. Selectively managing for high-value species may in fact decrease the overall carbon storage of a forest stand. Under these conditions of uncertainty, developing widespread acceptance of the policy goal may be far more critical than the selection of policy instruments that directly affect policy management practices.

Preserving the forest differs from conservation in that the goal is to ensure that the forest is never harvested and that the natural cycles of death and regeneration are permitted to proceed without human intervention. Tn the U.S., preservation of individual forests has been an important consequence of the Wilderness Act and has resulted in the preservation of significant tracts of first growth forest. This program has brought important scientific, recreational! and spiritual benefits. However, we cannot say that it has resulted in increased carbon sequestration. Preserving individual plots, while the demand for timber remains constant or increases, merely transfers harvesting activity to other locations. To be of interest as a carbon sequestration strategy we would also have to look at policy instruments that influenced demand for timber. The resulting substitutes, eg. concrete for timber in building, may actually exacerbate rather than improve net emissions. Preservation also presents another potential problem. We would guess that when most laypeople hear about reducing the greenhouse effect through forestry they are thinking about forest preservation rather than conservation strategies. The current controversies over subsidies to timber companies through use of public lands indicate that public support for forestry programs may wane as it is increasingly understood that this is not the case.

3.4 Biomass for Energy

Biomass energy programs have the potential to recycle atmospheric carbon through the terrestrial ecosystem with little or no net emissions. To the extent that such technologies can displace fossil fuels, they have the potential to reduce emissions. However, several significant policy design problems exist.

First, biomass energy technology may be a public good that will not attract sufficient investment to be developed and produced by the private sector. A carbon tax may not be sufficient to generate the requisite level of private investment because of the existence of a whole suite (Table 1) of significant risk factors to be overcome in the commercialization of biomass energy (Cantor and Rizy 1991). Furthermore, private research may be hindered by the *public good* characteristics identified in relation to RD&D. (See the discussion in section 1 of this paper.) In turn this could lead to a general lack of expertise necessary to reduce production costs as well as to establish an advocacy group within the industry to maintain continued research activities.

In the area of financial risk we know that smaller or limited investors (who may include many farmers) do not conform well to general models of rational profit maximization. Informational instruments would likely be required to present convincing arguments about payback periods and explore threshold levels of acceptable risk. Technical risks relate to data on large-scale monoculture plantations, biotechnology, harvesting costs and environmental damages, and the long-term effects on ecological diversity from biomass plantations. These, along with a number of potential environmental issues, would likely require research and development subsidies.

However, the issue of the government picking winners in technology development has become a highly charged political issue in the U.S. which may restrict the use of these instruments.

There is little basis on which to assess whether private motivations and information transfer activities are consistent with the objectives of public programs. However, prudence dictates that the degree to which biomass commercialization depends upon public sponsorship indicates a need to investigate and control for principal-agent risks (where sponsor and program participant may withhold knowledge from each other).

Other problems arise from the absence of related markets for input supplies, output demands, and substitute goods as well as a need for long-term supply contracts to mitigate the long delay in investment payback for woody biomass production.

Finally, widespread implementation of any biomass technology may lead to profound public controversy such as that over nuclear power. Biomass will alter the landscape as corn rows are replaced by large scale coppices or woody biomass shrubs. The character of agricultural communities is likely to change. Already in the U.S. the once heroic figure of the family farmer has been partially displaced by the image of the corporate despoiler of ecosystems through profligate use of agrichemicals. When the goal of agriculture becomes energy production rather than feeding people, we might reasonably expect increasing opposition to agricultural activity.

4. Implementation Challenges from Institutional Diversity

Our focus thus far on the U.S. is not the result of parochialism. We have merely sought to illustrate the problems that arise with implementing increasingly complex forest programs for carbon sequestration and emissions reduction in a society that has perhaps the most ideal characteristics for successful application of the whole suite of conventional policy instruments listed in section l.

These attributes include:

- a well developed institutional infrastructure for implementation of regulation;
- an economy that is likely to respond well to economic policy instruments because it is probably closest to the economists' model of the free market;
- a highly developed information industry and mass communications infrastructure, for educating, advertising, and jawboning; and
- a vast combined private and public annual RD&D budget for reducing uncertainties and establishing pilot programs.

To the extent that these close-to-ideal institutional conditions for conventional policy implementation are missing we may expect to encounter further obstacles to the effectiveness of policy instruments.

For example, many developing and newly industrialized countries have excellent legal, even constitutional, provisions for environmental protection including protection of forests. Many of these are clearly modeled on U.S. precedents.

The Brazilian *Codigo Florestal* of 1965 defines permanent areas of conservation along rivers and head waters, prohibits the use of natural resources in national and other protected parks and stipulates that in Amazonia, no more than 50% of land holdings may be cleared. However monitoring and enforcement of the *Codigo Florestal* is poor to non-existent. Even where it is enforced, there are no limits on subdivision of holdings, and the law has been frequently circumvented by clearing half of a plot and reselling the remaining forested half where once again the 50% law applies. The code has been modified and supplemented several times, but funds and credits for reforestation have never been reliable, and most of the economic incentives that did appear were applied in sub-tropical parts of Brazil where pines and eucalyptus could be grown (Hecht and Cockburn 1990).

The Brazilian Constitutional Convention of 1988 established national obligations for environmental protection. Title VIII explicitly discusses the importance of forest conservation, while Title IX provides for the implementation of large scale regional management exercises, such as the *Planofloro* zoning program for the State of Rondonia. *Planofloro* has focused on directing economic activities into appropriate areas using economic and ecological criteria elaborated from satellite imagery and ground mapping. Unfortunately, such exercises suffer in implementation from the absence of effective regulatory agencies to enforce zoning rules as well as from conflict with other powerful government agencies with different development priorities which receive stronger private sector backing than forest protection.

While this is by no means a comprehensive review, it is sufficient to indicate that, while Brazilian environmental law is well developed and in certain sectors quite innovative, the implementation of those laws may tend to leave more marks on paper than on reality.

We do not single out Brazil. This is a pattern repeated again and again across the developing world (See for example, Jasanoff 1993, Petrich 1993, Perlack, Russell, and Shen 1993). Neither do we see these observations as in any sense and indictment or criticism of these governments. The harsh reality is that they all face a serious problem of scarce resources to carry out the most elementary functions of government. Competition among state agencies for whatever resources are available inevitably leaves environmental protection and forest resource management agencies without the necessary investment to establish effective monitoring and implementation programs. The shortage of program resources is exacerbated by pressures to exploit forest products to earn foreign income and the increasing pressures of population to convert forest land to agricultural land and for human habitation. Under the combined weight of all these factors, the issue of optimizing across regulations, taxes, permits, education, and demonstration projects becomes increasingly academic.

Lack of implementation infrastructure may be the largest single obstacle to effective forestry policies under frontier conditions. These are situations where prior claims of indigenous populations are non-existent or disregarded, and where the ability to monitor behavior, settle disputes, and enforce rules and contracts lie with individuals and groups possessing the power to coerce (Cantor, Henry, and Rayner 1992). Unfortunately, conventional development approaches tend to dismiss these characteristics of the society as mere details of implementation when in fact they represent fundamental structural differences between frontier societies and those where the institutions of civil society essential to the functioning or regulatory regimes or efficient markets are either severely curtailed or altogether absent.

Conventional development approaches are equally complacent about other political, economic, and cultural structures that differ fundamentally from those that we take for granted in economies that most closely resemble the U.S. model. In particular, as we move away from societies in which production and consumption are distinctly separated by the operation of the free market, we begin to appreciate more clearly that the use of land, including forested land, is intimately tied to the satisfaction of a broad spectrum of basic human needs and wants (See Figure 2). The concept of market failure is hopelessly inadequate to capture the interlocking demands and expectation of the land and the human arrangements for its multiple use. It is not an exaggeration to say that the further we move away from the market concept the more the land itself becomes less of a commodity subject to market forces and more a medium of social relations.

This situation is exemplified in the interweaving of mythology and geography upon which certain indigenous North American and Australian societies are based. In the case of many Native Australian peoples the personification of the land is so strong that morphological features are identified as historical ancestors. The relationships of such features to one another actually represent the past history and the current family relationships of the people. If this seems an overly exotic example, it is worth remembering that many European land tenure systems, which even today may be highly localized, embody kin, family, neighborhood, community, and social class relationships which in turn constrain the ability of individuals to buy, sell, rent, or exercise usufruct over land as well as determine the uses to which it is put (Davis 1973, Stevenson 1991).

Other important changes accompany the transition from economic to social principles of human organization. Socially constrained exchange systems carry more complex information about the relationships among parties to transactions. Exchange does not depend solely on signals about price, quantity, and quality among anonymous traders, but signals status, kinship, ethnicity, calendrical periodicity, and a host of other factors essential to sustaining society. The homogeneity of *homo economicus* is replaced by localized adaptation of human society to ecological variation. This transformation is being recognized as all important factor in energy use. Whereas different societies traditionally adjusted their attire, construction practices, and work schedules according to climatic, seasonal, and diurnal variation, the tendency towards homogeneity in market driven systems increases demand for space conditioning, lighting, and transportation. Similarly homogeneity in forestry and land-use practices may increase stress on local environments, once protected by human adaptation. Examples include the &consequences of irrigation, enforced settlement, and changes in land management practices. In these contexts application of tools from the standard toolkit of policy instruments has provoked spectacularly perverse effects.

For 400 years the Sherpas of the Khumbu forests of Nepal maintained a sustainable system of forest management that assured them a plentiful supply of fuelwood (Thompson, Warburton, and Hatley 1986). The system was based on a rotating village office of *forest guardian* who monitored villager's extraction of the resource and whose office was maintained out of the fines he was permitted to levy on those who violated the commons by excessive use. However, in the name of modernity and efficiency the forests were nationalized during the 1950s and control was removed from local hands to those of distant bureaucrats. Once the gentle controls of community self-management were removed, people began taking too much wood from close by and not enough from further away, resulting in patchy and partial deforestation, leading to severe erosion, land degradation, and fuelwood shortages in the villages.

The situation was exacerbated when development experts, anxious to find appropriate technological solutions to a perceived fuelwood crisis provided villagers with alternative stoves to relieve pressure on the forests. Unfortunately, villagers perceived the forest as a resource convertible to farmland, rather than as a renewable resource that could now be preserved, and proceeded to cut the remaining stands of forest upon which they no longer depended for cooking and heating.

Examples of the perverse effects of development programs based on conventional economic theory are not confined to any one geographical area. They are ubiquitous. Certain traditional West American land-tenure systems are based on tenure in standing crops. Planting trees provided people with tenure in land for extended periods which also secured their right to farm annual crops on the understory. This resulted in a sustainable agroforestry system. Furthermore, the trees frequently provided cash crops for the farmers. Development economists, however, anxious to promote production of these cash crops reasoned that fewer than the optimal number of trees were being planted precisely because people did not have tenure in the land itself and therefore lacked security in their investment in trees. Providing tenure in the land however actually removed the principle tree planting incentive. Farmers pursuing shorter term productivity of annual crops actually removed trees, resulting in baked soil and loss of windbreaks leading to soil erosion, land degradation, and the collapse of sustainable agroforestry.

Perverse effects such as these are not exceptions to the rules of formal economics, but the reality that those rules fail to account for. Economists assume *ceteris paribus* when making instrument choices just as in determining goals. The point is that *ceteris* seldom is *paribus*, and the results, as described above, are frequently disastrous or, at best, irrelevant.

Of course, "Development experts have learned to their cost that the impressive arrays of policy levers displayed in the ministries of many of the less-developed countries are, all too often, not connected to anything" (Thompson, Warburton, and Hatley 1986:92). This is usually interpreted as a symptom of underdevelopment that can be remedied by nurturing market style institutions and regulatory regimes typical of the developed world. The effectiveness of this approach is debatable even when dealing with a relatively homogeneous commodity, such as energy. It completely ignores the fact that "Land use patterns are an expression of deep political, economic, and cultural structure; they do not change when all ecologist sounds the alarm that a country is losing its resource base" (Eckholm 1976:167). If the threat of losing valuable national resources does not motivate structural change, there seems little hope that any conventional policy instrument that ignores these aspects of deep structure will persuade people to alter their behavior to obtain uncertain benefits for the global climate.

4.1 Exploiting Diversity in Policy Implementation

Perhaps the challenge for policy implementation is not to force the U.S. free market model on the wo~ld, but to design programs for policy implementation that exploit political, economic, and cultural diversity.

The first way in which we might approach this goal is to abandon the search for the "magic bullet" of implementation. The prospect of perfectibility held out by neo-classical economic theory may prove to be the enemy of the political good. Even in the case of highly developed market economies, we have noted that different constituencies may have strong preferences for different kinds of implementation instrument based on considerations other than economic efficiency, This is not to argue that we should abandon the conventional suite of policy instruments, but that we need to pay more explicit attention to the reasons for these preferences and account for the relative distribution and strength of each constituency among the parties that the policy is designed to effect. This is also a powerful argument for focusing on policy implementation packages, rather than individual instruments in the process of policy design and implementation.

A second, complementary approach is to supplement the conventional suite of policy instruments by examining, indigenous traditional mechanisms of social regulation that we might harness to the policy goal of reducing greenhouse gas emissions through forestry. The traditional institutions of forest guardianship in Nepal and the traditional land tenure systems of West Africa are obvious examples. Other instruments may be more subtle. For example, long before the evolution of the modern nation state, religion was a powerful force in shaping individual and collective behavior. Even today It continues to be the overriding authority in the lives of much of the world's population. Let us at once disclaim any of the fashionable romantic notions that indigenous tribal peoples universally live in spiritual harmony with the natural world. For some, lack of technology and static population size are all that stands between them and massive environmental degradation (Rayner 1989). However, for others, such as the many of the Bantu speaking peoples of Africa, forests are the dwelling places of ancestral spirits which may not be violated with impunity. Modernization of traditional beliefs through education and religious conversion and the intrusion of outsiders into traditional territory through individualization of land tenure, has led to a decline in forest cover. Cases such as these raise the interesting question of whether culture, including religion and land - tenure traditions, can be used as effective elements in a package of policy instruments.

In some cases, religious protection of forest stands is effective, but limited in geographical extent. For instance, travelers in Rajasthan have been struck by the stark contrast between the prevailing desiccated shrubbery of the countryside and the lush oases surrounding Hindu shrines (Gold 1989). These are the domains of deities within which human actions that degrade the environment are subject to divine sanctions. Both ancient and modern tales abound of the misfortunes befalling those who violate these divinely protected areas. But, whether the tale concerns the death of an elephant sent to clear a grove by a Mughul iconoclast or a contemporary fatal accident involving road building machinery, the message is clear. The groves are protected from degradation.

One such tale from Rajasthan concerns an event in the 1930s which seems to have been a precursor of the modern Chipko movement. When faced with paying a tax to the Maharajah of Jodhpur or permitting his agents to cut wood, the villagers of Khejarli are reported to have responded that "To set a price is sinful." The villagers wrapped themselves around the trunks of the trees while the laborers chopped them down. One by one, 363 people were said to have been martyred to save these trees. The later emergence of the Chipko (literally tree-huggers) movement illustrates not only the deep cultural origins of a modern social movement strategy, but also points to another strategy worthy of investigation for those interested in policy implementation. That is the role of social movements in both developed and developing nations. Social movements, in combination with issues of cost, played an important role in forcing advanced market societies to abandon nuclear energy. Might their encouragement and nurturing not be worthy of consideration as part of a package of policy instruments dedicated to reducing carbon emissions through forestry?

Social movements are a specialized form of social networks. Networks work in other ways that could enhance forestry programs. For example, a vigorous program of private sector tree planting was undertaken in Los Angeles immediately prior to the 1984 Olympic Games (Tree People, 1983). A large lumber company provided 600,000 drought-resistant seedlings in containers that were distributed by a fast food chain, with postcards to be returned when the seedlings were planted. Schools and neighborhood groups also planted trees and undertook to water them for the critical first two years. Later in the program, distributors gave out more seedlings bringing the total to more than one million. Unfortunately, there was no evaluation of the program to see what fraction survived. However, less than $1 million were spent on the entire effort, mainly for printing and advertising, which translates into less than $1 per seedling. If only 20% survive to maturity the cost is still equal to the Akbari et al's 1988) lowest estimate of $5 per tree for urban plantings.

Networks can be especially powerful in highly localized situations where markets are likely to fail due to small numbers of traders, etc. Examples include successful common property regimes. Since the publication of Garret Hardin's (1968) celebrated essay on *The Tragedy of the Commons,* development experts have been intent on dismantling common property regimes wherever they are encountered. The true tragedy here is that Hardin was not talking about common property at all, but about open access regimes where no controls exist over the common use of renewable resources. Yet successful, sustainable common property regimes operate all over the globe (McCay and Acheson 1990). The Solway Marshes in the north of England are managed by a combination of privately owned *stints* or grazing rights, and collective control of the grazing level through a venerable local body that makes an annual assessment of the ecological status of the common and fixes the number of cattle or sheep per stint accordingly. Successful grazing commons exist in places as diverse as Botswana and Switzerland (Stevenson 1991). The same principles were implemented by the traditional forest management systems of Nepal. Such systems seem admirably suited to situations where monitoring and enforcement by central authorities is constrained and where efficient markets cannot operate. The essential features of successful common property systems include:

- clear definition of the boundary of the resource;
- a finite population of those entitled to use the resource;
- recognition of reciprocal externalities imposed by use of the resource; and
- the ability to enforce sanctions on violators.

Where central control is weak but these conditions can be satisfied, establishment of decentralized common property regimes may well be more viable instruments of forest protection than free market mechanisms.

We have suggested some directions in which we might explore unconventional alternatives to command and control regulation and markets. Are there unconventional analogues of informational and RD&D instruments as well?

The answer may well be yes, if we are able to muster the humility to listen as well as to speak and to observe as well as to demonstrate. Instead of merely lecturing the poor and the powerless about how to manage their resources we can give them the opportunity to communicate their needs to the rest of us. A successful program along these lines was one that provided the Kayapo Indians of Brazil with video cameras and training in how to use them. Possession of this technology allowed the Kayapo to make incontrovertible records of their negotiations and agreements with forestry companies seeking to operate on Kayapo lands. When the agreements were violated, the Kayapo were empowered to seek legal remedies in court and apply moral suasion by providing the video footage to the global mass media.

An unconventional analogue of RD&D programs focuses on the demonstration component. We suggest that learning from local knowledge of land use and management (including management of water resources and other essential inputs to successful forestry) may prove to be a useful tool for implementing forestry policy goals.

5. Conclusions

Although economic incentives appear to be attractive options for simple cases of tree planting on marginal lands, regulation, information programs, RD&D instruments, and even direct government production of carbon sinks, may also have a role to play in designing policy implementation programs for reducing greenhouse gas emissions through forestry. The actual selection of policy instruments may depend as much upon the inherent preferences of particular institutions - private sector, environmentalist, and regulatory - as upon judgments of relative economic efficiency. Conventional economists view such preferences as obstacles to efficient policy implementation and seek to override or eliminate them. However, we suggest that these preferences are so pervasive and entrenched (because they serve other important social goals) that we might do better designing our forest policy instruments to fit them.

Furthermore, the noneconomic instruments appear to increase in importance under two sets of conditions that may apply independently or simultaneously. The first of these is the increasing complexity of forestry technology. The second increase occurs as we move further from the idealized conditions of economic models to societies where land is not simply a commodity but may be a dominant idiom of social relations. We also conclude that failing to account for these different social, political, and economic structures, or treating them merely as issues of implementation, is to invite perverse policy outcomes. Policy implementation packages need to be tailored to take account of regional, national, and local diversity as well as the preferences of powerful constituencies.

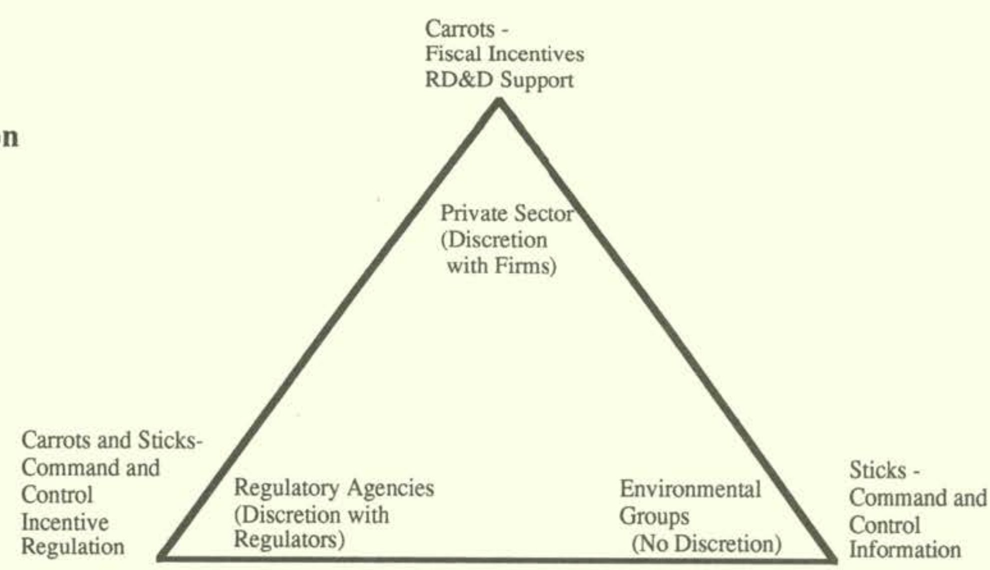
Finally, we have suggested that it might be worthwhile looking to these societies for new policy instrument concepts to supplement the conventional policy makers' toolkit. Notwithstanding the powerful tendency of neo-classical economics to homogenize human behavior and motives, in the final analysis, cultural diversity may prove just as valuable to humanity as biodiversity. The resulting forest policy implementation program may lack the loveliness of the neo-classical model, but it may be more effective.

Table 1 Risk Types and Underlying Issues

FINANCIAL	Harvesting costs Productivity Crop selection Future costs and time horizon
TECHNICAL	Production scale Genetic engineering Herbicides/insecticides/fungicides Monocultures Fertilization Harvesting Irrigation
ENVIRONMENTAL	Deforestation Wood combustion Fertilizers, pesticides, herbicides Competition with food production Irrigation Ecological diversity Soil erosion Nutrient depletion Sedimentation Dust emissions
PRINCIPAL-AGENT	Effort to grow biomass crops Value of biomass to energy strategies Communication channels Needs of private-sector participants
MARKET ACCEPTANCE	Missing related markets Long time horizons Traditional demand patterns Non-proprietary information Expertise
PUBLIC ACCEPTANCE	Labor resources Occupational risk Competition for land and water Disruptions of the natural environment Biotechnology Macroeconomic shifts

Source: Modified from Cantor and Rizy, 1991.

Figure 1
Policy Space for Implication Instruments



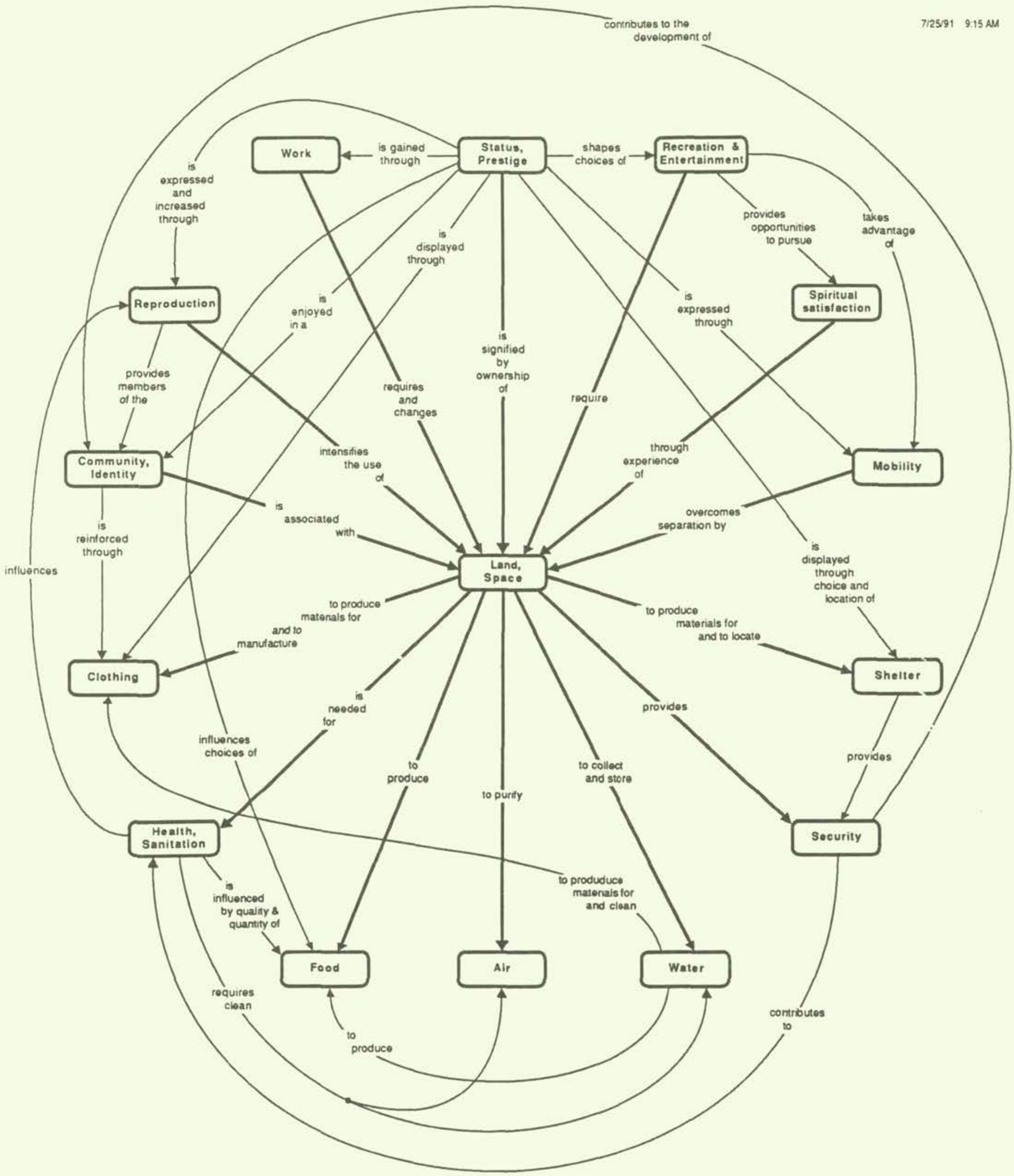


Figure 2: Human Needs and Land Requirements

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PUBLIC AWARENESS
-Public Policy and Energy Efficiency Information Programs-

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Abstract : Government and utility programs that are designed to encourage or regulate energy consumption in the US have been in existence for at least the last twenty years. Many of these programs have been less than successful at achieving their goal of decreased dependency on non-renewable energy sources. One reason for the lack of success appears to be the impersonal mechanisms used to communicate the purpose and goals of the programs. Although the public supports government conservation efforts and believes that energy efficiency should be one of its major focuses, individuals have taken very little action toward reducing their own energy needs. This follow paper will discuss the role of consumer education is making these programs more effective.

1. Consumer Education Theory and Practice[1]

In a recent article in Home Energy magazine[2] , Merrilee Harrigan, senior program manager with the Alliance to Save Energy in Washington, D. C. noted that although "...the public thinks government should make energy efficiency and renewables their first or second priority for energy funding and development" and that they "also support government incentives and regulation that promote efficiency..." only a small percentage of the population has actually purchased and installed energy efficiency measures or taken advantage of the range of services and programs offered by their local utility company. According to Harrigan, "Utility mailings and bill inserts typically get response rates of under 5%. Nationally, fewer than 6% of eligible households have taken advantage of free utility-provided energy audits."

Effective consumer education is defined by Harrigan and other experts in the field of energy education as information that is presented in such a way as to move the consumer to take some action. Some of the basic principles associated with effective education include:

- Individualized and personal information;
- Feedback;
- Recognition; and
- Commitment.

Consumer education is focused on changing both the attitude and the behavior of the public. Without a change in behavior, there can not be an measurable reduction in energy use, regardless of the public's "attitude" about energy issues. In another Alliance to Save Energy publication, "Moving Consumers to Choose Energy Efficiency"[3] , the author suggested that, among other things, "programs that provide only information are generally not effective in changing behavior", "...specific, relevant, graphic, and credible information...is effective in increasing the efficiency of home improvements" and "social interactions have a powerful influence over consumer behavior". In light of these theories, the following overview presents

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1 In the writing of this section, I have borrowed liberally from the research, application and writings of Merrilee Harrigan, Richard Katzev, Lydia Gill, Margery Kloepfer, J. Walker Perry, Hap Haven, Bonnie Esposito, the National Energy Education Forum, and many others who continue to develop and communicate sound adult education theory and practice.

2 Harrigan, Merrilee; "Can We Transform the Market Without Transforming the Customer?"; Home Energy, January/February, 1994; pp.17-23.

3 The Alliance to Save Energy; "Moving Consumers to Choose Energy Efficiency"; July, 1991.

some of the policy and information programs that have been used in an attempt to increase energy efficiency in the US. and discusses why some of these approaches may have not obtained their goal of decreased energy use.

2. Programs and Policy Mechanisms Designed To Increase Conservation

Energy plays a crucial role in the economic and environmental health of the planet; governments recognize this role and actively engage in the formulation and implementation of energy policy.[4]

Government policies and programs, as well as utility programs and utility-government partnerships have been used to promote conservation and energy efficiency for at least the past twenty years. Despite the fact that energy prices have been at a all time low in the United States, mechanisms as diverse as building and equipment standards, taxes, home energy rating systems, and consumer education have been used to encourage conservation and energy efficiency by both energy consumers and energy providers. Some of these approaches have been more successful than others in obtaining their conservation goals.

2.1. The Role of Building Codes and Standards

The use of building codes for both residential and non residential buildings is not a new phenomena. Building energy standards have been in existence for commercial building design and construction for nearly twenty years[5] , energy codes have been used in the States of Oregon and Washington to regulate non-residential buildings construction for over ten years[6] , and only four (4) states do not use either the Model Energy Code (1989), and ASHRAE/IES Standard 90 (1989) in the regulation of new construction of commercial buildings. (Thirty-six states apply these codes or standards to the construction of all buildings, while ten states only apply the code to certain public and state buildings). In addition to building codes and standards, codes and standards have been developed to address lighting, motors, shower heads, faucets, residential and commercial HVAC equipment, and other equipment and appliances.

Historically, the implementation and enforcement of energy standards for residential structures (1-3 units) has been more problematic. Although these standards may be a part of a state's energy policy, enforcement of these standards is often left to local governments, where the policy of "home rule" applies. In spite of the existence of these codes and standards, several research projects have suggested that a gap exists between the existence and the implementation of energy standards. As Conover noted, "...the adoption of a particular energy standard for new commercial buildings establishes legal requirements that influences the design and construction of the structure..." however, compliance may fall on state and local governments. Among other things, the lack of compliance has been attributed to 1) stringent and difficult to understand standards, 2) the lack of necessary information concerning energy, 3) instructions that are missing at the job site, 4)penalties for non-compliance are not often levied, and 5) the lack of training.[7]

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4 Berkowitz, Paul; Panel 6 Overview, Government, Nonprofit, and Private Programs, ACEEE 1992 Summer Study on Energy Efficiency in Buildings; American Council for an Energy-Efficient Economy.

5 Conover, David R., R. Jarnagin, D. Shankle; Pacific Northwest Laboratory; Commercial Building Energy Standards Implementation: Myth vs Reality; 1992 ACEEE Summer Study Proceedings.

6 Baylon, Bruce; Ecotope, Inc.; Commercial Building Energy Code Compliance in Washington and Oregon; 1992 ACEEE Summer Study.

7 Conover, David R

The lack of training is one area that can be addressed through the educational approach suggested by Harrigan and her colleagues. The approach based on individual and personal information, feedback, recognition, and commitment, used for residential DSM programs, could easily be adapted in the training of code developers and inspectors so that there is both recognition and accountability for the development of clear, simple codes and standards and their enforcement.

2.2. The Residential Conservation Service Program[8]

The Residential Conservation Service Program (RCS) was authorized by Title II of the National Energy Conservation Policy Act (Public Law 95-619). The program was mandated by Congress:

> *...to encourage the installation of residential energy conservation and renewable resource measures in the homes of customers of large gas and electric utilities and home heating suppliers.*

Under RCS, utilities with a large customer base were required to provide services and information that would promote conservation activity and the installation of conservation measures such as attic and sidewall insulation, clock thermostats, solar domestic hot water systems, and caulking and weather-stripping. RCS legislation stated that "State governments may prepare a State Residential Conservation Service Plan (State Plan) governing the development and administration of utility programs by covered regulated utilities operating within their states." Customers were to be offered a low-cost or free energy audit so that they could make informed choices about the effectiveness and cost effectiveness of different conservation strategies. Services provided under the Program included:

- Information about potential savings associated with various conservation measure;
- An energy audit
- Arrangements for the financing, purchase and installation of conservation measures;
- Lists of suppliers, contractors, and lenders associated with the Program; and
- Post-installation inspections.

The Program, which was mandated for a five-year period (through 1985) had an expected response rate of 7 percent. DOE estimated that 75 percent of the customers that requested an energy audit would "purchase at least one energy conservation measure addressed in the audit". DOE further estimated that environmental impacts, in the form of reduced pollutant emissions, would result from the installation of the conservation measures installed under the Program. It was estimated that the "reduction in residential energy usage for the Program [would be] 11.04 quads." Attic, wall, and water heater insulation were expected to account for nearly 71 percent (7.86 quads) of the total reduction in energy use.

Although the RCS program held much promise for communicating conservation opportunities to homeowners, a 1985 report by the Government Accounting Office found the program to be less than successful. The response rate was lower than expected (5%) and, according to the report, the fact that a household requested an audit did not necessarily mean that any conservation measures were installed. In 1985, Congress failed to re authorize RCS. In hindsight, it was clear that the mechanism for communicating the value of the RCS Program was one of the obstacles to its acceptance by consumers. Far too often, either out of ignorance about how consumers adopt new behaviors in their energy use or a simple lack of enthusiasm about being required to provide conservation services, utilities did little more than was required by law to inform their customers about the services available to them. It most cases, this information was provided through bill stuffers, a strategy, as noted earlier, that has been unsuccessful at changing behaviors. Customers apparently didn't know the RCS Program existed or were not motivated to change by the information they received.

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8 US. Department of Energy; Residential Conservation Service Program: Final Environmental Impact Statement; November, 1979.

2.3. US Department of Energy's Low-Income Weatherization Assistance Program

Since 1976, the US. Department of Energy (DOE) has operated one of the largest energy conservation programs in the nation - the low-income Weatherization Assistance Program (WAP). The program strives "to increase the energy efficiency of dwellings owned and occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, the handicapped, and children."

Recently, DOE, together with Oak Ridge National Laboratory, completed an evaluation of energy savings for units weatherized in the 1989 Program Year. The evaluation was the first endeavor to determine energy savings generated by the national program since an 1984 evaluation of unit treated during the 1981 Program Year. Since the 1984 evaluation, the weatherization program had instituted many regulatory and operational changes, including "new funding sources, management principles, diagnostics procedures, and weatherization technologies". In addition, many local and state programs through which the WAP is administered have, mostly on a volunteer level, included energy education as one of the services delivered.

The weatherization program treated 198,000 houses in the 1989 Program Year. Of the total houses weatherized, 95,832 heated their homes with natural gas, 18,018 with electricity, and 84,150 with other fuels (propane, wood, etc.). First-year energy savings per dwelling was estimated at 17.0 MBtu's, "resulting in a total savings of 3,370,000 MBtu's during the first year. At an equivalence of 5.8 MBtu's per barrel of oil, the program saved 581,000 barrels of oil during 1990...Over the 20-year lifetime of the weatherization measures, the Program's savings amount to 67,500,000 MBtu's or 11,638,000 barrels of oil.

In addition to direct energy savings, a conservative estimate of environmental benefits due to "reduced energy production, distribution, and consumption" was estimated at $12.85 per unit. These benefits, which were limited to the analysis of SO_2 and NOx for houses that heat with natural gas, fuel oil, kerosene, and liquid propane, are detailed in the following table. Based on the number of completion's in 1989, the total dollar benefit to the environment was over 2.5 million dollars.

Energy Form	Environmental Cost per MBtu	Adj. % of units using fuel type	1st year energy savings MBtu's	Environmental benefit per Wx dwelling
Natural Gas	$0.128	52.8	17.2	$1.16
Electricity	$4.103	9.9	18.8	$7.64
Fuel oil /kerosene	$0.775	22.4	21.8	$3.78
LPG	$0.128	14.9	14.2	$0.27
Total				$12.85

Unlike the programs described in the following section, the WAP does not currently have a formalized education component. On the state and local level, consumer education may be included in the services offered to program participants. The opportunities, however, for both consumer education and technology transfer are abundant. In some cases, like the partnership between a New York State utility company and the State Weatherization Program, the weatherization program installed conservation measures in the home and the utility funded the cost of education. In other examples, state offices though which the weatherization program is administered, either requires or strongly encourages some form of consumer education. Even when no formal education component exists, the weatherization program can serve as a model for emerging utility conservation efforts. (In the worse case, the program has served as a model of what not to do.)

As noted early, the weatherization program has changed considerably since it's inception. There is general agreement among weatherization practitioners and program evaluators that the weatherization program, as it exists in 1994, has improved considerably over the year addressed in the national evaluation. As the technology used in the implementation of the weatherization program continues to improve, consumer education is incorporated into more programs on the state and local level, and the mechanism for quantifying environmental effects is refined, the benefits of the conservation services to the environment will only increase.

To date, there is no comparable program available to middle and upper income households. The use of developing technologies and information in both the implementation and the evaluation of this program, if effectively communicated to consumers (regardless of program eligibility), can result in the expansion of energy efficiency efforts beyond the low-income population described in the above example. Public utility commissions and other regulatory bodies can play an active role in this communication process.

2.4. The Role of Public Utility Commissions

> *Over the past few years, regulatory commissions across the country have played a significant role in encouraging utilities to promote energy efficiency and conservation through DSM programs. The DSM-related efforts are linked directly to the role of the regulators in maintaining equity, by balancing the short term and long term needs of both the consumers and providers.*[9]

Increasingly, Public Service Commissions and other regulatory bodies have encouraged conservation activities through the regulatory process entrusted to them. Acting in behave of the consumer, these regulatory bodies have mandated or strongly encouraged utility companies to switch from a supply side to a demand side (DSM) approach to the energy services they offer to their customers. By encouraging conservation rather than production of natural resources, both the customer and the utility benefit. The customer benefits through reduced energy consumption and thus a lower energy bill; the utility benefits by decreasing their need for new construction of generating plants, better customer relations and, upon demonstrating that the DSM program was successful at obtaining it's goals, recovering the cost of the program through the customer ratebase. In theory, the total cost of the providing the conservation program is less than the benefits accrued to the utility, the customer, and society, so everyone is better off.

Several tests have been used to determine the overall costs and benefits of these programs. These tests include: 1) the participant test, 2) the rate-payer impact measure test (RIM, or the non participants test), 3) and the utility cost test, 4) the total resource cost test (otherwise known as the societal test). The Participant Test measures quantifiable benefits and costs to customer as a result of participating in a program. RIM measures impacts on customer rates from changing utility revenues and operating costs. The Utility Cost Test examines program benefits and costs purely from the utility' perspective. The Total Resource Cost Test, which combines the perspectives of the Participants test and the RIM test defines the programs benefits in terms of avoided supply costs to the utility and the program costs as the sum of the utility program costs, plus the costs to the participants and the utility's increased supply costs. Although, each of these tests include an estimate of the measures life expectancy, the cost of energy and an assumed discount rate, other issues that should be considered in the analysis of program costs and benefits are: persistence of savings; the effect of the time frame of analysis; and non quantifiable benefits. The tests themselves serve no purpose unless they can be interrupted so that governments and utilities can make more informed decisions about how the services address the public "good".

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9 Jennings, R, M. Pasqualetti, M. Harrigan, and R. Boscamp; DSM Programs Must Aim at Consumers not Just Technology; Public Utility Fortnightly.

For this reason, the issue of non-energy benefits, which has been the most challenging for program evaluators to identify and quantify, must be included in any calculation of program costs and benefits. Non-energy benefits include affordable housing (extending the lifetime of low-income housing and maintaining or enhancing property values, etc.), comfort, health, and safety (enhancing the livability of dwellings, improving thermal comfort, and reducing incidence of fires, hypothermia, and CO), impacts on household budgets (allowing families to use more of their income for non energy expenditures and reducing utility arrearage and cutoffs), employment and economic impacts (increasing economic output, increased earnings, increased employment and generating federal tax revenues; and environmental externality impacts. It is this last issue that links the field of energy conservation and energy efficiency with environmental issues such as climate control and global warming.

Regulatory bodies, like public utility commissions, owe it to themselves and the public they serve to be informed about conservation practices that work (and those that don't). They need to understand how measured results from conservation and energy efficiency programs can be effectively communicated to consumers and to energy providers in a way that leads to the expansion of programs and services that encourage responsible use of the world's limited energy resources.

3. Examples of Programs That Work

The following two programs present examples of energy savings that can be derived when programs implement consumer education using these basic principles.

3.1. Niagara Mohawk Power Corporation - Power Partnership Project -

Niagara Mohawk Power Corporation, a joint natural gas and electric utility in upstate New York, together with New York State's weatherization program, provided comprehensive conservation and energy education services to low-income families that had a history of high energy use and carrying a high debt with the company. During the pilot phase of the program, the population of eligible households were divided into three groups. The first group received no special services from the utility. Group 2 received weatherization services from the State's low-income weatherization program. Group 3, in addition to receiving energy efficient retrofits, received three home visits where a trained energy coordinator provided the family with information that would allow them to make more informed choices about their energy consumption.

Participants who received both weatherization measures and home visits reduced their gas consumption by nearly 496.4 therms (26%), compared to 303.9 (16.3%) for households that received only weatherization treatment. The control group households experienced a slight decrease in their gas consumption during the same time period. The examination of electric consumption produced similar results. While the non-treatment households increase their use of electricity by 256 kWh (3.7%), weatherization-only houses decreased their electric consumption by 511 kWh (4.5%) and households that received both weatherization measures and education reduced their electric use by 803 (7%).

Group	Savings (MBtu's)	Savings (kWh)	Environmental ($)
Control	36.6	-256	
Weatherization (Wx)	303.9	511	12.03
Education & Wx	496.4	803	16.31

Using similar assumptions as those described in the evaluation of the WAP, NMPC attempted to quantify the environmental benefits of providing conservation services to their customers. Based on these assumptions, the dollar benefit assigned to environmental externalities was around $12. for the group of houses that received only weatherization and over $16. for household that received both weatherization and energy education services.

3.2. The Duquesne Light Company's End-Use Pilot Program

The Duquesne Light Company (DLCO) designed and implemented the End-Use Pilot Program to low-income households that met specific usage and baseload requirements. The purpose of the pilot was to measure the potential for cost-effective electricity usage reduction focused on end-uses. DLCO, whose service territory is comprised of less than 5% electrically heated homes and whose baseload customers pay .1275 cents per kWh, hypothesized that lighting and refrigeration, among other end-uses, may offer more cost-effective, sustained electric reduction opportunities than approaches that address space heating. The goal of the pilot, which began in the second quarter of 1992 and lasted through August 1992, was to determine if a low-income residential conservation program based on electric end-use reduction can be delivered cost-effectively.

The pilot included a home visit by a trained Energy Manager who completed a walk-through audit with the occupant. During the home visit, an average of 5.2 incandescent bulbs (295 watts) were replaced with compact florescent lighting, hardware related to the use of hot water was installed if the household had an electric water heater, the willingness to replace a standard waterbed mattress with a form mattress was identified, and low efficiency refrigerators (>=5 kWh/day) were identified. By the end of the pilot 33 waterbed mattresses and 82 energy efficient refrigerators were installed. Fewer households than expected (24) used electricity to heat water. Of these households, all but two received some water heater treatment (wrap, low-flow showerhead, or faucet aerator).

Participants were grouped by the type of intervention they received. The difference in pre and post-treatment consumption was calculated and first years savings were estimated from findings for each of the three post-treatment months. The following table compares the estimates based on one month of data with the engineering estimates.

	Sept.	Oct.	Nov.	Average	Engi-neering
	Save/yr.	Save/yr.	Save/yr.	Save/yr.	Estimates
lighting Only					
Mean	1483.60	1042.54	822.90	1116.35	403.56
Median	1374.83	755.17	1052.80	1007.43	235.43
Lighting & Waterbed					
Mean	1241.60	2622.13	2759.43	2207.72	1617.44
Median	551.03	1993.66	3160.19	1690.62	1530.15
Refrigerator					
Mean	2264.59	2290.56	2303.82	2286.32	2011.60
Median	2192.99	1980.85	1912.64	1796.83	1819.28
Refrigerator & Waterbed					
Mean	2043.67	2134.22	2946.16	2374.68	3304.89
Median	2339.30	3216.91	3103.44	2795.74	3230.09

Preliminary results from both engineering estimates and short term billing analysis suggests that the end-use approach was effective at reducing energy usage. Based on average savings calculated from the three months of post treatment usage data, pilot participants saved 1698 kWh per year, which represents a savings of $217. The average direct costs (labor and materials) were $684 per household, resulting in a simple payback of 3.2 years. By including the total costs for providing the program (costs for training, program support, evaluation, etc.), simple payback for the pilot is 4.9 years.

Unlike the NMPC project, the End-use Pilot did not have a separate group that only received hardware installation, so it is difficult to separate out the effect of consumer education from the effects of the installed measures. The only indication of the educational effect is found in the difference in engineering estimates and savings calculations based on actual billing data for the group labeled "Lighting Only". This group received lighting measures and education only. The engineering estimates only account for the lighting. Although pushing what we actually know from examining these numbers, education could account for the difference between engineering estimates and savings calculation in this group.[10]

3.3. Summary

Based on measured results of both the Power Partnership Project and the End-use Pilot, it appears that the consumer education principles outlined earlier go beyond theory. In each of these cases, decisions of what services to offer were based on knowledge of the customers billing histories and conversations with the customer that helped the educator determine what services to provide. In both programs, customers were asked to make a commitment to change their energy consumption behavior, they were given feedback on the energy use through an analysis of their bills, and they were given personal and individual information about the energy choices available to them.

4. Opportunities for Technology Transfer and Market Transformation

> *...residential decision-makers are not energy experts and may begin with a very incomplete understanding of how they use energy...* [11]
> *One way to move our society toward a higher level of energy efficiency and broaden the benefits both to our economy and our environment is for regulators to encourage building educational partnerships between consumers and providers.*[12]

Although the results of each of the evaluations described above offer evidence that there exists a substantial opportunity for energy savings and benefit to the environment through energy efficiency programs, all three programs were targeted at a sub-group of low-income energy users, a group that might be motivated to save energy based solely on need. The challenge for government policy makers, regulators, and educators is to find mechanisms for communicating the possibilities for energy reduction and creating an environment where conservation is encouraged and rewarded for all consumers, regardless of their ability to pay for the energy they use. Several mechanisms exist for that communication process.

The educational system, at all levels, has been used to education students about the environment and the consequences of living in a society that is dependent on non-renewable fuel sources. Like some of the programs described earlier, this knowledge has not necessarily led to a generation that uses energy more wisely than our parents. Things may be changing. Utility companies and government have worked closely with school systems in providing information about energy choices. Government sponsored campaigns like "Energy Awareness Month" and programs like the National Energy Education Development Project, can be very effective if they begin to move beyond providing conservation information and begin to adopt some of the more individualized approached endorsed by the Alliance to Save Energy, The Professional Association for Consumer Energy Action (an outgrowth of the National Energy

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10 Refrigerators and waterbeds were, for the most part, not delivered until late September. Deliveries continued through November. Therefore, the engineering estimates assume the replacement of these appliances, but the monthly data does not begin to capture the full effect of these replacements until November.

11 Jennings, R; p4.

12 Jennings, R; p4.

Education Forum) and other individuals and organizations.

One last example of an opportunity to communicate the information that surfaced through the evaluation of energy efficiency and conservation programs is the application of these conservation and education principles via home energy rating systems.

4.1. Home Energy Rating Systems and Energy Efficient Mortgages

> *In March, 1991, the US. Department of Energy (DOE), in cooperation with the US. Department of Housing of Urban development (HUD) initiated a National Collaborative to develop a voluntary national program encouraging energy efficiency in homes through mortgage incentives linked to home energy ratings. Participating in the Collaborative were representatives of the primary and secondary mortgage markets, builder and remodeler organizations, real estate and appraiser associations, the home energy rating system industry, utility associations, consumer and public interest groups, state and local government interest groups, and environmental organizations.*[13]

In addition to the National Collaborative, several states have instituted, or are in process of instituting a Home Energy Rating System (HERS), a system that can provide the consumer of new or existing housing with a rating that lets them know how much that structure will cost to operate and, according to Millhone, "reduce the $100 billion we spend each year on energy for our nation's housing." Similar ratings systems have developed by utility companies in an effort to provide their customers with information on cost-effective energy efficient technology that can be used to both decrease a customers energy bill and increase the comfort level of the home.

To be effective, the HERS has to convey reliable and meaningful information to both the consumer and the range of stakeholders who may have a role in either communicating the value of a HERS to the potential buyer or seller of a home or have to make a financial decision based on the energy rating. When tied to an energy-efficient mortgage, the motivation to the potential consumer of an energy efficient home is the fact that a more efficient home will allow the borrower to more easily qualify for a mortgage because the cost of operating that home will be lower than a less efficient structure.

> *Energy Efficient Mortgages (EEMs) were established by President Carter in 1979. They were made available to consumers in the early 1980's after the five federal mortgage insurance agencies and federally chartered financial institutions (Federal Housing Administration (FHA), Veterans Administration (VA), Farmers Home Administration (FmHA), Fannie Mae and Freddie Mac) agreed to buy and guarantee EEMs.*[14]

Although EEMs have been around since the beginning of the 80s, very few buyers or lenders have been aware of their existence. Nationally, fewer than 1/2th of 1% have taken advantage of Ems. Not unlike the RCS Program, HERS and EEMs run the risk of not being adopted by consumers because the value of the rating system has not been communicated effectively. Because of the one-to-one contact associated with the home buying process (realtor, bankers, builders, etc.), the HERS and EEM process has the potential of greatly influencing consumers to make energy efficient choices.

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13 Million, John P., M. Jenior, B.Farhar; "The National Collaborative on Home Energy rating Systems and Energy-Efficient Mortgages; 1992 ACEEE Summer Study.

14 Rood, Marcy; Office of Energy Efficiency, Ohio department of Development; "Preliminary Recommendations to the Home Energy Rating System (HERS) State-Wide Steering Committee Regarding Energy Efficient Mortgages"; 10/93.

5. Conclusion

Between 1960 and 1979, energy consumption in the US increased from 44 Quads to 79 Quads. By 1986, consumption had dropped to 76 Quads. The 1990s have seen a different trend. Projections for 1992 increased consumption to 81 Quads. Most of the increase in consumption was projected to come from an increased use in electricity. It is clear that despite the array of government and utility funded programs designed in decrease the nation's dependence on non-renewable energy sources, we have a long way to go. To be effective, energy efficiency and conservation programs have to result in the public making choices to use less energy and to use the energy they do use more wisely. The existence of these programs alone will not matter unless the value of them is since by energy users. It is this value that must be communicated through sound, practical and effective education.

ENVIRONMENTAL AUDITING FOR POLICY INSTRUMENTS

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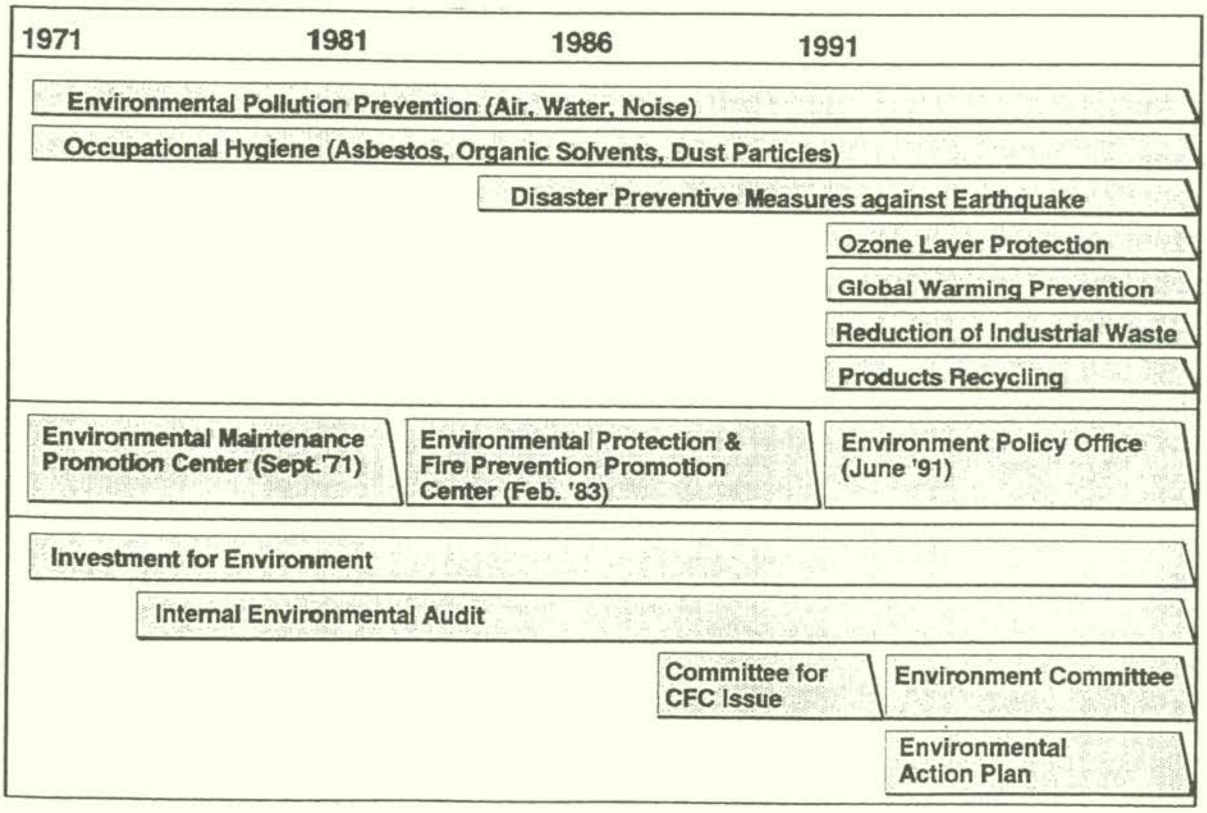
Abstract: In Japan large enterprises have been implementing environmental auditing since 1970s because environmental auditing is considered to reduce risks of pollution. Recently, large concerns on global environmental issues focus it on for policy instruments. In this paper, an experience of environmental auditing, which is carried out by a private company, is introduced and discussed focusing on global environmental issue. ISO (International Organization for Standards) has started to establish the international standards for Environmental Management System and Auditing and these standards will be finalized in this year. The possibilities and limits of the above activities in private sectors are discussed for improvement of environmental issues.

1. Environmental activities in a private company

Taking overview on the past environmental issues in Japan, they were acute and attacked urban area in 1960s. Under such circumstances the national government enacted a number of laws and put them into force mostly after 1970.

In 1971 examination of national qualification for pollution control was started. Considering these backgrounds, a private company Hitachi established Environmental Maintenance Promotion Center in September that year and started the activities for pollution prevention as shown in Fig. 1.

Figure 1 History of Environmental Protection Activities



It was considered that investments for environmental equipments and facilities are necessary to improve the environmental qualities. Therefore, the budget for these equipments have been made at the start of this Center separating from the budget for other investments of production. It is very important, otherwise, environmental investment will be ranked lower with mere comparison of their cost effectiveness, then they will be difficult to be made.

Taking account of these relation, it was natural for Hitachi to start internal environmental auditing to assure the environmental qualities and results of the investment. This relation is shown in Fig. 2.

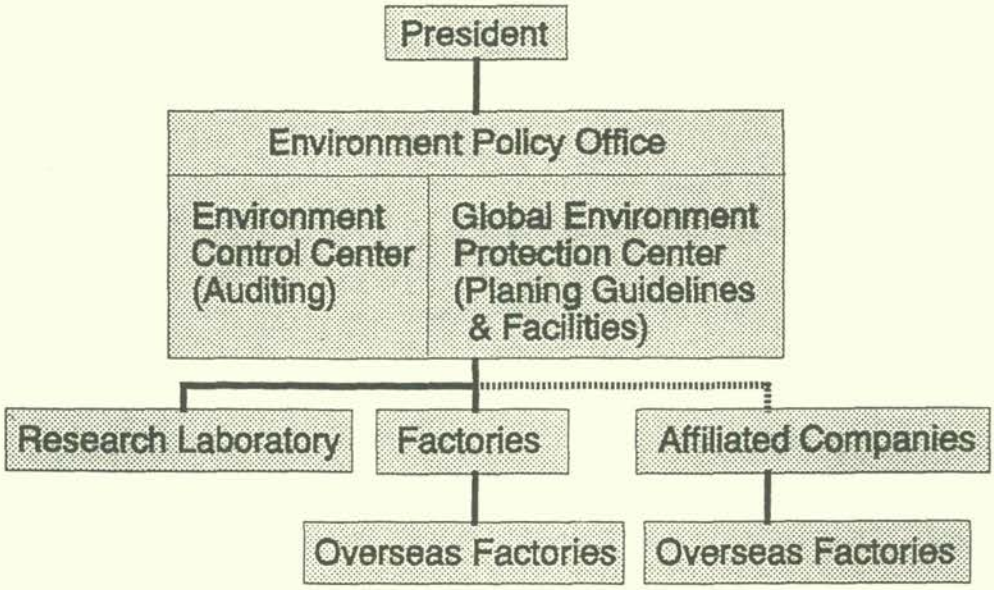
Figure 2 Stages of Environmental Management System

It can be said that there were two aspects in environmental auditing of Hitachi, the first is to audit the environmental qualities and the second is to audit the investment itself. The latter is also very important because the budget is separated from the investment for production as described the above.

In 1991 Hitachi reorganized the environmental structure and established the Environment Policy Office shown in Fig. 3. Also, the Standards of Corporate Conducts were amended recognizing world-wide current for global environment protection. The words "to promote harmony with the natural environment" were added to the conduct.

Four major Global Environmental Issues are now being promoted. These are Ozone Layer Protection, Global Warming, Products Recycling and Industrial Waste Management. For these subjects, the Environment Committee are organized, which has 4 subcommittees.

Figure 3 Organizational Structure for Environmental Management

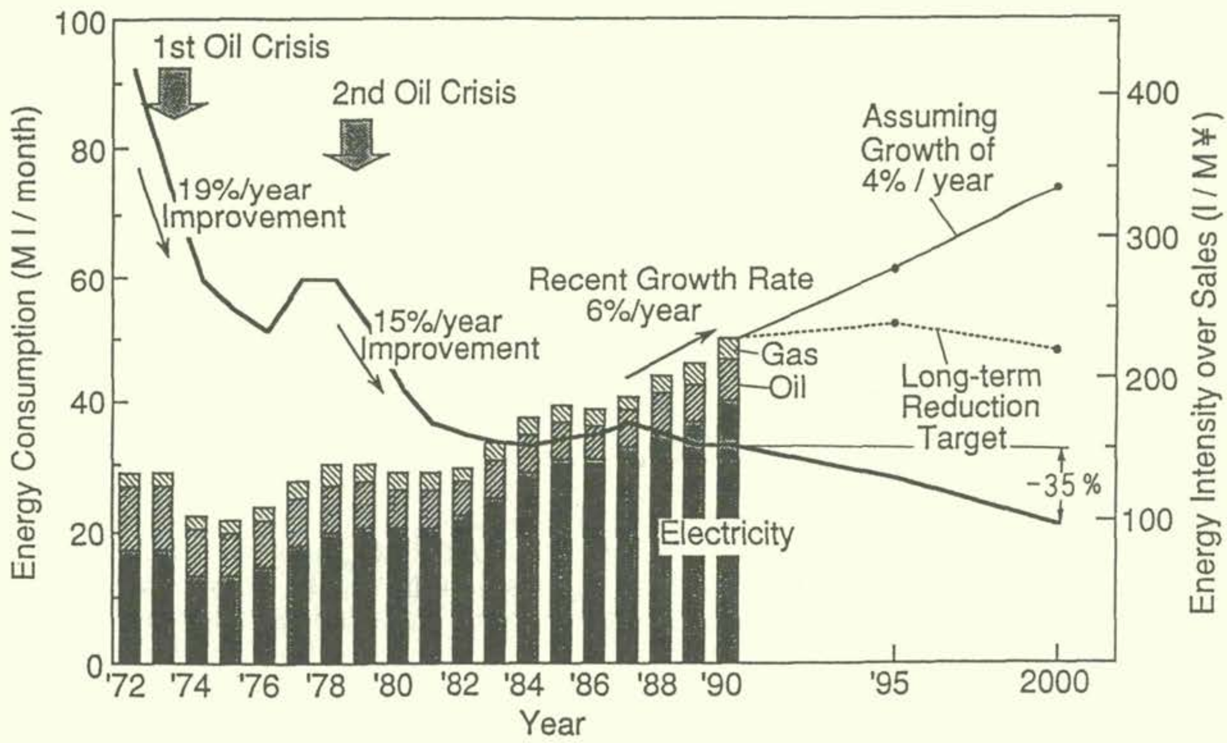


In 1992 at the Earth Summit held in Brazil, Dr. Sonoyama, Vice President of Hitachi was interviewed by journalists. Then, he explained an action plan to reduce 35% energy consumption per unit sale against global warming.

At the first oil crisis, almost 20% of energy consumption was decreased, and at the second oil crisis stabilized.

On the other hands, in those periods efforts to increase the sales were made, so the ratio of energy consumption to net sales were rapidly decreased as shown in Fig 4.

Figure 4 Transition of Energy Consumption and Research Scheme



Corresponding to the Japanese government action program, by the year 2000, the energy consumption will also be stabilized to the same level as 1990. Then, the ratio of energy consumption to net sales will decrease 35% when 4% growth of sales can be got in each year.

According to the investigation, large amount of energy is consumed for air conditioning and operation of furnaces. So, these energy consumptions will mainly be reduced.

Hitachi produces gas turbine generators and power transmission equipments. Previously, it was tried to develop a larger size plant to get higher efficiency in those technologies.

If it is necessary to utilize exhausted thermal energy, a smaller gas turbine is needed because there is no sufficient technology to transmit it to a long distance.

Therefore, Hitachi will actively introduce co-generation plants in its factories.

The amount of investment against global warming is going to increase rapidly and the improvement of environmental quality for the investment is not so visible as investment for previous pollution prevention. Therefore, one aspect of the environmental auditing for investment as described the above will become more important than before.

2. International Standardization for Environmental Management System and Environmental Auditing

Recently, concerns for global environment protection are largely increased. Therefore, it is welcomed for ISO to establish environmental management system and audit standards.

However, there is a very important point to be solved for standardization. The ISO standards has implemented the universal level settings and it is right for itself. ISO standards have been introduced business transactions and contributed to enlarge business activities in the world.

Against universal level settings of environmental issues, there is strong guiding principles in Rio Declaration on Environment and Development [1)], which was adopted by more than 178 Governments at the Earth Summit. Rio Declaration admits the special situation of region or country and it is impediment to set universal level. For example, Principle 11 in Rio Declaration describes as follows:

PRINCIPLE 11

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

Also, in Principle 12 there is a following description:

PRINCIPLE 12

States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or disguised restrictions on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

Therefore, it is very important theme how to harmonize these guiding principles with universal level settings and to establish effective and acceptable international standards. The lower international level is set widely to be accepted, the less global environment is improved.

If the standards require relative improvement of environmental performance level or target, which each organization has set, the standards can be universally applied to each organization even in developing countries.

Introduction of this concept to the ISO standards is a very important since the ISO Standards can be universal beyond the above pointed impediments.

Firstly, ISO will finalize the standards for Environmental Management System and Environmental Audit by the end of 1994 [2].

3. Possibilities and Limits of Environmental Audit in Private Sectors

It is described that implementation of environmental audit of a private company in Japan and establishment of international standards of it.

As for a policy instruments, at the first stage, the ISO standards of Environmental Management System and Environmental Auditing will not bring so visible effect on global environmental issues as that on pollution prevention.

However, implementation of these standards is a very important step for global environmental protection since world current for global environmental protection requires enterprises not only to make green products but also to take green manufacturing processes. These products and processes are also required to be verified. Furthermore, disclosure of these verification are requested.

In these social background, it is very important for enterprises to get verification and to disclose it. Otherwise, They will lose their reputation in society.

For the purpose of further improvement of global environmental quality, it is necessary to establish objective evaluation tools for green products and green processes. They are tools for Environmental Performance Evaluation and Life Cycle Analysis of products. ISO has also established sub-committees on these subjects in 1993. They are actively working to standardize EPE and LCA in 1996-1998 [2].

When these tools are established and applied to the Environmental Auditing, the global environment quality will make a greater progress and society will actually be filled with Sustainable Development.

References

1) Earth Summit Addenda 21 The United Nations Programme from Rio
2) ISO/TC 207 on Environmental Management
Secretary's Report
Meeting #1, 1993 TORONTO

Discussant's Comments

John K.E. Mubazi
Makerere University

Forestry

Dr. Rayner dealt with land use programs for conservation of forests and spelt out the increasing complexity that is associated with their application. He utilized the United States developments to what he termed "putting people back to the forests". To this terminology, I would say that it is the opposite in some parts of the developing world where the struggle is to get people out of the forests in the process of development.

He divided information instruments into five main types namely advertising, education (to which I would add training), auditing, moral suasion, and regulatory signals. The presentation emphasized the role of advertisement and the important role of reducing risk that Research Development and Demonstration (RD&D) programs have played in the United States. Education and training is an important instrument for the DCs given its low levels which can render the rest of the instruments less effective when applied. Also suasion can be ineffective in DCs where, for example, forest exploitation is for economic reasons in the absence of alternative economic activities. Further, regulatory signaling is weak in some developing countries where relevant infrastructures are weak at both the regulation process level and implementation.

Dr. Rayner also addressed issues of uncertainty in the United States focusing on scientific issues (e.g. yield), behavioral issues, and pragmatic and political issues. One may argue that these issues are important for a 'close model of a functioning market economy' as he stated, but the last two are critical for some developing countries, especially the last for the politically unstable ones.

Forest management was addressed with particular attention to conservation and preservation. Some examples outside the United States were used to illustrate this point. At the end of it all it was recognized that indigenous participation is very important. The need to recognize the traditional behavior which used to play these roles successfully before western models are attempted was noted. One may add that indigenous peoples' participation in the management, planning and development of their local environment is important in this regard.

Public Awareness

Ms. Gregory's main theme was the implementation problem. This was discussed with the aid of examples from the United States, giving two specific ones that had worked. She also looked at technology transfer and market transformation.

In her section on consumer education theory and practice, Ms. Gregory indicated the effectiveness of some of these devices in changing attitudes and behaviors based on some recent studies. She cited a few but one way on elaborate on selected communication tools as follows:

Advisory:
1. Print and broadcasting
2. Packaging - outlet
3. Packaging inserts
4. Mailings
5. Catalogs
6. Motion Pictures
7. House magazines
8. Brochures and booklets
9. Posters and leaflets
10. Directories

11. Reprints
12. Billboards
13. Display sings
14. Symbols
15. Photographs

Promotional:
1. Games, sweepstakes, lotteries
2. Demonstration
3. Entertainment
4. Stamps

Personal:
1. Presentations
2. Meetings
3. Television
4. Incentive program

Publicity:
1. Press kits
2. Speeches and position papers
3. Seminars
4. Written material such as annual reports, pamphlets, articles, news letters,and books
5. Audiovisual material such as films, slides-and-sound, video and audio cassettes, and closed circuit television
6. Charitable donations
7. Public relations such as events, public service activities, and telephone information services

Also a clear distinction between public awareness and educational programs was not highlighted at this stage. This is relevant because they are technically different activities, which scientifically are defined on the basis of distinct frameworks. In my view, education is a fundamental and more comprehensive and complex process than public awareness. Failure to establish this distinction or recognize this difference may lead to emphasizing the latter and reducing it to sophisticated propaganda.

Subsequent discussion concentrated on policy and information programs that were used in the area of energy efficiency in the United States and failure reasons to achieve their intended goals. While the implementation programs were discussed with particular reference to the United States, it was generally accepted that they were not peculiar to the United States but were even critical to less sophisticated systems.

The need of sound communication as concluded by Ms. Gregory, however, would benefit from distinguishing between micro and macro levels of intervention. A general part of the activities which accounted for the large gap between objective and achievement exposed in her presentation and, incidentally, that of Dr. Rayner invoke micro level actions and indigenous people in some respects. Programs while needing enabling policy at macro level, can only be put into effect through the associations, communities and particular groups that work at the micro level. There is a "Meso" level of intervention that may assist the macro/micro and it is represented for instance by the universities and, perhaps, the professional associations.

The examples that worked clearly demonstrated the role of education and training coupled with other information provision devices can play. One may argue that where their levels are very low at the initial stage, their impact is likely to be more dramatic than in the case of the United States.

Environmental Auditing

Mr. Ishii addressed environmental auditing with specific reference to Hitachi Ltd. Though at the closing of the presentation he highlighted global issues for its promotion. He discussed one information policy instrument in particular-environmental auditing-focussing on its possibilities and limitations with the help of Hitachi Ltd. experiences.

He started by giving a historical background for environmental activities in a private company in Japan. Prerequisites for a successful environmental program together with the rationale for establishing internal environmental auditing in the company were given. Auditing in the company focused on qualities a investment.

The 1991 reorganizations which took place to take account of recent developments globally and within the company broadened the issues to include Ozone Layer Protection, Global Warming, Products Recycling and Industrial Waste Management, he claimed. Achievements up to 1992 and plans for the year 2000 corresponding to the Japanese government action program were given. He noted the possible rapid increase in investment against global warming and improvement of environmental quality could increase the demand for environmental auditing.

What the above suggests is a systematic approach to environmental auditing. The approach is micro but, with relevant changes, it can be emulated at a macro level or at a micro level by other companies.

In the second part of the presentation, Mr. Ishii addressed the rationale that lead to the development of International Standardization for Environmental Management System and audit standards, and the role International Organization for Standards (ISO) has played in this regard together with its effects. Also the guiding principles of the Rio Declaration on environment and development were discussed highlighting principles 11 and 12 thereof. He concluded that introducing these guiding principles to the ISO standards is very important.

In the third and last part of the presentation, possibilities and limits of environmental audit in private sectors were discussed. He stressed the need for enterprises to get and disclose verification in order to gain society's reputation. Also for further global environmental quality improvements, he expounded the need to establish objective evaluation tools mentioning that ISO established sub-committees on these subjects in 1993.

Overall the presentation was a focused piece of work commendable to emulate for purposes for environmental auditing. Perhaps too focused for purposes of public awareness in general.

Discussant's Comments

Tohru Morioka
Osaka University

Energy saving services and assistance programs associated with systematic reviewing, summarizing and furnishing information on energy efficiency are generally useful for stimulating environmental awareness and enabling end-users to change their attitudes to energy use.

This process of giving information on energy efficiency should be coupled with another process of reporting by end-users and gathering citizens' opinions about acceptability and preferences for alternative energy saving actions, especially at the local level. In this two way communication between local government and end-users, citizens and business sectors are able to share the tasks of information gathering, evaluating energy inputs and emissions, and reporting voluntarily energy-consumption levels.

This discussant would like to emphasize the significance of voluntary actions by individuals in identifying their own activities which are the origin of environmental impacts. How is this done? Local governments in Japan have supported citizens in recording their energy-consuming activities and impacting behaviors using modified housekeeping notes. In NGOs, for example, consumer cooperatives have developed check sheets or 'Environmental Household Accounts'. 'This information has been used to check citizens' awareness and behaviors and is furthermore being developed towards eco-balance or eco-accounts in the household economy.

A key question for discussion is how much have daily behaviors changed, when information service programs have been implemented. In the case of Itabashi Ward of Metropolitan Tokyo, the total score, which indicates the degree of environmentally friendliness in terms of points or physical dimensions such as kwh, increased in the period of self-recording even in three weeks.

About 9 thousand members participated in the consumer cooperatives information gathering and reporting program, the total scores of surrogate indicators distinguished the worst three actions performed by a little numbers of COOP members. In the case of "To bring own shopping bag", environmental loads are quantified using the life-cycle assessment technique by the COOP leaders. The combination of environmental inventory analysis, impact analysis and improvement analysis for MDPE bags, revealed that if all generations of 9 thousand members follow the present manner of the most eco-responsible generation, 1.2kl of crude oil would be saved in a year. This is just a local experience, but illustrates a fundamental measure for any bottom-up energy-saving program.

Other issues in energy information communication is what kind of comprehensive planning is advanced and how are the opinions and preferences of citizens are being integrated into strategic policies for environmentally sustainable regional and local action programs for reducing CO_2 emission. In the case of Itabashi, there are ten action programs, which in addition to promoting the environmentally-responsible-housekeeping project, are also important in establishing 'local amenity associations' and in co-ordinating the information disclosure program in eco-police center with the services of local environmental education, and, in the new stage of commitment, to coordinate activities between local governments, citizens and business sectors.

In commenting on Mr. Ishii's presentation.There is some degree of similarity in the scheme of inputs/outputs of material/energy in the household economy and the business sector, and also in the management cycle itself such as initial review, target specification, program implementation, recording and auditing. How do you intend to monitor, record and audit energy-saving and CO_2 reduction performance beyond the conventional level of compliance?

Rapporteur's Summary

Tom Jones
OECD

This session focused on the potential for public awareness activities to contribute to reducing greenhouse gas emissions or to promoting sinks.

Dr. Rayner (Main Presenter) emphasized that the use of market instruments can lead to perverse results in forest management if sufficient consideration is not given to the way in which land tenure and management interact with social goals. The subsequent discussion indicated a general consensus that market instruments may be difficult to apply to developing countries because of the specific roles that forestry tenure and management play in those societies.

Ms. Gregory (Main Presenter) revealed that, despite the theoretical potential of energy efficiency programmes to reduce emissions in the developed countries, and despite the wide-spread public acceptance of these programmes in principle, the "take-up rates" for them have remained surprisingly low. One consequence of this phenomenon, as Ms. Gregory pointed out, is that "bottom up" engineering studies tend to overestimate the implementation effectiveness of potential abatement strategies. The subsequent discussion revealed a view that, if energy efficiency policies are not taken advantage of in developed countries, the prospects for them to be applied effectively to developing countries was not very good. It was also noted that the role of programme evaluation is to investigate why gaps exist between anticipated and actual take-up rates, and to suggest appropriate ways of reducing this gap.

Mr. Ishii (Main Presenter) showed that considerable progress is being made on institutionalizing environmental issues into business decision-making through the development of international environmental auditing standards. Several interventions concerning this paper focused on the practical application of such standards. It was noted that, although there is no international legislation governing environmental auditing, the generation of international standards is an important step forward (just as the development of international accounting standards has already promoted the exchange of accounting information across countries). Once again, however, interveners expressed the view that environmental audits were predominantly applicable to only developed countries. Similarly, although Prof. Morioka's Commentary showed the success of environmental awareness programmes in Japan (i.e. the Environmental Household Accounts Programme), such ideas would have limited applicability in the developing countries.

7. Policy Mix & Portfolio of Instruments[1]

1 Scott Barrett's presentation for this session was based on his paper contained in Chapter 1: Taxes. This Chapter includes just the discussant's comments and rapporteur's summary to avoid duplication.

Discussant's Comments

Akihiro Amano
Kobe University

I really enjoyed reading Prof. Barrett's paper. It surveys most recent quantitative estimates of the so-called carbon leakages, and points out a wide variation requiring further explanations. The paper then considers ways of reducing leakages and deterring free-riding, both being involved in a partial (i.e., less than global) attempt to control global warming.

Let me focus on two questions. One is concerned with the estimates of carbon leakages and the other with the use of tariffs as a policy instrument to reduce carbon leakages.

(1) I have been studying the Manne-Richels' model for some time, and find that the scenario difference between stabilization and 20% cut is not a major reason explaining the difference between M-R and GREEN results. I think one reason can explain the difference: rather large changes in trade of energy intensive products between OECD and non-OECD regions in the M-R model. The GREEN model, on the other hand, reports the small scale of trade between OECD and non-OECD regions as one reason explaining their small leakage estimates. This seems to be the first aspect to be taken up in a model-comparison exercise. In relation to the question of carbon leakage, I should like to point out that the ordinary definition of carbon leakage tends to underestimate the efficacy of unilateral action. The usual definition (adopted in Barrett's paper) gives

$$1.\ \text{Leakage rate} = \frac{\begin{array}{c}\text{Indirect increase}\\ \text{in non-OECD (C)}\end{array}}{\begin{array}{c}\text{Direct reduction}\\ \text{in OECD (A)}\end{array} + \begin{array}{c}\text{Indirect reduction}\\ \text{in OECD (B)}\end{array}}$$

whereas the index representing the efficacy of a unilateral action is given by

$$2.\ \text{Leakage rate} = \frac{\text{Net indirect increase in the World (C-B)}}{\text{Direct reduction in OECD (A)}}$$

To the extent that B is positive, (1) overstates the leakage rate.

(2) I agree that a partial co-operation introduces distortions, and that tariffs can rectify them. I am a little worried, however, about the use of the optimum tariff arguments in this respect, because the optimum tariff element included in the measure is derived from optimization of co-operative groups interests rather than from global optimization. As is known in international economics, optimum tariffs are the means of redistributing gains from trade in favor of the imposing party at the expense of non-participating countries by exploiting the monopoly power. I do not find any reason to support this element of tariff policy from an efficiency ground.

However, a ban on imports or exports is a different story. I, therefore, quite enjoyed reading Section 5 of the Barrett's paper as well as his arguments for joint implementation except for one reservation that the exact definition of "free-riding" in an equitable manner is not quite easy in the case of global warming issue.

Discussant's Comments

Aca Sugandhy
Ministry of State for the Environment, Indonesia

The greenhouse problem is not simply an energy problem even though it is the utmost driving force for CO_2 emission sources. It is a multifaceted environmental, economic and societal problem, solutions to which will require policies initiatives in a wide variety of areas at global, regional and country level.

Developed/industrialized countries and developing countries may implement policies and measures jointly with other parties and may assist other parties in contributing to the achievements of the objective of the convention.

What policy can be mixed and what portfolio of instruments can be developed to reduce leakage and to restrict free riding. To make the most for both parties, it became clear that much discussion and classification to determine the criteria for policy mix and portfolio of instruments between developed and developing countries is urgently needed.

Various economic and regulatory instruments that exist or will be developed in industrialized countries to satisfy emission reduction targets should be examined. The impacts and use of these instruments in the non-industrialized countries should also be assessed.

Consistent with their national priorities for sustainable development, developing countries can participate on a voluntary basis to apply economic and regulatory instruments.

To meet those objectives, the developed and developing countries may involve different degrees of cooperation at the global, regional and country level.

The concept of cooperation should be based on Article 3 and Article 5 of the convention and would provide the finance for cost-effective emissions reduction in which the polluter pays principle should be taken into consideration carefully to ensure both parties benefits at the lowest possible cost.

The practical application of policy mix and portfolio instruments used in industrialized countries to developing countries (either to government sector, private sector or community level) should be encouraged. Developing countries need access to information, financial assistance and environmentally sound technology transfer.

To implement the agreed policy mix and portfolio instruments by both parties, of the implications on environment and trade the managed market, mutual fund, and, clearing house at the global, regional and country level should be assessed.

In developing the policy mix and, portfolio instruments, the following factors should be considered:

1. Interagency cost evaluation

2. Regulatory measures effectiveness due to bureaucratic system

3. Cooperative action among government sector, private sector and community

4. Political impact

Rapporteur's Summary

Lee Solsbery
International Energy Agency
OECD

Following the presentation by the speaker, Prof. Barrett, the following key points were raised:

Prof. Amano presented results of his work which complemented the work presented by Prof. Barrett. He showed results which suggested the tax rates needed to achieve a 20 percent emissions reduction over time were not as much higher in magnitude than one might imagine, compared to those needed to achieve stabilization. He also presented results on leakage which showed very different leakage rates between oil alone and oil plus energy-intensive industries. He also suggested a modified definition of leakage which, if used, gives greater support to the benefit of countries taking unilateral action.

There was skepticism regarding Prof. Barrett's comment regarding the use of tariffs, both with respect to their potential for contributing to further economic distortions and to further political difficulties in the trade arena.

There was a re-statement of the FCCC provisions which invite joint undertakings and a comment that we should not be debating whether to have them, but how, taking into account in a reasonable fashion the problems of leakage and free-riding.

Prof. Barrett clarified that he is not talking about the type of tariffs which we seek to reduce under the GATT, rather, he is talking about tariffs to prevent free-riders.

It was acknowledged that identifying free riders in this context is very difficult but that it is very important to pursue this in order to promote fairness among the participants who undertake responses in a meaningful and good faith fashion.

8. Implementation in Developing Countries

GREENHOUSE GAS OPTIONS AND ISSUES IN ASIA REGION

Ali M.Azimi
Asian Development Bank

Abstract: The issue of what roles developing member countries should play in mitigating greenhouse gas emissions and financing mechanisms to encourage their participation are becoming increasingly prominent topics in international forums. Given the significance of the energy sector for global warming, any evaluation of the range of options available to tackle the greenhouse gas emission problem and the potential for their effective implementation must consider the evolution of energy policy and planning in developing countries. Given the scientific and economic uncertainties, the fact that global climate change is determined by policies and activities outside their borders suggest that it is reasonable for developing countries to take the position that they will not take measures to address global environmental problems unless it is in their own economic and social interest to do so. The appropriate strategy in both developing and industrialized countries is to given priority to those projects and policy reforms which satisfy both economic and environmental objectives.

1. Introduction

There is a growing segment of the scientific, governmental and lay community that believe the world-wide emissions of greenhouse gases cannot be allowed to grow at historical rates. The reality is that continuation of recent trends and fulfillment of expectations about economic growth among developing countries would probably overwhelm any conservation and fuel switching measures undertaken solely by the industrialized nations. Although there are compelling arguments that the economic growth potential of developing countries cannot be seriously hampered by efforts to control greenhouse gas emissions, there seems no escaping the conclusion that if the world is to reduce greenhouse gas emissions, then developing countries, particularly the major ones, must be active participants in the control process. Of course, if global climate change concerns prove to be well-founded, developing countries also have much to lose from such climatic change and they will be far less able than the wealthier nations to finance adaptation measures. The issue of what roles developing member countries (DMCs) should play in future controls on greenhouse gas emissions and how to finance their participation are becoming increasingly prominent topics in international forums.

Although it is the industrialized nations which presently account for the major share of greenhouse gas emissions, the developing countries must be an active part of any workable solution for two basic reasons. First, developing nations are the fastest growing emissions sources and unless such increases are substantially slowed, they would more than wipe out even highly aggressive efforts by the industrialized nations to curtail their own emissions. Second, an essential feature of the greenhouse problem is that a ton of carbon or other greenhouse gas removed from a power plant in China or India has the same expected benefits in terms of global climate to North America or Europe as the same amount removed from a power plant in the U.S. or Germany.

The question of who should pay for reducing emissions is a separate one from questions of which type of reductions are most urgent or where they can be readily and inexpensively implemented. Most cost-effective measures to reduce greenhouse gas emissions will be in developing countries, in part, because income constraints have often resulted in relatively inefficient process being used.

2. Carbon Emissions

We believe that considerable work will be required to fully assess specific developing country emission source targets and to evaluate options for implementing specific desired actions. There are a number of initiatives on-going and planned both at the national and regional levels, for instance, a GEF-funded project titled *Asia Least Cost Greenhouse Gas Abatement Strategy* that will be executed by the Bank will assist twelve participating Asian countries in preparing an inventory of man-made emissions and sinks of GHG, evaluating the costs and effectiveness of measures available to reduce GHG emissions and enhance sinks, and developing national action plan policy responses that will be required to implement the measures that are identified. The project will also contribute to meeting the training needs of the countries and the region of institutions in meeting the commitments of the Framework Convention on Climate Change (FCCC).

The project is formulated within the context of the developing country parties' commitments to the FCCC and the commitments of the developed country parties to provide technical and financial resources to help the developing countries achieve these commitments. The objective of this project is to assist the development and implementation of least-cost GHG reduction plans in Asia. These national inventories will also provide the basis for countries to begin the process of formulating least cost GHG reduction strategies, promoting sustainable resource management, conserving and enhancing GHG sinks and reservoirs.

Projections of energy use and associated carbon emissions for the next several decades cover a broad range as analysts attempt to not only extrapolate existing trends, but also assess the potential impact of various intervention strategies. Generally, such projections/scenarios indicate that a continuation of existing trends would result in a two-fold to three-fold increase in fossil carbon emissions by about 2010 compared to that for the late 1980s. Various moderate to ambitious interventions, e.g., using limited price increases and restricting some fuel choices, are projected to lead to much slower growth, resulting in either no increase or no more than an additional 20 per cent or 30 per cent increase by the Year 2010 compared to present levels. Even more ambitious (optimistic) scenarios suggest that absolute decreases are possible, with annual emissions perhaps falling by the year 2010 to 3.5 to 4.5 GT/yr. If the presumed natural absorptive capacity of the environment (particularly deep ocean, long-term sequestering of carbon) proves to be reasonably accurate, annual emissions of 1 to 3 GT might not lead to further build-ups of carbon dioxide in the atmosphere.

Thus, it is possible that by the middle of the next century, an equilibrium might be attained, even with substantial continuing use of fossil energy, albeit much more efficiently used and involving much less coal. However, even this rather satisfying state would still involve a difficult allocation of the limited carbon absorptive capacity among the nations of the world. The OECD countries would probably have to scale back considerably from their present emission levels of about 2.8 GT/yr. of carbon from fossil fuels (1990), deforestation would have to be halted, reforestation would have to be seriously undertaken, and the developing countries would have to alter their present rapid increases in fossil energy consumption, particularly coal, and in general follow much more energy efficient development paths (though their absolute carbon emission levels presumably would continue to grow for a time).

Extending existing trends, and considering the possibility that the recent exponential increases for some countries would probably not be fully sustained for several more decades, suggests country-level fossil fuel carbon emissions in the range of those shown in Table 1. They should be viewed as simply indicative of the implications of a continuation of such trends, not as predictions of the future.

Table 1 Extrapolation of Existing Trends for Carbon Emissions from Fossil Fuel Use (in million tons Carbon)

Country	Estimated Range for Year 2010		
China	1000	to	2000
India	260		480
Indonesia	60		200
Pakistan	30		70
Philippines	na		
Thailand	30		60

Source: Trend analysis using consumption data from ADB National Energy Balances.

For comparison, state planning agency projects from China and Indonesia for the year 2010 indicate carbon emissions of roughly 1.4 GT/yr tons for the former country and 0.8 GT/yr tons for the latter. This suggest that for at least these two countries, national planners themselves envision energy consumption growth rates which more closely fit linear growth paths than exponential ones. Taking the lower bound for the projected growth in carbon emissions in Table 2, the Asian countries in total would produce about 2.5 GT by 2010.

If global carbon emission levels of 1 to 3 GT are eventually to be achieved, clearly, the range estimated here for the six large economy, lower income Asian countries is likely to be incompatible with allowable global totals, and hence to become a matter serious of policy dialogues.

Asian countries are presently more carbon-intensive in their economic activities than are the industrialized nations. This is to be expected, given the relatively less-efficient use of energy and higher reliance on coal. China, in particular, emits 5 to 6 times as much fossil carbon for each unit of economic activity, as do most industrialized nations. It is estimated that the region is endowed with about 1.6 trillion tons of coal, i.e., about 64 per cent of the world's proven reserves. It is expected that coal will remain the dominant fuel for China and India accounting respectively 76 and 60 per cent of their primary energy supply. It is clear that any serious effort to substantially reduce total worldwide fossil fuel CO_2 from among the Asian region, efforts must be aimed primarily at China and India, and focus on coal use in the industries and power sector. The use of coal in China's residential/commercial sector also provides an attractive target area for carbon control efforts. Switching away from coal briquettes to some other fossil fuel would not only help the global environment, but would also benefit the health of the Chinese population.

Given the significance of the energy sector to global warming, any evaluation of the range of options available to tackle the greenhouse gas emission problem and the potential for their effective implementation must necessarily consider the evolution of energy policy and planning in developing countries of the region.

Table 2 Summary of the ESCAP Projection of Asian and Pacific CO_2 Emissions; Base-Case Scenario Assumptions for all Countries

Region/ Year	Emissions (Millions of tons of carbon) Actual Projections			Average annual growth rates (Percentage) 1991-2000			2001-2010		
	1986	2000	2010	Population	GNP	CO_2	Population	GNP	CO_2
Group A -	(High contribution to regional CO_2 emissions								
China	549	938	1,353	1.2	6.5	5.1	0.8	4.5	4.4
India	119	226	395	1.9	4.0	6.4	1.8	4.0	7.5
Republic of Korea	48	99	127	1.4	7.1	7.6	1.4	5.8	2.8
Islamic Republic of Iran	36	62	87	1.8	4.0	5.2	1.8	4.0	4.0
Democratic People's Republic of Korea	36	54	72	2.4	..	3.6	2.4	..	3.5
Indonesia	27	67	127	1.9	6.0	10.6	1.8	5.0	9.0
Taiwan Province of China	24	49	63	1.5	6.0	7.8	1.2	5.0	2.8
<u>Group B -</u>	Medium contribution to regional CO_2 emissions								
Pakistan	13	31	26	2.2	6.0	9.8	1.9	5.0	5.8
Thailand	12	42	94	1.8	8.0	9.2	1.7	7.0	8.4
Singapore	10	15	19	0.8	6.0	2.7	0.7	5.0	2.6
Malaysia	9	16	29	1.9	5.0	4.2	1.9	5.0	6.3
Hong Kong	8	11	16	1.2	..	3.2	1.2	..	5.0
Philippines	7	14	24	0.8	6.0	5.3	0.7	5.0	5.2
Viet Nam	4	9	14	1.9	..	5.0	1.9	..	5.0
Bangladesh	3	6	8	2.6	..	5.4	2.0	..	4.0
Group C -	Low contribution to regional CO_2 emissions								
All other South-East Asian countries	3	6	10	2.9	..	5.3	2.6	..	5.5
Pacific islands	2	3	5	..	..	4.8	..	..	3.9
Sri Lanka	1	3	4	..	..	15.1	..	..	5.3
Total Asia Pacific	911	1,652	2,502				5.8		5.1

Source: Summary of data adapted from ESCAP, Energy Policy Implications of the Climatic Effects of Fossil Fuel Use in the Asia-Pacific Region (ST/ESCAP/1007), pp. 29-57.

3. Energy Planning

Review of the energy policies of the countries indicate that all have committed themselves to a greater or lesser degree to the expanded use of coal, either through increased domestic production or through imports, or both. While such a policy was acceptable (and indeed encouraged) by various national and international funding agencies during the latter part of the 1970s and 1980s, there must now a major question mark hanging over the desirability of such trends in the 1990s and beyond. Realistically, we must recognize that these countries have in most cases already committed substantial capital investment to coal production and handling facilities and to coal-based thermal generating plant with life expectancies stretching well into the next century. It will not be easy to deflect these policy trajectories towards more environmentally acceptable options. However it appears probable that the countries themselves, especially the major coal users, will come under increasing pressure in the decade ahead to make such a move. It appears that the way ahead will almost inevitably involve major resource transfers from the richer industrialized nations to the poorer developing nations if such an energy transition is to materialize.

Although the countries in the region differ enormously in terms of the scale and complexity, they do nonetheless show certain important commonalities with respect to the objectives of energy policy since the mid-1970s. The first oil price shock of 1973-74 prompted most developing countries in the region to explore opportunities to reduce the level of petroleum imports. Even in China and Indonesia, development of domestic coal resources has been seen as a means of freeing more oil production for export. Oil import reduction was typically associated with a drive to develop as much as possible indigenous energy resources.

A second common feature of energy policy evolution has been a generally greater emphasis on the use of coal, particularly in the power sector. A third common theme in policy terms has been a growing commitment to energy conservation. However, the effectiveness and success has varied widely among the countries. Fourthly, although not always stated in explicitly polity terms, generally energy pricing has been characterized by high levels of government intervention resulting in tariff and fuel cost structures which are generally distorted through subsidies and cross-subsidies among the fuels concerned. This may ultimately prove to be a highly important dimension in the overall problem of containing and subsequently reducing greenhouse gas emissions. Finally, a review of energy policy documents that have emerged from these countries since the late 1970s indicates that environmental factors whether local or regional have virtually taken no part in the shaping of national energy development strategies. The supply systems that have developed since the late 1970s and which will provide much of foundation for meeting energy demand through the 1990s and beyond has emerged within a policy-making framework which has been largely unconstrained with respect to environmental considerations.

4. Emission Quotas

It is clear that if the nations of the world do seriously attempt to limit future carbon emissions, it appears unlikely that per capita emission levels alone would serve as the basis for international agreements on greenhouse gas emissions. If world population in the year 2010 is roughly 7 billion, even holding fossil energy carbon emissions to about present levels would require a reduction from about 1.1 tons to about 0.75 tons per person annually. This is a level which (under present trends) China would likely exceed well before that date. Further, a uniform global per capita fossil carbon allocation would imply carbon emission levels in the industrialized nations of less than one fourth present levels and the attainment of such reductions is only about two decades. While this is perhaps a worthy goal, long lead times in much of the energy sector make it unlikely. And in any case, uniform national per capita emission quotas probably would not be the sole basis of future international carbon control agreements.

At this point, it seems likely that international targets would be set in stages to first slow further increases and then to gradually reduce global greenhouse emissions. An ultimate global emission quota would presumably be based on improved estimates of the long-term carbon absorptive capacities of the oceans and other sinks, probably in the range of 1 to 3 GT/year. On-going net reforestation would provide further opportunities for limited fossil carbon emissions without additional net releases to the atmosphere. National allocations might eventually be based on formula accounting for population, the level and type of economic activity, and credit for net reforestation. Arrangements for other gases would likely be developed individually. International financing of measures for controlling greenhouse gas emissions would presumably be based in part on national income considerations, with resource transfers from the wealthier to the poorer nations.

Under such arrangements, the Asian countries of interest here would benefit from components of allocation formula accounting for per capita emission quotas of carbon, but would be penalized if a similar formula were used for methane. These countries would be at a minor or major disadvantage in terms of allocation formula reflecting allowable emissions per unit of national income. Carbon emission penalties for continuing deforestation would significantly affect Indonesia, Thailand and the Philippines. Only China among the Asian countries would, under present national initiatives, would benefit from credits for net reforestation. With the possible exception of Thailand, the Asian countries would likely be significant recipients of internationally financed efforts, such as through the Global Environment Facility (GEF) to control greenhouse gases through resource transfers to lower income countries, both because of their importance as sources of greenhouse gases and because of their income status.

5. Sinks and Sources

In the case of deforestation, there are already very compelling environmental and economic arguments in favor of much more rigorous policy initiatives intended to stabilize forests through effective management and control measures. However, even if the various uncertainties surrounding the process of deforestation and its contribution to carbon emissions can be resolved in the short term, nonetheless there will remain significant institutional and human obstacles to the implementation of effective forest management strategies. It must be recognized that forests constitute a highly valuable resource involving large cash transfers both within and between nations. Effective forestry management and control measures in one region or one country may simply serve to divert the attention of commercial interests to those areas in which such measures have yet to be introduced or which lack adequate policing mechanisms. There are indications that this may already have happened in Thailand, where a national ban on commercial logging proposed in early 1989 following severe flooding in the south of the country appears to have resulted in an intensification of logging operations in neighboring Laos and Burma.

The issue of methane emissions associated with rice production and livestock rearing may become a much more significant concern in the coming decade, again possibly resulting in new kinds of pressures on developing nations to modify existing food production strategies or to initiate perhaps completely novel approaches to meeting national food needs. This is clearly an extremely sensitive and complex area which touches upon the most basic of human needs. With regard to paddy production, dry rice cultivation is obviously a possibility but not without potentially serious limitations. In many regions, paddy fields are used not only to cultivate rice but also to rear fish, which represent a valuable protein source. Furthermore, wet cultivation of rice also provides a reasonably effective mechanism for weed control. A switch to dry cultivation might necessitate considerable inputs of pesticides with negative implications for production costs and well-being of humans and the local natural environment.

As far as livestock rearing is concerned, it is difficult to envisage significant changes in stocking patterns of ruminant animals at this time given that these patterns are themselves long established, representing a complex mix of social and cultural preferences and basic determinants in the form of the types and quantities of fodder available from region to region. Much of the fodder consumed by grazing livestock is from otherwise unproductive (to humans) marginal land.

6. Economic Incentives and Options

It is clear that developing countries could be expected to cooperate in global environmental programs only to the extent that such cooperation is consistent with their national growth objectives. Some of the options have inherent national benefits and include the following.

Providing the correct economic signals or, more specifically, price rationalization in getting energy prices right would *prima facie* represent first order of priority in any economic policy to contract greenhouse gas emissions. Total world energy subsidies in 1990 are estimated to be in excess of US$230 billion and elimination of these subsidies would translate into a 20 per cent reduction in carbon emissions in the subsidizing countries. Based on a survey of cost estimates to achieve and equivalent reduction in tons of emissions in OECD countries, a carbon tax of US$60 per ton would be imposed in the OECD countries. This would result in a total annual cost of US$15.5 billion. This amount could represent the upper bound for the OECD compensatory transfers to the subsidizing countries instead of imposing a US$60 per ton carbon tax in the OECD countries. It is also interesting to note that very large (37-68 per cent) reductions in global carbon emission are possible if the world were to adopt German or Japanese standards of energy efficiency.

Taxes on carbon content of fossil fuels to combat global climate change have been recently implemented in Finland, Netherlands and Sweden. The European Community is also considering a proposal to introduce a community-wide carbon-cum-energy tax at US$3 per barrel. The tax would increase by $1 a barrel each year in real terms until it reached $10 per barrel in year 2000. Relative to the Asian region, such a tax would result in 26.2 per cent and 2 per cent increases respectively in the price of coal and petroleum products in India.

Tradeable emission permits represent an alternative instrument that afford direct control over quantities of emissions as opposed to indirect influence through prices under a carbon tax regime. It is also considered easier to implement as an allocation of such permits reduces resistance of existing emitters.

The principle of joint implementation (JI) is embodies within the Framework Convention on Climate Change (FCCC). Joint implementation is expected to involve "project investments" wherein countries facing higher abatement costs would invest (or would encourage investments) in greenhouse gas emission abatement or sink enhancement projects in countries facing lower abatement costs.

Whatever policy instrument is used to respond to climate change, it will have to deliver environmental improvement, some degree of economic efficiency and perceived as being equitable. There is a spectrum of technological options which the developing country could potentially utilize in order to improve energy efficiency and thereby reduce environmental effects arising from power sector activity. These range from simple infrastructural retrofit to the use of advanced generation technologies.

7. Technological Options

Among the short term technological options for the developing country's power sector, reducing transmission and distribution losses and improving generation plant efficiencies appear to be the most attractive. While estimates of developing country power system losses vary, they all point to levels in South Asia have been estimated at 17 per cent and in East Asia at 13 per cent. The consequences of reducing these losses can be quite remarkable. On the basis of previous estimates of capacity requirements, a one percentage point reduction in losses now would reduce required capacity by over 1 per cent or over 2.2 GW for Asian developing countries. The estimated saving in capital investment would be around 4 billion dollars. Over time the savings would, obviously, be even greater. The United States Agency for International Development (USAID 1988) has estimated that the average heat rate of developing countries power plants is around 13,000 Btu/kWh, compared to 9,000-11,000 Btu/kWh if these plants were operated efficiently. The energy savings (and positive environmental consequences) implied in these figures are phenomenal.

Similar gains are possible by conservation on the demand side. End-use technologies can have a major impact on energy efficiency. These technologies (which developed in the industrialized countries as a response to the oil price escalation in seventies) can be easily applied towards more efficient lighting, heating, refrigeration and air conditioning.

Substitution of primary energy sources in power generation is another potential means of achieving dual benefits. In the developing world, natural gas is the most likely candidate for fossil fuel substitution. The economic benefit of natural gas substitution comes from either import substitution for petroleum products or releasing these products for export. On the environmental front, natural gas firing typically achieves reduction in carbon emissions of 30-50 per cent. Many DMCs are endowed with significant resources of natural gas, including Malaysia, Indonesia and Thailand.

In the longer term, the developing countries will need to rely on more advanced technological options which are currently being developed in the industrialized countries. Power generation capacity in developing countries is expected to nearly double by the turn of the century, and will increase further thereafter. This provides opportunities to add state-of-the-art technologies which have been designed with regard to both economic and environmental criteria. Clean coal technologies, such as fluidized bed combustion, cogeneration, gas turbine combined cycles, steam-injected gas turbines etc. are all part of this menu of technologies which have important potential in developing countries. Similar applications will become available for emission control technologies. However, the developing countries will look to the industrialized nations to provide the leadership in refining and proving these technologies before they are implemented in the developing world.

Since developing country cannot afford to finance even their present energy supply development, to address global environmental concerns they will need financial assistance on concessionary terms that is additional to existing conventional aid. Past growth in the industrialized countries has exhausted a disproportionately high share of global resources, suggesting that the developed countries owe an "environmental debt" to the larger global community. This approach could help to determine how the remaining finite global resources may be fairly shared and used sustainably. Finally, the economic efficiency criterion indicates that the "polluter pays" principle may be applied to generate revenues, to the extent which global environmental costs of human activity can be quantified.

8. Conclusion

Given the scientific and economic uncertainties the fact that global climate change is determined by policies and activities outside their borders suggest that it is reasonable for developing countries to take the position that they will not take measures to address global environmental problems unless it is in their own economic and social interest to do so. The appropriate strategy with regard to greenhouse problem, in both developing and industrialized countries, is to give priority to those projects and policy reforms which satisfy both economic and environmental objectives. There appears to be ample opportunity for all countries, particularly for developing countries, to identify "no-regrets" options that will yield benefits even if the expected climate change do not occur.

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ENERGY POLICY FOR SUSTAINABLE DEVELOPMENT IN DEVELOPING COUNTRIES[1]
- Case of China -

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1. The Diversification of Energy Policy in Developing Countries

There is no strict definition for the "Developing Country". Every developing county has her unique conditions in terms of natural resource, population, language and culture, as well as characteristics of social and economic development. I don't think there is common energy policy for developing countries as well, although there may be some common ground in various national energy policies of many developing countries. As SUSTAINABLE DEVELOPMENT still remains as an unclarified approach of development for many of the developing countries, the energy policy for sustainable development for developing countries should be considered as a subject to be explored.

1.1 The Different Levels of Development in Developing Countries

There are many indexes to evaluate the development level, which include not only the economic indexes but also many other social indexes which can hardly be valued. Among many others, Per Capita GNP (or GDP) is one of very important index for development evaluation. The gap of per capita GNP between developed countries and developing countries are very wide, and it become wider and wider. Among the developing countries, the difference seems big enough as well. The lowest is only a few tens of US dollars GNP per capita for the poorest countries, while some developing countries have achieved more than five thousand US dollars GNP per capita or even higher level. One obvious backward for GNP per capita as a major index of economic development is that the incomparable characteristics of local currency with the hard currency. For example, in last 13 year, the economic growth rate in China averages 9 percent per year, while because of the significant change of the exchange rate between the Chinese local currency and US dollar, the per capita GNP didn't change some, although the living standard in China has been dramatically improved in this period.

Table 1.1 Energy Consumption per Capita in 1988

Country or Area	Energy Consumption	Country or Area	Energy Consumption
World Average	1959	Korea	2029
Africa	414	Bangladesh	70
Egypt	664	Turkey	959
North America	7011	China	854
Canada	10540	India	287
Mexico	1651	Japan	3921
U.S.A.	10015	Europe	4418
South America	1042	Italy	3624
Brazil	779	France	3665
Asia	752	Australia	6942

From the view point of energy economist, the volume of energy consumption per capita may be one of the best indexes of development. Obviously, energy consumption per capita in developing countries is much lower than that in developed countries. In 1988, average energy

1 Shen Longhai of State Planning Commission introduced this paper for Z. Dadi.

consumption per capita in Asia was only 752 kgce, with 287 kgce for India, 70 kgce for Bangladesh; the figure for Africa was 414 kgce; 1042 for South America; while for Europe it was 4418, and 7011 for North America. Most of the developing countries have energy consumption per capita less than 1000 kgce, while in OECD countries, the lowest energy consumption per capita is higher than 3600 kgce, with more than 10000 kgce per capita for Unite States and Canada. (Table 1.1)

1.2 Economic Development is the Most Important Task for Developing Countries.

The developed countries and developing countries face different challenges. Although many developing countries achieve great improvement, but as a whole, the developing countries have not obtained enough opportunities of development. Economic development can not be considered seriously in countries where the ethnic violence, civil war, social disintegration lead to poverty and hunger. Calculated by GNP per capita, the gap between the developed countries and the developing countries become bigger. More and more people agree that almost all the social and economic difficulties in developing countries can only be overcome in the context of development. For countries over populated, such as China and India, many tens of years will be needed before they become to be of the medium level of developed country, even providing the economic growth rate can be kept as high as expected for another half century. For example, the ambitious target of Chinese government is to become a moderately developed country by the 2050 in terms of GNP per capita, which is planned as only 4000 US dollars per capita in year 1980 value. Many developing countries may not sacrifice the speed of economic development to mitigate the global climate change.

1.3 Various Level and Pattern of Energy Consumption in Developing Countries

In developed countries, there are some common characteristics in energy consumption. The energy consumption per capita is high in all the developed countries without exception, although some higher than others. They consume more oil and natural gas, but less solid fuel, especially in the end use.

Electricity contribute a big share in the end use as well. While the pattern and level of energy consumption is varied in developing countries. In some developing countries with rich energy resources, energy export become one of the important incomes, where the energy consumption level are relatively high in general. Many developing countries rely on the imported energy, where oil is the main commercial energy but not coal, although in general the energy consumption per capita is not high. In China and India, coal still play the dominant role even in the end use, and they mainly rely on the domestic supply of energy. Due to the variety of energy consumption in developing countries, different factors will be considered when developing the energy policy. There is no common energy policy for developing countries as a whole. As China has one fifth of the total population in the world and consumes about ten percent of the energy in the world, it will be helpful to analyze the energy policy for sustainable development in China. The China case can be considered as one of the typical representatives of energy policy for sustainable development in the developing countries.

2. Energy Consumption and Supply in China

2.1 Characteristics of Energy Consumption in China

Because of the big population, the total energy consumption in China is big enough, ranking the third in the world. While comparing with the developed countries, the energy consumption pattern in China is of backward.

2.1.1 Low energy consumption per capita

Energy consumption per capita in China is very low, only 863 kgce in 1990. Basic energy service requirement has not been met. There is no energy supply or facility for space heating in middle and south of China, where the average temperature in January is as low as 2 to 5 degree centigrade. In the summer, no air conditioning for almost all the residential houses or government offices, while in middle and south of China, the average temperature achieve 28 - 29 degree centigrade in July and August. In the last few years, air conditioning developed rapidly in the commercial buildings, but as a whole it still is a very luxury facility for Chinese. There is no heat water supply in almost all the houses. In the end of 1992, there were only about 7 million motor vehicles in the mainland of China, with about 170 peoples shall a car or buss.

2.1.2 Rural energy consumption and supply

The industrialization process is far from completed in China. At present, about 72% of population live in rural area. 58% of the labor force are working in the agriculture sectors. In the rural area, biomass are the major energy source for farmers' daily life. From the surveys, about 300 million tce of biomass including firewood, plantation wastes are used in the rural area per year. There is no commercial energy supply for households in most of the rural villages, with only necessary fuel for agricultural productive activities. Mini-hydro power generation are developed in rural area, combine with firewood forestation, energy efficient stoves, and so on, but most of the farmers can not access commercial energy supply up to now.

2.1.3 Energy consumption structure by sectors

In China, most of the energy are consumed by industry sectors. Transport and household only consume relatively small proportion of energy. In the developed countries, industry consumes only about 30 to 40% of total energy, while residential use consumes more than 30% of the total. In some european countries, residential use occupy more than 40% of the total.

Table 2.1.3 Energy Consumption by Sectors in China

Sector	1985	1990
Total	100.00	100.00
Production Sectors	79.41	80.47
--agriculture	5.27	4.92
--industry	66.60	68.47
--construction	1.70	1.23
--transport	4.84	4.60
--commercial	1.00	1.26
Nonproductive Sectors*	3.22	3.52
Residential Use	17.37	16.01

*government, hospital, education, academic, and so on;

2.1.4 Solid fuel dominates energy consumption

Coal is the major fuel in China, accounting to 76.19% of the total energy consumption in 1990. Oil contributed only 16.63%, and 2.05% by natural gas, 5.13% by hydro. In 1990, more than 1.05 billion tons of coal were burnt in China. Only about 30% of the total were transformed into electricity, coke, gas for end use. 70% of the raw coal were directly burnt in industrial ovens and kilns, boilers, residential stove, and so on. In general, steam coal are not washed before delivered. Coal is the major fuel for residential use as well. In 1990, coal accounted to 80.19% of the total of commercial residential energy use, electricity contributed 11.99%, gaseous fuel contributed only 4.2 of the total.

2.1.5 Local and regional environmental pollution problems

Energy consumption characterized by coal combustion leads to serious environmental pollution. Chinese government has paid great attention to environmental protection. But the level of environmental protection remains at primary stage. Flue gas ash emission control has not been completed well. SO_2 emission has not been disposed at all, although many researches on SO_2 emission disposal technology and a few demonstrate projects conducted. In practice, aside rain become more and more frequent and severe in many regions in China. Besides of environmental pollution directly related with energy utilization, China faces a lot of urgent environmental protection subjects as well, such as waste water treatment, city solid residue disposal, land erosion, water resource degradation, and so on.

2.2 Energy Demand Forecast for the Medium and Long Term

Many projects on energy demand forecast have been conducted in China. Most of them project the energy demand for the 2000 year. A few projects project the energy demand for longer period, such as 2010, 2020, or even 2050. Table 2.2 lists some of the results from these analyses.

Table 2.2 Energy Demand Forecast of China

Projector	Primary Energy Demand 10^8 tce		Time Completed
	2000 year	2010 year	
ERI	14.59-15.96		1984
ERI	14.6		1989
Qinghua Univ.	13.7		1989
CSER	15.6-17.0		1989
World Bank	13.26-17.64		1989
NCNI	17.7-18.2	26.7-28.1	1990
SSB	15-17		1991
Qinghua Univ.	14.0	24-30	1991
Qinghua Univ.	13.8-22.6		1992
SSB	16.1		1992
ERI	14.72-15.73		1993
DE, SPC	14.7-15.5		1993
ERI	16.05	23.75	1993

ERI: Energy Research Institute, State Planning Commission
CSER: Chinese Society of Energy Research
NCNI: National Company of Nuclear Industry
SSB: State Statistic Bureau
DE,SPC: Department of Energy, State Planning Commission

2.2.1 Significant increment in total volume

Almost in all the energy forecasts listed in Table 2.2, energy consumption elasticity coefficient were estimated relatively small. In general it is about 0.5. The reason is energy consumption coefficient for last 10 years is less than 0.6, and more energy conservation activity is expected in the future. Another consideration is that most of the planners and researchers concern the bottleneck of coal transportation in the future, and the environmental pollution related with coal burning as well. While it is forecasted that significant increase of the total volume of energy consumption will be inevitable in the future due to the economic development and population increase. Basic point is the existing energy consumption per capita is very low, and there is no any exception in the developed countries that per capita energy could as low as less than, say, 1500 or 2000 kgce at current practice.

2.2.2 Arguments on energy composition

Based on the previous trends and the limitation of the proven oil and natural gas reserves, many experts forecasted that coal will keep the position of dominant fuel in China for the next 50 years or even longer. Most of the forecast are pessimistic for the development of oil and natural gas. For example, domestic production of oil was projected not exceed 200 tons per year or somewhat near this figure, natural gas will slowly achieve the peak of 150 billion cubic meters after 2010, etc. The conclusion seemed that China has to rely on the domestic coal reserves which are abundant. A different opinion is that it is doubtful if energy supply based on coal can support China to realize her target of moderately developed. At least up to now, no any developed country has proved that a competitive and developed economy can be based on coal dominated energy system. The question is if China can explore a unique way toward the future based on coal context, that has been proved as low efficiency, high pollution, and less economic, comparing with oil and natural gas energy context. If clean coal technology can be realized in China, what will be the cost? And, more important, what is the alternative?

2.2.3 Energy import and export in the future

As China is a big country with so big a population and already huge amount of energy consumption, the impact on the world oil market will be determinative, if China practice the process of energy system transform from coal into oil or natural gas. Along with the economic reform, market mechanism will lead to restructure the energy supply system early or later. Users are asking for high quality energy supply, that is the liquid, gaseous fuel or electricity, and they will ask for further more in the future. Net energy import, mainly oil and gas, will be inevitable, although the government has not prepared enough for the change.

3. Energy Policy for Sustainable Development

To develop an energy policy or strategy for sustainable development is a blend new subject for developing countries, including China. Some criteria should be considered in this context.

3.1 Energy is Only One among Many Others.

Sustainable development is a challenge and an opportunity for developing countries. Because most of the developing will need many decades before they can be of developed category, the development may not be sustained for long period, if no proper policy developed and adopted to deal with the problems related with economic development. Population control, land protection, pollution control, water resources, biology protection, and so on, are faced by countries under developing. Energy is only one of the puzzles.

3.2 Sustainable Energy Supply

For big countries like China, India, etc., first subject related with energy for sustainable development will be how to guarantee sufficient energy supply for the economic development, that increases continuously with huge volume. As we described above, additional 1 to 2 billion tce of energy will be needed for China's development in the foreseen future. If India took the same pace of increase, another 1 billion tce of energy would be needed. To explore and develop enough supply of energy will become number one task for China. That is why so many experts in China projected 2 billion tons of coal will possibly be needed in 2010, and 3 to 4 billion tons of coal will be needed by 2050, even though they concern the associated environmental impact cause by so much coal burning.

3.3 Energy Related Environmental Protection

Local and direct pollution control will have higher priority, comparing the distant and indirect impacts. Flue ash and solid waste disposal will still become current subject of environmental protection related with energy in China. Along with the expansion of coal exploitation, land recovery and other measures related with coal mining and processing will be of more importance in the coal mining regions. The next urgent target may be the SO_2 emission control. The cost of SO_2 control will be a main constraint for adopting strict standard for sulphur dioxide emission, as investment in shortage will not be solved soon. Air pollution caused by motor vehicles in urban area become more and more severe, and it may attract more attention in the near future especially in big municipalities such as in Beijing, Guangzhou, etc. Many measures of waste disposal may consume more energy, such as SO_2 emission control, and urban waste water treatment. Comparatively, GHG emission control seems more difficult in this context.

3.4. 21 Century Agenda in China

The State Planning Commission and State Science and Technology Commission sponsored a program to develop the policy package for sustainable development in China. A draft of Outline for 21 Century Agenda of China has been published and under review. Many aspects related with sustainable development are discussed in the document. In the energy volume, four subjects of energy policy were suggested, including:

A. Comprehensive Energy Planning and Management. It is suggested that energy plan should be developed based on the comprehensive integrating economic, environment and energy development, but not only increase the energy supply.

B. Energy Efficiency Improvement and Energy Conservation;

C. Development of the Environmental Sound Coal Mining Technology and Clean Coal Technology;

D. Development of the New and Renewable Energy;

Many specific policy items have been discussed for each of the above four policy subjects.

One important comment for above policy suggestion is related with the restructure of the energy composition, that challenge the coal based energy structure in China. It is suggested, natural gas may play a much more important role in China as well, and more investment should be put into the exploration of natural gas from now. Comparatively, new and renewable energy will contribute much less than that if effort is paid for natural gas in the foreseen future.

3.5 Response to Climate Change - No Regret Policy

GHG emission control is a rather far issue for many developing countries, including China. Too many uncertainties have to be identified and explored before any specific energy policy measure will be considered specially for the climate change. Chinese government is organizing a series of research projects on climate change, both of scientific evidence and policy alternatives. Comparing with the urgent subjects of economic development and reform, policy for sustainable development can only be taken into consideration in the context of no-regret measures. It is supposed that any policy alternative will hardly be adopted at this stage if it has negative impact on the current development but only beneficial in the future. Only the policy speeding up the economic development is really welcome, no regret policy alternatives will be the only appropriate at present.

Discussant's Comments

Kanji Yoshioka
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It is said that the 21st century is the era of developing countries. More than 90% of the 10 billion population will live in the developing countries. Reading Prof. Dadi's paper, I feel today's situation in China is a sort of simulator of the 21st century's world. In his paper, he says, "China is a big country with so big a population and already huge amount of energy consumption. The impact on the world oil market will be determinative." And, "There is no energy supply or facility for space heating in middle and south of China. In the summer, no air conditioning for almost all the residential houses or government office." So, he insists that the ambitious target of the Chinese government is to become a moderately developed country by the year 2050 in terms of GNP per capita, which is planned as only 4,000 U.S. dollars. Since his estimates of income elasticity of energy is around 0.5, this target means that the future Chinese energy consumption will surprisingly increase to be 5 times the current level.

Having read Prof. Dadi's paper, I felt that:

1. There is no reason to deny the moderate economic growth of developing countries.
2. But, the feasibility of his prescriptions for global sustainable in his paper is skeptical and he should re-examine the additional policy instruments.

Although I can only add tentative comments to this big problem, I hope he re-examines their feasibility in China.

1. It might be difficult to introduce a carbon tax or energy tax in China so quickly. But the contemporary economic growth in China is highly based on a huge government deficit. Therefore, even China will have to introduce a modern taxation system to continue the economic growth without hyper inflation.

The recent situation with income distribution in China might be dangerous. From private sector to public sector and from urban to rural area, income discrepancies are apparent. Energy tax revenue will tend to be used to subsidies environmental research in the public sector or for agricultural forest activity.

2. In addition the controlled cheap energy price has been one of the reasons for low-energy efficiency in Chinese factories. And besides, the controlled cheap fare for mass transportation causes excess demand for its activities and the deficit of mass transportation services. By increasing these prices, the derived profits can help to invest more to the mass transportation activity.

3. Once the system of tradable permits or absorption of GHGs is enforced among countries, new businesses in forestry activity, for example, will be created especially in the developing countries. If so, farmers are could work in these new businesses and their incomes will increase.

4. A sustainable society will be identically supported by a high saving rate. Because of high saving, such increased income will mainly go to the capital formation for energy saving or anti-pollution equipment. And the lagged consumption from saving will induce relatively lower emissions. However, we should keep in mind that to build a sustainable society we have to exhaust more energy than usual society at the starting point, because to produce capital goods including energy saving equipments induces more energy than to produce almost all consumption goods at the one dollar worth level in this real society.

Rapporteur's Summary

Catrinus J. Jepma
University of Grouingen

The discussant noted that - according to the Dadi paper about Energy Policies in China - China will play an increasingly important role at the world energy market, and that the target of becoming a moderately industrialized country by 2050 (GNP/capita of about $4,000-) in conjunction with an estimated income elasticity of demand for energy of 0.5, will cause the projected Chinese demand for energy by 2050 to be about fivefold the present level.

In this respect he called for new ideas, also from the side of China itself. He indicated that the present extremely high rates of economic growth in China may well be not sustainable, because of the growing government budget deficit (and consequent need for establishing a proper tax base), the increasing inflation, and the risks emanating from the increasing disparities in the distribution of income, e.g. between the urban and rural sector. He also remarked that the controlled cheap energy and cheap mass transportation policies of the Chinese government, that had contributed significantly to Chinese energy use, would need adjustment. Finally, he pointed out that the high rate of savings in China may have a dual impact on energy consumption: on the one hand the resulting high levels of investment may create scope for the introduction of energy saving technologies; on the other hand higher growth will, ceteris paribus, lead to a larger demand for energy.

Discussion: A participant from Africa made the general observation that, whatever energy policy instrument is being discussed, one should always bear in mind that the developing countries' primary concern is poverty, even if one realizes that combatting poverty may have adverse environmental consequences.

Solsbery (IEA/OECD) wondered what the developing countries point of view is on the potential for Joint Implementation, and what forms of J.I. would be considered feasible. In this respect Prof. Read noted that the scope for application of J.I. is probably limited, because negotiations about the J.I. - terms will have to take place on a case-by-case basis. He, therefore, expressed the view, that, e.g. in view of the magnitude of the emerging energy/environment problem of China, one also has to search for other mechanisms that successfully might involve the participation of the major business and industries. These alternative options might be the more promising, if they could make a contribution to solving the increasing unemployment problem in the industrialized countries.

Azimi (ADB) responded that the ADB had tried to persuade Asian countries to abandon energy price support, but without considerable success. Another approach to help countries such as China and India in the field of introducing new technologies such as the promotion of co-generation, or the more efficient operation of maintenance of power stations, had proven to be much more successful. He expressed to agree with Read's viewpoint on the scope for J.I.

Longhai stressed once again that, irrespective of the scenario one has in mind, energy demand in China will increase significantly. However, during the last year China has already taken first steps to try to reduce energy consumption, e.g. by increasing the share of energy offered at world market prices (as opposed to subsidized energy), and by paying attention to energy conservation.

In addition he remarked that the low level of energy consumption per capita, and the low level of energy efficiency should not be mixed up. With respect to the former, he illustrated that energy consumption indeed still is extremely low, by referring to the negligible availability of air conditioning in the southern part of the country, the virtual absence of warm water supply in the households, or the relatively small number (7 million) of motor vehicles.

Finally Prof. Amano remarked by the referring to the information given in the paper by Shah (World Bank), that in actual practice the efforts of the Chinese government in trying to deal with emission control have thus far remained rather modest. Lee (Korea Energy Economics Institute) summarized the session by arguing that still for a long time the greenhouse problem will remain a problem of sustainability for the industrialized countries, but a problem of survivability for the developing countries.

ROUND TABLE SESSION ON IMPLEMENTATION IN DEVELOPING COUNTRIES

-Some Conclusions-

Anwar Shah
World Bank

This session sought developing countries perspectives on global climate change. There was a surprising degree of uniformity in views expressed by panelists on various aspects of this issue discussed. Some conclusions:

- There is now a high level of awareness about the seriousness of this issue and political resolve to undertake limited action now rather than wait for better scientific knowledge,
- In terms of policies, developing countries are keen to explore mitigation alternatives and eager to participate in joint implementation agreements with industrialized countries. Global carbon taxes and tradeable permits regimes appear as non-starters. There is some willingness to look at policies that aim at "getting energy prices right".
- Developing countries have high expectations on assistance from industrialized countries in adopting both mitigation and abatement strategies.

Rapporteur's Summary

Erik Heites
Technical Support Unit IPCC/WG III

This round table session featured a round table discussion on policy implementation in developing countries.

Members of the round table for the discussion on policy implementation related to climate change in developing countries were:

Dr. Anwar Shah, World bank, Chair
Mr. Jorge Benavides De La-Sotta, Peru
Prof. Shen Longhai, China
Prof. Richard Odingo, Kenya
Dr. David Omotosho, Nigeria
Mr. Paulo Cesar de Oliveira Campos, Brazil
Mr. Radu Plamadeala, Moldova
Dr. Janaka Ratnashiri, Sri Lanka

The panel members first commented on the awareness of climate change and its implications for their country. In general, scientists and government officials in developing countries are aware of climate change as a global problem. In most cases they aware of a variety of potential adverse impacts on their countries, particularly their vulnerability to the increased frequency or severity of extreme events.

Awareness of climate change and its potential impacts is very low among the general public in most developing countries. Increasing public awareness is difficult given the limitations of the communications media and literacy levels in developing countries.

Governments in developing countries believe that it is important to address climate change through the Framework Convention on Climate Change. But climate change is not as pressing as poverty, hunger, disease, education, economic development and the other problems of developing countries. In addition most developing countries are very small contributors to greenhouse gas emissions.

As a result the panel members felt that most developing countries believe that industrialized countries must take primary responsibility for addressing climate change. The industrialized countries, through their economic development, are responsible for past increases in atmospheric concentrations of greenhouse gases, they are the source of most of the current emissions of greenhouse gases, and they have the economic resources to deal with the problem.

Panel members next turned to the urgency of acting to address climate change. All felt that it was important to begin to deal with climate change and that they had signed the Framework Convention on Climate Change for this reason. However, the capacity of developing countries to act is constrained by limited technical resources, very limited financial resources and competition from other pressing priorities. Action by developing countries will require transfer of technology and financial resources from industrialized countries as provided for by the Framework Convention on Climate Change.

Actions that developing countries can undertake to address climate change that were mentioned by panel members include: improved energy efficiency, forest protection and reforestation, and greater utilization of biomass and other non-fossil energy sources.

Most of the panel members indicated that their country is interested in joint implementation as a mechanism for transferring technology and resources while combatting climate change. However, they pointed out that the acceptability and success of joint implementation will depend on what is actually negotiated. There is a risk that joint implementation will be perceived as a form of "ecological imperialism." If this is the case its contribution to limiting climate change will be minimal.

Sri Lanka already imposes a surcharge on electricity prices during droughts when oil has to be imported to generate electricity. This is a form of carbon tax. Several of the panel members indicated that they did not favor internationally coordinated carbon taxes in their countries. While there is interest in learning more about tradeable permits, most panel members did not feel that they had enough information on such a system to assess how it would affect their country.

Asked to comment when they thought a binding global regime to manage climate change might be implemented, most of the panelists estimated 20 to 50 years.

9. Concluding Session

CONCLUDING SESSION

Rapporteur's Summary

Erik Heites
Technical Support Unit, WG III, IPCC

Prof. Kuroda provided a summary of the theoretical properties of economic instruments. A list of these properties is attached. He also reviewed the performance, equity effects, and efficiency properties of alternative policy instruments to address climate change. A table summarizing these characteristics of the policy instruments is attached.

Prof. Kuroda's assessment of the alternative policy instruments led him to conclude that there is no single best policy for dealing with climate change. All of the available instruments have properties that are desirable under some circumstances. They also have limitations.

Finally, Prof. Kuroda made the point that the objective to be attained through climate change policies may vary dramatically from country to country. He illustrated this point by comparing model estimates of the size of the carbon tax needed to achieve the same percentage reduction of greenhouse gas emissions in Japan and the United States. The required tax rate is many times higher for Japan.

Dr. Fisher summarized his impressions as follows:

- Many policies that governments implement for purposes other that climate change nevertheless affect greenhouse gas emissions. Subsidies for fossil fuel or agriculture production are examples. Changing some of these policies can yield net economic benefits and reduce greenhouse gas emissions.

- No regrets or low cost measures to mitigate climate change are available in many countries. Examples include energy efficiency measures, improved forest management, and efforts to reduce local pollution.

- Other actions may have climate change benefits but adverse environmental impacts. Hydroelectric developments generate electricity with greenhouse gas emissions well below those associated with fossil-fired generation but hydroelectric projects flood land, disrupt river flows and impose other environmental costs.

- All countries can contribute to mitigation of climate change but it may be necessary to focus on a small number of countries because of their current or future emissions. The United States, the former Soviet Union and China are among the latter countries.

- A mechanism that facilitates transfer of resources to developing countries is essential to a successful international effort to address climate change. Joint implementation is the most likely candidate in the near term, but tradeable permits or redistribution of carbon tax revenue may be better in the long run.

- Policy instruments will affect different countries differently thus making international cooperation more difficult to achieve. Fossil fuel exporters, for example, are likely to be adversely affected by policies to mitigate climate change.

- Some climate change is inevitable given the emissions of greenhouse gases that have already occurred. Thus both mitigation and adaptation policies will be needed.

- One legacy of the process of economic development of the industrialized countries is increased concentrations of greenhouse gases in the atmosphere with the attendant consequences for climate change. Another legacy of is the knowledge and technologies that are already being used by developing countries such as electrical appliances, most manufactured products, motor vehicles, communications technologies, and improved crops and agricultural practices.

- Developing countries face a daunting challenge in attempting to establish priorities for addressing the many priorities they face. Overcoming famine, disease, and poverty while correcting local environmental problems and promoting sustainable development poses enormous challenges for the governments of developing countries.

- There are strong economic linkages among the countries of the world, so any adverse economic impacts due to climate change or mitigation of climate change policies have indirect impacts on other countries. Climate change policies or impacts that have high economic costs for a particular country or group of countries will have indirect economic effects on many other countries as a result of changes in imports or exports. Thus international cooperation to address climate change in a fair and cost-effective manner is essential.

SUPPORTING MATERIALS FOR THE CONCLUDING SESSION

Masahiro Kuroda
Keio University

1. List : Properties of Economic Instruments (In Theory)

(1) Theoretically economic instruments are assumed to be performed in the perfectly competitive market domestically and globally.

(2) The marginal cost of reducing net emissions are equal for all types of abatement.

(3) To provide automatic incentive for users to achieve emission reduction efficiently.

(4) Tradeable permit could prove as efficient as the net emission charges.

(5) To provide incentives for the Research & Development into technology dynamically.

(6) Assuming revenue neutrality, added tax system is expected to be able to raise revenue and offset the distortions of the already performed tax system.

(7) Even in the perfect competitive market, the distribution of the cost is worried to have substantial biased impacts among individuals unit.

2. Table : Rates of Carbon Tax and its Revenue in Japan

Case I

Employ an endogenous carbon tax to stabilize per capita CO_2 emissions at the level of 1990, 2.14tC, from 1991. The carbon tax is levied as a indirect tax on secondary energies proportional to their carbon contents. The revenue from carbon tax is applied so as to hold government spending constant at its base case level and allow government transfer to the rest of the world to adjust to keep the government deficit constant.

Year	Rates of Carbon Tax	Carbon Tax per 1tC	Per Capita Revenue	GNP/Revenue
1991	1.6%	1,730 yen	3,702 yen	0.1%
2000	61.1%	62,749 yen	134,437 yen	3.8%
2030	78.9%	97,997 yen	209,822 yen	5.0%
2050	97.1%	134,492 yen	289,214 yen	6.2%
2100	99.4%	143,769 yen	307,737 yen	6.5%

Case II
Under the same stabilization program as case I, rate of capital income tax is reduced by 10%. The application of revenue from carbon tax is the same as case I.

Year	Rates of Carbon Tax	Carbon Tax per 1tC	Per Capita Revenue	GNP/Revenue
1991	16.4%	16,048 yen	34,578 yen	1.2%
2000	74.0%	68,806 yen	147,355 yen	4.2%
2030	103.0%	120,608 yen	258,178 yen	6.0%
2050	120.2%	158,357 yen	339,105 yen	7.1%
2100	121.8%	166,283 yen	356,040 yen	7.3%

According to the results shown in the above tables, we (Kuroda and Shimpo) have to impose the carbon tax at the level of 600-700 dollars (62,749-68,806 yen) per 1 ton carbon in order to stabilize per capita CO_2 emission in the year 2000 at the level of 1990. On the other hand, Jorgenson-Wilcoxon (1993) resulted that in the United States 17 dollars carbon tax levy per 1 ton carbon is enough to stabilize the emissions at the per capita level of 1990. Comparing two results carefully, we can conclude the main sources of the difference between two came from the differences of reducing level of CO_2 emission in the year 2000. The Japanese economy will be expected to continue fairly higher economic growth and to expand the emissions rapidly rather than that in the United States. In our results we have to reduce CO_2 emission in 2000 by almost 40%, while in the U.S. 14.4% reduction is enough to stabilize. We try to estimate carbon tax levy per 1 ton carbon at the same level of the reduction of CO_2 in our model.

Results are as follows :

	Jorgenson-Wilcoxen	Kuroda- Simpo	
Period	Steady State(2050)	1993	1994
CO_2 reduction (%)	14.4%	13.4%	18.6%
Carbon Tax/tC	$ 16.96/tC	$ 37.09/tC	$ 52.59/tC

There are still some differences at the level of carbon tax even if we would try to adjust the reducing level. It might come from the possibility of the energy saving in the technology in terms of the substitutability among factors and the feasibility of the technical progress, which mostly depend upon the level of the energy efficiency at the present stage in each country. Therefore, we can conclude that it is highly important to choose and adjust the policy target reducing CO_2 emissions carefully at the level of development stage of the economy internationally in order to avert inequality of the burden of the economy stemmed from the differences of the targets.

3. Table Framework of Policy Instruments and the Assessment of their Implication

Instruments	Performance or Impacts		Equity: Domestic	Equity: International	Effectiveness: Domestic	Effectiveness: International
Market Based or Market Oriented	Unilateral :non cooperative	Carbon Tax or Subsidies	Among Instruments Among Sources Among Individuals		Adjustment Cost Revenue Neutrality R&D Efficiency	Leakage Problem Trade Liberalization:Duties Outflow of Capital
		Tradable Permit	Allocation of Rights Among Sources	Free-rider DCs vs. LDCs DCs vs. DCs	Transaction Cost Monitoring Cost	Leakage Problem Outflow of Capital
	Global: cooperative	Carbon Tax or Subsidies	Differences of Energy Efficiency and Cost Level of Stabilization, Distributional Impacts	Free-rider	Adjustment Cost	
		Traceable Permit	Allocation of Rights Level of Reduction		Transaction Cost Monitoring Cost :Imperfect Market	
Negotiated Based	Unilateral: partly cooperative (joint Implemen-tation)	Competi-tion based	Set of Base-line of Environment Total Quantity of Environment Available		Transaction Cost:Clearing House	
		Trading Based			Imperfect Trading Market	
Regulatory	Technology-Based		Differences of Cost among Sources Monitoring Cost		Incentive	
	Performance-Based		Differences of Cost among Sources		Monitoring Cost	
Adaptation	Unilateral		Distributional Impacts of Place and Time		Exclusiveness	
Enhancement of GHG Sink:Deforestation etc.	International Fund System					
Recycle	Refund System					
Energy Conservation						

REGIONAL SESSION

Economic Measures & their Implications for Asia-Pacific Region

-Keynotes-

REMARKS FOR THE REGIONAL SESSION

N. Sundararaman
Secretary, IPCC

The IPCC is an intergovernmental scientific-technical body that (a) periodically assesses available scientific-technical information on the science, impacts and the economics of climate change and on the mitigation and adaptation options for addressing climate change, and (b) provides technical and scientific advice to the Intergovernmental Negotiating Committee for the Framework Convention on Climate Change (INC). Since its establishment, the IPCC had emphasized the importance of encouraging the full participation of the developing countries in its activities. The earlier Special Committee on the Participation of Developing Countries (1989-1992) of the IPCC had defined full participation as having the national capacity to assess the scientific basis of climate change and the impacts of climate change on the nation and of evaluating available response options in order to develop appropriate national strategies.

At the time the IPCC reorganized itself in 1992, it instructed its three Working Groups to address issues of concern to the developing countries as part and parcel of their work. It has also made special efforts to involve experts from the developing countries in the drafting and reviewing of its reports. For example, every writing team for the chapters of the planned IPCC Special Report to the first session of the Conference of the Parties to the Climate Convention (SR) and the IPCC Second Assessment Report (SAR) contains at least one lead author from the developing world. (The SR is expected to be completed in November 1994 and the SAR in late 1995.)

Part of the work of the IPCC involves understanding and elucidating the uncertainties associated with various aspects of climate change such as its prediction. Reducing these uncertainties entails identifying gaps in the knowledge base and such gaps more frequently are encountered in the developing countries. In this context, institutional and other infrastructure needed to implement research, monitoring and other programmes to fill the gaps need to be identified also. The regional session provides a good opportunity to do this.

OVERVIEW OF THE SCOPE OF IPCC WG III

Hoesung Lee
Co-Chair, WG III, IPCC

IPCC is an intergovernmental organization that assesses the current state of science as it related to climate change. The first reports of the IPCC were issued in August 1990. This report has now become a standard reference of work that is widely used by policy makers, scientists, and others. In November 1992, the IPCC was restructured into three new working groups, each of which was asked to provide input to a Second Assessment Report to be produced in 1995. The activity of Working Group III is being overseen and co-ordinated by the Working Group III Bureau, which consists of Co-chairs from Canada and Korea and Vice Chairs from Norway and Kenya.

The WG III will prepare a report comprising its contribution to the IPCC SAR and containing a technical assessment of the state of knowledge of the socio-economics of climate change mitigation, adaptation, and impacts, taking into account the factors the Terms of Reference.

Technical assessments of the socio-economics of impacts, adaptation and mitigation of climate change, short/long term, regional/global levels.

- top-down/bottom up economic modelling
- the evolution of technological change
- methods for risk assessment
- methods for the generic assessment of response instruments

The WG III will also prepare a report, in time for the first meeting of the Conference of the Parties to the Climate Convention, on the validity, appropriateness, and utility of existing greenhouse gas emissions scenarios, taking account of gaps and uncertainties in available knowledge, especially concerning the evolution of socio-economic development and technology. The scenarios are intended to assist WG I, II in their assessment of a range of future changes of atmospheric composition resulting climate changes, and their impacts.

Preparation of WG III contribution is being carried out by ten teams of lead authors who was officially nominated by the Governments and assigned by the Bureau of WG III. Major themes to be considered are as follows.

Part I : Scope of the Assessment

Part II: The Socio-economics of impacts, adaptation, and mitigation of climate change

- Applicability of sustainable development, benefit-cost analysis and other paradigms to climate change
- Costs of climate change
- Costs of mitigations of greenhouse gas emissions in the short run
- Costs of mitigation of greenhouse gas emission in the long run
- Decision-making framework to address climate change
- Generic assessment of response options
- Policy instruments
- Equity and social considerations

Part III: Emissions scenarios

Working Group III will address issues in methods and applications of cost-benefit analysis, costs and effectiveness of the response options including adaptation and mitigation options, policy instruments for domestic and regional use. Socio-economic factors will be considered in relation to decision making for climate change including risk assessment. The Working Group will pay special attention to the equity considerations which will have important implication for Asia-Pacific regions.

OVERVIEW OF WG III

Erik F. Haites
Technical Support Unit, WG III, IPCC

The IPCC meeting at Harare in November 1992 created three working groups. Working Group III was asked to assess the existing emissions scenarios for the Report to the Conference of the Parties and to cover "cross-cutting" issues for the Second Assessment Report. At the same meeting Korea and Canada were elected as co-chairs and Kenya and Norway were elected as vice-chairs of the Working Group III Bureau.

The work plan for Working Group III was developed at a workshop held in Montreal in may 1993. This work plan included a an outline of the Working Group III report together with a work schedule. The work plan was approved with minor changes at the IPCC meeting in Geneva in June 1993.

The work of assessing the literature is performed by experts nominated by participating countries and organizations. These experts are organized into teams of lead authors. The Working Group III Bureau divided its report among ten writing teams. The lead authors for these writing teams were selected from among the nominees by the Working Group III Bureau during July and August. The selection was based on the scientific credentials of the nominees and the need to balance geographic representation on the writing teams.

The members of the ten writing teams are shown in the attached list. Typically a writing team has between four and ten members, one of whom serves as the convening lead author. In accord with IPCC policy, every team includes at least one expert from a developing country. The lead authors may invite other experts to assist them by summarizing specific aspects of the scientific literature. The work of these invited experts is recognized by listing them as contributing authors.

The lead authors for Working Group III met in Seoul early in September to organize their work. Each team developed a rough outline of its chapter, apportioned the work among the team members, and developed a schedule for production of the material. Writing Tear 10 on emissions scenarios must complete its draft report by March 1994 while the other writing teams must complete their draft chapters by mid-August of 1994.

The schedules are determined by the IPCC review and approvals processes. The Report to the Conference of the Parties will be approved by the IPCC at a meeting scheduled for Harare in November 1994. The assessment of existing emissions scenarios will form part of that report, so the review and approvals process must be completed by November 1994. As shown in the attached schedule, the draft chapter is first subjected to peer review. The comments received from experts are collated and sent to the lead authors who then revise the draft chapter as appropriate. The revised chapter is submitted to participating governments and organizations for review. Again the comments are collated and sent to the lead authors. They make any further revisions that are appropriate. The revises text is then submitted to the Working Group III Bureau, the Working Group III plenary and the IPCC plenary for adoption.

The remaining chapters will be subjected to the same review and approvals process. However, since they will form part of the Second Assessment Report which will be published in the fall of 1995, the schedule for the other chapters and writing teams differs from that for writing team 10. The schedule for the Second Assessment Report is attached.

To facilitate the work assessing the literature and reviewing the material produced by the writing teams, Working Group III plans to support a series of workshops during the first eight months of 1994. The Tsukuba Workshop on Policy Instruments and their Implications is the first of these workshops. Each workshop is expected to have both a technical and a regional focus. The Tsukuba workshop focuses on policy instruments and the Asia-Pacific region.

Other workshops, as shown on the attached list, will focus on emissions scenarios and Central and South America, top-down and bottom-up modelling and the Eastern Europe, and equity and social considerations and Africa. The Bureau also hopes to be able to hold a workshop in the middle east.

It is important to realize that the role of the IPCC is to assess the available scientific literature. The IPCC does not perform original research or analyses of its own. Thus, Working Group III will not be developing new emissions scenarios, nor will it be preparing its own estimates of the damages due to climate change or the costs of limiting emissions. It will only review the available literature in each of these, and other areas.

If you are aware of relevant studies or reports on any topic within the mandate of Working Group III, I encourage you to bring it to the attention of the appropriate writing team. Please feel free to contact me at the address shown on the list of participants if you have any questions concerning Working Group III. I will be pleased to respond to your questions to the best of my ability. If you wish to contact any of the lead authors, I can provide you with the address and other contact information.

PROPOSED WRITING ASSIGNMENTS FOR
THE WORKING GROUP III
SECOND ASSESSMENT REPORT
(Draft November 15, 1993)

PREFACE working Group III Bureau

EXECUTIVE SUMMARY Working Group III Bureau for review by all lead authors

SUMMARY FOR POLICY MAKERS Working Group III Bureau for review by all lead authors

PART I: SCOPE OF THE ASSESSMENT

Writing Team 1: SCOPE OF THE ASSESSMENT
C Jose Goldemberg, Brazil
Joe Stiglitz, U.S.A.
Akihiro Amano, Japan
Xie Shaoxiong, China
Ruby Saha, Mauritius

PART II: THE SOCIO-ECONOMICS OF IMPACTS, ADAPTATION, AND MITIGATION OF CLIMATE CHANGE

CHAPTER 1: SOCIO-ECONOMIC FRAMEWORK FOR DECISION-MAKING

Writing Team 2: DECISION-MAKING FRAMEWORK
C Jyoti Parikh, India WG II
Kenneth Arrow, U.S.A.
Gonzague Pillet, Switzerland
Carlos Suarez, Argentina

* = Participation still to be confirmed
C = Proposed Convening Lead Author

Writing Team 3: **APPLICABILITY OF BENEFIT-COST ANALYSIS TO CLIMATE CHANGE**
C Mohan Munasinghe, World Bank
Michael Hoel, Norway
Sung-Woong Hong, Korea
Carlos Hurtado, Mexico

Writing Team 4: **EQUITY AND SOCIAL CONSIDERATIONS**
C Harold Jacobson, U.S.A.
Karl Goran-Maler, Sweden
Michael Grubb, U.K.
Tariq Banuri, Pakistan

CHAPTER 2: **ASSESSiNG THE BENEFITS OF RESPONSES TO CLIMATE CHANGE**

Writing Team 5: **BENEFITS OF RESPONSES TO CLIMATE CHANGE**
C David Pearce, U.K.
William Cline, U.S.A.
R.K. Pachauri, India WG II
Pier Vellinga, Netherlands WG II

CHAPTER 3: **EVALUATING THE COSTS OF MITIGATION OF GREENHOUSE GAS EMISSIONS BY SOURCES AND REMOVAL BY SINKS**

Writing Team 6: **COSTS OF MITIGATION OF GREENHOUSE GAS EMISSIONS IN THE SHORT RUN**
C John Robinson, Canada
Thomas Johansson, Sweden WG II
Plino Nastari, Brazil
Ogunlade Davidson, Sierra Leone
Youba Sokona, Senegal
John Weyant, U. S .A

Writing Team 7: **COSTS OF MITIGATION OF GREENHOUSE GAS EMISSIONS IN THE LONG RUN**
C Jean-Charles Hourcade, France
Richard Richels, U.S .A.
Dale Jorgenson, U.S.A.
Domenico Siniscalco, Italy
Sergey Pegov, Russia
Jin-Gyu Oh, Korea
Peter Sturrn, OECD

Writing Team 8: **POLICY INSTRUMENTS**
C Brian Fisher, Australia
Scott Barrett, U.K.
Peter Bohm, Sweden
Anwar Shah, World Bank
John Mubazi, Uganda
Masahiro Kuroda, Japan
Robert Stavins, U.S.A.
Boguslaw Fiedor, Poland

* = Participation still to be confirmed
C = Proposed Convening Lead Author

CHAPTER 4: GENERIC ASSESSMENT OF RESPONSE OPTIONS

Writing Team 9: GENERIC ASSESSMENT OF RESPONSE OPTIONS
C Catrinus Jepma, Netherlands
Shakespeare Maya, Zimbabwe
Irving Mintzer, Stockholrn Environment Institute
Majid Al-Muneef, Saudia Arabia
Mohammed Asaduzzaman, Bangladesh

PART III: EMISSIONS SCENARIOS

CHAPTER 5: CONSIDERATIONS OF CONSISTENT SCENARIOS

Writing Team 10: EMISSIONS SCENARIOS
Joseph Alcamo, the Netherlands
Tsuneyuki Morita, Japan
James (Jae) Edmonds, U.S.A. WG II
Zhou Dadi, China
Aca Sugandhy, Indonesia
Amulya Reddy, India

NOTE: At the WG III Lead Authors meeting in Seoul several authors raised concerns about the benefit-cost orientation implicit in the structure of the report. The WG III Bureau was requested to consider a revised structure that would cover the same material, but present it in a manner that is more closely linked to the policy questions related to climate change. An alternative report structure that involves the same writing teams and the same division of responsibilities is currently being considered by the WG III Bureau and lead authors.

* = Participation still to be confirmed
C = Proposed Convening Lead Author

Schedule for the Work of Working Group III for Second Assessment Report

Revised July 30, 1993

Sept. 1993 to Aug. 1994	Workshops are held and lead authors prepare first drafts of Second Assessment Report (SAR) chapters.
Dec. 6-8, 1993 Shepperton, U.K.	WG III bureau participates in proposed WG I Bureau meeting to review progress of collaborative efforts.
Feb. 4-5, 1994 Geneva	IPCC Bureau meets to review collaborative mechanisms and to monitor progress of IPCC work.
April 11-15, 1994 Fortaleza, Brazil	WG III participates in proposed joint workshop with WG I and WG II on stabilization of atmospheric concentrations, regional climate change scenarios and implications for impacts assessments.

Aug. 31, 1994	Drafts of chapters for the SAR sent to the WG III Bureau by writing teams for preparation by Bureau of Executive Summary and Policy Makers Summary.
Sept. 8-10, 1994 Geneva	Lead authors meeting to discuss draft chapters, overlaps, and key points for summaries.
Oct. 1994	Co-chairs distribute first draft of SAR chapters, draft Executive Summary and Policy Makers Summary for peer review.
Dec. 1994 to Feb. 1995	Lead authors and WG III Bureau revise SAR based on peer review comments.
Jan. 1995	Workshop on Article 2 of the Framework Convention on Climate Change.
End Feb. 1995	Revised draft of SAR circulated for review by countries and organizations.
Apr. to May, 1995	Lead authors and WG III Bureau prepare final draft of SAR including the Executive Summary and Policy Makers Summary based on comments from IPCC countries and organizations.
May 1995	WG III Bureau meets to approve SAR chapters, Executive Summary and Policy Makers Summary.
June 1995	WG III Plenary considers SAR chapters and approves Executive Summary and Policy Makers Summary.
Sept. 1995	IPCC Plenary adopts SAR.
Oct. 1995	SAR printed and distributed.

Schedule for the Work of Working Group III for Emissions Scenarios

Revised July 30, 1993

Sept. 1993 to Feb. 1994	*Lead authors for review of current emissions scenarios prepare first draft of their chapter.*
Feb. 3, 1994 Geneva	*Expanded WG III Bureau meeting t~ review evaluation of current emissions scenarios.*
Mar. 1, 1394	*Draft evaluation of current emissions scenarios completed and distributed for peer review.*
Mar. 31, 1994	*Peer review comments on draft evaluation of current emissions scenarios received. Experts prepare the first draft of material for the COP.*
April 1994 Fortaleza, Brazil	*Expanded WG III Bureau meeting to review draft material for the COP. Workshop on emissions scenarios.*

May 1994	*Draft evaluation of current emissions scenarios for COP circulated for review by countries and organizations.*
July 1994	*Draft evaluation of current emissions scenarios for COP revised in light of government comments.*
Sept. 5, 1994 Geneva	*WG III Bureau Meeting to approve emission scenario report for COP.*
Sept. 6-7, 1994 Geneva	*WG III Plenary to approve emission scenario report for COP.*
Nov. 10 -12, 1994 Nairobi	*IPCC Plenary approves evaluation of current emissions scenarios for COP.*

List of Workshops

WORKING GROUP III WORKSHOPS (Attendance by invitation only)

January 17-20, 1994 **Japan**	**Policy Instruments and their Implications** A workshop on policy instruments and their implications, Tsubuka, Japan.
April 7-8, 1994 **Brazil**	**Greenhouse Gas Emissions Scenarios** A workshop on the review of current emissions scenarios, Fortaleza, Brazil.
April 27-29, 1994 **Italy**	**Top-Down and Bottom-Up Modelling: What Can We Learn from Each Approach?** A workshop on top-down and bottom-up modelling and what we can learn from each approach, Milan, Italy.
July 18-22, 1994 **Kenya**	**Equity and Social Considerations: What is Science? What are Values?** A workshop on equity and social issues related to climate change, Nairobi, Kenya.
August 1994??	**Sustainable Development, Cost-Benefit Analysis and Decision Making Related to Global Warming** Saudi Arabia has indicated that it might be interested in hosting a workshop for WG III.

WORKING GROUP III EXTENDED WRITING TEAM MEETINGS (Attendance by invitation only)

March 3-6, 1994 **Switzerland**	**Decision-making Under Uncertainty & CC Risk Economics** A meeting dedicated to discussing decision making under uncertainty as it applies to climate change, Montreux, Switzerland.
Summer 1994??	**Social Costs of Climate Change Tentative** A meeting dedicated to estimating the social costs of climate change.

ECONOMIC MEASURES AND THEIR IMPLICATIONS OF ASIA-PACIFIC REGION

-Basic Guidance-

-The Framework Convention on Climate Change States-

Aca Sugandhy
Ministry of State for the Environment, Indonesia

"Policy measures and economic instruments to combat climate change i.e. emissions reduction should not constitute a means of arbitrary on unjustifiable discriminate or a disguised restriction on international trade."

"And development needs of any country and societal benefit."

Introduction to the discussion on the Joint Implementation and cooperated research in Asia-Pacific region.

The issues.

A. Global policy instruments and their implications to Asia Pacific region and country level.

a. Emission reduction of energy related CO_2 emissions and non-CO_2 emissions.
b. Emission reduction of forestry and land - use related CO_2 and non-CO_2 emissions.
c. Uncertainty results on net green house gases emissions-sources and sinks driving forces.

B. Economic policy instruments developed bias toward industrialized countries condition/mechanism.

a. Taxes i.e. - Carbon/energy taxes -Energy intensive

b. International trade/regulatory instruments i.e.
- Forest product: Eco labelling
- Agri product: Green label

c. Financial incentives/Compensation i.e.
- Subsidies : For energy cost recovery
  : For agricultural
- Incentives: For special purposes

d. Tradeable permits for production and consumption of emission sources i.e. to internalize the social cost and environmental cost of pollution to the polluter and of user with receive the greatest benefit.

e. Recycling revenues

f. Voluntary market responses

C. Their implications to Asia Pacific region and country level.

a. International economic cooperation i.e.
- environment and trade: GATT, APEC
- financial and technical assistance.

b. Unilateral or bilateral action
- Developed country action that will affect international trade: import banned, protectionism, trade restrictions.

- Developing country action on a voluntary based on their capacity and priority of their national development needs: GNP growth, debt service

D. Possible joint implementation and co-operated research in Asia Pacific region

The objectives of the joint implementation in abating CO_2 and non-CO_2 emission are

1. To meet the merit as asked by article 3 of Framework Convention on Climate Change

2. To secure full cooperation on global environment management i.e. protection of the atmosphere through the stabilization of the green house gases concentration.

3. To develop fair agreement and or negotiation between parties and non-parties to take action on emission reduction.

4. To secure financial mechanism and transfer of technology to developing countries, however, it should be fully aware that to develop appropriate policy instruments on related green house gases emissions reduction, its economic instruments and regulatory instruments, it is crucial at the first place to understand the characteristics of the emission sources and sinks at the regional and country level of Asia by considering those objectives and due to the uncertainty of the global climate scenario caused by the lack of scientific assessment at the regional and country level of Asia by considering those objectives and due to the uncertainty of the global climate scenario caused by the lack of scientific assessment at the regional and country level, henceforth, the possible joint implementation and co-operated research in Asia pacific region should be taken in this following steps:

1. To strengthen the Asia pacific regional center for networking climate change information, monitoring and the related GHG's emission sources and sinks.

2. To strengthen national institution capability in dealing with the protection of atmosphere.

3. To improve human resource development research capability through training, infrastructure development for climate data, climate change monitoring, climate modelling.

4. To cooperate in intensifying energy efficiency and in developing energy such as solar energy, and innovative environmentally.

5. To cooperate in developing policy economic and regulatory instrument related to GHG's emissions reduction by considering carefully. The national development needs and societal benefit.

6. To assess the feasibility and the socio-economic and political implications of any instrument developed or introduced for reducing the GHG'S emissions.

7. To discuss the result of any assessment in transparencies within "an international / regional clearing house as an input for international cooperation" i.e. to link the cost and implication for protection the atmosphere, global environment and trade either negotiation for the implementation of climate convention and its protocols or international economic cooperation such as GATT and APEC.

8. To do pilot project for exercising policy mix and port-folio instrument at the regional and country level of Asia Pacific.

REGIONAL SESSION

Economic Measures & their Implications for Asia-Pacific Region

-Round Table Session[2]-

2 Experts from Asia-Pacific Region discussed about global warming policies in their countries in this round table session. This chapter includes papers which were submitted to this session.

GLOBAL WARMING POLICIES IN AUSTRALIAN

Brian Fisher
Australian Bureau of Agricultural and Resource Economics

In 1992 the Australian Government published its National Greenhouse Reports strategy (Commonwealth of Australia 1992). In that strategy Australia set out its interim planning target,mainly that Australia would:

Stabilize greenhouse gas emissions (not controlled by the Montreal Protocol on substances that deplete the Ozone Layer) based on 1988 levels, by the year 2000 and to reduce these emissions by 20 per cent by the year 2005....subject to Australia not implementing response measures that would have net adverse economic impacts nationally on Australia's trade competitiveness, in the absence of similar action by major greenhouse gas producing countries.

The first phase response measures concentrated on measures of a no regrets' nature. These are set out in detail in Commonwealth of Australia (1992). This strategy is complimented by a comprehensive research and development program in energy efficiency, a new energy sources and the assessment of environmental impacts.

Important in Australia's response is the implementation of complementary policies designed to increase efficiency in energy generation and distribution. The benefits of micro economic reform in the electricity and gas sector is set out in ABARE (1993 (a)).

Australia is active in developing a comprehensive greenhouse gas inventory including all sources and sinks. The methods being adopted are fully consistent with the draft. IPCC guidelines which have been distinguished to dept. The most recent projections of energy supply and demand for Australia are set out in ABARE (1993 (b)).

References

ABARE (1993 (a)), The Economics of Interconnection : Electricity Grids and Gas Pipelines in Australia, *Research Report 93.12,* Canberra

ABARE (1993 (b)), Energy Demand and Supply Projects, Australia, 1992-1993 to 2004-05, *Research Report 93.2*, Canberra

Commonwealth of Australia (1992), National Greenhouse Response Strategy, AGPS, Canberra

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GLOBAL WARMING POLICIES IN BRUNEI

Eddie Haji Sunny
Ministry of Development, Brunei

Brunei Darussalom, being basically a coastal state is aware of the implications of climate change - especially global warning. Most of our population centers and economic activities are situated on the coastal zone, and such are vulnerable. Being a developing country, we have many of the problem and concern of other developing countries. Being a small country however, both in terms of land area and especially population, puts us at an added disadvantage.

We have a basic problem of not having enough human resources to address global issues, however much we like to. We lack the technology and necessary knowledge. Unlike other countries may have started their efforts decades ago, our own data and information on environment in general, and emissions in particular, have a long way to go. It is thus difficult to comply to any given standard, when complete and basic data is not yet available. Thus, we had capacity building - even before we took about other measures.

However, we do what we can. The government in early 1993 set up a National Committee on Environment, comparing of relevant government agencies and the private sector: An environment client under the Ministry of Development has also created to act as Secretariat to the Committee. This modest start underscores a very important concept: that responsibility for the environment is everyone's concern.

For the past few years too, we have been limiting our oil production. Our timber logging industry, since 1991 has had to halve its production compared to 1991 levels, as part of our forestry conservation effort.

We also support international activities. For example we will be hosting the 4th southeast Asian Research Council for START meeting under the International Geosphere - Biosphere Programme, at the end of the month. We also participate in other activities as part of our capacity building effort.

More need to be done. But when we talk about the measures and policy instruments that were elaborated in the last few days, being as oil and gas producing nation, being largely dependent on our oil and gas exports at present, and in trying to encourage other industrial activities in order to reduce our dependency on our oil and gas exports, we are naturally concerned about the implications of carbon tax. Other measures would have to be studied in our own context. Just as we agree in one of the pervious sessions that the market should be allowed to choose policies and instruments without international intervention, heavy - handed or otherwise.

GLOBAL WARMING POLICIES IN CHINA

Shen Longhai
State Planning Commission, China

In 1990, "State Coordinating Panel on Climate Change" has been set up in China. In 1992, China was one of the first 10 countries to ratify the United Nations framework convention on climate change.

China will actively participate the activities on global climate change, including global warming policy, China will actively cooperate with some organizations such as IPCC, WCP, START, APN, TEACOM, etc.

China has further formulated priority projects of China's agenda 21. It is proposed that an international round-table meeting will be held in Beijing sometime in June of 1994 to call for more financial and technical support from other countries, international organizations and related agencies.

China will stress on R&D on global and China's climate change. SSTC and SPC will put climate change into the state R&D projects further.

China will make every effort to reduce GHG's emission. First, to enhance energy conservation and improve energy efficiency, we will continue to carry out the principle of "Lay equal stress on both exploitation and conservation of energy and at present, energy conservation must be put in the first position. Second, to control of atmospheric pollution and prevention of acid rain. Third, to implement afforestation in a massive scale to increase the absorption of carbon dioxide. Fourth, to develop new and renewable energy, such as wind, sober, biogas, etc.

China will set up monitoring, forecast and service system for climate change to provide basis for adaptation strategies.

China has to introduce advanced and sound technologies and equipment.

China welcomes continually more much financial support.

China has to conduct personnel training in order to raise public awareness on environmental protection.

GLOBAL WARMING POLICIES IN FIJI

Mangal Jiten Prasad
Ministry of Finance & Economic Planning, Fiji

Fiji has signed the Montreal Protocol. To comply with obligations under this protocol a consultative committee on Ozone Depleting Substances has been set up to oversee implementation of Government's commitment to phase out CFCS. Representatives in this committee are from both the public & private sectors.

The Framework Convention on Climate Change has been signed and ratified by Fiji.

An Environment Management Unit was set up in 1989 to assess the environmental situation in Fiji and develop an appropriate response. It produced the "National State of the Environment" report under the sponsorship of the Asian Development Bank and in collaboration with IUCW-The World Conservation Union.

In 1992 the Department of the Environment was established which produced Fiji's "National Environment Strategy" (NES). These two documents provide analysis of environmental problems in Fiji & a framework for action.

Concerning climate change and coastal zone management, the NES says, "The coastal zone is of vital importance. It brings together a unique assemblage of resources such as reefs, mangroves, water, agriculture, seafood and high quality landscapes. Yet it is also the location of every significant town in Fiji, most villages and the vast majority of the population together with industry and commerce."(p.53)

"The implications of global warming for Fiji are severe but as yet cannot be determined with any degree of accuracy. However, it is now an established fact that global warming is occurring and Fiji can expect effects from sea-level rise and climate change."(p.54)

To increase public awareness about climate change and other pressing environmental matters, there is now a national environment week held each year. This public awareness effort is supported by the media, government, schools and NGOs.

The essential element of Fiji Government policy is to ensure sustainable development through protection of the environment against activities that threaten long term productive potential.

This implies:
- ensuring that renewable resources are used in a sustainable manner,
- ensuring that environmental management is an integral part of the planning and development process,
- strengthening of institutional capacity for sound environmental management,
- ensuring that environmental expenditures are prioritized on the basis of best estimates of their contribution to socio-economic development.

GLOBAL WARMING POLICIES IN INDONESIA

Aca Sugandhy
Ministry of State for the Environment, Indonesia

1. Policies:

a. National strategy to anticipate climate change related to greenhouse gases emissions concentration.
   -halt global warming for the global environment
   -anticipate adverse effects on environment?
b. National interagency committee to deal with global climate change.
c. Ratification of climate change convention by laws, since this issue considered very strategic at national level, and not only concern with global environment.

2. Researches:

a. socio-economics impacts assessment of climate change to agricultural (UNEP) finished.
b. Indonesian country study on CO_2 emission sources (JICA) finished.
c. Indonesian country study on CO_2 sinks by forest (Norway) finished.
d. Indonesian country study on CH_4 emission sources (USAID) will be started.
e. NGO's participation on national policy responses to combat adverse effects of climate change (ADB) finished.
f. Sea level rise potential study

3. Action Programs = (on a voluntary basis & international assistance)

a. One million planting trees program in 27 provinces (in 1993, 140 million planted).
b. Energy efficiency program in urban areas.
c. Energy alternative program i.e. coal, solar, biomass, geothermal.
d. Improving climate data in meteorological and geophysical agency.
e. Establishment of more climate data stations (from 200 to become 900) including infrastructure for GHG's monitoring.
f. Establishment of the equatorial radar monitoring.
g. Improved regreening and reforestation program.
h. Urban climate campaign to reduce CO_2 emission in urban area.
i. Agro-forestry program to reduce forest conversion.
j. The preparation of AIREV.

4. Institutional Capacities

a. Limited knowledge on greenhouse gases phenomena.
b. Inadequate capacity for climate modelling.
c. Shortage of institutes and academic/scientist involved in climate change/global warming/greenhouse gases stabilization issues.
d. Limited capacity and capability in government and private sector policy instruments, economic instruments and regulatory instruments.
e. Shortages of funds and technological innovations to response to global warming policies GHG stabilization. i.e. Emissions reductions, due to national development need priority to push growth on per capita income, equity, employment opportunity, poverty alleviation, etc..

5. International Cooperation:

a. Intensive research in the role of Indonesia as tropical/equatorial and second largest tropical forestry country in the greenhouse gasses sinks and future emissions sources.
b. Monitoring net greenhouse gases emissions.
c. Access to information, technology for: c1,-halting global warming--sea level rise; c2,-monitoring climate change and its impact on agriculture.

GLOBAL WARMING POLICIES IN JAPAN

Shuzo Nishioka
Center for Global Environmental Research
National Institute for Environmental Studies

One of the more interesting aspects of global environmental issues is that the relation between policy and science is so closely tied to understanding both nature's mechanisms and future changes caused in nature from anthropogenic pressure. These understanding are indispensable to timely and effective decision making. At the same time, no single nation or group can solve these issues without collaboration with others, making international collaboration essential. To achieve this goal, developed counties have the responsibility to establish action plan with clear target to reduce their emission of greenhouse gases, and to lead regional and global cooperative activities in this field.

In 1990, the Government of Japan launched up the Action Program to Arrest Global Warming and set a target goal of stabilizing carbon dioxide emissions at 1990 levels by the year 2000; accordingly, the central and local governments, industry, and the public have all started to act towards this end. In 1992, an assessment of the feasibility of the Action Plan was carried out and it was found that considerably more effort in each sector would be required to meet this goal,and that a more comprehensive policy should be established that include not only technological innovation, but also changing in living styles and value judgement.

Responding to the recommendations of the World Climate Congress,the Government of Japan, in collaboration with countries in the region and international organizations, initiated a series of Asia-Pacific Seminar on Climate Change to disseminate the result of the IPCC report and to search the possibility of regional cooperation to tackle global warming. At the Second such seminar, held in Bangkok in 1993, preliminary results of country studies carried out under the initiative of the Asian Development Bank were reported. Participants in a meeting in November of 1993 at ESCAP discussed how to establish a regional cooperation mechanism. As a follow-on to these activities, the third Seminar will be held in Osaka from 28 to 30 March, 1994, and will focus mainly on a regional cooperation strategy and, as the first step to such a strategy, on a common methodology for inventory of greenhouse gas emissions.

Intensive research effort is continuing to this area, including japanese collaboration with the international research programs of IGBP, WCRP and HDP. Many governmental research institutes devote resources to this area, coordinated by the Environment Agency under the Global Environment Research Program. The Asian GHG emissions, impacts of climate change, and possible countermeasures, can be used as a common tool in discussing a regional strategy. Assessment of regional vegetation and human health, is another area for regional research.

The New Earth 21 Plan also launched in 1990 aims to set up a long range sequence of investigations into technology as one of the possible solution; parallel to that effort is a study of the fundamental structure of the socio-economic system that is looking for the possibility of a social breakthrough. Already, many NGO's and members of the public promote and engage in the recycling and reuse of goods and materials, and some local government are drafting local agenda to cope with climate change.

The IPCC has been playing very important role in assessing the state-of-the-arts of climate change related researches and in helping the decision-makers of the world have a common understanding of the implications of climate change. Japan has so been very active in this work. In the first cycle of IPCC activities from 1988 to 1992, Japan was the co-vice chairman of Working Group II(WG II) and the lead authors of impact assessment and countermeasures reports in the energy and industry fields. In the second cycle that started in 1993, Subgroup A of the new WGII is co-chaired by Japan; guidelines for assessing impact of and adaptation is climate change were jointly developed by Japan and the United Kingdom. The Tsukuba Workshop is another contribution to WGIII, Three economists were appointed as lead authors there. Japan has contributed to the assessment work of WGI by giving the results of the GCM coupled model developed by the Meteorological Research Institute.

Japan now plans to strengthen research collaboration among and between the regions. The Asia-Pacific Research Network on Global Change described in a Japanese initiative Last year is being discussed by regional scientists participating international scientific programmers and by regional policy makers. This network could serve to strongly enhance research collaboration in all global environment research fields including global worming. Through continuation and evolution of those activities, Japan is eager contribute to the international effort struggling to deal the most difficult environmental issue humans face in these decades.

GLOBAL WARMING POLICIES IN KOREA

Tae Yong Jung
Korea Energy Economics Institute

Korea was the 47th country to ratify the Framework Convention on Climate Change in December 1993.

For governmental level, inter-ministry committee on global warming has been launched in order to integrate policy matters and help relevant research institutes in undertaking major research projects on global warming issues.

Korea Energy Economics Institute is actively involved in international joint research projects imitated by some developed countries, such as USA, Japan, and Australia to encourage the collaboration between developed and developing countries.

Not only Korea Energy Economics Institute, but also Korea Institute of Science and Technology and other national institutes are conducting research projects which are not only policy-oriented but also technology-oriented studies, in order to figure out this issue on national level.

Researches have been continued to refine energy system models in top-down as well as bottom-up approaches to analyses the impact of policy instruments for mitigating greenhouse gas emission.

A study on Korean regional energy conservation system is triggered to propose how to construct efficient energy system in practical sense. This study will contribute to implementing policy instruments for limiting greenhouse gas emissions in Korea.

Energy conservation programs have been started in many areas. for instance, energy efficiency labelling system in major home appliances, and auto mobile has been effective. Specific demand side management programs are working now and planned by electric utility company.

Though public awareness keeps increasing these days, especially after Rio summit, it may take time for policy makers to incorporate into their policy making processes. In this sense, there should de more active researches in national, regional and global level.

GLOBAL WARMING POLICIES IN MALAYSIA

Leyu Chong Hua
Malaysian Meteorological Service

Malaysia is of the opinion that, be it warming or cooling, there are bound to be some forms of climate change associated with increasing GHG concentrations, which could bring about adverse consequences. It therefore warrants precautionary measures to be taken particularly in the control of GHG emissions. However, in formulating policy mechanisms aimed at controlling GHG emissions, differential treatments should be applied to developing and developed countries. Developing countries should be allowed to eradicate poverty and also improve the living standard of their people to certain level without being subjected to the additional burden of complying to various forms of policy mechanisms. On the other hand, developed countries who have enjoyed a "free ride" over the last 150 years or so should play their role in reducing GHG emissions with no further delay.

Research

There are some studies currently being done in Malaysia to evaluate the implication of various policy instruments particularly "joint implementation" with developing countries.

There are also various other studies being carried out in the country such as in the area of potential socio-economic impacts and policy responses resulting from climate change, studies sponsored by ADB, IGBP, etc.

Measures Taken to Reduce GHG Emission

Malaysia has identified the energy sector as the main source of carbon dioxide emissions and has taken measures to promote efficient energy utilization and to discourage wasteful patterns of energy consumption. Cars are heavily taxed, up to over 300% for those with very large engine capacities. Car pooling is introduced and light rail public transport system is being constructed. Guidelines have been launched to entrance energy efficiency in new buildings.

The country pursues prudent forest policies to maintain it as a carbon sink. In this respect, 61.2% of the total land area of the country is still covered with natural forests and plantation.

Institutional Capacities

In the wake of climate change and its possible adverse impacts, the Government first established a National Steering Committee on Environment Land Development to handle all issues related to climate change. Membership of the Committee comprises of various relevant agencies in the government who have one way or another a role to play in addressing climate change issues.

Malaysia's expertise and manpower in this area is inadequate and requires assistance from developed countries.

GLOBAL WARMING POLICIES IN MALDIVES

Abdullahi Majeed
Department of Meteorology, Maldives

Situated in the central Indian Ocean about 600 km south of Indian and about 670 km west of Sri Lanka, the Maldives Archipelago of approximately 1200 islands the equator from in to is the average elevation is 1.6 mm above sea level. This setting together with the main livelihood of fishery and make Maldives potentially vulnerable to the global warning, climate change and its consequent sea level rise.

Should the IPCC projected one matter rise in sea-levels occurs by the years 2100, it would be catastrophic to Maldives. At least 80% of its land area will be wiped out and the remaining 20% will be often prove to flooding at the of winds and waves during storm surges.

Recent extreme weather events have proved this to a great extent to many Maldives. In 1987, almost 1/3 of the country was flooded due to a distant storm surge while the following year 1988, storms floods many islands. The worst storm in the recorded history of Maldives occurred in 1991. For 12 days from end of May to the middle of the second week in June that year, a rapidly formed cyclone vistsilly brought Maldives to a standstill winds of over 60 kph with a max. of 150 kph along with heavy fishing and the operations of our international airport for days. For the first time, Maldives appealed for international assistance to cope with this disaster. Recently two months ago in November 1993, a deep depression with its winds of over 70 kph and scions lashed the country.

The government of Maldives gives a high priority for the conservation of the environment. The overall responsibility for the preservation of the environment is assigned to the Ministry of Planning, Ituman Resources and Environment. A consultative body consisting of 20 members from key government ministries and departments called the National Council for the protection and Conservation of the Environment is also formed to assist the Ministries its work. Two years back the government created the Environmental Research Unit, with the tasks of carrying out environmental impact studies, coastal erosion and management etc.

In 1993, our parliament passed the bill on the conservation of environment in Maldives. Under this law, all the major projects require an environmental impact assessment before their commencement. The Environment Law, also imposes a five equivalent from US$10.00 to us$100.00 to millions depending on the gravity of the infringement. Another practical measure the government has taken is to restrict the sand and coral mining used as the traditional building materials. In the meantime, import duties levied on pebbles, sock aggregates, cement and soil are returned to this action.

The also mentioned a modest climatic network and records the water level. We have found out that the average temperature for the decade 1980 to 1990 has risen by 0.3c compared to the preceding decade 1970 to 1980 for the capitol Mali.

Maldives also keeps up a strong campaign of public education and awareness under the slogan of "Environmental Preservation Everybody's Responsibility." The general public is quite aware of the climate change and its possible. Threat to their lives though they cannot themselves alone do much about that for this is due not from their own making or choice.

Thus for I have only dwelt upon the domestic area. Maldives also tries hard to keep pace with international developments with regard to climate change. In fact, it is our president H.E. Marbmouabsed Byoam who first Brought this issue to the attention of the Commonwealth Soviet in 1987. In the same year, he also actively took part in the UN Debate on Environment and Development.

Maldives is among the first countries to ratify the United Nations Framework Convention on Climate change (UN/FCCC) and the Biodiversity convention. The Ministry of Planning, Resources and Survision of Represents the country at most major UNEP meeting while the Department of Meteorology takes part in important meetings of WMO and IPCC.

I do not mean to state that our efforts to combat the climate change is complete. For from that though we have the basic infrastructure in place, we lack severely in trained manpower and equipment. This brings me to a subject close to my hear request assistance in this regard. Therefore I appeal all the competent international organizations and friendly countries to lend us a high in training and equipment. We are doing all within our names to encounter the threat of climate change. We ask only to share understand and take action in our burdens globally for this is a global challenge.

GLOBAL WARMING POLICIES IN NEPAL

Batu K. Uprety
Ministry of Forests and Soil Conservation, Nepal

Nepal is a signatory of the Framework Convention on Climate Change and is in the final stage of formally ratifying it. Nepal has signed and ratified the Convention on Biological Diversity in addition to other conventions.

Nepal, a small and land-locked country with distinct climatic and attitudinal variations, is facing environmental problems associated particularly with forestry sector and the urban and industrial problems are location specific. Environmental problems are aggravated by its low per capita income i.e. poverty and inadequate infrastructural facilities. It indicates low level of CO_2 emission from development activities, however she will be affected by global warming phenomenon.

To offset the emerging local environmental problems, Nepal has recently endorsed National Environmental Policy and Action Plan (NEPAP) keeping in view the National Conservation Strategy, the Master Plan for Forestry Sector and the Eighth Plan (1992-'97), Agenda 21 and the Constitutional provision on environment, in order to manage efficiently and sustainable the natural and physical resources, to balance development efforts and environmental conservation by fulfilling the basic needs of the people, to safeguard national heritage, to mitigate adverse environmental impacts of development projects and human actions and, to integrate environment and development through appropriate institutions, adequate legislation and economic incentives and sufficient public resources.

Though there is no direct policy regarding the global warming, there are lots of policies which will contribute for CO_2 absorption. Some of them are to improve forest management by encouraging community participation and greater private sector involvement in managing national forests, to promote research and development of alternative energy sources to reduce dependence on biomass sources (focussing on rational use of energy), to reduce the level of indoor smoke/industrial and vehicular emission and to promote greater efficiency in reducing emission of air pollutants. The policy direction is also towards enabling the government to meet its obligation as a signatory of various international conventions by amending the existing legislation or enacting new laws. Emphasis is also given to expand the use of economic incentives to encourage more environmentally benign activities and also to review government expenditure to ensure significant allocation for environmental protection.

After the reinstatement of democracy in 1990, His Majesty's Government of Nepal has expressed its strong commitment to dealing with environment-related matters in the development process by developing environmental guidelines and by other administrative decisions. However, there is a need of increased assistance in programme implementation and human resources development.

In-country CO_2 emission level and its impact on climate change has not been studied. A regional study was conducted for the SAARC (Association of South Asian Countries) region, of which Nepal is a member. Nepal could play a significant role locally in CO_2 absorption by promoting the activities for the development, management and sustainable use of forestry resources and the conservation of biological diversity. Nepal is recently implementing a GEF Biodiversity Conservation Project. Similarly, a GEF Small Grant Programme, in Nepal, is also focussing to involve the local grass-root NGOs in forestry management and conservation activities. In addition, implementation of forestry development activities, based on MPFS's (Master Plan for Forestry Sector) findings, in its 42 percent of land (forest land) and bringing about 13 percent of the total land under the protected area system (by establishing national parks, wildlife reserves, hunting reserve and conservation areas) will support the conservation of biological diversity and help to absorb the CO_2 emission. The Forests Act of 1993 calls for people's participation in managing community, private, lease-hold and national forests while the National Parks and Wildlife Conservation Act of 1973 (amendment 1993) has made provision to retain 30 to 50 percent of locally generated revenue for community development projects which, I believe, will also facilitate people's participation in protected areas management.

Forest conservation activities, in Nepal, will not only help to CO_2 absorption but also help to reduce its forestry associated environmental problems such as soil erosion, landslide, floods, scarcity of fuelwood, fodder and timber etc. It will be difficult for us to protect the forest for reducing global warming. Harnessing the vast potential of hydro-power energy will promote for clean energy use.

The newly established Environment Protection Council, under the chairmanship of the Rt. Hon'ble Prime Minister, as a policy coordinating body, is a new step in institutional development. In addition, a Parliamentary Committee on the Natural Resources and the Environment Conservation is facilitating the incorporation of environmental aspects in the amended and new Acts. Nepal is also establishing more meteorological stations (including new air quality monitoring stations in Katmandu Valley) are in a process of establishment in order to see the change in climatic characteristics and for generating basic data also for infrastructure development. Similarly, research activities are conducted in forestry sector by the Forest Research and Information Center and other aspects of environment by other agencies including university.

I believe that global instruments such as carbon tax, tradeable permits etc for reducing the global warming should ensure the development needs and aspiration of the poor people which is one of the major cause of environmental problem in Nepal. We also believe that forests should not be focussed for protection but should be for conservation and sustainable use. It is my pleasure to welcome the idea of greenling and replantation in the barren lands provided that it can be used for socio-economic development of the country. Also forestry development works are very difficult without poverty alleviation efforts. Hence development and environment conservation priorities, in Nepal, are on poverty alleviation, natural resources management and its sustainable use and the integration of environment in development process.

Note : The views expressed here are personal.

GLOBAL WARMING POLICIES IN NEW ZEALAND

Peter Read
Massey University

I work in New Zealand but not for the N.Z. government and I do not represent the New Zealand government. Nor is it part of my work to keep abreast of climate change policies in N.Z. and I have not come to this meeting to brief on the current position.

The inadequacy of what toller will make it obvious that it in no sense should be taken as a statement of the N.Z. governments position.

1. N.Z. has ratified the FCCC (around August '93 I believe).

2. N.Z. has extension for planting programs motivated primarily to country erosion of over - gazed land. It is behind that N.Z. would this in its response strategy.

3. N.Z. recent adverse trend in fuel efficiency (fuel used per unit GPP) has been brought to attention and research is in hand to determine the causes and possible policies to reverse the trend.

4. N.Z. adopted a substantial comprehensive programs of actions and policies on Climate Changes (around mid 1992?) but I am not sure how far it has been put into effect.

GLOBAL WARMING POLICIES IN PAKISTAN[1]

Ata Qureshi
Climate Institute

Introduction

Even though greenhouse gas emissions from Pakistan are relatively quite small, global climate change could have profound implications on Pakistan's economic and societal development. Critical areas of concern include impacts on production agriculture, monsoon fluctuations producing floods or droughts, water resources, forests and human health to name a few.

Pakistan thus has been an active participant in the international dialogue on climate change and is signatory to the climate convention and the convention on biological diversity. Pakistan has served as first chair of the Group of 77 which has played a significant role in the international negotiation process. Pakistan is also a very enthusiastic participant in the activities of various international bodies such as the IPCC, UNEP, WMO, UNDP, CSD, INC, INCD, world Bank, IUCN and in the work of such regional and bilateral agencies as the ADB, ESCAP, SAARC, SACEP, CIDA, JICA, USAID and others.

Current Programs and Future Actions

Pakistan has already initiated preparation of greenhouse gas inventory for CO_2, NH_4, N_2O and other gases using the IPCC/OECD guidelines, under the recently completed ADB supported Asia-Pacific country studies which I had the honor of directing. However, there still remain gaps in the existing data and, therefore, further work on inventory process must be continued in order to properly evaluate vulnerability and implications of climate change on various

1 Views expressed in this article are personal views of the author and not necessarily of the Government of Pakistan.

economic sectors as well as to develop national strategies for coping with global climate change.

The Pakistan Government during the late '80s created a separate division of Urban and Environmental Affairs within the federal government. In 1990 Cabinet Minister for Environment was appointed and since 1993 a permanent post for the Secretary of Urban and Environmental Affairs division has been created to work on the environmental issues including the climate change.

In cooperation with IUCN, a comprehensive conservation strategy for Pakistan has already been developed and its Implementation has been started. Through the ADB support for the Pakistan Study, preliminary adaptation and mitigation response strategies have been identified for priority areas. If further funding becomes available, Pakistan could continue to develop further inventories of greenhouse gases and continue development of adaptation, and mitigation response strategy work that has already begun on national scale. During 1992 and 1993 Climate Institute while assisting Pakistan in implementation of the ADB Project catalyzed the establishment of an Inter-ministerial Committee for Pakistan consisting of at least 17 Pakistani Departments at Federal and State levels to oversee work related to climate change in Pakistan.

Convincing the Policy Makers for Taking Further Action

Various options can be considered to minimize Pakistan's vulnerability to climate change and to monitor emissions of greenhouse gases in the future. Given that Pakistan is not a major contributor of GHGs, the strategy options do not have to be justified solely as GHG abatement options. Many of the strategies could be undertaken for economic returns or to achieve developmental and environmental objectives. Examples of such strategies might include:

1. Flood control measures

2. Enhancement of reforestation and afforestation programs for timer, fuelwood, soil conservation, watershed management or other benefits.

3. Development of farming practices and cultivars optimally suited for a changing climate.

4. Investments in lower carbon or no carbon technologies including natural gas, hydro power and renewable energy.

Policy Instruments and Immediate Priorities for Investment and Funding to Cope with Global Climate Change for Pakistan

In order to begin work on a potentially huge agenda, the first task is to priorities. With a projected doubling of the frequency of heavy rainfall events, adaptation to greater and more frequent floods is likely a highest priority for Pakistan. Second priority would be to enhance agricultural productivity to meet demand of food for its increasing population. The third priority is to meeting energy needs cost effectively while minimizing environmental impacts. Other strategies could include strengthening of existing institutions and developing further capacity through new training and research facilities.

For South Asia and Western Asia, Pakistan could serve as a central site for development of response measures through research and testing to cope with any negative implications of global climate change as it is centrally located between south and western Asia. It represents all variolous ecological zones including higher mountains of Himalayas, the plateaus, the alluvial plains best known for productive agriculture, the desserts of Sind and Baluchistan and deltas of such rivers as the mighty Indus as well as coastal zones inhabited by heavily populated city of Karachi. More information on climate change implications is needed for monsoons on the one hand and development of models for winter rains on the other. Quantifying the effects of various floods and their frequencies on economic sectors, crop productivity and agricultural infrastructures and reviewing the design specification of flood control measures could be highly useful. Establishment of early waning systems for extreme events such as floods and droughts would be another worthwhile investment.

Priorities among key energy conservation and development should be established and implemented including such measures as energy efficient lighting, higher fuel economy vehicles, reduction of transmission and distribution losses, renewable energy sources including forests, and long term planning for sustainable development should be part of the future agenda for Pakistan.

GLOBAL WARMING POLICIES IN PHILIPPINES

Clarissa C. Arida
Department of Environment and Natural Resources, Philippines

The philippines is one of the parties to the Framework Convention on Climate Change and as such it recognizes the need for concerned efforts to stabilized greenhouse gas concentration in the atmosphere, a level that would not cause advanced effects to the ecosystem.

The Inter-Agency Committee on Climate Change, composed of government, non-government organizations and the academia is in charge of scientific assessment, impact assessment and formulation of response strategies on climate change.

The development of national Greenhouse Gas (GHG) emission inventory is one of the priority areas identified in order to be able to project climate change with a higher degree of accuracy not only on a global scale but on a regional scale as well. This is consistent with the Climate Convention which requires all countries to develop its own national GHG inventory.

In September 1993, a Scientific Assessment Report on GHG Emission Inventory for 1990 was completed by the IACCC. This identifies the major authorized sources of CO_2, methane, nitric oxide and nitric oxide emissions in the Philippines. Other GHG such as fluorocarbons, carbon non-oxide and non-methane volatile organic compounds, however, are not included in the assessment. This Report hopes to save as a foundation from which to build on expertise and information in order to come-up with improved climate in the future. This assessment, however, is still not definitive on agriculture and land use. Carbon dioxide emission from fossil fuel use are within our acceptable degree of accuracy the methodology employed are those recommended by IPCC/OECD.

Using 1990 as the bone year, fossil fuel burning was identified to be a major source of CO_2 commissions accounting for 53% of the total estimated CO_2 emission of 72Mt. Land use change due to forest clearing and conversion of grasslands to cultivated lands accounted for 38%.

It is hoped that this inventory can give a pictures of the relative contribution of each sector to the total emissions and would have as a basis for developing national programs on measures related to climate change.

Among the other measure being undertaken with respect to climate change in the Philippines are:

formulation of response strategies to climate change as well as conduct of scientific assessment and impact and impact assessment studies.

- oceanographic, hydrographic, and geographical sways including publication of nautical charts, maintenances of network tide stations, etc.

- impact assessment special on agriculture.

- identification of forest management activities with emphasis on reduction of deforestation and forest degradations proclamation of watershed forest resources, implementation of the Phil. Master Plan for Forestry Development as well as the National Integrated Predicted Areas System Law.

- Air pollution monitoring and abatement.

- Formulation and implementation of country Program of ODS, etc.

Possible impacts of climate change include:

- Submergence potential of small islands and some reclaimed coral in Metro Manila and Metro Cebu and some lakeshore area in Laguna Lake.

- Agricultural impacts can be found to be more serious in agricultural areas prone to typhoon and floods,areas frequently visited by draughts and those near costal areas most vulnerable to storm and salt water intrusion.

The Philippines has just started reviewing policy interments such as market - based interments to contain pollution. It welcomes opportunities for technical and technological assistance on climate change endeavors.

GLOBAL WARMING POLICIES IN THAILAND

Suphavit Piamphongsant
Ministry of Science, Technology and Environment, Thailand

Thailand, like several other countries, is now experiencing extreme climatic events, especially very hot and cold temperatures, storm surges droughts and heavy rainfalls. In the short run, extreme climatic variations really affect the Thai people to a significant degree. Therefore, there should be no difficulties in establishing policies to deal with climatic change.

Thailand is in the preparatory process to ratify the Framework Convention on Climatic Change. It is expected that it would be able to ratify the convention before the First Meeting of COP.

The National Environment Board, which is the high-level decision-making body in matters relating to environment, having the prime minister as its chairman, has recently established an Inter-Ministerial Sub-Committee to Co-ordinate policy matters and activities relating to climate change as well as to pave way for the ratification and implementation of the Framework Convention.

A Study on national strategies to address the problem of climate change, funded by ADB, has just been completed. It deals with economics of reducing CO_2 emissions, economic analysis of forestry options as well as the development of national inventories of CO_2 emissions using the only IPCC/OECD guidelines for the year 1990. Besides, another UNEP-sponsored project on the socio-economic imparts of semi-level risk has completed its first phase.

Research activities relating to global climatic change are being formulated by the IGBP National

Committee within the framework of the START Program. A request for funds to be allocated to policy-oriented research is being submitted by office of Environmental Policy and Planning to the Budget Bureau for the 1995 fiscal year. It is envisaged that a number of research work, for example, work on methane emissions from wet rice cultivation, will be funded in order to serve as a basis for sound policy formulation with regards to measures to combat climate change. In the meantime, methane emissions from rice cultivation in Thailand will, anyhow, gradually, decrease, because the Thai Government has determined to reduce the area of wet rice cultivation, at least more than 150,000 hectares in the coming growing season, thereby automatically reducing methane emissions from rice cultivation.

At present, the process of formulating global warning policies has just barely begun, using among often, the results of the already mentioned study as a basis. The results of the Tsukuba Workshop on Policy Instruments and their complications will also serve as useful inputs to the policy formulation in Thailand. In developing and implementing such policies, following guiding principles among often, will be taken into consideration:

1) The feasibility of adopting economic measures as a response to climate change is to be explored. Concepts such as tradable permits joint implementation, carbon tax, etc. will be carefully scrutinized.

2) Cooperation with developed countries is to be sought in matters relating to technology cooperation, capacity-building, scientific research etc.

3) The extent to which developing country parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country parties of their commitments under the Convention related to financial resources and transfer of technology and will take fully into account that economic and social development and poverty eradication are the first and overriding priorities of the developing country parties.

4) Emissions from developing countries are growing and may need to grow in order to meet their development requirements.

5) Industrialized countries and developing countries have a common but different responsibility in dealing with problems.

GLOBAL WARMING POLICIES IN VIETNAM

Nguyen Trong Hieu
Hydromete Orological Service of Vietnam

(1) Completing the planning of hydrometeorological station networks to detect climate fluctuations.

(2) Implementing a data programme to obtain scientific evidences in studying climate change.

(3) Implementing preliminary study on climate change in Vietnam

a. Calculating parameters expressing grade and feature of climate fluctuation is main elements.

b. Analyzing the tendency and periodicity of main elements.

c. Assessing impacts of climate change in various scenarios on socio-economic rectors.

(4) Inventorying emissions of major greenhouse gases:

a. Estimating current emissions of CO_2, CH_4, N_2O.

b. Estimating expectant emission of CO_2, CH_4, for various periods: 1996-2000, 2000-2010.

(5) Testing and examining long range forecast of some important elements: typhoon number and season, heavy rain and flood, drought, etc.

(6) Attending most of international activities related to climate change issue.

(7) Organizing national and regional seminars on climate change and its impacts.

(8) Establishing national climate programme in Vietnam.

(9) Preparing for the pilot programme of UNITAR (United Nation Institute of Training and research) to implement the Framework Convention on Climate Change in Vietnam.

(10) Suggesting alternative options to respond to climate change, especially global warming, as follows:

a. Carrying out programs of afforestation and forest protection.

b. Developing hydro power potential .

c. Establishing upstream storage reservoirs.

d. Improving and enhancing existing sea dike systems of 2,700 kms and building new ones.

REGIONAL SESSION

Economic Measures & their Implications for Asia-Pacific Region

-Closing Address-

CLOSING ADDRESS

Akihiro Amano
Kobe University

As exemplified by the addresses of three IPCC bureau members in the opening part of this session, a wider range of policy issues related to global warming besides those on policy instruments has been extensively discussed in the regional session. Led by an excellent and exhaustive summary of issues we are confronting in the Asia-Pacific region reported by Dr. Ir. Aca Sugandhy, delegates from fifteen countries of the region commented and discussed current policy issues and future agenda.

First of all, it was quite encouraging to hear that participating countries have attained advancement in the field of scientific research on climate change and studies on Inventories of GHG emissions and sinks. Co-operation among developed and developing countries are reported, and such co-operative assistance and transfers of technical know-how should be encouraged further. On the part of socio-economic policies to combat global warming, various governments have been taking diverse measures. During this workshop, however, many delegates from developing countries indicated difficulties of information dissemination concerning global environmental policies. People are usually interested more in local environmental issues related to their health and living conditions, and local organizations both public and private have strong handles over such matters.

However, once people realize that global, regional and local environmental degradations all share the same roots, namely, negative externalities and the lack of public goods provisions, then we can take advantage of the existing local networks for the promotion of public awareness to the effect of strengthening the activities of local organizations by giving them new impetus and orientations.

To illustrate the importance of an integrated approach in environmental policies, I should like to refer to the results of my recent study on the estimates of secondary benefits of limiting carbon dioxide emissions in the Asia region (see the attached supporting material). They have been obtained from a modified Manne-Richels' global model. I have extended their earlier model involving five regions so that it can cover Japan, India, Dynamic Asia Economies (DAE, including Thailand, the Philippines and four Asian NIEs) as well as China. The model is also modified to include local air pollutants, i.e., sulphur dioxides and nitrogen oxides. This extended model has been used to simulate the effects of carbon taxes introduced to stabilize carbon dioxide emissions in each country, region or economies. The simulation experiment does not intend to advocate the adoption of carbon taxes in these countries/regions, but simply to indicate the size of possible secondary benefits that can offset potential economic costs of limiting greenhouse gases.

Our calculations show that in Japan and India, total secondary benefit arising from reduced emissions of acid deposition precursors induced by lower fossil fuel use would more than outweigh the potential economic costs of carbon dioxide emission limit. In the year 2010, the latter are estimated as 0.20 per cent and 0.38 per cent of GDP in Japan and India, respectively, while the total secondary benefits also represented as percentages of GDP are 0.32 and 0.43 per cent, respectively. In China and DAE, total secondary benefits fall short of the initial economic costs, but they offset some important part. It is also found that assumed values of the elasticity of substitution among factor inputs are important determinants of the magnitudes of net benefits. The larger the substitution elasticities, the larger the net benefits. These observations clearly indicate the need for an integrated cost-benefit calculation, and they strongly support the view expressed by Dr. Anwar Shah on the first day.

As to the application of international economic measures extensively discussed in the past three days, there have been relatively few responses from the participants from developing countries except for some general observations. It seems that we need more detailed assessments of the implications and the impacts of new policy measures on various groups of countries with different conditions in terms of the stage of development, relative importance of the global environmental impacts, the position in the energy markets, and so on. Critical assessments of proposed policy instruments from the perspective of different countries would help encourage the construction of new, trustworthy mechanisms that involve both efficient and effective policy instruments for global environmental issues and a workable system that encourages smooth flows of resources and technologies from industrial to developing countries for mutual benefits.

Supporting Material for the Closing Address

Estimating Secondary Benefits of Limiting CO_2 Emissions in the Asian Region

ESTIMATING SECONDARY BENEFITS OF LIMITING CO_2 EMISSIONS IN THE ASIAN REGION[1]

Akihiro Amano
Kobe University

1. Introduction

It is well known that environmental systems are interdependent (Siebert (1987), Chap. 9). This point is usually emphasized to underline the fact that environmental policies narrowly addressed to a particular aspect of the environmental problems are likely to fail in the long run because of the interdependent ecological systems and the possibilities of substitutions among different environmental resources. However, there is another side of the coin, i.e., the possibility that measures taken to rectify certain negative externalities can, at the same time, have beneficial influences to improve other environmental conditions.

An obvious example is a climate policy to resist global warming. To the extent that such a policy tends to reduce the use of fossil fuels, the reduction of sulphur and nitrogen oxides emissions and of automobile uses will bring forth various forms of secondary benefits. The staff of Central Bureau of Statistics in Norway have attempted to quantify some of such secondary benefits due to climate policies (GlomsrØd *et al.* (1992) and Alfsen *et al.* (1992)). They found that the secondary benefits of reducing local pollution go some way toward mitigating the economic costs of the climate policy in terms of reduced output.

The purpose of this paper is to apply their results to assess possible extent of such benefits if the Asian region were to take measures such as carbon taxes to mitigate global warming.

2. Emissions of Sulphur and Nitrogen Oxides in the Asian Region

A research institute associated with the Science and Technology Agency of Japan recently published a couple of detailed studies on energy uses and the environment in the Asian region (Science and Technology Policy Research Institute, Science and Technology Agency (1992, 1993)). These studies cover 25 countries and economies in the Asian region, and in the cases of China and India they have also dealt with 29 and 13 local regions, respectively. The primary purpose of these studies is to estimate current and future levels of emissions of SOx, NOx, and CO_2 in these countries.

In this paper we shall only take up the following countries/economies for later use: Japan, China, India, and "Dynamic Asian Economies (DAE)" including Thailand, the Philippines, and four Asian NIEs (i.e., the Republic of Korea, Taipei-China, Hong Kong, and Singapore). Table 1 summarizes SOx and NOx emissions as well as consumption of primary energy in this region. These figures are taken from the "natural" case where no particular policy is envisaged (i.e., the business-as-usual case). The emission coefficients of SOx and NOx emissions per unit of primary energy consumption, shown in Table 2, are calculated from figures in Table 1. Since sulphur and nitrogen oxides emissions have been calculated according to energy consumption of various fuel-types in different sectors, the emission coefficients vary over time due to assumed changes in fuel compositions and sectoral distributions. (In the case of SOx emissions, sulphur contents of fuels are also considered.)

Using the emission coefficients for sulphur and nitrogen oxides derived above, we can obtain rough estimates of these emissions if we can project the levels of primary energy consumption in the region. Furthermore, we need to estimate the effect of measures controlling carbon dioxide emissions upon primary energy consumption. The model developed by Professor Alan Manne and Dr. Richard Richels called "Global 2100" is most convenient in this

1 The author gratefully acknowledges his indebtedness to Prof. Alan Manne and Dr. Richard Richels who kindly provided various versions of their Global 2100 model in GAMS language. This study is based on a modified version of their model, and any possible errors are the responsibility of the present author.

application (see, e.g., Manne and Richels (1992), Manne and Rutherford (1993), and Manne (1993)). We incorporated two countries, Japan and India, and one region, DAE, into the original five region model including the United States of America, Other OECD, former USSR, China, and the Rest of the World. In this version of their model, each country/region can be run separately, except that the Rest of the World region must be run after variables for all other regions have been calculated because this particular region, which includes major oil exporting countries, must supply oil exports demanded by other countries. In the present application, we used only three countries and one sub-region models, i.e., those for Japan, China, India, and DAE.

Table 1 Primary Energy Consumption and the Emissions of SOx and NOx

	Primary Energy (MTOE)			Sulphur Oxides Emissions (Million tons)			Nitrogen Oxides Emissions (Million tons)		
Country/ Economy	1990a	2000	2010	1990a	2000	2010	1990a	2000	2010
Japan	389.5	455.5	540.8	1.197	1.406	1.495	2.174	3.207	3.518
China	703.1	919.9	1054.6	21.454	27.317	37.243	8.087	11.015	15.150
India	249.9	336.8	411.2	3.500	5.430	8.175	2.910	4.485	6.758
Korea	79.4	146.6	206.5	1.509	2.532	3.880	0.688	1.406	2.286
Taipei,China	46.5	92.6	148.6	0.797	2.024	3.655	0.422	1.008	1.798
Thailand	34.4	51.5	80.7	0.667	0.898	1.808	0.456	0.806	1.520
Philippines	23.0	34.1	55.2	0.400	0.520	0.732	0.208	0.314	0.507
Hong Kong	10.5	16.5	22.2	0.173	0.279	0.460	0.157	0.265	0.445
Singapore	10.4	19.9	28.6	0.193	0.398	0.654	0.109	0.226	0.375
DAE Total	204.6	361.2	541.8	3.770	6.651	11.189	2.046	4.025	6.931

[a] Figures for 1990 have been interpolated from those of 1987 and 2000.
Source: Science and Technology Policy Research Institute, Science and Technology Agency (1993)

Table 2 SOx and NOx Emission Coefficients (Million Tons per MTOE)

	SOx Emission Coefficients			NOx Emission Coefficients		
	1990	2000	2010	1990	2000	2010
Japan	0.003074	0.003087	0.002764	0.005582	0.007040	0.006505
China	0.030513	0.029697	0.035317	0.011502	0.011975	0.014367
India	0.014006	0.016124	0.019880	0.011645	0.013318	0.016435
DAE	0.018430	0.018416	0.020650	0.010001	0.011145	0.012791

The Manne-Richels model is one of the most influential global model developed to analyze the effects of carbon dioxide emission control. It combines the energy-technology assessment model involving major energy production processes with a macroeconomic block represented by an aggregate production function of a nested CES/Cobb-Douglas type. Energy inputs are aggregated into electricity and nonelectric energy. Electric energy is produced by five existing technologies (gas fired, oil fired, coal fired, hydroelectric, and nuclear) and four advanced technologies (advanced combined cycle, new coal-fired, high-cost and low-cost carbon free technologies). Nonelectric energy supply sources include six existing technologies (tradeable oil, coal direct use, low-cost and high-cost domestic oil, and low-cost and high-cost domestic natural gas) and two new technologies (synthetic fuels and nonelectric backstop technologies). The time horizon of this model is 2100, with various new technologies being introduced in the 20s and the 30s of the next century, but in the current application we only look into the future up to the year 2010 where fossil fuels will remain dominant.

Now, Table 3 compares the BaU scenario emissions of our calculation with those of Science and Technology Policy Research Institute. Except for Japan, our emission estimates are generally lower than those of STPRI because the Research Institute assumed more vigorous growth in the Asian region. Even with our lower estimates, however, Table 3 shows an alarming picture in that major acid deposition precursors will grow at an annual rate of 2 to 3.5 per cent for coming decades. The annual percentage rates of growth of SOx emissions are: 2.1 for Japan, 2.3 for China, 2.5 for India, and 3.0 for DAE; and similar rates of NO_X emissions are: 3.4 for Japan, 2.7 for China, 2.5 for India, and 3.6 for DAE. If global climate policies can indirectly contribute to mitigate the acid rain and other related problems to a noticeable extent, this will strengthen the case for cooperation among developed and developing countries in the area of climate policy.

Table 3 Business as Usual Scenario Emissions (Million Tons and MTOE)

SOx	Japan		China	
	STPRI	This Study	STPRI	This Study
1990	1.197	1.197	21.454	21.454
2000	1.406	1.590	27.317	22.013
2010	1.495	1.799	37.243	33.872
	India		DAE	
1990	3.500	3.500	3.770	3.770
2000	5.430	3.514	6.651	4.456
2010	8.175	5.749	11.189	6.759
NOx	Japan		China	
	STPRI	This Study	STPRI	This Study
1990	2.174	2.174	8.087	8.087
2000	3.207	3.626	11.015	8.877
2010	3.518	4.235	15.150	13.779
	India		DAE	
1990	2.910	2.910	2.046	2.046
2000	4.485	2.903	4.025	2.696
2010	6.758	4.753	6.931	4.187
Primary Energy	Japan		China	
	STPRI	This Study	STPRI	This Study
1900	389.5	364.6	703.1	629.0
2000	455.5	515.1	919.9	741.3
2010	540.8	651.0	1054.5	959.1
	India		DAE	
1900	249.9	181.2	204.6	189.8
2000	336.8	217.9	361.2	241.9
2010	411.2	289.2	541.8	327.3

3. Estimating the Secondary Benefits of Carbon Dioxide Emission Control

When the macroeconomic effects of limiting carbon dioxide emissions through such measures as carbon taxes are analyzed, the estimates of macroeconomic costs do not usually take into account such side benefits that can be derived from reduced emissions of acid deposition precursors. In integrating such side effects into the above model, we need some quantitative estimates of the magnitude of damages or of benefits from preventing such damages. The studies reported by the staff of Norwegian CBS mentioned above provide us with such estimates. According to Alfsen *et al.* (1992), sulphur dioxide emissions in Norway will increase, in their reference scenario, from 0.074 million tons in 1988 to 0.077 million tons in 2000.

On the other hand, if the emission of carbon dioxide is stabilized at the level of 1989, then, the level of SO_2 emissions in 2000 will be reduced to 0.061 million tons. The 20.8 per cent reduction means a 1.73 per cent cut per year. Similar rate of annual reduction for NOx turns out to be 0.9 per cent. On the benefit side, a reduction in health damage due to SO_2 emissions is estimated to result 0.285 billions of 1990 NOK benefits. A similar number for NOx emission reduction is 2.0 billion NOK, and total benefits including abated damages in nature, corrosion and road traffic is estimated as 6.155 billion NOK (all in 1990 prices). The average annual rate of growth of real GDP in Norway for the period of 1980-1990 is 2.46 per cent p.a. (based on IMF, *International Financial Statistics Yearbook,* 1992), and if we extend real GDP in 1985 prices to 2000 at this rate, the average level of real GDP for the period of 1988-2000 becomes 598.99 billions of 1985 NOK.

Table 5 Secondary Benefits from Carbon Emission Stabilization (per cent)

	Japan				China			
	Gains from				Gains from			
	SO_2 Cut	NOx Cut	Total	CO_2 Cut	SO_2 Cut	NOx Cut	Total	CO_2 Cut
2000	0.006	0.079	0.220	-0.148	0.010	0.135	0.378	-0.938
2010	0.008	0.114	0.319	-0.200	0.017	0.227	0.633	-2.095
	India				**DAE**			
	Gains from				Gains from			
	SO_2 Cut	NOx Cut	Total	CO_2 Cut	SO_2 Cut	NOx Cut	Total	CO_2 Cut
2000	0.010	0.134	0.373	-0.074	0.047	0.637	1.780	-5.622
2010	0.011	0.154	0.429	-0.389	0.073	0.992	2.769	-9.518

The benefit estimates mentioned above are converted into 1985 price figures and then distributed evenly to 12 years. We then calculate percentages of these benefits relative to the average real GDP in the period concerned. The percentages are: 0.00324 for SO_2, 0.02272 for NOx, and 0.0699 for total benefits. Finally, we divide figures for SO_2 and NOx by annual percentage reductions of respective emissions (1.73 and 0.9, respectively) to arrive at relative benefits expressed as a percentage of real GDP corresponding to a 1 per cent reduction in acid precursor emissions: 0.00187 for S02 and 0.02524 for NOx.

Next, we consider a carbon emission stabilization scenario. In each country/region, carbon emissions are assumed to be stabilized at the 1990 level from 2000 to 2010. This particular stabilization scenario is used only to estimate the probable size of secondary benefits. The levels of carbon taxes can be calculated from the shadow prices of carbon emissions in terms of output. The model can generate total primary energy consumption so that we can derive the gains associated with changes in SOx and NOx emissions by using the above pseudo-elasticities. Table 5 summarizes the results. As expected from the Norwegian experiences, gains from NOx reductions are much larger than those from SOx reductions, and "other effects" yet dominate the total gain. In two countries, i.e., Japan and India, where the original emission levels are relatively lower, total benefits tend to outweigh the economic costs of the carbon emission stabilization. In China and DAE, on the other hand, the macroeconomic costs of carbon stabilization are substantially higher. High rates of economic growth are one common reason. Another factor may be heavy reliance on coal: nonelectric energy supply in China and expected use of new coal-fired electricity plants in DAE in early 2000s. If these estimates are correct, these regions might find it rather difficult to participate in an international agreement to stabilize carbon emissions. Even then, our results suggest that there exist moderate side benefits of control over carbon dioxide emissions, and that side payments required to induce these countries or regions to participate into such programs need not be the full amount of internal macroeconomic costs.

4. Elasticity of Substitution and Net Gains

Cline (1992, Chap. 4) examined principal economic models of global warming. In relation to the present topic, he states that "[in the Manne Richels' model] the use of a substitution elasticity of 0.4 between energy and other factors may tend to be downward biased." For developing counties and regions, the Manne-Richels model adopts the value of 0.3, which may well be another cause of relatively high output costs in our results for China and DAE. We therefore performed another set of simulation experiments with the value of 0.5 for the substitution elasticity in all relevant countries/regions with everything else unchanged.

Table 6 presents the results. Comparing Tables 5 and 6, we can make two observations. First, economic costs of carbon emission limit are significantly reduced in developing countries, especially in DAE. Second, China and India both increased secondary benefits by reducing primary energy consumption and reduced economic costs due to carbon emission abatement, but DAE reduced economic costs without increasing the secondary benefits very much. Since DAE is not well endowed with domestic energy resources, substituting oil and natural gas for coal cannot be done as easily as in China and India. The reduction of carbon emissions must therefore rely on substitution of non-fuel inputs, especially capital, for fuels. This is why reductions in economic costs are not accompanied by proportionately increased secondary benefits in DAE.

Table 6 Secondary Benefits with the Elasticity of Stabilization 0.5 (per cent)

	Japan				China			
	Gains from				Gains from			
	SO_2 Cut	NOx Cut	Total	CO_2 Cut	SO_2 Cut	NOx Cut	Total	CO_2 Cut
2000	0.006	0.076	0.211	-0.149	0.011	0.151	0.421	-0.645
2010	0.009	0.119	0.333	-0.201	0.025	0.335	0.936	-1.577
	India				DAE			
	Gains from				Gains from			
	SO_2 Cut	NOx Cut	Total	CO_2 Cut	SO_2 Cut	NOx Cut	Total	CO_2 Cut
2000	0.024	0.328	0.915	0.165	0.048	0.641	1.790	-2.939
2010	0.032	0.436	1.218	-0.066	0.076	1.032	2.881	-5.402

In any case, a larger value for the substitution elasticity from 0.4 to 0.5 in industrial countries and from 0.3 to 0.5 in developing countries tends to make net benefit positive in Japan and India and make the secondary benefits more than 50 per cent in absolute value of the economic costs of carbon emission abatement. Our simulation experiments thus suggest to pay more serious attention to subsidiary benefits and the impact of substitution possibilities in evaluating "net" costs of carbon dioxide abatement.

5. Summary and Conclusion

This paper attempts to evaluate the secondary benefits of limiting carbon dioxide emissions in the Asian region. The model used in thispaper is Manne-Richels Global 2100 model, which has been modified to incorporate SOx and NOx emissions in some of the Asian counties and economies. We applied the data constructed by Science and Technology Policy Research Center in Japan and the simulation results performed by the Norwegian Central Bureau of Statistics. By the simulation experiments of stabilizing carbon dioxide emissions in Japan, China, India, and Dynamic Asian Economies (including Thailand, the Philippines, and four Asian NIEs), we found that the secondary benefits arising from reduced local environmental degradation are likely to more than offset the macroeconomic costs of the carbon emission stabilization in Japan and India, and that these benefits tend to mitigate the macroeconomic costs substantially in China and DAE.

We also found that a modest change in the value of elasticity of substitution in the Manne-Richels model can have a noticeable effect upon the cost/benefit calculations of climate policies. This suggests that we should devote more efforts to obtain reasonable estimates of the substitution elasticities in the production processes, especially in developing countries.

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ATTACHMENTS

IPCC Working Group III
Tsukuba Workshop on Policy Instruments and their Implications
17-20 January 1994, Tsukuba, Japan

Monday January 17 *Policy Instruments 1* (Session Host)

Session 1 9:00-10:30 **Introduction** (A. Amano & M. Kuroda)

(1) Opening Address
Dr.Hoesung Lee, Co-Chair, WG III, IPCC
Dr.Erik Haites, Head of Technical Support Unit,WG III, IPCC representing Dr.James Bruce, Co-Chair, WG III, IPCC
Dr.Atsunobu Ichikawa, Director General, National Institute for Environmental Studies, Japan
(2) Scope of the Work on Policy Instruments
Dr.Brian Fisher, Australian Bureau of Agricultural & Resource Economics, Australia
Rapporteur: Ms.Sally Thorpe, Australian Bureau of Agricultural & Resource Economics, Australia

Session 2 10:45-12:15 **Taxes (Review)** (A. Amano)

(1) Climate Change Policy and International Trade (i)
Prof. Scott Barrett, London Business School, U.K.
(2) Energy Pricing & Taxation Options for Combatting the "Greenhouse Effect"
Mr.Anwar Shah, World Bank.
Discussants: Dr. Irving Mintzer, Univ. of Maryland, U.S.A.
Prof. Stefan Schleicher, Univ. of Graz, Austria
Rapporteur: Ms.Sally Thorpe, Australian Bureau of Agricultural & Resource Economics, Australia

Session 3 13:45-15:15 **Taxes (Consequence)** (M.Kuroda)

(1) The Effectiveness of Carbon Taxes at the International Level
Mr. Andrew Dean, OECD
(2) The Economic Effects of a Carbon Tax
Prof.Dale Jorgenson, Harvard Univ.,U.S.A.
(3) The Economics of Stabilizing Atmospheric CO_2 Concentrations
Dr. Jae Edmonds, Battelle Pacific Northwest Lab., U.S.A.
Discussant: Prof. Stefan Schleicher, Univ. of Graz, Austria
Rapporteur: Ms.Sally Thorpe, Australian Bureau of Agricultural & Resource Economics, Australia

Session 4 15:30-17:00 **Forestry, Public Awareness & Environmental Auditing** (R. Karimanzira)

(1) I think that I shall Never See...A Lovely Forestry Policy : Land Use Programs for Conservation of Forests
Dr.Steve Rayner, Battelle Pacific Northwest Lab., U.S.A.
(2) Public Policy & Energy Efficiency Information Programs
Ms.Judith Gregory, Applied Energy Research Group, U.S.A.

(3) Environmental Auditing for Policy Instruments
Mr. Yoshiyuki Ishii, Hitachi Ltd., Japan
Discussants: Prof. John Mubazi, Makerere Univ., Uganda
Prof. Tohru Morioka, Osaka Univ., Japan
Rapporteur: Mr.Tom Jones, OECD

17:00-19:00 **Welcome Party**

Tuesday January 18 ***Policy Instruments 2***

Session 5 9:00-10:30 **Regulatory Instruments & Administrative Guidance** (A. Sugandhy)

(1) The Role of Regulation in Duch Climate Change Policy
Mr. Jip Lenstra, Ministry of Housing, Physical Planning & Environment, Netherlands
(2) Non-Economic Instruments: Regulation & Standards, Administrative Guidance, & Action Plan & Program
Prof.Hidefumi Imura, Kyushu Univ., Japan
Discussants: Mr. Lee Solsbery, OECD/IEA
Prof. Eiji Hosoda, Keio Univ., Japan
Rapporteurs: Mr. Lee Solsbery, OECD/IEA
Prof.Hiroshi Asano, The Univ. of Tokyo, Japan
Prof.Catrinus Jempa, Univ. of Groningen, Netherlands

Session 6 10:45-12:15 **Subsidies & Financial Incentives** (K.Yamaji)

(1) Incentives to Environmental Innovations
Prof. Stefan Schleicher, Univ. of Graz, Austria
(2) Incentives to Renewable Energy
Prof. Thomas B. Johansson, Lund Univ., Sweden
Discussants: Mr. Stephen Harper, EPA, U.S.A.
Mr. Anwar Shah, World Bank
Rapporteur: Ms.Clarissa Arida, Dept. of Environment & Natural Resources, Philippines

Session 7 13:45-15:15 **Tradable Permits (1)** (T. Morita)

(1) A Dynamic Game Approach to Greenhouse Policy
Dr.Brian Fisher, Australian Bureau of Agricultural & Resource Economics, Australia
(2) Practical Lessons from the U.S. Experience
Mr. Stephen Harper, U.S. EPA, U.S.A.
Discussants: Prof. Scott Barrett, London Business School, LA, U.K.
Prof. Noriyuki Goto, Kanazawa Univ., Japan
Rapporteur: Dr.Erik Haites, Head of Technical Support Unit,WG III, IPCC

Session 8 15:30-17:00 **Tradable Permits (2)** (P. Bohm)

(1) Forests to Capture Carbon : Tradable Permit Schemes
Dr.Roger Sedjo, Resources for the Future, U.S.A.
(2) Implementation Issues for a Tradable Permit Approach to Controlling Global Warming
Prof.Tom Tietenberg, Colby College, U.S.A.
Discussants: Dr. Jin Gyu Oh, Korea Energy Economics Inst. Rep. of Korea
Dr. Matthias Mors, EC
Rapporteur: Dr.Erik Haites, Head of Technical Support Unit,WG III, IPCC

Wednesday January 19 Policy Instruments 3

Session 9 9:00-11:00 **Other Economic Instruments** (H. Imura)

(1) On the Feasibility of Joint Implementation of Carbon Emissions Reductions
Prof.Peter Bohm, Stockholm Univ., Sweden

(2) "Joint Implementation" as a Policy Instrument for Responding to Climate Change
Mr.Tom Jones, OECD

(3) Tradable Absorption Obligations
Prof.Peter Read, Massey Univ., New Zealand

(4) The Waste Problem & Economic Policy Instruments
- The Deposit-Refund System & Assignment of User Fees for Waste -
Prof.Kazuhiro Ueta, Kyoto Univ., Japan

Discussants: Dr. Tsuneyuki Morita, NIES, Japan
Dr. Theodor Hanisch, Ministry of Labour, Norway
Rapporteur: Mr. Lee Solsbery, OECD/IEA

Session 10 11:15-12:00 **Policy Mix & Portfolio of Instruments** (T.Hanisch)

(1) Climate Change Policy and International Trade (ii)
Prof. Scott Barrett, London Business School, U.K.

Discussants: Prof. Akihiro Amano, Kobe Univ., Japan
Mr. Ir Aca Sugandhy, Ministry of Environment, Indonesia
Rapporteur: Mr. Lee Solsbery, OECD/IEA

Session 11 13:15-14:15 **Implementation in Developing Countries** (H.Lee)

(1) Greenhouse Gas Options & Issues in Asia Region
Dr. Ali Azimi, Asian Development Bank

(2) Energy Policy for Sustainable Development in Developing Countries
- Case of China -
Prof.Zhou Dadi, Energy Research Institute, China
introduced by Prof. Shen Longhai, State Planning Commission, China

Discussant: Prof. Kanji Yoshioka, Keio Univ., Japan
Rapporteur: Prof.Catrinus Jempa, Univ. of Groningen, Netherlands

Session 12 14:30-16:30 **Concluding**

(1) Round Table Session - Implementation in Developing Countries - (A. Shah)
Mr.Jorge Benavides, Ministerio de Relaciones Exteriores, Peru
Prof.Shen Longhai, State Planning Commission, China
Prof.Richard Odingo, Co-Vice-Chair, WG III, IPCC
Dr.David Omotosho, Federal Environmental Protection Agency, Nigeria
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Mr.Radu Plamadeala, Ministry of Foreign Affairs, Moldova
Dr.Janaka Ratnashiri, Ministry of Environment & Parliamentary Affairs, Srilanka

(2) Concluding Session (A. Amano)
Prof. Masahiro Kuroda, Keio Univ., Japan
Dr.Brian Fisher, Australian Bureau of Agricultural & Resource economics, Australia

Rapporteur: Dr.Erik Haites, Head of Technical Support Unit, WG III, IPCC

Thursday January 20 Regional Session
-Economic Measures & Their Implications for Asia-Pacific Region-

Session 13 9:00-12:15 **Opening & Discussion** (A. Amano)

(1) Overview of the Scope of WG III & Views from Asia-Pacific
Dr.N. Sundararaman, IPCC Secretary
Dr.Hoesung Lee, Co-Chair, WG III, IPCC
Dr.Erik Haites, Head of Technical Support Unit,WG III, IPCC
(2) Economic Measures & their Implications for Asia-Pacific Region - Basic Guidance -
Mr. Ir. Aca Sugandhy, Ministry of Environment, Indonesia
(3) Round Table Session
Dr.Brian Fisher, Australian Bureau of Agricultural and Resource Economics, Australia
Mr.Eddie Haji Sunny, Ministry of Development, Brunei
Prof.Shen Longhai, State Planning Commission, China
Mr.Mangal Prasad, Ministry of Finance & Economic Planning, Fiji
Mr. Ir. Aca Sugandhy, Ministry of Environment, Indonesia
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Dr.Peter Read, Massey University, New Zealand
Dr.Ata Qureshi, Climate Institute, U.S.A. (Pakistan)
Ms.Clarissa Arida, Dept. of Environment & Natural Resources, Philippines
Ms.Suphavit Piamphongsant, Ministry of Science, Technology & Environment, Thailand
Prof.Nguyen Hieu, Hydrometeorological Service, Vietnam
(4) Closing Address - Estimating Secondary Benefits of Limiting CO_2 Emissions in the Asian Region -
Prof. Akihiro Amano, Kobe University, Japan

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