Originally Processed With FOIA(s):
2017-0310-F

FOIA Number:
2017-0310-F

FOIA MARKER

This is not a textual record. This is used as an administrative marker by the George Bush Presidential Library Staff.

Record Group/Collection: George H.W. Bush Presidential Records
Collection/Office of Origin: Counsels Office, White House
Series: Holmstead, Jeffrey, Files
Subseries: Environmental Subject Files

OA/ID Number: 45131
Folder ID Number: 45131-003

Folder Title:
Global Climate Change [2][3]

Stack: **Row:** **Section:** **Shelf:** **Position:**

THE EUROPEAN INSTITUTE

TELEFAX COVER SHEET

Date: January 27, 1992

Name: Francis

Company /Organization: Office of C. Boyden Gray

Number of pages attached: 6

Telefax number: 456-6279 **Telephone number:**

From: Shaazka Beyerle, Executive Director

Message:

Following are the transcripts of Mr. Gray's comments at our seminar on January 10, 1992.

4801 MASSACHUSETTS AVENUE, N.W. SUITE 400, WASHINGTON, DC 20016
TELEPHONE: (202) 895-1670 ■ FAX: (202) 362-1088

DRAFT

FOR INTERNAL USE:

"U.S. Environmental Policies"

C. Boyden Gray

Counsel to the President of the United States

Remarks made at "Towards a Transatlantic Environmental Policy," an International Round Table Seminar conducted by The European Institute, January 10, 1992.

***

The U.S. has frequently been faulted domestically and internationally for not doing enough on the environment and that will always be a criticism levelled, I suspect, at any country. No one is ever satisfied, nor should I suspect anyone ever be satisfied. But I do want to make a few points about the good news of what the U.S. has done, and what I think we can contribute and what I think we must be heeded on internationally if we are to make a progress in global environmental issues.

I am going to leave to one side for a minute the fact that we spend a higher percentage of GNP than any country in Europe. We haven't been able to get comparable data about Japan, so I couldn't list that here. Absolute dollars or absolute percentage of GNP don't necessarily tell the whole story if the money is not spent well. But I did want to make that point. I don't want to belabor it. I don't want belabor how much our Clean Air Acts (not just our current one, but our previous ones), have done to clear the air of most of our cities. Los Angeles still has a terrible problem but it probably will always have a bad problem. It was known long before the automobile was invented as the "Valley of the Smokes" back in very early days of our history. It is geographically like Mexico City, like Denver in our country, just a problem situation.

We've also developed certain innovations that we believe are essential not only to internal progress in any country but to any external international progress. These are innovations in market incentives that I though I heard being referenced as I came in. These market innovations must be heeded if we are to do anything constructive on the international front. The complaint that many of us have in this country is that, in the global warming context and in the context of what might seem to be totally unrelated field of agriculture and trade, market mechanisms and market realities are, we believe, being ignored in such a simultaneous and parallel fashion in both fields that the ignorance makes you wonder whether the demands of the market are being recognized fully enough internationally.

I want to return to that but let me go through a little more detail of what we've done in this country which I think merits more international recognition because of the lessons that these achievements hold for the future. We have totally phased out lead for all intents and purposes from our gasoline pool and done it in

DRAFT

a very short period of time in the eighties at relatively minor cost and relatively minor disruption. I have to confess there were a few independent refineries that went down as a result. They were probably too inefficient to survive in any event in a highly competitive atmosphere. There was as a result some consolidation, but the refinery industry is still highly competitive nationally and internationally. We saved because of the use of market mechanisms, trading and lead rights, saved hundreds of millions of dollars and many years in doing this phaseout. The payoff of course has been enormous. It's not just a question of limiting lead exposure, a terrible toxic, but also permitting our automobile and oil companies to work towards the development of catalytic converters with which our cars are all now equipped. That in turn has met a reduction of the criteria pollutants and I think our country leads by any measure.

The acid rain phasedown is working well. It was feared that our fifty percent reduction which is a huge reduction to bite off at one time. I think it's not going to be as big an economic problem as was thought. Amidst all the gloom and doom that one reads about in our economy and worldwide, the acid rain program is not cited as one of the culprits. Now I don't want to wake up tomorrow and read about it as the sole cause of double dip recession, but I don't think it is.

I was reading in Forbes Magazine just over the holidays the industry outlook for various industries. I just happened to glance through the utility outlook. It's quite positive: no mention of Clean Air Act, no mention of the SO_2 phasedown. CFCs: if we hadn't done it, I don't believe the rest of the world would have done it. And I don't think it could have been done in this country, in the Montreal protocol, unless there were the flexibility internally permitted to trade the rights to produce CFCs and to give credit for accelerated phasedown.

Tax Policies

We also have an excise tax that taxes the pollutant. This is not totally new, the idea of taxes generally. Europe does it with their high gasoline taxes. One of the unintended consequences, I believe unintended from the original tax, is of course a measure of pollution reduction. To be sure but it's not that carefully tailored. The excise tax that we have in this country is that carefully tailored and it's working very well. It's a model for how we might all proceed in the future.

All of these measures combined with what we're trying to do with our National Energy Strategy which Congress has not yet adopted, and may not adopt in an election year. I see a Congressman here so I'm not going to belabor this point too much because I don't want to get shot back at for saying things that he disagrees with in this spirit of international cooperation. But we may try to do much of what we can do internally, that is, within the

DRAFT

Executive branch and those agencies that some argue about within the Executive branch and those agencies that some argue about, as to which branch they belong to, namely the natural gas regulatory agencies.

We hope to promote the use of natural gas in this country. The Europeans, as I understand it, are trying to do the same thing. It's a natural thing to do. It's a smart thing to do because it is the cleanest fossil fuel we have. But if we were to have the Congress adopt the NES, we would have total greenhouse gas, that is all greenhouse gases, stabilization at 1987 level through the year 2030, which claim I believe no European country can claim.

These market incentive trading ideas hold great promise for the future in forestry and in wetlands management, perhaps also fisheries management. Certainly control of air toxics is a prime contender. We're working now trying to see if something can be done in forestry on an international basis. This is not unrelated of course to global warming because forests are a major sink and should not be ignored. We have a difficulty often in our country linking all of these things together because of the fragmentation of our Congress.....

U.S. Environmental Institutions

One of the problems with this fragmentation is that we've had difficulty integrating in our own bailiwick in the Executive branch at the Pennsylvania Avenue all of the relevant agencies. One Senator whose name shall go unidentified who's a member of the Energy Committee called me a couple years ago to berate me for our lack of leadership on global warming and I was begging for time and saying we're having difficulty integrating the Agriculture Department into the interagency process. They haven't been included in the past. It's been sort of a private preserve of the EPA and the Department of Energy. And he said, "Why are you interested in the Department of Agriculture?" And I said, "Well because it's a major player." Agriculture worldwide accounts for some sixteen percent of all the greenhouse gases in terms of nitrogen fertilizer, rice which is a methane emitter, and cattle. We all know about cattle as a methane emitter. And of course the sinks. The sinks are not irrelevant: the trees and the crops and the forests. And he said, "Trees, crops, forests? They're irrelevant to global warming." I said "How can you say that, Senator, how can you say that they're irrelevant to global warming?" And he said "Different committee." [Laughter]

If you look to the market of course, markets override committees. That's one of the problems with markets because they have no reasonable respect for committee jurisdiction. One of the beauties of the marketplace is that it doesn't respect committee turf. That's a problem for us though in the Executive branch. We have turf problems too. And the beauty of the market is that it forces us to cooperate with our fellow "turf fighters."

DRAFT

U.S. View of European Environmental Policy

Europe's approach to global warming, and I'm going to exaggerate for the purpose of making a point and I want that understood at the outset, but the way we look at it in our paranoid way in Washington, DC is that Europe is seeking to "game" global warming in the same way that the Midwest has gamed over the years or the West has gamed our Clean Air Act. It's just a globalization of the games that geographic regions play. We've seen it. We've lived through it so we perhaps sort of tend to recognize it, fear it, perhaps sooner than others. But the object always seems to be to get the focus back on CO_2 and to ignore the other greenhouse gases, especially methane. Which we think is a mistake because the plan, laudable as it may be to switch more utilities to natural gas, we're doing the same thing here of course, to switch from coal to natural gas. Laudable as that may be, the greenhouse gains from reducing coal use will more than offset, or at least offset, the methane leakage from a somewhat archaic pipeline system. Now all that can be fixed, but one shouldn't be so confident at producing the end result by this fuel switching, if you ignore the other side of the equation. That is, if you ignore what you're doing with methane, which you can't if you have what we call a comprehensive approach, which treats all greenhouse gases alike as best science can determine on their radiation forcing effect. This we believe to be very very important.

Europe as a body does not seem to want to agree to this comprehensive approach. They do and they don't, they do and they don't, it's now you see it, now you don't. I don't ever get a sense that they're fully committed to it nor do I get a sense that Europe or the whole system, that is the whole world system, including less developed countries, are fully committed to trading between countries on these emission reductions. I think that's very shortsighted, especially for the less developed countries because it is the trading which will provide the technology transfer, a far more efficient transfer of technology through trading than through outright grants of money which is what everybody seems to want in the international fora. Our Clean Air Act is going to provide an unbelievable technology transfer in this country and it's going to be far more efficient, believe me, than recycling money through governments, through legislatures, and through spending bureaucracies.

The Agriculture Issue

Of course by ignoring the comprehensive approach one ignores the farming side of it which I mentioned before. Again I think this is shortsighted but it leads me to talk about the Common Agricultural Policy. As I said farming worldwide is a big factor in global warming. It offers great promise on the sink side to do

DRAFT

something about it, but the high level of subsidization is a threat to adoption of any kind of market approach. And this, we believe, threatens not only world trade but threatens future petrol cooperation between all countries. I want to say now, and I'm going to repeat again at the end, that in the long term if you look at global warming it's a problem of how to get the same improvement in the less developed countries that we have in the United States and in the OECD. That's where greenhouse gases are growing. But if you don't have economic growth that can finance the improvements that we've made here and that Europe has made, then you're never going to get anywhere and you're losing the forest for the trees.

I can't say that we are blameless in terms of subsidizing agriculture. We have some ten, twelve billion in subsidies which we ought to eliminate and we have a lot of non-tariff barriers which we ought to worry about, a lot of restrictions in peanuts and tobacco in my own state. We have restrictions in oranges and almonds out in the West. We have sugar barriers that hurt our Latin neighbors. These are not things to be proud of, but they pale in comparison to the 40 or 50 billion in subsidies that Europe funds and pours into agriculture. This isn't good for world trade. It threatens the GATT round as we all know. We have signed on to the Dunkel proposal, that's in the newspapers today. We hope that this can get resolved, but at the current rate of cooperation it may not. To think of all that money being spent, it's understandable.

Anyone who travels through Europe appreciates the countryside. The French countryside I know better than Bavaria for example but I have no doubts that Germany can claim as much beauty as France, Switzerland or the others. I don't know which is the most beautiful but agriculture definitely plays a role in the quality of life, in the preservation of values which are important to all of us in the global commons. And all of us I think would be willing to pay for it.

But I think we ought to pay more directly for the value of the land than do it indirectly through these subsidies where the marketplace can't really put a true value and where perhaps the wrong people are paying. By that I mean perhaps the less developed countries which are trying to get their agriculture economies going, they're the ones who ultimately suffer the most. They're the ones who ultimately pay, in my opinion. This is not obviously agreed to by everybody, but I'm just saying that I think the people that ultimately pay for these subsidies in the end are those who need the money the most. Now one can preserve the land by direct payments. Even our own domestic policy on the wetlands, as controversial as it is, may make more sense, to do it in a direct regulatory fashion, to be more direct and open and honest and at least accountable, than to do it by such massive subsidies.

Alternative fuels

One of the possibilities of course is to convert some of the

DRAFT

surplus into fuel. This is one of my long time interests. And so I won't dwell on it because it is a conflict of interest to be talking about it I suppose in this gathering. But it does take subsidies, people say, it's not competitive, say people. This is true today, I'm not sure it will always be true. But even so, in our country as hotly contested as it is for ethanol, which is a very successful pollution fighter. We know it's being very successfully use today in eliminating our carbon monoxide problems especially in the West. The tax subsidy, it's not an outright grant, but it's less than a billion dollars. That's a small amount compared to the forty billion that Europe spends. You could just take one billion of that and convert a lot of agricultural surplus into something that might not so badly impoverish less developed countries although it might take a bite out of the Saudis, but they can afford it. The Saudis can afford it.

I don't want to go on too much longer, except to say that if one puts all of this on a market footing, I believe that we will have better progress in international trade, better progress in global environmental management between countries, and a better growth in less developed countries which is where we must get it in order to finance the environmental improvements. One need only look to eastern Europe and to the former Soviet Union to see what non-market economies can do to the environment. The better off one is economically, the better off one is environmentally.

to: jeff holmstead
david struhs

from: howard gruenspecht

date: 01/23/92 (Thursday) 1:12pm

subject: CO2 intensity: lying with statistics and the danger of self-inflicted wounds.

The talking points on CO2 emissions per dollar of GDP present calculations that could, in a purely mathematical sense, be factually correct. However, anyone who uses them should understand several points:

- The results depend largely on an anomaly in 1985 exchange rates; using the proper exchange rate concept (which is available) for such work would give very different results.

- Recalculating these figures for a recent year (1989 or 1990) would put the U.S. near the bottom of the list. We could be called upon to explain why things have deteriorated so fast since 1985.

- For up-to-date calculations, the methodology underlying these talking points probably makes the U.S. look worse than we look under the analytically correct approach.

Discussion

In 1985, the dollar was at unprecedented highs in the foreign exchange market. The use of 1985 market exchange rates to express output in different countries in terms of a common currency grossly overstates the size of the 1985 U.S. economy relative to others. By inflating the relative size of the U.S. economy, all ratios of physical quantities to $GDP are artificially reduced for the U.S. For example, the same calculation done for energy intensity (energy use per dollar of GNP) would show that the U.S. was virtually identical to other OECD countries in 1985. If you believe this, I have a bridge you might be interested in buying.

Assuming that the original calculation is correct, a defensible version of the 1985 calculation, using purchasing power parity exchange rates, would put Italy down with Japan, the U.K. slightly below the U.S., the Netherlands slightly above the U.S., with Germany, Canada, and Australia remaining above the U.S -- but by much smaller margins.

In addition to exchange rate considerations, you also need to recognize that the U.S. did not fare particularly well on the emissions side after 1985 -- another reason why the selection of that year as an indicator of present relative positions is extremely misleading. Indeed, growth in emissions between 1985 and

1989 is the reason that the U.S. has not stabilized its emissions over the last 15 years -- a statement that one might expect to find in the company of those in this paper. An up-to-date version of the meaningful (or the meaningless) calculation would put the U.S. even further down the list -- possibly above only Canada and Australia.

Finally, if the same (economically meaningless) ratios for emissions or energy were repeated with 1989 or 1990 data, the results would be very different -- the U.S. would be nearer to the bottom of the list rather than the top. Are we trying to make a statement about 1985 exchange rates, or a meaningful statement about CO2 emissions?

cc: alex christofaro

1/30/92

To: Jeff Holmstead
From: Jonathan Wiener

Re: CO2 per GNP, comparing US to other countries

1. The numbers are highly vulnerable to the exchange rates used in each year. That makes the numbers of uncertain value. Gruenspecht and Cristofaro agree on this.

2. Gruenspecht reports that revising the numbers for "purchasing power parity" to eliminate effect of exchange rates puts the US near the top of OECD in terms of most CO2 per GNP in most years.

3. The chart from CEA's 1990 report on climate (attached) shows 1986 numbers. The US emits less CO2 per GNP than Canada, Australia or the UK, but more than all other European countries. South Africa, India, China, and Poland emit the most per GNP.

4. The numbers in an older set of talking points you provided me, showing the US near the least CO2 per GNP, were apparently in error, according to Cristofaro. The numbers for Europe used 1985 data for "lbs. of CO2 per $ of GNP," ranging from 0.32 (Japan) to 0.80 (Australia). But Cristofaro informed me today that the US number (0.46) was actually 1990 data not 1985 data. Recalculated with 1985 data for the US, the US comes out at 0.66 -- higher than all the Europeans and lower than only Australia.

5. The Action Agenda from 1990, chart 20, using 1988 data, also showed the US to be higher than all except Canada and Australia.

From: US Interagency TF, "Economics of Long-Term Global Climate Change," DOE (for CEA) 1990

Table III.4 — Carbon Dioxide Emissions Per Capita and Per Dollar of GNP, 1986

Country	Per Capita (metric tons of carbon per capita)	Per Dollar of GNP (kilograms of carbon per dollar)
United States	5.005	0.28
Canada	4.094	0.29
Japan	2.109	0.16
West Germany	3.066	0.25
Australia	3.853	0.32
France	1.794	0.17
United Kingdom	2.938	0.33
Italy	1.655	0.19
Spain	1.284	0.26
Poland	3.321	1.60
Mexico	0.909	0.49
South Africa	2.785	1.51
Brazil	0.379	0.21
China	0.527	1.76
India	0.187	0.64
East Germany	5.499	n.a.
Czechoslovakia	4.212	n.a.
USSR	3.593	n.a.
Romania	2.408	n.a.

Notes: From Department of Energy and *World Bank Development Report, 1988*. Top set of countries listed from highest to lowest GNP per capita. Includes emissions from fossil fuel combustion and cement production only. n.a.= means GNP not available in the sources employed.

agricultural effects. Nations differ substantially in their vulnerability to sea-level rise. A higher share of GNP originates in climate-sensitive activities in developing nations, but these nations generally lack resources for adaptation. In short, *while global action is essential to limit greenhouse emissions significantly, differences among nations may make it difficult to find universally acceptable emissions targets or ways of sharing the costs involved.*

3. Incentives and Market Failures

Consistent with its approach to domestic regulatory issues, this Administration feels that *an approach to limiting net anthropogenic greenhouse emissions that encompasses all important greenhouse gases and gas sinks as well as gas sources is more promising than one that considers each source of greenhouse gases individually.* An international limitation agreement based on the comprehensive approach, for example, would allow each nation to devise a strategy that reflects its own situation regarding opportunities for emissions reduction and sink enhancement. The Administration also feels that *any set of nations should be free at any time to develop a joint strategy to meet their pooled ceilings, as long as net global emissions are not thereby increased.* An approach incorporating these principles was outlined in a U.S. concept paper introduced at the IPCC.

Former Talking Points

For comparative purposes, CO2 per dollar of GNP in the following countries (1985 dollars and exchange rates):

Country	lbs CO2 per $ of GNP
Japan	0.32
U.S.	0.46
Italy	0.46
W. Germany	0.58
Canada	0.62
Netherlands	0.62
U.K.	0.62
Australia	0.80

0.66

wrong

1/30/92 After ramp the US # is for 1990, not 1985 so this is wrong ① ② It all depend on exchange rates — not reliable

- **More important, a similar story can be told for total GHG emissions.** Currently, the U.S. generates roughly 0.9 pounds of CO2 equivalent per dollar of GNP. EPA predicts that this ratio will drop to about 0.66 pounds per dollar of GNP within 10 years and will fall to about 0.50 pounds in 20 years. Again, this is based solely on actions to which the Administration has already committed. (Comparative information on total GHGs is not available.)

③ may depend on GNP vs. GDP.

- **Many proposed climate policies are unsound -- or worse**

-- Fuel-switching. Several EC nations (e.g. Netherlands, Germany) are planning to reduce their CO2 emissions by switching from higher-CO2 coal (or oil) to lower-CO2 natural gas imported from the Soviet Union and Eastern Europe.

But natural gas leaks from pipelines and distribution, thereby emitting methane (CH4) to the atmosphere -- which is over 20 times more potent a warming gas per kilogram than CO2. At just a 6% leakage rate, CH4 leaks fully offset all the CO2-related reduction in warming potential achieved by switching to natural gas from coal. (For switching away from oil to natural gas, a 4% leakage rate wipes out the warming savings.)

US 1985 lbs CO2 / GNP = billion metric tons / $4014.9 bil = .0989 tons ×1000 = .29 kg/$ ×22 = 0.658 lbs/$ GNP

1990 US = 0.50

In the Soviet Union and Eastern Europe, where the EC is aiming to get its low-CO2 natural gas, the leakage rate is estimated at 5-10% -- meaning that the EC's fuel switching policy could well reduce CO2 but actually increase the potential for global warming! Even in Australia, the average CH4 leakage rate is about 3%, severely limiting the value of fuel switching.

If other nations followed the "comprehensive approach" that the U.S. advocates, accounting for net emissions of all GHGs and not just CO2, this problem could be avoided. Furthermore, the comprehensive approach would direct attention to other cost-effective measures that are warranted now and that would also reduce GHG emissions, such as recapture and sale of leaking CH4.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

March 11, 1992

OFFICE OF
POLICY, PLANNING AND EVALUATION

MEMORANDUM

TO: Addressees

FROM: Alex Cristofaro AC
US EPA

RE: Review Report Analyzing Greenhouse Gas Emissions in the EC and the US

In September 1991 Mr. Alders and staff from the Commissions of the European Communities (EC) visited the US and discussed global warming issues with members of the Bush administration. As a result of this visit, the EC coordinated a project on comprehensively computing the greenhouse gas emissions of both the EC and the US for the years 1990-2000. The participants in this project included the US, represented by the Environmental Protection Agency, the Netherlands, and the Directorate General XI-Environment, Nuclear Safety and Civil Protection of the EC.

An expert group convened earlier this fall to discuss the goals and management of the project. A consulting firm, McKinsey & Co., was hired to assess the reported emissions. The process of collecting the emissions forecasts and assessing the methodologies continued through December.

A copy of the report is attached and I am pleased to share the results with you. Some of the major findings include:

o Government policies in both regions are likely to reduce greenhouse gas (GHG) emissions in 2000 by 4-5 percent in the US and by over 20 percent in the EC, relative to 1989 levels. This result was derived using the IPCC GWPs estimates to measure each gases role in global warming. The largest contributions to these reductions will come from initiatives directed at CFC, CO and NOx emissions.

o While the ultimate result of EC stated policies may be greater emission reductions in the future, the US is further along than the EC in the implementation of its actions.

o CO2 is the greatest contributor to global warming and is projected to grow in the future for both the EC and the US absent any future policies for its control. In the EC, fuel switching from fossil fuels to natural gas greatly reduces potential greenhouse gas emissions. In the US, coal use increases as an energy source, driving

Printed on Recycled Paper

up CO2 emissions. In addition the population is growing faster in the US than in the EC.

o New scientific evidence may greatly affect the GWPs associated with these GHGs. Scientists are re-estimating the indirect effects of some of the gases. Preliminary evidence reveals that the GWPs for CFCs, NOx, VOCs, CO and CH4 may change dramatically. Any revision of the GWPs will change the relative impacts each gas has on global warming and total warming impacts may be different than originally predicted.

o Using a range of GWPs to reflect the new scientific information shows that present policies may not reduce GHG emissions in either region; in fact, GHG emissions may rise substantially. This is primarily due to the large drop in CFC GWPs, which will diminish the impact of the CFC reductions.

I would appreciate your comments on this report by March 20.

Thank you in advance for your comments.

Attachment

Adressees:

Howard Gruenspecht
Ray Squitieri
Jonathan Wiener
Jeff Holmstead
Dan Reifsnyder

McKinsey & Company

TOWARDS REDUCED GREENHOUSE GAS EMISSIONS IN THE EUROPEAN COMMUNITIES AND THE UNITED STATES

COMMISSION
OF THE EUROPEAN
COMMUNITIES

Ministry of Housing,
Physical Planning
and Environment
The Netherlands

Findings and Conclusions

January 1992

SUMMARY

This report summarizes the main findings and conclusions from a comparison of anticipated developments through the year 2000 in overall greenhouse gas (GHG) emissions of the European Communities and the United States. The investigation was carried out during the months of October and November 1991 at the request of the EC Directorate-General XI, Environment, Nuclear Safety and Civil Protection, the U.S. Environmental Protection Agency (EPA) and the Netherlands Ministry of Housing, Physical Planning and Environment.

The investigation drew on data submitted by the EC Member States and the U.S. on actual GHG emissions and projections based on ongoing trends and existing policies, as well as on information from the U.S. EPA, the EC and the Environment Ministries of the EC Member States on proposed or recently adopted government policies impacting GHG emissions. Major areas of uncertainty in emission projections were reviewed with relevant experts nominated by the U.S. EPA and the EC.

The report concludes that the reduction in overall GHG emissions likely to be achieved by the year 2000 is significantly more pronounced in the EC than in the U.S., both in absolute terms and relative to the size of the population or the economy (Exhibit 1). This conclusion is based on the present understanding of relative contributions towards the greenhouse effect of individual gases. To a large extent, the difference in projected developments stems from the impact of policies adopted before 1990, rather than from additional policy measures planned or adopted by the two regions since then. This conclusion is based on two key findings:

- Under pre-1990 government policies alone, it is likely that overall GHG emissions would drop in the EC and rise marginally in the U.S. over the 1989-2000 period. This development in overall GHG emissions in both regions would be the result of a significant decline in CFC emissions and an increase in "man-made" emissions of virtually all other gases, including a rise of carbon dioxide emissions of approximately 8 percent in the EC and 19 percent in the U.S.

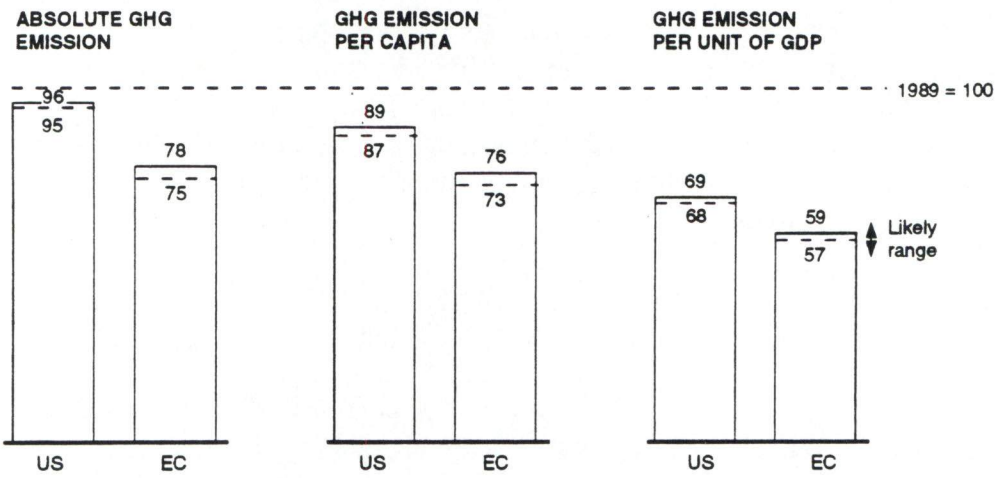
- Additional government policies in both regions are likely to lower overall GHG emission levels by 10-15 percent relative to those projected for the year 2000 under pre-1990 policies. The largest contributions to these reductions will come from initiatives directed at carbon dioxide and nitrogen oxide emissions. By the year 2000, these additional policies are likely to reduce GHG emissions by approximately 5 percent in the U.S. and by over 20 percent in the EC, relative to 1989 levels.

Despite this anticipated progress in limiting climate change, the need for further action exists in both regions. Economic growth will continue to exert upward pressure on carbon dioxide emissions beyond the time period considered here. Longer term, both regions will require even more stringent policies if they are to contribute towards the goal of stabilizing atmospheric greenhouse gas concentrations recommended by the Second World Climate Conference of 1990.

Exhibit 1

The rate of reduction in GHG emissions in the EC is expected to exceed that in the US

PROJECTED GHG EMISSION IN 2000 RELATIVE TO 1989
Index of CO_2 equivalents; 1989 = 100



Note: 2000 data reflect "scenarios under additional policies" discussed in this report

Source: Team analysis

The need for further improvement is also underscored by the current scientific re-evaluation of the relative contributions of GHGs to global warming. In particular it is suspected that the global warming factors for CFCs and nitrogen oxides are actually significantly lower than presently assumed. If this is confirmed, the decline in overall GHG emissions would be less pronounced than suggested here, or indeed the overall emissions could rise substantially over the 1989-2000 period.

This comparison of projected GHG emissions in the EC and the U.S. highlights the difference in overall impact of government policies in the two regions. It suggests the need for further substantive measures and initiatives to improve policy development. Ultimately, it is hoped that the investigation will provide a stepping stone towards strengthened international coordination, thereby helping to improve the effectiveness and efficiency of policy approaches.

TOWARDS REDUCED GREENHOUSE GAS EMISSIONS

IN THE EUROPEAN COMMUNITIES AND THE UNITED STATES

TABLE OF CONTENTS

	Page
INTRODUCTION	1
1 - PRE-1990 POLICY SCENARIO	3
Carbon Dioxide	3
CFCs	4
Methane	4
Nitrous Oxide	5
Ozone Precursors	5
2 - SCENARIO UNDER ADDITIONAL POLICIES	7
U.S. Policies	7
EC Policies	9
Moving Forward	11
APPENDIX	

INTRODUCTION

Climate change is one of the major environmental issues facing policymakers worldwide. For the past few years it has held a prominent place on the political environmental agenda, fueling considerable debate on the potential effectiveness and efficiency of policy options available to limit its impact.

Against this background, the European Communities Directorate-General XI, Environment, Nuclear Safety and Civil Protection, the United States Environmental Protection Agency (EPA) and the Netherlands Ministry of Housing, Physical Planning and Environment invited McKinsey & Company, Inc. to carry out a quantitative assessment of projected greenhouse gas (GHG) emissions in the EC and the U.S. More specifically, this assessment would indicate and compare the anticipated developments in overall GHG emissions through the year 2000 for these two major regions, which together account for close to 40 percent of worldwide GHG emissions. The scope was limited to the emissions effects of existing or currently proposed policies, and thus did not include an evaluation of the cost-effectiveness or other economic consequences of those policies. This report summarizes the findings and conclusions of the work undertaken by McKinsey in accordance with the project proposal of October 4, 1991.

The McKinsey investigation covered all major "man-made" emissions of GHGs and the so-called ozone precursors*. Anticipated emissions of these gases in the year 2000 were compared with those recorded in 1989**, or the most recent year for which actual emissions data were available. The emissions were measured in terms of an integrated GHG index, reflecting relative contributions of gases to radiative forcing over a 100-year period, as agreed by the Intergovernmental Panel on Climate Change (the so-called Global Warming Potentials or GWPs). The assessment of future emissions proceeded in three steps:

- ¶ Data collection for the "Pre-1990 Policy Scenario". In the first step, the project team asked the U.S. EPA and Environment Ministries of the EC Member States to supply actual GHG emission data and projections based on ongoing trends and on the continuation of government policies in existence prior to 1990. These data were validated and - where not available by individual country - complemented by data provided by the EC, as well as by publicly available information from international organizations or research institutes, such as the United Nations Economic Commission for Europe (ECE), the International Energy Agency (IEA), the Intergovernmental Panel on Climate Change (IPCC), and the Organization for Economic Cooperation and Development (OECD). "Pre-1990 policies" in this context included the phase-out of CFCs, to which the U.S. and the EC indicated their commitment in 1989, and were otherwise defined as those policies for which specific and legally binding government regulations had been adopted as of January 1, 1990.

---

* For the sake of convenience, the term "greenhouse gases" (GHGs) will be used in the following pages to denote both "proper" greenhouse gases and ozone precursors, which indirectly affect atmospheric greenhouse gas concentrations.

** Originally, the year 1990 was intended to serve as the base year for analysis, but lack of data made this infeasible.

Exhibit 2

Major areas of uncertainty in projected GHG emissions have been submitted to expert assessment

FOCUS OF EXPERT CONSULTATIONS

	EC PROJECTIONS/POLICIES	**US PROJECTIONS/POLICIES**
ENERGY	Prof. U. Colombo Chairman ENEA; Rome	D.A. Lashof Senior Scientist, Natural Resources Defence Council; Washington D.C.
	S. Pariente-David Director, Data Resources Inc.; Paris	Prof. H. Lee Director Environment and Energy Policy, J.F. Kennedy School of Government, Harvard University; Cambridge, Mass.
	R. Skinner Director Long Range Planning, International Energy Agency; Paris	J. MacKenzie and R. Pomerance Senior Associates, World Resources Institute; Washington D.C.
		Prof. R.L. Schmalensee Professor, Sloan School of Management, Massachusetts Institute of Technology; Cambridge, Mass.
LANDFILLS		R.L. Ajax President, Robert L. Ajax & Associates; Carey, N.C.
		J.R. Farmer Principal Scientist, Research Triangle Institute; Raleigh, N.C.

- Compilation of additional policies. The project team also obtained information from the U.S. EPA, the EC Directorate-General XI, and the Environment Ministries of the EC Member States on proposed or recently adopted* government policies impacting GHG emissions. This information concerned the nature of the policies, the anticipated effects by the year 2000 and the current stage of policy development. EC policies considered included Community protocols or directives, to be implemented through national regulation, and measures by individual Member States. The U.S. policies included federal laws, regulations and initiatives.

- Evaluation of projections. In the third step, the information on actual and projected GHG emissions was analyzed for consistency across the two regions in terms of underlying environmental and economic assumptions. Major areas of uncertainty in emissions projections were then reviewed with relevant experts nominated by the U.S. EPA and by the EC (Exhibit 2). These experts were asked for their perspectives on ongoing trends, the likelihood of implementation of additional policies, and the impact of these policies if their targets were reached. This approach allowed the project team to narrow the range of uncertainty with respect to emissions projections for the two regions.

The findings and conclusions of this report are thus based on emissions data, proposed policy descriptions, expert opinions and supporting documentation made available to the team during the project. Generally speaking, GHG emissions statistics should be regarded as order of magnitude estimates rather than precise data, because the nature of underlying processes often does not lend itself to direct observation or measurement. In addition, although the information provided has been checked for consistency, no independent verification has taken place. Nonetheless, the project team has no reason to question, within the context of this investigation, the validity of information used and the directional conclusions derived from it.

Interim results of the project were reviewed with representatives from the U.S. EPA, the EC Directorate-General XI and the Netherlands Environment Ministry in informal discussions and later in a formal review meeting on December 2, 1991. The constructive comments made during these meetings were taken into account in preparing this report.

***

The findings and conclusions of this report are presented in two chapters. The first addresses the anticipated development of GHG emissions under pre-1990 government policies, and the second outlines the impact of additional policy measures on emissions by the year 2000. Detailed supporting information is provided in the Appendix.

---

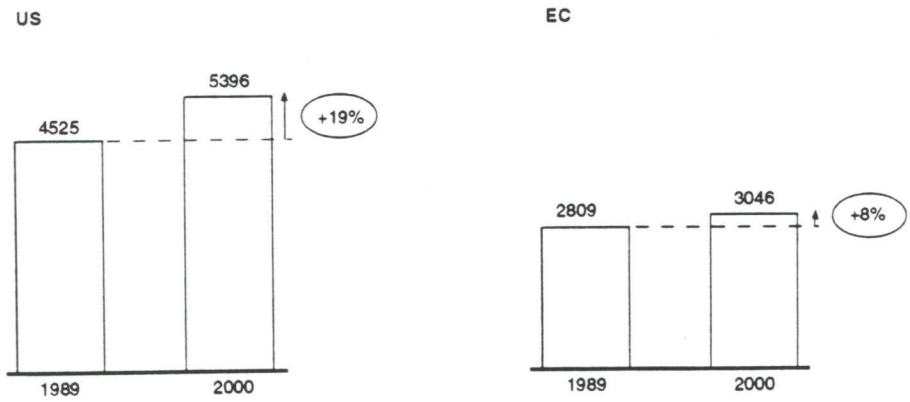
* I.e., since January 1, 1990.

Exhibit 1-2

Under pre-1990 policies, CO_2 emissions in the US would rise faster than in the EC ...

CO_2 EMISSION
Mton*

PRE-1990 POLICY SCENARIO



Note: CO2 data throughout this report cover all man-made, energy related emissions (see also Appendix)

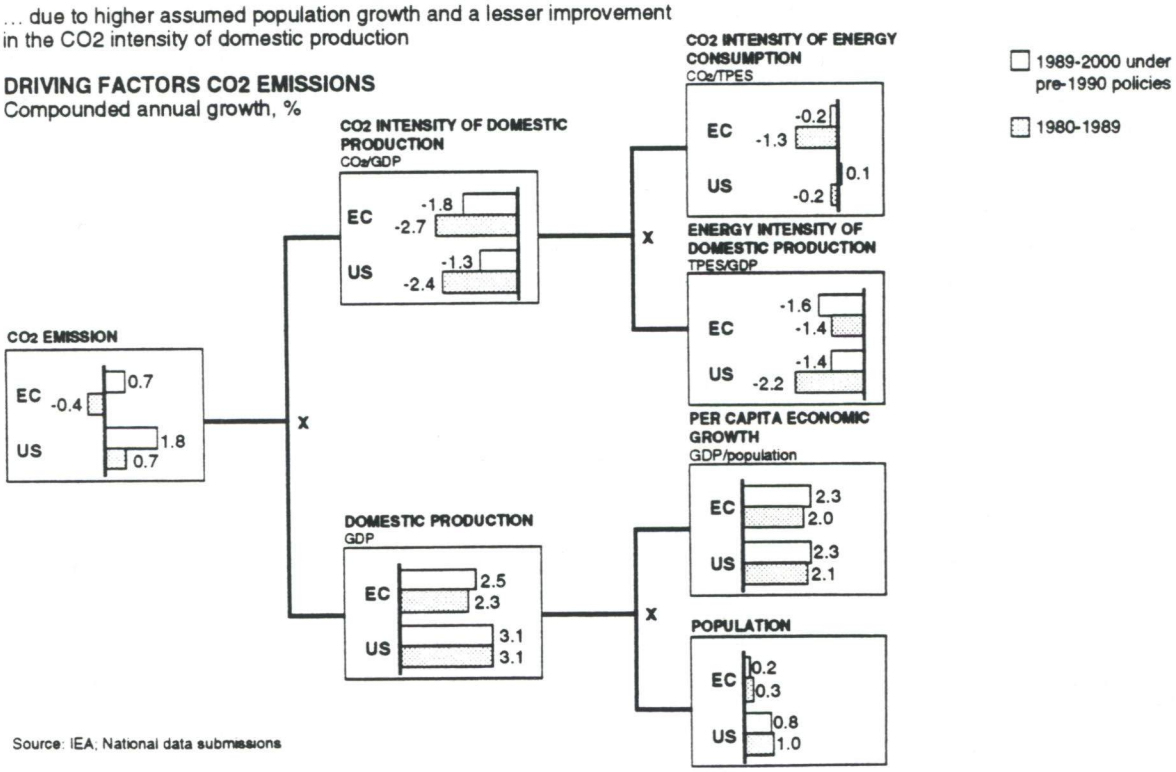
* "Ton" refers to metric ton throughout this report

Source: IEA; National data submissions

Exhibit 1-3

... due to higher assumed population growth and a lesser improvement in the CO2 intensity of domestic production

DRIVING FACTORS CO2 EMISSIONS
Compounded annual growth, %



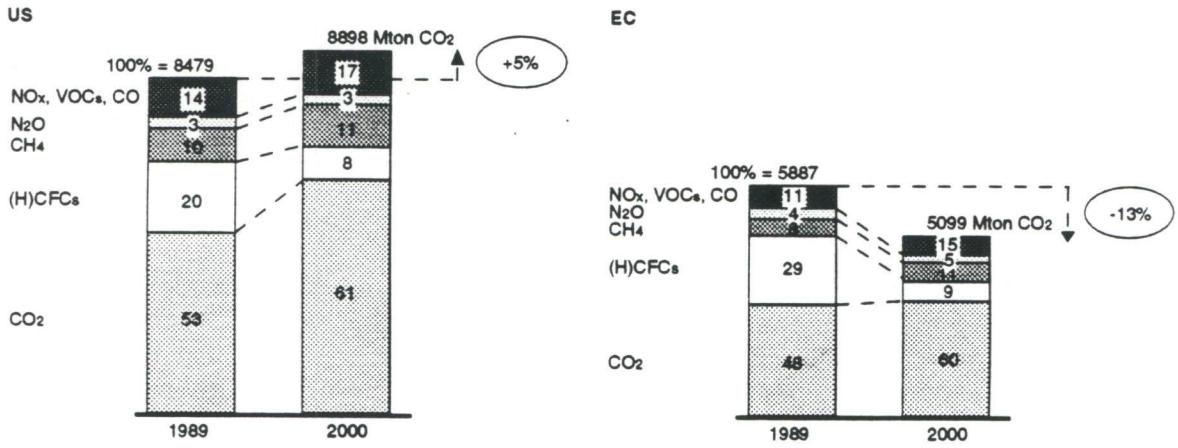
Source: IEA; National data submissions

Exhibit 1-1

Under pre-1990 policies, total emissions would most likely rise in the US and fall in the EC

TOTAL GHG EMISSION ESTIMATE
Percent of CO_2 equivalents

PRE-1990 POLICY SCENARIO



Note: Based on IPCC GWP factors

Source: National data submissions; IEA; OECD; IPCC

1 - PRE-1990 POLICY SCENARIO

If pre-1990 government policies were maintained throughout the coming decade, and no additional policies introduced, overall GHG emissions would most likely drop in the EC and rise marginally in the U.S. over the 1989-2000 period (Exhibit 1-1). This finding is based on the IPCC GWP factors, which reflect current scientific knowledge of individual gases' contributions toward the greenhouse effect.

The change in overall GHG emissions under present IPCC GWPs in both regions would be the net result of a significant decline in CFC emissions and an increase in man-made releases of carbon dioxide and other GHGs, with the possible exception of nitrous oxide in the EC. The projections for each of the major GHGs under this scenario are discussed below.

CARBON DIOXIDE

Given ongoing trends and the government policies in place at the end of 1989, carbon dioxide emissions would rise by approximately 8 percent in the EC and 19 percent in the U.S. between 1989 and 2000 (Exhibit 1-2), substantially more than during the 1980s.

For the U.S. the "Pre-1990 Policy Scenario" for carbon dioxide corresponds with the "Current Policy Case" in the National Energy Strategy. Emission estimates submitted by EC Member States are consistent - within the accuracy requirements of this investigation - with IEA statistics and, for example, with model data used in a recent study commissioned by the EC*. The major factors underlying the discrepancy in growth rate between the EC and the U.S. are as follows (Exhibit 1-3):

- CO2 intensity of energy consumption. This factor would change in both regions primarily under the influence of fuel switching in power generation. For example, pre-1990 policies in the EC point toward a larger share of natural gas-generated electricity, while strong electricity growth in the U.S. would be expected to lead to, inter alia, more coal-fired installations.

- Energy intensity of gross domestic production (GDP). Both regions would experience further improvements on the basis of ongoing energy conservation measures.

- Growth in gross domestic production. According to present projections, the U.S. will experience a higher rate of GDP growth, reflecting a higher population growth rate, while its per capita GDP growth rate will match that of the EC. These growth rates, assumed in projecting carbon dioxide emissions, are consistent with recent data published by the IEA.

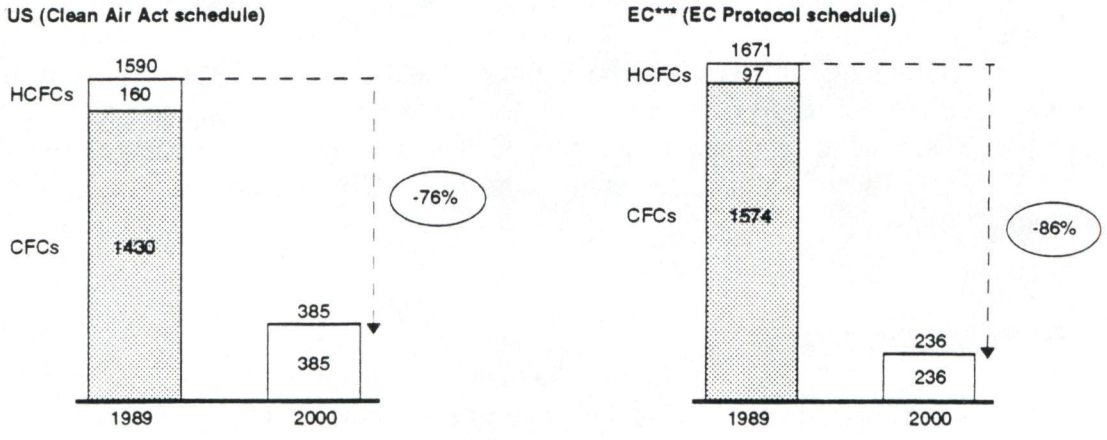
---

* "The Economic Impact of a Package of EC Measures to Control CO2 Emissions", Data Resources, Inc., November 1991.

Exhibit 1-4

Under existing phase-out schedules CFC production in both regions will be ended before the end of the decade, but partial substitution by HCFCs will take place

(H)CFC PRODUCTION*
Mton CO_2 equivalents**



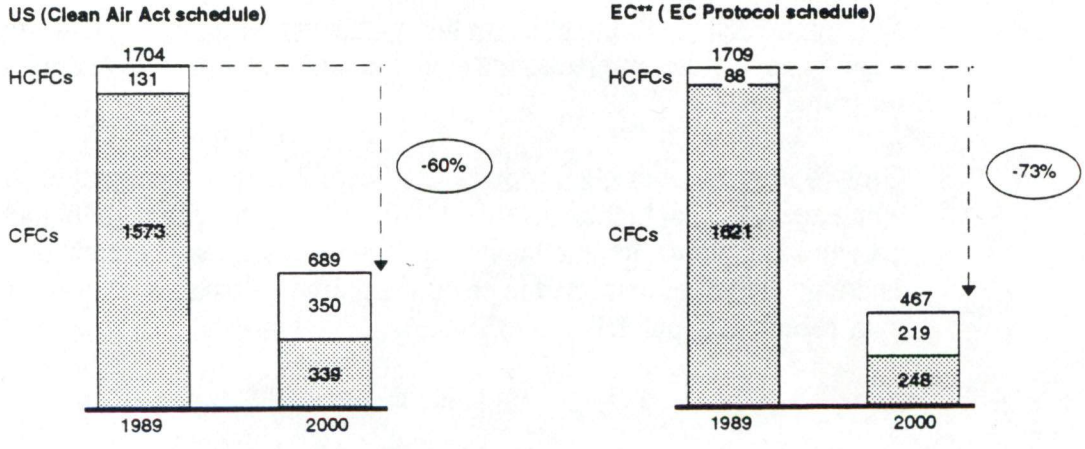
* Excluding production for export
** Based on IPCC GWP factors (see Appendix)
*** Based on RIVM "Escape" model data excluding former E. Germany

Source: National Institute of Public Health and Environmental Protection, the Netherlands (RIVM); EPA

Exhibit 1-5

CFC emissions lag the production phase-out

(H)CFC EMISSION
Mton CO_2 equivalents*



* Based on IPCC GWP factors (see Appendix)
** Based on RIVM "Escape" model data excluding former E. Germany

Source: National Institute of Public Health and Environmental Protection, the Netherlands (RIVM); EPA

CFCs

As previously noted, a decline in CFC emissions would generate the largest contribution to the reduction in overall GHG emissions in both regions. Through the Helsinki declaration of May 1989, the U.S. and the EC, inter alia, indicated their commitment to phase out CFCs before the end of the decade. More formally the parties to the Montreal Protocol agreed, at their 1990 London meeting, to eliminate production of so-called fully halogenated CFCs and halons by the year 2000. In accordance with this agreement, both regions have developed and set in motion rapid phase-out schedules. The Clean Air Act schedule in the U.S. stipulates an 85 percent reduction in the production of major CFCs by the year 1997, while all production is to be halted by 2000. In the EC Protocol on CFCs, these years are 1996 and 1998, respectively. There appears to be widespread confidence that these reduction targets will be reached in both regions. In fact, the U.S. may even eliminate CFCs well ahead of the Clean Air Act deadline, and the accelerated phase-out planned by some EC Member States may also lead to rapid achievement of targets.

Several fully halogenated CFCs are being replaced by partially halogenated CFCs (so-called HCFCs) with lower or no ozone depleting potential. However, although GWPs of HCFCs are also lower than those of CFCs, some greenhouse warming potential remains. Overall, CFC and HCFC usage by the year 2000 expressed in GWP terms is expected to be some 80 percent lower than today (Exhibit 1-4).

The reduction in CFC and HCFC emissions lags behind the production phase-out schedule. This is due to the fact that in CFC applications such as foam-blowing or refrigeration, the release of the gas does not occur instantaneously, or indeed may be postponed until the product is destroyed. The delay depends on the nature of the CFC application and, accordingly, differs by type of substance. Models developed by the U.S. EPA and, for the EC, by the Netherlands National Institute of Public Health and Environmental Protection (RIVM) have been used to translate the planned production phase-out into reduced emissions by the year 2000. These models are technically similar in the sense that the assumed production-to-emission delays by application are broadly comparable.

The model calculations show that CFC emissions over the coming decade will fall by more than 70 percent in the EC and by approximately 60 percent in the U.S. (Exhibit 1-5). Between 1989 and 2000, the EC emission reduction will exceed that in the U.S., first, because of the later production phase-out in the U.S. and second, because the U.S. initiated CFC reduction at an earlier point in time. Hence, while applications such as in aerosols have virtually disappeared in the U.S., they still represent approximately 20 percent of CFC consumption in the EC. Since these applications are characterized by an instantaneous release, the time lag between elimination of production and elimination of emissions is minimal.

METHANE

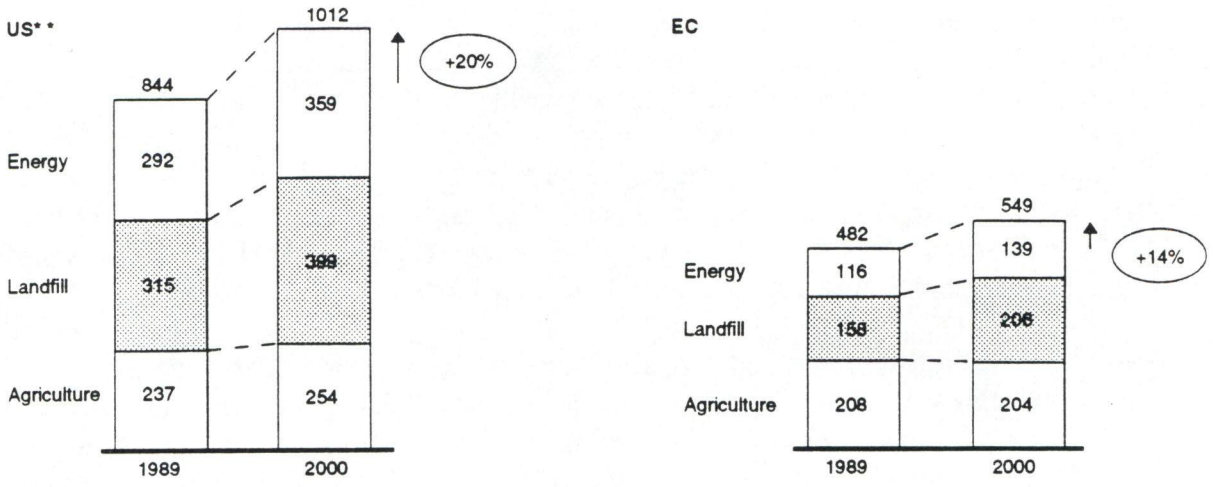
"Man-made" emissions of methane in the U.S. and the EC result from decomposition of municipal solid waste in landfills, from manure and gas produced by cattle, from rice cultivation, and from gas leakage or venting in fossil fuel production and natural gas distribution. Clearly, the nature of these sources imposes limitations on the ability to gather accurate data and thereby make informed projections of methane emissions. Thus, it is not

Exhibit 1-6

Methane emissions would rise in both regions due to growth in landfill and energy related emissions

METHANE EMISSION
Mton CO_2 equivalents*

PRE-1990 POLICY SCENARIO



* Based on IPCC GWP factor throughout this report (see Appendix)
** Average of EPA low and high estimates

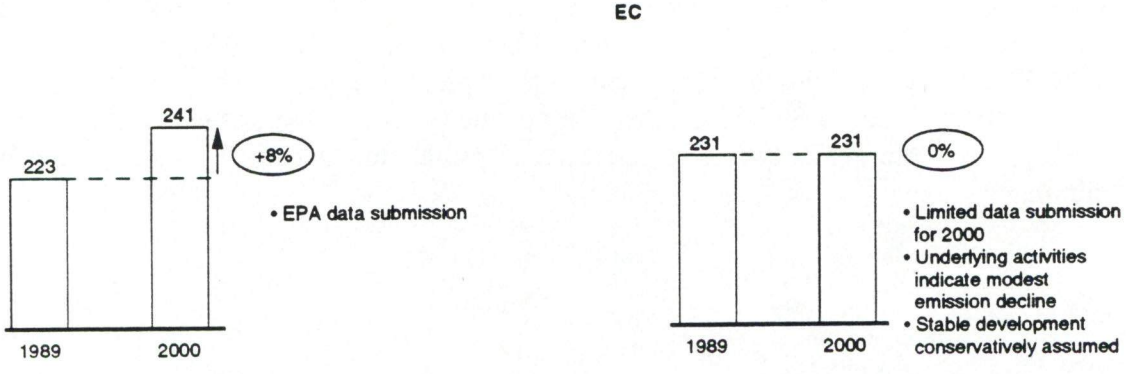
Source: OECD; Harwell Laboratory UK; EPA; EC Connair

Exhibit 1-7

N_2O emissions are expected to increase modestly in the US, while remaining stable in the EC

N_2O EMISSION
Mton CO_2 equivalents*

PRE-1990 POLICY SCENARIO



* Based on IPCC GWP factor throughout this report (see Appendix)

Source: National data submissions; IFA databank

surprising to find that actual and projected emissions provided by EC Member States and the U.S. differ considerably with respect to implicitly or explicitly assumed emission factors for specific activities (e.g., annual methane emissions per ton of municipal solid waste in landfills). The project team has applied the (generally higher) U.S. factors to the European situation to derive consistent emissions estimates.

These estimates indicate that, in the pre-1990 scenario, U.S. emissions would exceed those of the EC, primarily due to substantially higher coal and natural gas production levels and to a larger per capita volume of municipal solid waste landfilled. A higher growth projection for relevant activities in the energy field would account for the more rapid increase in U.S. methane emissions (Exhibit 1-6).

NITROUS OXIDE

Nitrous oxide emissions arise from the use of fertilizers in agriculture and from fossil fuel energy combustion. As in the case of methane, only rough estimates of man-made emissions of this greenhouse gas can be obtained.

The EPA anticipates a rise in U.S. nitrous oxide emissions of approximately 8 percent over the 1989-2000 period. The major factors underlying this projection are increases in energy consumption and in fertilizer use.

Limited data on projected emissions are available from the EC Member States. Lower fertilizer consumption, partly offset by a more modest growth in energy demand than that projected for the U.S., could conceivably reduce the total nitrous oxide emissions in the EC. However, for the purposes of this investigation, a stable emissions level has been conservatively assumed (Exhibit 1-7).

OZONE PRECURSORS

Three groups of ozone precursors can be distinguished: nitrogen oxides (NOx), volatile organic compounds (VOCs) and carbon monoxide (CO). Under pre-1990 government policies, substantial and comparable increases in the emission of these gases would occur in both the EC and the U.S. (Exhibit 1-8).

Among the ozone precursors, NOx makes the largest contribution to total GHG emissions given present IPCC GWPs*. NOx is primarily released through fossil fuel consumption in road transportation and power generation. Since no emission projections for the year 2000 are available for the EC under the "Pre-1990 Policy Scenario", the project team assumed that NOx would rise in line with the growth in both passenger vehicles and electricity demand in the EC. The more rapid increase projected for the U.S. mainly reflects the faster growth predicted for U.S. electricity demand.

---

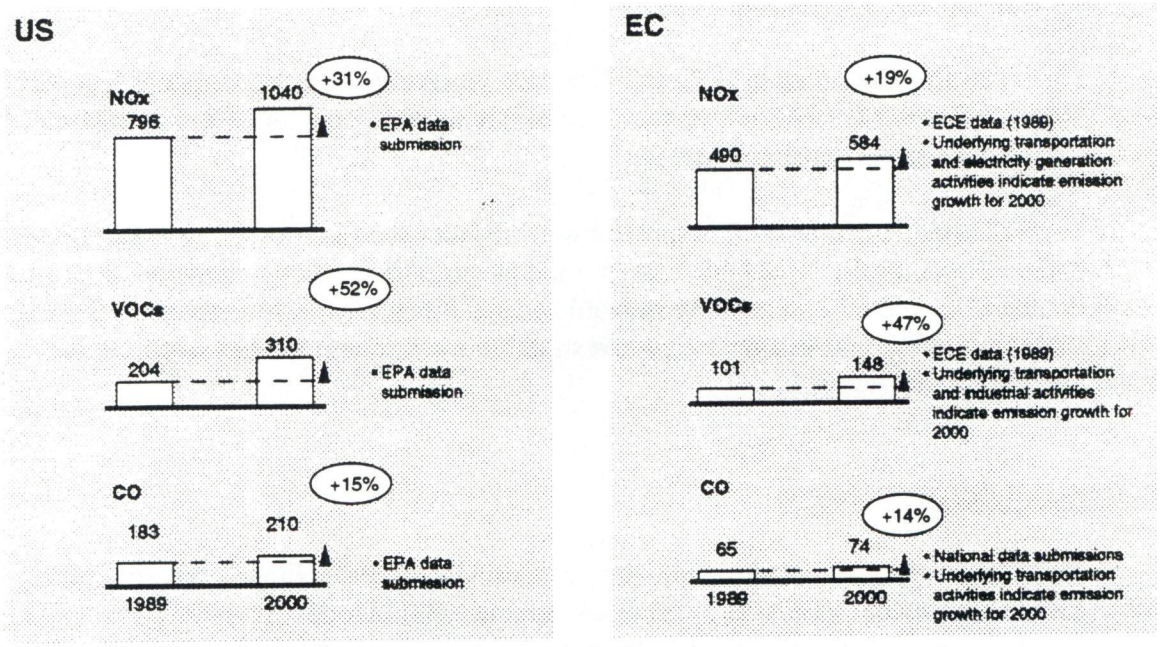
* The GWP for NOx is currently being reconsidered (see also Chapter 2). The revised factor may amount to less than 20 percent of the present value; if so, this would significantly reduce the importance of NOx in the overall GHG balance.

Exhibit 1-8

Under pre-1990 policies ozone precursor emissions would increase substantially

OZONE PRECURSOR EMISSION
Mton CO_2 equivalents*

PRE-1990 POLICY SCENARIO



* Based on IPCC GWP factors (see Appendix)

Source: National data submissions; IPCC; ECE; DRI

VOC emissions primarily result from road transportation and applications of industrial solvents. The project team assumed for the EC "Pre-1990 Policy Scenario" that VOCs would rise partly in line with the growth in passenger vehicles and, for the industrial part, at the same rate as the growth rate projected by the EPA for these applications in the U.S.. The overall increase over the 1989-2000 period would be on the order of 50 percent for both regions.

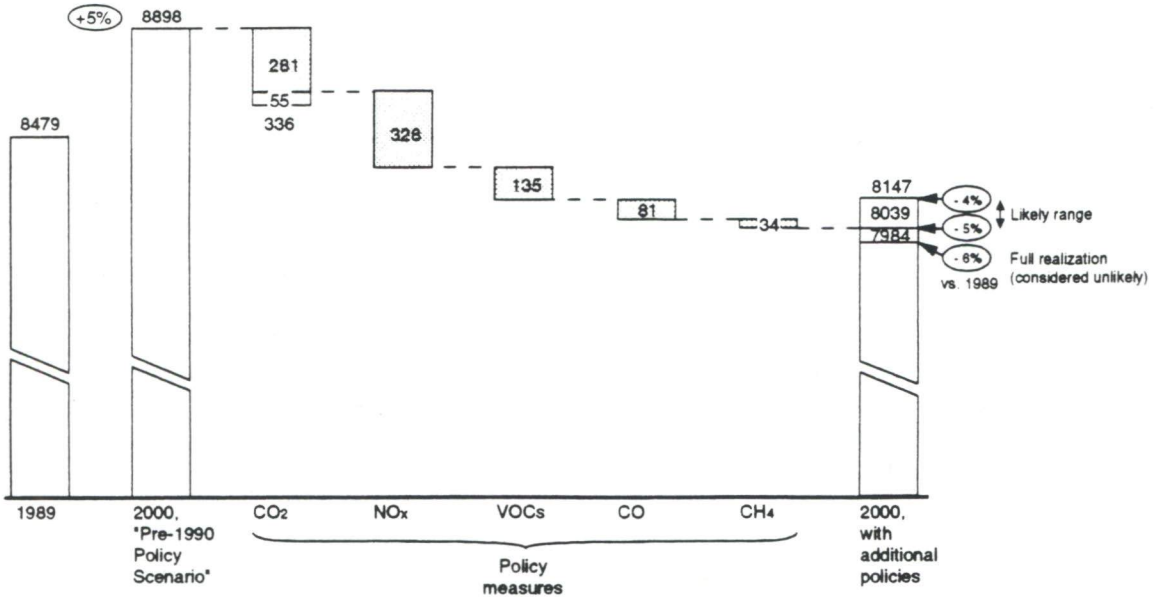
Since CO is largely emitted by the transportation sector, the EC projection for the year 2000 again has been based on the growth in passenger vehicles in the EC, in the absence of national emission projections under pre-1990 policies. This increase corresponds to the rise in CO emissions projected for the U.S. by the EPA.

Exhibit 2-1

The total US emission is expected to drop 4 to 5 percent

TOTAL GHG EMISSION ESTIMATE - US
Mton CO_2 equivalents

SCENARIO UNDER ADDITIONAL POLICIES



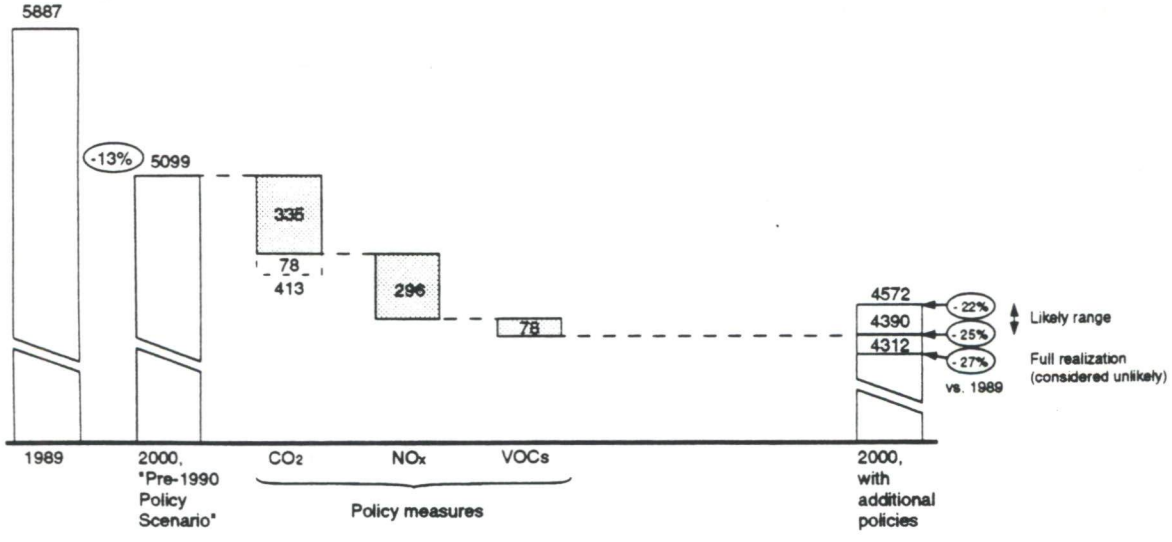
Source: EPA; IEA; Interviews; Team analysis

Exhibit 2-2

The total EC emission is expected to drop over 20 percent

TOTAL GHG EMISSION ESTIMATE - EC
Mton CO_2 equivalents

SCENARIO UNDER ADDITIONAL POLICIES



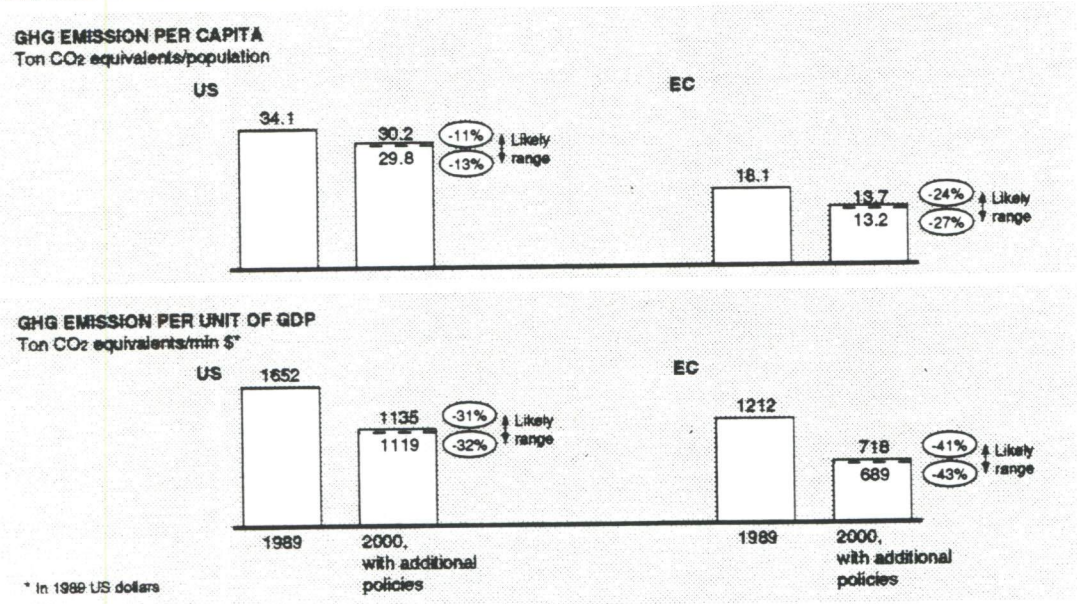
Source: National data submissions; IEA; Interviews; Team analysis

Exhibit 2-3

GHG emissions relative to population size or economic output are expected to decline substantially in both regions

RELATIVE GHG EMISSIONS

SCENARIO UNDER ADDITIONAL POLICIES



Source: National data submissions; EPA; IEA; OECD; Team analysis

2 - SCENARIO UNDER ADDITIONAL POLICIES

In both the EC and the U.S., various additional government policy measures to limit GHG emissions are being proposed, have been adopted recently or are in early stages of implementation. These measures primarily affect net carbon dioxide and nitrogen oxide emission levels, although they will also help reduce emissions of methane, VOCs and carbon monoxide.

In absolute terms, the reduction from additional policy measures relative to overall GHG emission levels in the "Pre-1990 Policy Scenario" is estimated at 10-15 percent in each region when using the IPCC GWPs. Combining additional policies with the pre-1990 policy case results in a scenario whereby the overall GHG emissions likely to be achieved in the year 2000 drop by 4 to 5 percent in the U.S. (Exhibit 2-1), and by over 20 percent in the EC (Exhibit 2-2), relative to 1989 levels. As indicated earlier, the major reasons for these diverging developments are the more pronounced effect of the CFC phase-out as well as the lower growth in carbon dioxide emissions in the EC.

Relative to the size of the population and the economy, the projected reduction in the EC likewise exceeds that in the U.S., although the difference is less pronounced than on an absolute scale. For example, per capita emissions of GHGs are likely to decline by over 10 percent in the U.S. and by some 25 percent in the EC. Measured relative to GDP, the projected reduction is more than 30 percent in the U.S. and more than 40 percent in the EC. On both dimensions, GHG emissions in the U.S. are likely to remain well above those in the EC (Exhibit 2-3).

The GHG emission scenario under additional policies is further explored below.

U.S. POLICIES

Additional government policies in the U.S. include measures affecting carbon dioxide, methane and ozone precursor emissions.

Full realization of U.S. policies affecting carbon dioxide would result in a 6 percent emission reduction relative to the level projected for 2000 under pre-1990 policies. According to the experts consulted, it is likely that at least a 3 to 5 percent reduction will be achieved. Relative to the 1989 level this would yield an emission increase of 13 to 15 percent (Exhibit 2-4). The major policies considered here are the following:

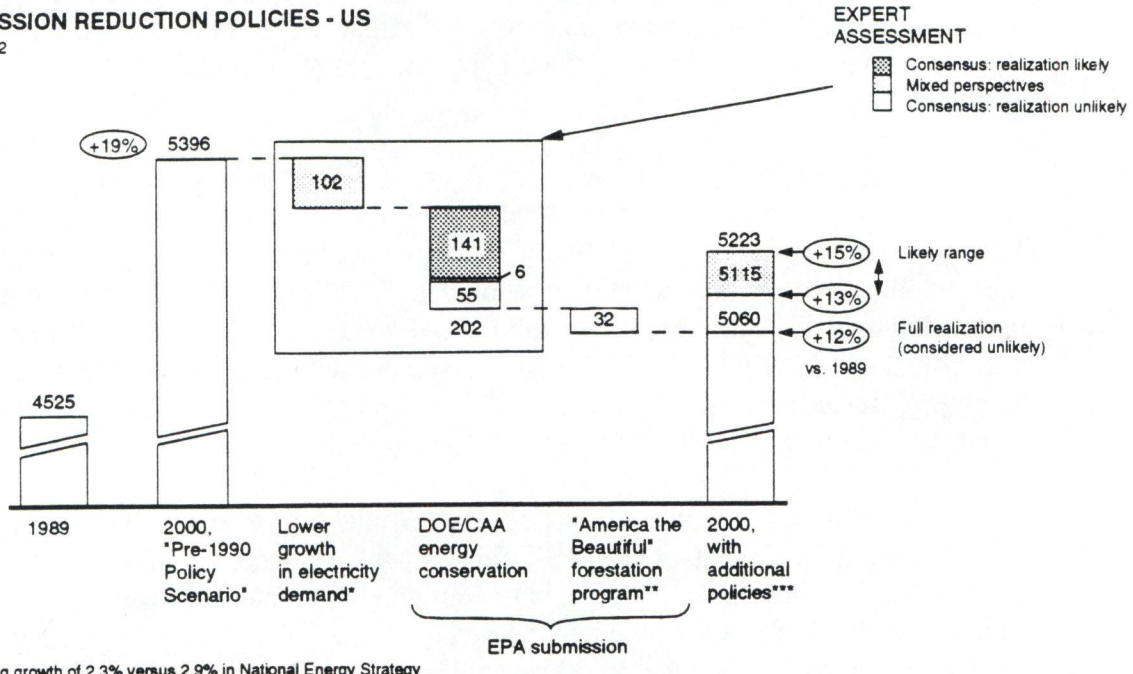
- ¶ National Energy Strategy. The National Energy Strategy published in February 1991 lists energy conservation actions based on initiatives by the Department of Energy (DOE) and incorporates major recent amendments of the Clean Air Act.

  - The major DOE initiatives aimed at reducing carbon dioxide emissions include the introduction of standards for household appliances; promotion of more efficient lighting in federal and commercial buildings, promotion of state adoption of building standards set by the federal government; promotion of least-cost utility planning by states; establishment of energy analysis and diagnostic centers; and expansion of hydro-power generation.

Exhibit 2-4

With additional policies, US CO_2 emissions in 2000 are likely to be more than 10% above the 1989 level

CO_2 EMISSION REDUCTION POLICIES - US
Mton CO_2



* Assuming growth of 2.3% versus 2.9% in National Energy Strategy
** No expert assessment; assuming full realization of policy measure submitted
*** Excluding "Green Lights" and "Golden Carrot" programs, for which no emission reduction estimates are available

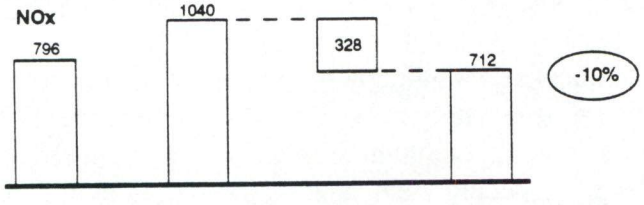
Source: EPA; Interviews; Team analysis

Exhibit 2-5

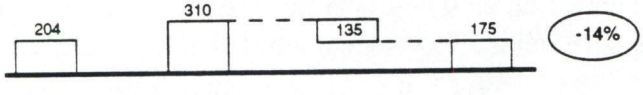
The US Clean Air Act is expected to reduce considerably the emission of ozone precursors

OZONE PRECURSOR EMISSION - US
Mton CO_2 equivalents

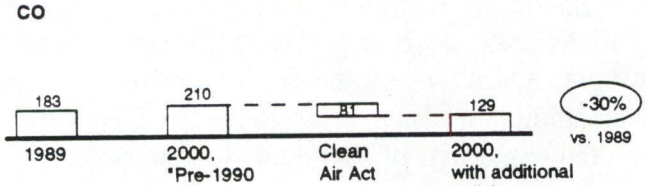
SCENARIO UNDER ADDITIONAL POLICIES



- EPA data submission
- CAA affects automobile and utility emissions



- EPA data submission
- CAA affects automobile emissions



- EPA data submission
- CAA affects automobile emissions

Source: EPA

While many of these initiatives have been adopted through administrative action during 1990 and 1991, experts have voiced reservations about the likelihood of their full realization, in part because of limited direct federal authority over implementation, in part because of legislative difficulties (e.g., in the proposed hydro-power expansion). On balance a minimum realization of 75 percent of these initiatives is anticipated.

In addition, experts have expressed doubts about the National Energy Strategy's projection of electricity growth, which is closely correlated to a high economic growth rate forecast for the 1990s. An annual economic growth of 2.5 percent (versus the 3.1 percent used in the "Pre-1990 Policy Scenario") would reduce CO2 emissions by 2 percent. Given the currently low U.S. economic growth rate, some experts favored a more conservative projection.

- Following the passage of the Clean Air Act in 1970, major amendments were adopted in November 1990. These amendments aim at significant reductions of SO2, NOx, VOCs and CO emissions. Due to the cost of compliance with new regulations, electricity prices are estimated by the DOE to increase by an average of 5 percent. Presumably, this price rise will dampen demand and hence lower carbon dioxide emissions in the electricity sector. Also anticipated is a further, less important emission reduction, which will result from fuel-switching to natural gas in the transportation sector. The energy experts consulted firmly believe that the Clean Air Act regulations will be implemented, but were skeptical about the electricity demand reduction induced. Thus, the impact of the Clean Air Act on carbon dioxide emissions has been lessened in this analysis, notwithstanding the previously mentioned possibility of lower overall electricity demand growth.

¶ "America the Beautiful" forestation program. This program sets the goal of planting 1 billion trees per year for 10 to 20 years, starting in 1991. At this stage the program has been partly funded. Even if fully realized, however, its estimated impact (through carbon dioxide sequestration) on net emissions in the year 2000 would be limited. Accordingly, this particular initiative has not been reviewed with forest management or policy experts.

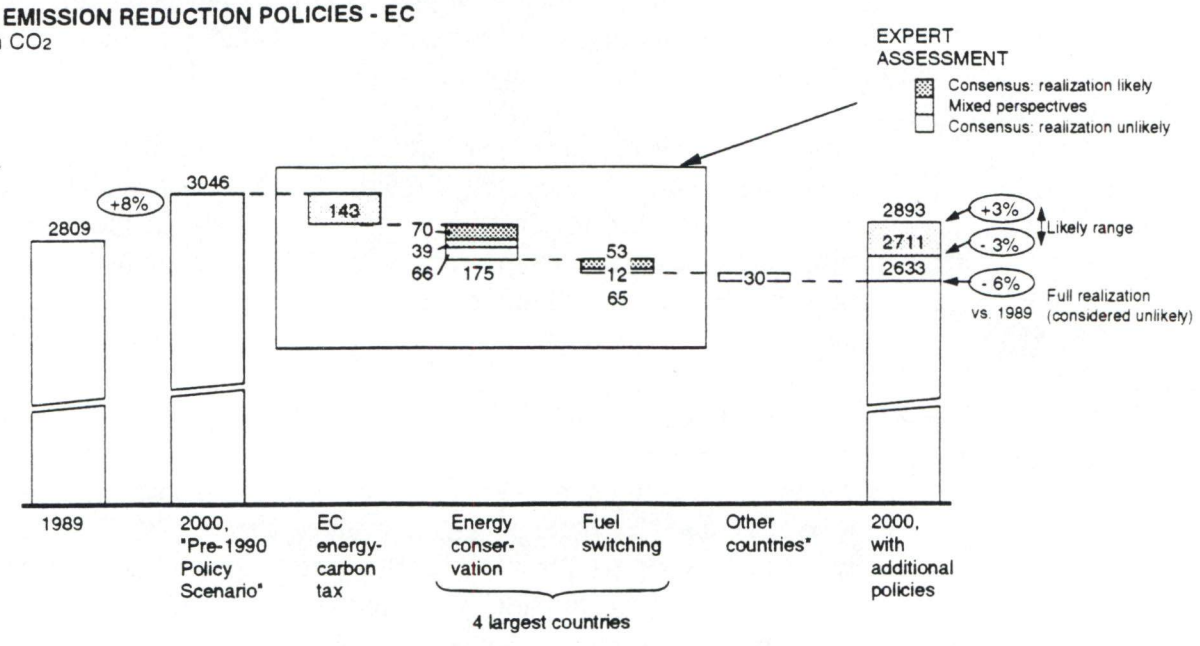
Methane emission will be addressed through the Federal Landfill Regulation. This regulation was proposed on May 30, 1991 and is scheduled to be finalized by the U.S. EPA by mid-1992. It aims to reduce emissions of non-methane organic compounds in large landfills through collection by wells for recovery or combustion. Methane will also be collected as part of this process. However, the overall impact is an emission reduction of only 3 percent, owing to the limited number of landfills subject to the regulation. According to experts, this is a conservative estimate.

Finally, the Clean Air Act, referred to in the above review of carbon dioxide emission reduction measures, will significantly lower ozone precursor emissions. Automobile exhaust standards and utility regulations are projected to reduce NOx emissions by the year 2000 by 10 percent below their 1989 level. For VOCs and CO, even further reductions are foreseen (Exhibit 2-5). As noted above, experts clearly anticipate the full implementation of the Clean Air Act regulations. Since these are directly aimed at reducing emissions of, inter alia, NOx, VOCs and CO, the corresponding effects on overall GHG emissions are held to be realistic.

Exhibit 2-6

With additional policies, the level of EC CO_2 emissions in 2000 is likely to be around that of 1989

CO_2 EMISSION REDUCTION POLICIES - EC
Mton CO_2



* No expert assessment: assuming full realization of policy measures submitted

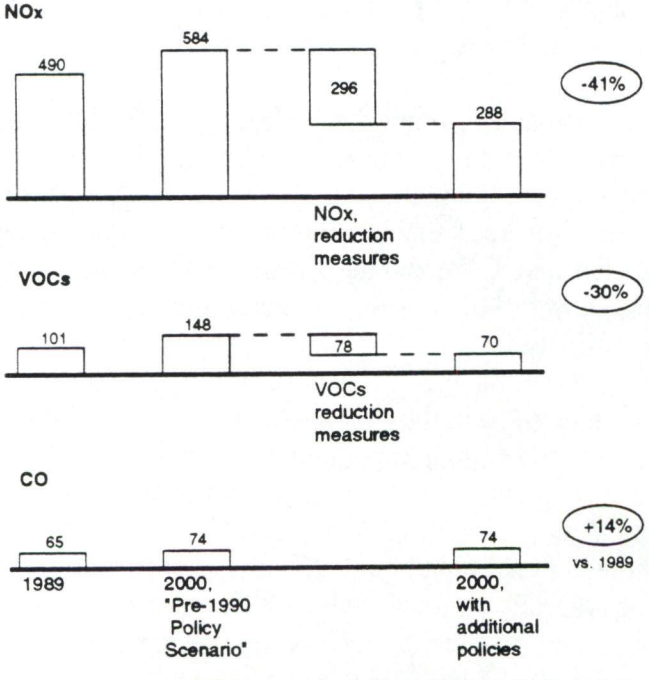
Source: National data submissions; IEA; Interviews; Team analysis

Exhibit 2-7

Additional policies in the EC will have a major impact on the emission of ozone precursors

OZONE PRECURSOR EMISSION - EC
Mton CO_2 equivalents

SCENARIO UNDER ADDITIONAL POLICIES



- Policy measure impact based on ECE data
- VOC protocol demands reduction of 30% in 1999
- EC Consolidated Vehicle Directive and VOC Industry Sector Directives are being prepared and formulated
- No 2000 projections available
- No target set, but EC Consolidated Vehicle Directive is likely to reduce emissions
- Stable development conservatively assumed

Source: National data submissions; ECE; European Chemical News; VOC protocol; NOx protocol

EC POLICIES

The additional policies in the EC address carbon dioxide and ozone precursor emissions.

Full realization of proposals to limit carbon dioxide would bring emissions in the year 2000 to a level approximately 14 percent below that of the "Pre-1990 Policy Scenario". However, experts discount the impact of several proposals and it is more likely that a 5-10 percent reduction will be achieved. The proposals on balance can be expected to bring emissions in 2000 to a level around that of 1989 (Exhibit 2-6). Within the major additional policies put forward by the EC and its Member States in this context, a distinction has been made between the planned EC energy-carbon tax (which will raise the real price of energy) and energy conservation and fuel switching measures, assuming constant energy prices in real terms:

- EC energy-carbon tax. The current strategy developed by the European Commission includes a mixed tax on energy (50%) and on the carbon content of all non-renewable energies equivalent to US$3 per barrel of oil in 1993, increasing to the equivalent of US$10 per barrel in 2000. Such a tax is expected to reduce 2000 energy consumption by approximately 3 percent* and carbon dioxide emissions by 143 Mtons CO2 through energy conservation and fuel switching.

  Experts consulted in November 1991 on the EC tax plan did not question its assumed impact if realized, but expressed serious reservations about the likelihood of it being approved in its present form. They did not exclude, however, the possibility of the introduction of some form of energy or carbon tax. On December 13, 1991, the EC Joint Energy and Environment Council requested the Commission to submit a formal proposal for the tax before May 1992. Thus, the energy-carbon tax remains on the political agenda for 1992. Accordingly, for the purposes of this investigation, the energy-carbon tax plan has been classified in the "mixed perspectives" category.

- Energy conservation measures in the four largest Member States. Because the carbon dioxide emissions of France, Germany, Italy and the United Kingdom together represent approximately 75 percent of the EC total, conservation policies in these countries will dominate European measures. Accordingly, expert consultation was sought only on the proposed policies in these four largest Member States. The experts' collective opinion is that the current policy proposals in Germany and France are likely to be realized, while proposals in Italy have a considerably lower probability of implementation at present. The experts differed in their views on the likelihood of full realization of energy conservation measures in the United Kingdom. The stage of policy development and funding support by central governments played a major role in these considerations. Little doubt was raised about the impact of the proposed policies if implemented, although the German estimates were considered ambitious given the already high

---

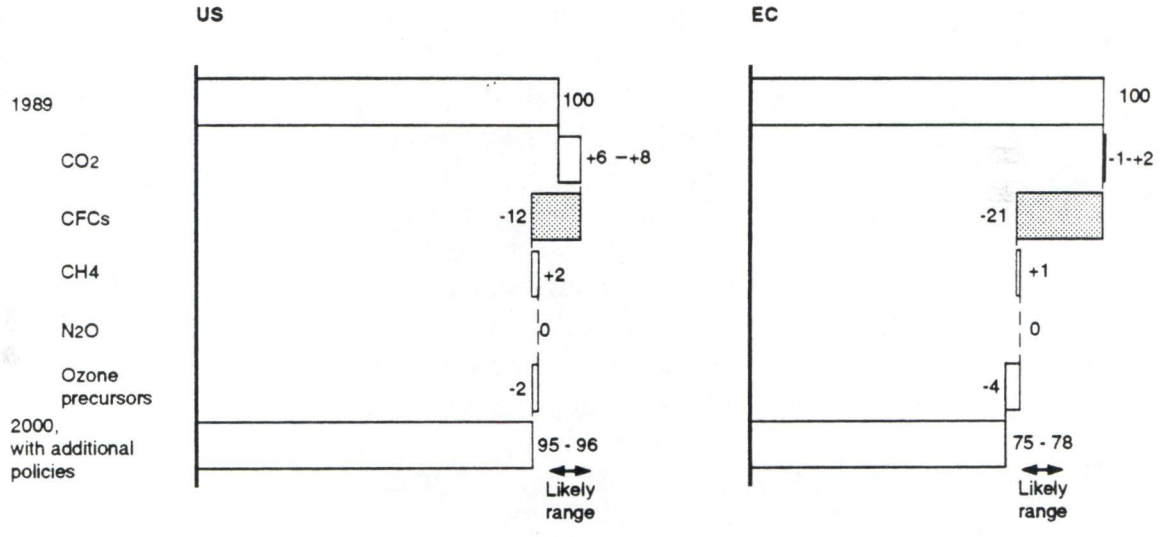
* The recent study by Data Resources, Inc., footnoted on page 3, indicates a potentially higher impact of the tax by the year 2000, possibly with the partial inclusion of energy conservation measures in the EC referred to below.

Exhibit 2-8

Most of the GHG emission reduction stems from the existing CFC phase-out policies

SOURCES OF GHG EMISSION REDUCTION
Index of CO_2 equivalents; 1989 = 100

SCENARIO UNDER ADDITIONAL POLICIES



Source: Team analysis

energy efficiency of that country. Overall, the expert assessment indicates that 40 to 60 percent of the proposed carbon dioxide emission reduction is likely to be realized, assuming that real energy prices remain around today's level.

At the EC level, the "SAVE" program has been proposed to introduce energy efficiency standards and labeling of household appliances. However, since the program is to be carried out through specific measures by individual Member States, its impact is, for the purposes of this analysis, assumed to be incorporated in the energy efficiency gains projected for individual countries.

- Fuel switching in the four largest Member States. As in the case of the energy conservation measures, only the power generation fuel-switching policies of France, Germany, Italy and the United Kingdom have been submitted for expert review. The experts' consensus is that the additional policy proposals to switch from coal to natural gas are likely to be implemented in Germany and the U.K. in line with plans to reduce domestic coal production subsidies. For Italy, the "Pre-1990 Policy Scenario" already assumes that original targets to expand coal-fired capacity will not be realized over the period in question. At the same time, experts cast doubt on the likelihood of a minor further switch to natural gas, considered here as additional policy, because planning at this stage is not sufficiently advanced. Finally, experts hold the view that the planned expansion of gas-fired capacity in France is likely to occur to meet peak load demand that cannot be met by additional nuclear capacity; this will actually raise carbon dioxide emissions. Overall, the expert evaluation implies that approximately 80 percent of additional fuel switching policies will be realized, assuming that energy prices remain constant in real terms.

- Additional policies in other Member States. As far as other Member States are concerned, Denmark and the Netherlands have set forth specific policy proposals limiting carbon dioxide emissions. Since the potential impact of these policies on total EC carbon dioxide emissions is relatively minor, European energy experts have not been consulted on the likelihood and degree of implementation. For the purposes of this analysis full realization has been assumed.

In addition to measures to curb carbon dioxide emissions, several protocols and EC directives are designed to substantially lower emissions of ozone precursors (Exhibit 2-7). The largest reduction in terms of GHG emissions is likely to come under the NOx protocol, signed in November 1988. The protocol aims to stabilize NOx emissions by 1994 at 1987 levels. However, policy measures formulated and in part taken by EC Member States since the signing of the protocol are expected to lower NOx emissions by approximately 40 percent from 1989 levels, through strict emission standards for power plants and for automobiles. In view of the political agreement on this issue and the nature of measures to be taken, there appears to be confidence that the projected reduction will be realized.

A VOC protocol was signed in November 1991 by all EC Member States except Portugal and Ireland. The protocol stipulates a reduction of annual VOC emissions of 30 percent by the year 1999 relative to 1988 levels. Implementation should follow the proposed EC Consolidated Vehicle Directive and the proposed EC VOC Industry Directives. The first of these proposed directives also addresses CO emissions in the transportation sector, but no data are available on the projected impact. To be conservative, therefore, no change relative

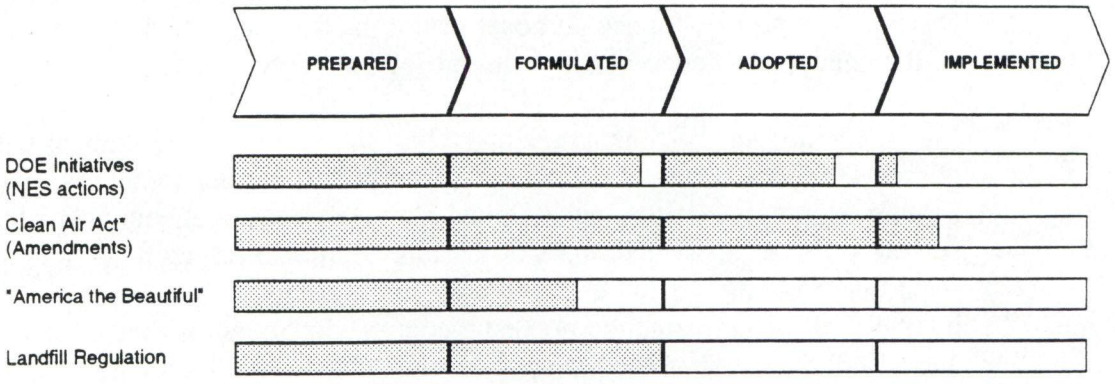
Exhibit 2-9

In the US, the more important DOE initiatives and Clean Air Act regulations are in later stages of development ...

ADDITIONAL POLICY MEASURES BY STAGE OF DEVELOPMENT - US

INDICATIVE

▨ Percent of total measures per stage completed



* Includes: CO, VOC, NOx and CO2 reduction measures

Source: EPA; Team analysis

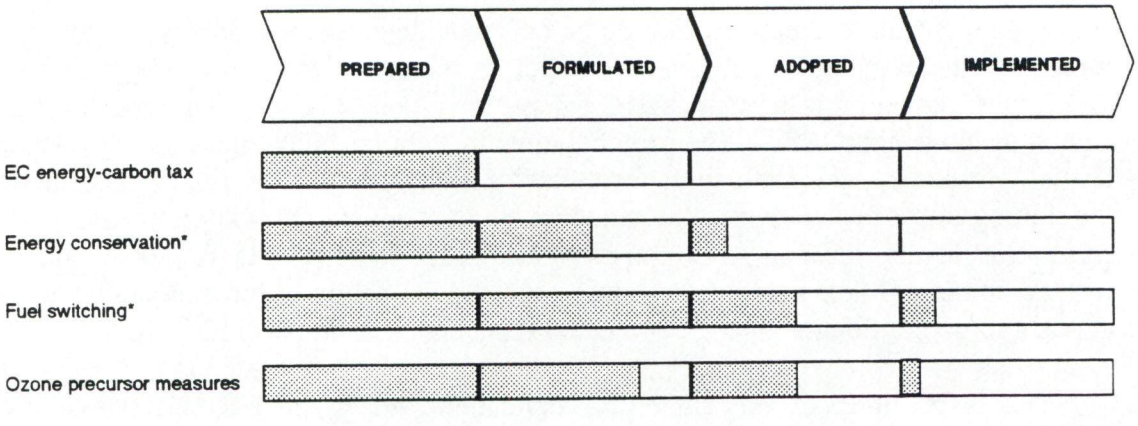
Exhibit 2-10

... while EC measures, with the exception of fuel switching and NOx measures, are less advanced

ADDITIONAL POLICY MEASURES BY STAGE OF DEVELOPMENT - EC

INDICATIVE

▨ Percent of total measures per stage completed



* Weighted average of policy measures in France, Germany, Italy and UK

Source: IPCC; National data submissions; Team analysis

to the "Pre-1990 Policy Scenario" has been assumed for CO. Because of the relative size of the projected impact of the directives on overall GHG emissions, these additional policies were not submitted for expert review.

MOVING FORWARD

As previously discussed, the combination of pre-1990 and additional government policies would yield a net overall reduction in GHG emissions in both regions if IPCC GWPs are used (see also Exhibit 1). The reduction in the EC would be significantly more pronounced than in the U.S., largely due to pre-1990 rather than additional policies. To ensure improvements over the longer term, substantive further measures are required in both regions.

Comparison of Emission Reductions

The EC and the U.S. follow different strategies for addressing global climate change. The EC has set a goal of stabilizing overall EC emissions of carbon dioxide at 1990 levels by the year 2000. In addition, several EC Member States have established specific reduction targets and are now formulating additional policy measures to reach them. In contrast, the U.S. has not announced a target for the reduction of carbon dioxide emissions, but it follows a comprehensive approach incorporating the sources and sinks of all GHGs. The National Energy Strategy, including the Clean Air Act amendments, makes important contributions in this regard. As previously noted, the net overall reduction in GHG emissions in the EC is likely to exceed that in the U.S., with most of the difference in emission reduction stemming from the existing CFC phase-out policies (Exhibit 2-8). Still, the relevant U.S. measures tend to be in further stages of policy development.

For example, important additional U.S. policies have been adopted by the relevant authorities and are beginning to undergo implementation (Exhibit 2-9). Generally speaking, comparable additional policy measures in the EC are still in earlier stages of development. Exceptions are energy conservation measures in Germany and selected fuel-switching proposals (Exhibit 2-10). This difference in stage of policy development is also reflected in the experts' evaluation. There is, for example, consensus that at least 70 percent of the potential impact of the U.S. carbon dioxide policies submitted for review is likely to be realized, versus one-third of that of the EC policies.

Need for Further Improvement

Despite the projected reductions in overall GHG emissions in both regions, the need for further policy measures clearly exists. There are two major reasons for this.

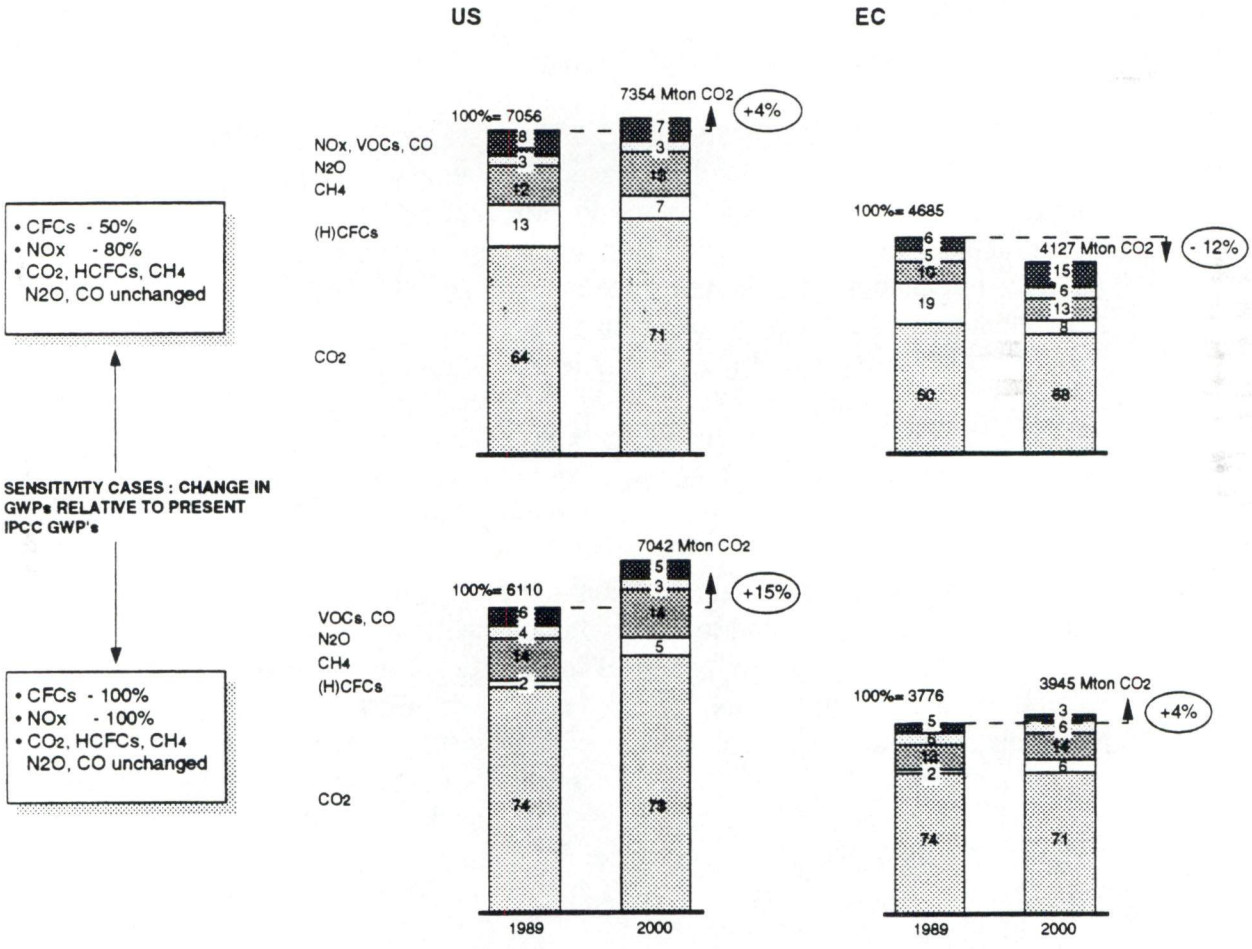
First, with CFCs phased out by the end of the 1990s, further gains will have to come chiefly from reduced carbon dioxide emissions. At the same time, however, economic growth will continue to exert upward pressure on greenhouse gases. This means that by the end of the decade, the U.S. will need to strengthen its policies in order to realize further progress regarding climate change. The same applies to the EC, where further action is needed in the medium term to ensure that it can maintain, or move beyond, carbon dioxide

Exhibit 2-11

Total GHG emissions might rise over the 1989-2000 timeframe, if GWPs of CFCs in particular were lowered substantially

TOTAL GHG EMISSION ESTIMATE - LOWER GWP FACTORS CFCs/NOx
Percent of CO_2 equivalents

SCENARIO UNDER ADDITIONAL POLICIES



Source: National date submissions; IEA; IPCC; EPA

emission stabilization. Longer term, both regions require even more stringent policies if they are to contribute towards the goal of stabilizing atmospheric concentrations of greenhouse gases, which was recommended by the Second World Climate Conference in 1990.

Second, the need for further action will become even more pressing if scientists reach the conclusion that the relative contributions of CFCs and ozone precursors to climate change are significantly lower than assumed to date. New scientific evidence is bringing into question the validity of the IPCC GWPs. GHGs cause climate change through both direct warming effects (where the gas directly affects the reflection of heat) and indirect effects (where the gas undergoes chemical transformations that may positively or negatively affect climate change). Scientists are now examining the extent to which cooling offsets the direct warming effects of several GHGs. Thus, GWPs could be reduced substantially, thereby greatly affecting the overall GHG emission projections. This is illustrated in Exhibit 2-11, which uses revised estimates of GWPs broadly reflecting some of the more recent scientific findings. This analysis of the sensitivity of emission projections to lower GWPs for CFCs and NOx demonstrates that the decline in overall GHG emissions in the EC would be less pronounced than discussed earlier, or emissions might even rise modestly over the time horizon considered. The possibility of a rise in emissions would certainly apply to the U.S. projections. Thus, under the more far-reaching assumptions, no environmental progress would be achieved in either region, despite the present additional policies.

A broad range of further measures can be considered. First, the present policies, which largely focus on domestic GHG reductions, could be expanded. Opportunities to tighten national measures remain, and national or regional approaches could be broadened. For example, steps to curb methane emissions from landfills could be considered in the EC. Second, international cooperation could be developed within the context of a worldwide approach to limit climate change. Starting from a base of largely domestic policies, cooperation could be built within the OECD (e.g., through concerted approaches by individual industry sectors), with Central and Eastern Europe (particularly directed at available energy efficiency improvement opportunities), and with developing nations (e.g., focusing on forestation and energy-efficient economic development).

To support the development of effective and efficient initiatives, policy tools must be strengthened. As indicated earlier, emission data for several greenhouse gases are imprecise, methodologies for evaluating the impact of policies on emissions are dissimilar, and consistent cost-effectiveness assessments are not available. While present efforts within the context of the IPCC may improve the fact base and the understanding of policy instruments in the longer term, more immediate improvements in policy support are also clearly needed.

***

This comparison of projected GHG emissions in the EC and the U.S. highlights the difference in overall impact of government policies. As emphasized above, further substantive measures to enhance policy development are required. Ultimately, international coordination will need to be strengthened in order to maximize the effectiveness and efficiency of policy approaches. It is hoped that this report will serve as a stimulus for multi-party discussions and concrete initiatives to ensure continuing progress toward limiting climate change.

APPENDIX

TABLE OF CONTENTS

IPCC GWP factors	A-1
CO2 emission	A-2
(H)CFC production	A-3
(H)CFC emission	A-4
Methane emission	A-5
N2O emission	A-6
Ozone precursor emission	A-7

IPCC GREENHOUSE WARMING POTENTIAL (GWP) FACTORS OF GREENHOUSE GASES

GREENHOUSE GAS	CO_2 EQUIVALENCE OF 1 TON GREENHOUSE GAS EMISSION* Ton CO_2
CO2	1
CH4	21
N20	290
NOx	40
VOCs	11
CO	3
(H)CFCs	
CFC-11	3500
CFC-12	7300
CFC-113	4200
CFC-114	6900
CFC-115	6900
CCL4	1300
HCFC-22	1500
HCFC-123	85
HCFC-124	430
HCFC-141b	440
HFC-152a	140
HFC-125	2500
HFC-134a	1200

Note: "Ton" refers to metric ton throughout this report

* Relative contributions of gases to radiative forcing over a 100 year time period

Source: Intergovernmental Panel on Climate Change

CO_2 EMISSION
Mton

	DATA SOURCE			PRE-1990 POLICY SCENARIO	ADDITIONAL POLICIES (FULL REALIZATION)	SCENARIO UNDER ADDITIONAL POLICIES
	1989	2000	1989	2000		
Belgium	IEA	IEA	110	143	0	143
Denmark	National data submission	IEA	53	49	3	46
France	National data submission	National data submission	380	397	28	369
Germany	National data submission	National data submission	688	683	102	581
Greece	IEA	IEA	70	88	-	88
Ireland	IEA	IEA	27	29	-	29
Italy	National data submission	National data submission	458	488	30	458
Luxembourg	IEA	IEA	10	9	0	9
Netherlands	National data submission	National data submission	182	177	27	150
Portugal	National data submission	IEA	38	50	-	50
Spain	National data submission	IEA	218	254	-	254
United Kingdom	National data submission	National data submission	576	680*	80	600
EC level	EC	EC			143**	-143
Total EC			**2809**	**3046**	**413**	**2633**
Total US	National data submission	National data submission	**4525**	**5396**	**336**	**5060**

Note: CO_2 data cover all man-made, energy related emissions, and exclude emissions from industrial processes (such as cement making) and man-induced forestry emissions or sinks. The only exception is the "America the Beautiful" program covered in the "additional policies" of the U.S.

* Average of range (601-759) submitted
** Energy-carbon tax (50% energy and 50% carbon)

Source: National data submissions; EPA, IEA, EC

(H)CFC PRODUCTION

		EC				US			
		1989		2000		1989		2000	
	GWP	Mkg	CO_2equivalent Mton	Mkg	CO_2equivalent Mton	Mkg	CO_2equivalent Mton	Mkg	CO_2equivalent Mton
CFC-11	3500	85	299	-	-			-	-
CFC-12	7300	137	1000	-	-			-	-
CFC-113	4200	56	234	-	-			-	-
CFC-114	6900	0	0	-	-			-	-
CFC-115	6900	0	0	-	-			-	-
CCL4	1300	32	42	-	-			-	-
Subtotal CFCs		310	1574	-	-	255*	1430*	-	-
HCFC-22	1500	65	97	131	196	106	160	177	266
HCFC-123	85	-	-	125	40**	-	-	86	7
HCFC-124	430	-	-			-	-	8	4
HCFC-141b	440	-	-			-	-	88	39
HCFC-152a	140	-	-	-	-	-	-	9	1
HCFC-125	2500	-	-	-	-	-	-	-	-
HCFC-134a	1200	-	-	-	-	-	-	57	68
Subtotal HCFCs		65	97	256	236	106	160	425	385
Total (H)CFCs		**375**	**1671**	**256**	**236**	**361**	**1590**	**425**	**385**

Note: EC emission does not include former East Germany

* EPA provided data on total CFC production. GWP factor of 5600 is weighted average of US CFC emissions
** Based on average GWP of HCFC - 123, HCFC - 124 and HCFC - 141b

Source: National Institute of Public Health and Environmental Protection, the Netherlands (RIVM); EPA

(H)CFC EMISSION

		EC				US			
		1989		2000		1989		2000	
	GWP	Mkg	CO_2equivalent Mton	Mkg	CO_2equivalent Mton	Mkg	CO_2equivalent Mton	Mkg	CO_2equivalent Mton
CFC-11	3500	94	327	17	58	65	228	31	107
CFC-12	7300	135	986	26	188	131	953	30	218
CFC-113	4200	62	260	1	2	70	292	-	-
CFC-114	6900	-	-	-	-	5	34	-	-
CFC-115	6900	-	-	-	-	4	24	2	14
CCL4	1300	34	48	-	-	32	42	-	-
Subtotal CFCs		325	1621	44	248	307	1573*	63	339
HCFC-22	1500	59	88	120	179	87	131	154	231
HCFC-123	85	-	-	} 125	} 40*	-	-	86	7
HCFC-124	430	-	-			-	-	8	4
HCFC-141b	440	-	-			-	-	88	39
HCFC-152a	140	-	-	-	-	-	-	9	1
HCFC-125	2500	-	-	-	-	-	-	-	-
HCFC-134a	1200	-	-	-	-	-	-	57	68
Subtotal HCFCs		59	88	245	219	87	131	402	350
Total (H)CFCs		**384**	**1709**	**289**	**467**	**394**	**1704**	**465**	**689**

Note: EC emission does not include former East Germany

* Based on average GWP of HCFC-123, HCFC-124, and HCFC-141b

Source: National Institute of Public Health and Environmental Protection, the Netherlands (RIVM); EPA

METHANE EMISSION

	DATA SOURCE		EMISSION FACTOR	EC				US			
				EMISSION SOURCE		EMISSION		EMISSION SOURCE		EMISSION	
	EC	US		1989	2000	1989	2000	1989	2000	1989	2000
ENERGY RELATED			Unit: Mton CO_2 equivalent/MTOE	Unit: MTOE		Unit: Mton CO_2 equivalent		Unit: MTOE		Unit: Mton CO_2 equivalent	
• Coal production	IEA	IEA/EPA	0.17	159	119	27	20	512	584	87	99
• Natural gas production	IEA	IEA/EPA	0.1	126	168	13	17	405	505	41	51
• Natural gas supply	IEA	IEA/EPA	0.37	205	272	77	102	443	560	165	209
			Total			**116**	**139**			**292**	**359**
LANDFILL RELATED			Unit: Mton CO_2 equivalent/ 1000 ton	Unit: 1000 ton		Unit: Mton CO_2 equivalent		Unit: 1000 ton		Unit: Mton CO_2 equivalent	
• Municipal solid waste landfilled	OECD	OECD/EPA	2.62	60	79	158	206	120	139*	315	365*
			Total			**158**	**206**			**315**	**365**
AGRICULTURE RELATED			Unit: Mton CO_2 equivalent/million	Unit: Million		Unit: Mton CO_2 equivalent		Unit: Million		Unit: Mton CO_2 equivalent	
• Number of cattle	OECD/Eurostat. Stockholm Environment Institute	OECD/EPA	2.39	86	84	205	201	92	99	220	237
• Wet rice						3	3			17	17
			Total			**208**	**204**			**237**	**254**

* Includes landfill regulation reduction effect of 12,800 ton, which translates into a methane emission reduction of 33.6 Mton CO_2 equivalents

Source: OECD; IEA; EPA; Eurostat; Stockholm Environment Institute

N_2O EMISSION
Mton CO_2 equivalent

	DATA SOURCE		PRE-1990 POLICY SCENARIO	ADDITIONAL POLICIES	ASSUMPTIONS FOR DEVELOPMENT EC PRE-1990 POLICY SCENARIO		
	EC: 1989 US: 1989; 2000	1989	2000		Driving factor	Share*	Annualized growth
Belgium	IFA databank	5		-			
Denmark	National data submission	4		-			
France	IFA databank	62		-			
Germany	IFA databank	34		-			
Greece	IFA databank	10		-	• Fertilizer use in agriculture	58%	-0.8%**
Ireland	IFA databank	9		-			
Italy	National data submission	12		-	• Fossil fuel consumption		
Luxembourg	-	-		-	- industry	32%	0.7%***
Netherlands	National data submission	12		-	- transportation	10%	
Portugal	IFA databank	3		-			
Spain	National data submission	12		-			
United Kingdom	National data submission	68		-			
Total EC		**231**	**225**	**-**			
Total US	National data submission	**223**	**241**	**-**			

* Data represent US shares as provided by EPA; same mix assumed for EC
** IFA database estimate
*** Growth rate CO_2 emission under pre-1990 policy scenarios

OZONE PRECURSOR EMISSION

Mton CO_2 equivalent

		DATA SOURCE			PRE-1990 POLICY SCENARIO	ADDITIONAL POLICIES	SCENARIO UNDER ADDITIONAL POLICIES	ASSUMPTIONS FOR DEVELOPMENT EC PRE-1990 POLICY SCENARIO		
		1989	2000	1989	2000			Driving factor	Share***	Annualized growth
EC	NOx	ECE	ECE*	490	584	296	288	• Electricity demand	56%	2%
								• Number of vehicles	40%	1.2%
								• Other	4%	0.4%
	VOCs	ECE	ECE*	101	148	78	70	• Industry	43%	5.4%
								• Number of vehicles	35%	1.2%
								• Other	22%	3.2%
	CO	Nds**	-	65	74	0	74	• Number of vehicles	66%	1.2%
								• Other	34%	1.2%
US	NOx	Nds**	Nds**	796	1040	328	712			
	VOCs	Nds**	Nds**	204	310	135	175			
	CO	Nds**	Nds**	183	210	81	129			

* ECE data for EC NOx and VOCs emission in 2000 represent a scenario under additional policies. The pre-1990 policy scenario was derived using the assumptions provided in the table, thus allowing the estimation of the impact of the additional policies

** National data submission

*** Data represent US shares as provided by EPA; same mix assumed for EC

Source: National data submissions; ECE, IPCC, DRI; European Chemical News; VOC protocol; NOx protocol

U.S. Department of Justice

Environment and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

FAX NUMBER (202) 514-0557
(FTS) 368-0557

CONFIRMATION NUMBER (202) 514-2701
(FTS) 368-2701

FROM: Jonathan Wiener

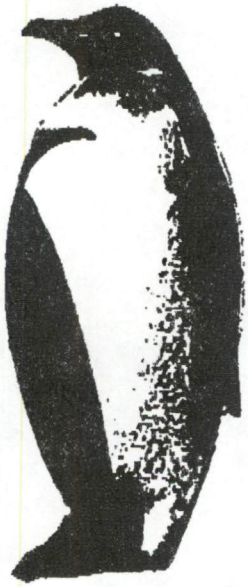
NO. OF PAGES: 14
(INCLUDING COVER PAGE)

TO: Jeff Holmstedt, WHC

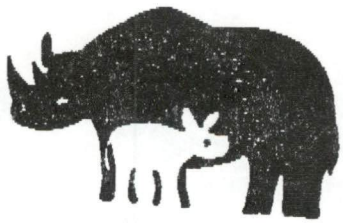
TELEPHONE NO: 456-7953

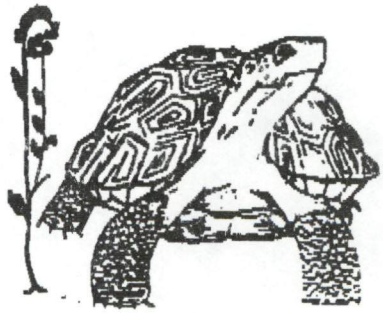
FAX NO: 456-7929

MESSAGE:



PLEASE NOTIFY SENDER IMMEDIATELY IF YOU HAVE ANY PROBLEMS RECEIVING THESE PAGES.





U.S. Department of Justice

Environment and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

February 3, 1992

MEMORANDUM TO: Ray Squitieri, CEA

CC: Ad Hoc Group on US National Strategy

FROM: Jonathan Wiener

SUBJECT: Section of US National Strategy on US Cooperative Activities Abroad

As you requested, I have assembled the attached explanation and "preliminary draft" selected list of US activities abroad that contribute to limiting net greenhouse gas emissions. The current preliminary draft list draws on "Technology Cooperation Related to Global Climate Change: A Selected Inventory," Dec. 1991; a submission from EPA/OAR/Global Change Division; and publicly available sources.

This is a preliminary list, which can be expanded and/or edited as desired. Several items need additional information, and ongoing activities in certain areas -- e.g. forestry and agriculture -- are not yet adequately covered. This list has not been edited and cleared by the involved agencies, and ought to be before it is used in any official communications.

I am nonetheless providing you with this preliminary draft list at this stage because you may require it in advance of the DPC Global Change Strategy Group meeting this afternoon. Please advise me of the next steps to take in completing this document.

Preliminary Draft 2/2/92 -- Official Use Only, Not for Distribution

U.S. Cooperative Activities Abroad That Limit Net GHG Emissions

I. INTRODUCTORY NOTE

In the exposition of national strategies to limit net greenhouse gas emissions, each nation should be able to include bilateral, multilateral or regional **"cooperative arrangements"** with other countries that limit net emissions.

- The United States has endorsed this concept, among other places, in its written submission to the INC on March 15, 1991, and in its intervention at the fourth INC session in Geneva, December 1991.

- Briefly, each nation could include in its "national strategy" both domestic actions to limit net GHG emissions and actions taken overseas through "cooperative arrangements" with other nations. (If it is important to quantify and allocate the net emissions reductions thereby achieved, the investor nation and the host nation would measure the reduction according to sound emissions accounting procedures and apportion it between them according to their mutually voluntary arrangement.)

- The U.S. has already begun to publicize its significant "technology cooperation" activities with other countries, in which U.S. agencies invest abroad in projects that also limit net GHG emissions or could assist in adaptation to potential climate change. In particular, the U.S. published "Technology Cooperation Related to Global Climate Change: A Selected Inventory" in December 1991, and will host a symposium on the topic during the negotiating session in February 1992 in New York.

- Since GHG emissions mix globally and have global effects, it is the aggregate global net emissions that are of environmental interest. Limitations achieved anywhere on the globe are equally significant (with some qualifications for certain gases, which can be addressed through technical translation factors). Nations therefore ought to have the flexibility to pursue limitation projects wherever they are most cost-effective.

Some other countries have proposed complex and encumbered versions of the "cooperative arrangements" idea, dubbing it "joint implementation." These variants contain much with which the U.S. can agree, but also elements that are potentially at odds with U.S. policy. For example, Norway has helpfully articulated the rationale for joint implementation, but also linked joint implementation to a uniform emissions target & timetable. Germany has implied that joint arrangements could be undertaken only with countries that are members of a regional group like the EC (excluding developing countries and Eastern Europe).

But the basic notion of "cooperative arrangements," unfettered by such other provisions, remains sound and practical. Such **cooperative arrangements would offer several important advantages:**

- Consenting adult nations could exercise the **flexibility** to achieve emissions limits in concert.

- This flexibility would **improve the cost-effectiveness** of any GHG abatement efforts under national strategies, by enabling countries to find and invest in the most effective, least costly limitations projects worldwide.

- Such international cooperative arrangements would serve as a **decentralized, market-based vehicle for investments** in countries offering low-cost emissions limitation opportunities. Potential recipients would compete to offer projects yielding the most GHG reductions at the least cost; potential investors would compete to offer the best financial and technical assistance. **Both investors and host countries would gain** -- or else choose not to engage in such arrangements, which would necessarily be voluntary market transactions.

- Since cost-effective emissions limitation opportunities are especially likely to be found in **developing countries and Eastern Europe**, an investment flow to those areas could be expected. (Indeed, the U.S. approach contemplates investments in developing and Eastern European countries, whereas the German/EC limited version would preclude investment there.)

- While **limiting global net emissions**, cooperative investments would confer a **cost saving** to countries (most likely industrialized countries like the U.S.) where emissions limitations would be more expensive.

For example, a U.S. national strategy to limit net GHG emissions could be achieved at less cost if the U.S. could invest in projects abroad with a lower marginal cost of abatement than in the U.S.

- Investor nations could also hope to gain **new markets for key technologies**, e.g. energy supply and conservation technologies, biotechnologies, and agricultural technologies. Japan, for example, has announced its intention to spread its environmental technologies worldwide, and is already the site of the UN Environment Program Technology Institute.

- This **market-based vehicle** would be an **alternative to concessional funding through centralized funds.** It would rebut calls for gratuitous wealth transfers unaffiliated with emissions reductions, while tying real investments to real environmental protection projects. It would employ existing institutions for bilateral and multilateral investment and assistance, and expend no additional resources on management of a central fund.

II. PRELIMINARY LIST OF U.S. COOPERATIVE ACTIVITIES

The **attached list** of U.S. cooperative activities is selected and anecdotal. It suggests the range and importance of U.S. activities that might be incorporated in the U.S. "national strategy," were a formal convention to call for such national strategies.

This list is not the entire of set of U.S. activities abroad that contribute to net GHG emissions limitation. At the same time, this list does not attempt to quantify the precise amount of emissions reduction that accrue to the U.S. from the listed activities. The precise allocation of emissions reductions between investor nation and host nation (i) depends on a mutually agreed arrangement between the two nations and (ii) is unnecessary and premature in advance of formal national strategies being prepared pursuant to a convention.

A. Bilateral Activities

A.1 Methane Recovery from Coal Mining

Host: Poland, Czechoslovakia, Hungary, Russia, Ukraine

US Agency: EPA

Project description: Effort to assist in recovery of CH4 currently leaking during coal mining, and use recovered CH4 as a fuel. 3 phases: (i) assessing size of CH4 resource, recovery options, and potential end uses; (ii) examining specific options at specific gassy mines; (iii) developing feasible recovery projects at specific mines (in conjunction with US industry). Phase (i) underway or completed, phase (ii) beginning this year.

Emissions Impact: recovery of some or all of 4-8 Tg/yr CH4 currently leaking from these mines; and reduced CO2 emissions where recovered CH4 replaces coal as combustion fuel

A.2 Natural Gas System Improvements

Host: Russia

US Agency: EPA

Project description: Effort with Gas Ass'n of CIS and US industry to identify recovery and efficiency options, e.g. uniform gas processing for cleaner gas, leakage measurement, pipeline rehabilitation.

Emissions Impact: recovery of some portion of the 15+ Tg/yr CH4 currently lost from Russian gas systems

A.3 Krakow Clean Fossil Fuels and Energy Efficiency Project

Host: Poland

US Agency: DOE, AID

Project Description: Multifaceted assistance to improve efficiency of city's energy supply and demand. Attention to industrial and residential boilers, district heating system, switching boiler fuel from coal to natural gas or replacing boilers with utility electricity, better building design. $20 million over FY 1991-93; $1.5 million in FY'91 specifically for energy efficiency.

Emissions Impact: reduced CO2, CO, NOx, SO2, other emissions, through increased energy efficiency and fuel-switching.

A.4 Energy Efficiency through Emergency Energy Program

Host: Eastern Europe, Baltic republics
US Agency: AID
Project description: Short-term measures to boost energy efficiency. Teams of US private sector experts organized by AID to identify and implement low-cost measures, including energy audits, management techniques, low-cost equipment. Substantial energy savings already achieved at several facilities, with short payback periods, since program began in November 1990. $11.8 million in FY 1991. Has identified opportunities for investments by US private and public sector.
Emissions impact: reduced CO2, CO, NOx, SO2, other emissions through increased efficiency.

A.5 Energy Demand Management

Host: Morocco
US Agency: AID
Project description: Conducts energy audits of major users, identifies feasible investments to be made in energy use efficiency improvements, helps finance selected investments in proven technologies, trains Moroccan managers and engineers, disseminates information about case studies in Morocco. Average annual expenditures of $1.8 million over FY 1988-93.
Emissions impact: reduced CO2, CO, NOx, SO2, other emissions through increased efficiency.

A.6 Science and Technology for Development

Host: Egypt
US Agency: AID
Project description: Demonstrates energy-efficiency technologies in industrial and commercial facilities; trains managers, engineers, energy auditors; provides partial grants for technology installation. Will demonstrate about 60 technologies, mostly proven in US applications, in chemical, cement, metallurgical, and other industries. Average annual expenditures of $4.2 million related to greenhouse gases, over FY 1986-95.
Emissions impact: reduced CO2, CO, NOx, SO2, other emissions through increased efficiency.

A.7 Energy Management Consultation and Training

Host: India
US Agency: AID
Project description: Pre-investment studies of investment options for energy use in industrial sector (50% of Indian commercial energy use). Training of 50 persons in the US to become trainers in India, and training of 1000 persons in India, on energy efficiency in both supply and demand. Average annual expenditures of $3.3 million over FY 1991-97.
Emissions impact: reduced CO2, CO, NOx, SO2, other emissions through increased efficiency.

A.8 Global Energy Efficiency Initiative

Host: multiple, worldwide
US Agency: AID, EPA, DOE
Project description: Assists public and private sector experts from US in working with groups in developing countries and Eastern Europe to identify and initiate concrete projects that will increase energy efficiency. Projects then presented to funding/lending agencies.
Emissions impact: reduced CO2, CO, NOx, SO2, other emissions through increased efficiency.

A.9 Integrated Energy and Environmental Planning

Host: Algeria, China, Indonesia, Mexico, Peru, Poland, Romania, Sudan, Turkey, Venezuela
US Agency: DOE/Argonne National Laboratory
Project description: Provides an eight-week training course on how to conduct integrated analyses, covering all energy and environmental aspects (including air, water, wastes and land use) throughout the fuel cycle. GHGs included in air analysis. $120,000 in FY 1991; $150,000 expected in FY 1992.
Emissions impact: reduced CO2, CO, CH4, NOx, SO2, other emissions through improved planning and increased efficiency.

A.10 Renewable Energy Applications and Training

Host: global, esp. Central America, Caribbean, North Africa, South and Southeast Asia
US Agency: AID
Project description: Identifies good opportunities and suitable technologies for renewable energy supplies (solar, wind, small hydro, geothermal) in developing countries. Assists in preparation of proposals for investment support. Recent funding of $3 million; extends from FY 1985-94.
Emissions impact: reduced CO2, CO, NOx, SO2, other emissions as renewable sources are used instead of fossil fuel combustion.

A.11 Photovoltaic Design Assistance Center

Host: Mexico, Dominican Republic, Honduras
US Agency: DOE
Project description: Brings together potential users of photovoltaic electricity systems, equipment suppliers, and engineers who evaluate needs and identify available equipment. Assists projects funded by AID and World Bank. $450,000 in FY 1991.
Emissions impact: reduced CO2, CO, NOx, SO2, other emissions as photovoltaics provide energy instead of fossil fuel combustion.

A.12 U.S. Debt-for-Environment Exchanges

Host: Americas; to date Chile, Bolivia, Jamaica
US Agency: Treasury, State, EPA, others
Project description: through Enterprise for the Americas Initiative. Exchanges are currently being negotiated in which publicly-held debt will be exchanged and reduced in return for economic reforms; interest on the new debt will then be paid in local currency into local environment funds administered by local committees including local NGOs and USG representatives. The US holds about $12 billion in foreign aid debt; some of this has been authorized for these exchanges.
Emissions Impact: CO2 sequestered by conserving and/or planting forests.

A.13 Forestry Assistance

Host: multiple
US Agency: US AID, USDA/USFS
Project description: [to come from AID, USDA]
Emissions Impact:

A.14 Biomass Energy Systems and Technology

Host: multiple
US Agency: AID
Project description: Studies and invests in commercially proven technology to recover energy from agricultural, forestry and municipal waste disposal. $2 million in FY 1991; project extends from FY 1989-96.
Emissions impact:

A.15 Biomass Energy Development in Yunnan Province

Host: China
US Agency: DOE
Project description: Completed feasibility study of biomass-to-energy system for Yunnan Province. Awaiting proposal from Province officials to develop two biomass-electric facilities based on renewably grown biomass and direct combustion technology. $41,000 in FY 1990.
Emissions impact:

A.16 Committee on Renewable Energy Commerce and Trade (CORECT)

Host: global, with participation to date by Mexico, Indonesia, Philippines, Caribbean countries
US Agency: DOE, DOC, EPA, AID, EXIM Bank, Special US Trade Rep., OPIC, Treasury, USIA, SBA, DOD
Project description: Assists US industry in exporting renewable and efficiency technologies to developing countries. $1 million in FY 1990; $1.5 million in FY 1991.
Emissions impact:

A.17 Alternate Energy Resources Development

Host: India
US Agency: AID
Project description: Supports research in use of: woody biomass as a fuel source; more efficient coal combustion systems, e.g. combined cycle/gasification; energy efficiency in pulp and paper, sugar, cement and transportation industries. Average annual expenditures of $1 million over FY 1986-92.
Emissions impact:

B. Multilateral Activities

B.1 Methane Recovery from Coal Mining

Host: China
US Agency: EPA
Project description: Effort with UNDP to implement a GEF project to demonstrate CH4 recovery and use at coal mines. 3 goals: demonstrate recovery technology; train Chinese engineers and government personnel to recover and use CH4; assess total size of Chinese coalbed CH4 resource and identify best recovery methods.
Emissions Impact: full development of recovery at mines currently venting gas would recover 3-5 Tg/yr CH4.

B.2 Energy Efficient Refrigerators

Host: China
US Agency: EPA
Project description: EPA has proposed to World Bank a project to assist China in retooling two refrigerator production lines, identify marketing strategies, and disseminate information industry-wide.
Emissions Impact: 300,000 metric tons/yr CO2 through retooling two production lines; 8 million metric tons/yr if entire Chinese refrigerator market is transformed.

B.3 Regional Energy Efficiency Project

Host: Eastern and Central Europe
US Agency: AID, DOE, NRC (in cooperation with World Bank, EC, and IEA)
Project description: Assists in energy efficiency, including: training on cleaner and more efficient use of coal; energy efficiency training; cooperation between US and host country electric utilities; assistance in use of renewable resources; assistance in nuclear safety. $15.5 million in FY 1991.
Emissions impact: reduced emissions through increased efficiency, non-fossil sources.

B.4 Forestry Assistance

Host:
US Agency: AID, USDA/USFS (through GEF, FAO, etc.)
Project description: [to come from AID, USDA]
Emissions impact:

C. U.S. Private Sector Activities

C.1 Methane Extraction from Coalbeds

Host: Poland, Czechoslovakia
Project description: US industry is working to improve CH4 extraction from newly mined coalbeds, for use as a fuel.
Emissions Impact: would help prevent future CH4 venting; and reduce CO2 emissions by replacing some coal combustion with combustion of natural gas.

C.2 Debt-for-Nature Swaps by U.S. Banks and NGOs

Host: multiple, e.g. Costa Rica, Ecuador, Poland, Bolivia
Project description: Banks agree to repayment terms that forgive or reduce part of the face value of debt (market value is below face value); part or all of repayment/interest is paid in local currency to local funds managed by environmental NGOs. 17 swaps to date worldwide (not all by US entities), totalling $60 million in conservation funding from $100 million in debt relieved. As one example: in 1990 BankAmerica announced forgiveness of $6 million in Latin American debt, starting with $500,000 of Mexican debt to be repaid to WWF and Conservation International, and $100,000 of Ecuadoran debt to the Smithsonian.
Emissions Impact: CO2 sequestered by conserving and/or planting forests.

C.3 Forestry Efforts by US Energy Suppliers

Host: Guatemala
Project description: Applied Energy Systems, Inc. conserved/planted a portion of Guatemalan rainforest to sequester CO2 equal to the amount to be emitted from a new AES electric generating plant in the US.
Emissions impact: CO2 sequestered by forest.

February 13, 1992
1:38 pm
6 Page(s)

To: Jeff Holmstead
White House Counsel

Fax No: 9-456-7929

From: 25.Condon

Subject: Agr. Trade Liberalization and the Environment

Comments:

Following up on the meeting last week with Boyden Gray, I drafted the attached based on technical studies and papers I obtained from USDA, EPA and other sources. The positive links between agricultural trade liberalization and economic growth and environmental improvement seem to be pretty well covered. However, I found that there hasn't been a lot of work done to specifically examine the effects of agricultural trade liberalization in developed countries and environmental improvement in developing countries. Most papers implied that there would be a positive indirect impact on the enviromentaln developing countries which would come from general economic growth expected to flow from agr trade liberaliation. Please feel free to mpdify this as you see fit. If you need any of the supporting studies or expenditure data, call me on 5006.

Fax Cover Sheet

U.S.EPA
Office of Policy Analysis
Fax # (202) 260-6405
Tel # _____

To: Boyden Gray White House
Fax #: 456-6279
From: Al McGartland
Comments: _____

Pages to follow: 2

home (around 1:30) 703-264-1498

What Would Happen If the EC Moved All Corn Subsidies to Ethanol Production?

	US	100% EC Corn to Ethanol ↓ EC	Or Perhaps.... 80 Percent of Corn Subsidy	60 Percent	40 Percent	20 Percent
Bushels of Corn for Ethanol	363,636,364	1,813,809,091	1,451,047,273	1,088,285,455	725,523,636	362,761,818
Total Gallons of Ethanol	800,000,000	3,990,380,000	3,192,304,000	2,394,228,000	1,596,152,000	798,076,000
Per Gallon Ethanol Subsidy	$0.60	$0.60	$0.60	$0.60	$0.60	$0.60
Total Subsidy	$480,000,000	$2,394,228,000	$1,915,382,400	$1,436,536,800	$957,691,200	$478,845,600
CO2 Reduction Per Gallon (kg)	3.3	3.3	3.3	3.3	3.3	3.3
CO Reduction Per Gallon (kg)	0.79	0.79	0.79	0.79	0.79	0.79
Total CO2 Benefit (MT)	2,640,000	13,168,254	10,534,603	7,900,952	5,267,302	2,633,651
Total CO Benefit (MT)	632,000	3,152,400	2,521,920	1,891,440	1,260,960	630,480
Total Carbon Reduction (MT)	1,297,067	6,469,736	5,175,789	3,881,842	2,587,894	1,293,947
Total Reduction in CO2 Equivalents (MT)	5,168,000	25,777,855	20,622,284	15,466,713	10,311,142	5,155,571

Sources:

Methodology and data were derived in: Abt (1991). A Methodology for Evaluating Costs and Global Warming Implications of Ethanol, Prepared for US EPA, Office of Policy Analysis, April 2. EEC data (e.g., subsidy estimate) was derived by the SWOPSIM model in: Roningen, V.O., and Praveen M. Dixit (1989). Economic Implications of Agricultural Policy Reforms in Industrial Market Economies EC subsidy for a bushel of corn is $0.40 ($0.18 per gallon ethanol).

What We Did.....

Based on the US experience of susbsidizing ethanol production, we estimated the effect of the European Community (EC) subsidizing ethanol at the same level ($0.60 US cents per gallon).

We assumed initially (column labeled EC) that all money used to subsidize corn production in the EC was used to subsidize ethanol production. The SWOPSIM model reported a EC subsidy for corn production of $114 per metric ton in 1987. We know the EC raised 21 million metric tons of corn in 1987. Therefore, the total EC subsidy for corn production was approximately $2.4 billion US dollars. At $0.60 per gallon, this money could fund almost 4 billion gallons of ethanol. This would require 1.8 billion bushels of corn which is about the current rate of corn production.

The global warming benefits of ethanol amount to 3.3 kg/gallon of CO_2 and 0.8 kg/gallon of CO (Based on the EPA report on Ethanol and Global Warming). The total benefit in CO_2 equivalents for this extreme case is 25.8 million. The current US rate of ethanol production yields a benefit of 5 million.

Other columns show the effect of partial transfer of funds to ethanol production at 80, 60, 40, and 20 percent of total subsidy.

Forests, Scapegoats and Global Warming

By George M. Woodwell and Kilaparti Ramakrishna

WOODS HOLE, Mass. The earth's last great forests are being destroyed in this century, torn apart for trifling profits. Some destruction is deliberate — logging for lumber and pulp, burning to create pasture land. And some of it is collateral damage — assault by air and water pollution, the general toxification of an environment downwind of thousands of smokestacks.

But letting forests die is self-destructive. Their role as a filter of the world's pollution, a sponge that absorbs carbon dioxide and slows global warming is crucial to the life of the earth. Governments are only slowly recognizing the need for a global plan to manage the earth's forests. And the implications scare them.

Forest management is turning into one more issue over which industrialized and developing countries are fighting. In July 1990, the world's seven wealthiest nations endorsed the idea of an international agreement for managing the world's forests. Writing such a document is now on the agenda of the United Nations Conference on Environment and Development to be held in Brazil this June. The last of the meetings to arrange that conference are to be held in New York this month and in March.

But the discussions have not gone well. The world's poorer nations recognize that they are likely to be made the scapegoats of global warming.

Simply put, if the warming trend is to be slowed down, there need to be more trees and fewer exhaust pipes. Reducing pollution depends on energy efficiency and gradually switching from fossil fuels to renewable energy — an idea that is anathema to some industrialized nations, particularly the United States. In the eyes of developing nations, the developed countries are instead pushing strongly for saving forests because this would be less economically painful.

Certainly one aspect of the debate seems to suggest that the developing countries are right. Most of Canada, the eastern U.S. and Russia are covered by trees. But discussion of global warming has focused almost entirely on tropical forests. True, these forests are diverse and fascinating but they are also almost entirely in underdeveloped countries. And it is on those forests that developed nations are working hardest to impose their wills. But the north seems unable to live by the rules it wants to impose on the south: government-subsidized greed is allowing wide swaths of Canada and the northwestern U.S. to be clear-cut, and lumber companies are now maneuvering to make profits from the Siberian taiga.

> Industrialized nations are hypocritical.

As a result, a "convention on forests" has become unacceptable to many nations preparing for the Brazil conference. Now the best that seems possible is a "non-legally binding authoritative statement of principles for a global consensus on the management, conservation and development of all types of forests." That promises little.

The scandal is the common assumption of these meetings: that forests are only valuable for their timber, pulp and fuel. All but dismissed are their intrinsic value as protectors of watersheds, safeguards against landslides, renewers of farm fertility, recreation areas and homes to diverse plants, animals and people. The discussions reveal ignorance of what forests do for the world and why international action to assure that they do not vanish is essential.

Deforestation is the second biggest source of carbon dioxide, which traps the sun's heat in the atmosphere; only the burning of oil, coal and gas produces more. But scientists are beginning to recognize the possibility that the earth's warming will speed the decay of organic matter in soils, adding extra carbon dioxide and methane to the atmosphere. If this is to be slowed, the world must not only stop cutting and burning large forests, but replace many millions of acres that have been destroyed.

There is little immediate prospect of improvement without major changes in leadership and perspective. One promising suggestion is the creation of an International Commission on the Conservation and Utilization of World Forests to strengthen the scientific and economic analyses available and to draft an agreement for all countries to sign.

The project is urgent. The cost of the delay could be the world's forests, the biotic wealth they contain, the environmental services they perform and a possibly irreversible contribution toward making the earth too hot to live on. □

Christophe Vorlet

George M. Woodwell is director of the Woods Hole Research Center. Kilparti Ramakrishna is senior associate for international environmental law at the center.

New York Times Feb. 11, 199-

Wall Street Journal 2/12/92

GATT Report Says Trade Liberalization Will Aid Global Environment Protection

By Bob Davis
Staff Reporter of The Wall Street Journal

WASHINGTON – Trade liberalization would enhance environmental protection world-wide, the General Agreement on Tariffs and Trade said, even though some tough U.S. environmental laws couldn't be applied internationally.

Despite the overall conclusion, the GATT report is sure to increase environmental groups' opposition to sweeping changes proposed for the world trading system. Under the GATT interpretation, U.S. laws that bar the imports of foods and other products, unless they are produced in a way deemed by the U.S. to be environmentally sound, would be considered improper restraints of trade.

"To allow each (GATT) party unilaterally to impose special duties against whatever it objects to among the domestic policies of other parties would risk an eventual descent into chaotic trade conditions similar to those that plagued the 1930s," the GATT environmental report said.

Lori Wallach, a staff attorney for Public Citizen, a Ralph Nader-affiliated consumer group that is organizing opposition to the GATT, said the report shows "the GATT perspective on environmental issues—that they're an impediment to trade." She said that "mind-set" has prompted consumer and environmental groups to target GATT, which for years has had little visibility and evoked little passion in the U.S.

The GATT, based in Geneva, is currently negotiating a broad liberalization in international trade rules. The talks, which involve 108 nations, are stalled primarily by disputes between the U.S. and European Community over agricultural subsidies. But if negotiators can reach a compromise, the GATT's powers to settle trade disputes involving environmental issues would be greatly strengthened. Any GATT agreement would have to be approved by Congress, which is likely to pay close attention to environmental concerns.

C. Fred Bergsten, director of the Institute for International Economics in Washington, said that GATT needs to develop an environmental code, in which a country could try to impose its environmental standards on others. But the country would also have to notify the GATT of its rules and try to resolve controversies among trading countries. "That would provide a channel for national actions intended to foster advances in environmental norms," he said.

The GATT report said that liberalized trade would aid the environment largely because it would lessen subsidies and shift agricultural production to countries such as Argentina, Australia and Thailand. Those countries use less than one-tenth the amount of chemical fertilizer per acre than countries in Europe. The EC has become one of the world's biggest agricultural exporters largely because of a huge system of export subsidies.

"In all likelihood, there would be a substantial increase in global environmental quality," the report said.

Jagdish Bhagwati, a Columbia University economist who advises the GATT and oversaw the drafting of the environmental report, said GATT rules don't apply to environmental policies that are strictly domestic. For instance, the GATT would have nothing to say about U.S. requirements that cars driven in the U.S. must be equipped with tailpipe devices to reduce pollution.

But he said GATT rules don't permit one nation to impose its environmental standards on another through the use of trade restrictions. "If you start objecting to the way other people do things, then they can object to what we do," Prof. Bhagwati said. "Then it becomes almost open-ended."

U.S. environmentalists have been incensed over a GATT ruling that disallowed a U.S. law barring imports of tuna that are caught in nets that can trap dolphins as well. Under the law, the U.S. has prohibited imports of tuna from Mexico, Venezuela and Vanuatu. Last year, Mexico objected to the GATT; a GATT dispute-settlement panel found in Mexico's favor, saying that the U.S. couldn't embargo a product simply because Mexico's regulations didn't satisfy the U.S. Mexico and the U.S. are now trying to resolve the dispute.

The GATT environmental report backed the reasoning in the tuna case. "In principle, it is not possible under GATT's rules to make access to one's own market dependent on the domestic environmental policies of the exporting country," the report said.

Prof. Bhagwati said that environmentalists—if not governments—would still be

Please Turn to Page A6, Column 2

GATT Report Says Trade Liberalization To Aid Environment

Continued From Page A2

free to organize boycotts against an offending country. And nations could negotiate a multilateral treaty on environmental standards, such as the one phasing out chemicals suspected to be thinning the Earth's protective ozone layer, he said. If those treaties contain trade sanctions against non-complying countries, the agreements could be treated as waivers of general GATT rules, which usually require two-thirds of GATT's membership to agree.

GATT Director-General Arthur Dunkel said the organization "must protect against the risk of the environment being kidnapped by trade protectionist interests." But Ms. Wallach, the consumer activist, said the greater problem is the "environmental crisis," which requires individual countries to insist on tougher standards. "There's no time to wait for global consensus," she said.

MULTILATERAL AGRICULTURAL TRADE LIBERALIZATION AND ENHANCED ENVIRONMENTAL QUALITY

Excessive farm supports misallocate global resources, distort trade, shackle economic development in third world nations, and contribute significantly to environmental degradation. The United States is not completely free of guilt in this area, but European agricultural support levels border on the obscene.

While U.S. farm subsidies have been declining and we have been urging global reform in the context of a Uruguay Round agreement, European supports have been increasing at an alarming rate. Budgetary spending on farm support in the 12 European Community (EC) nations now totals more that four times the level of support provided to U.S. farmers. Furthermore, primarily because of its reluctance to enter into an agreement which would require significant cuts in farm spending, the EC is presently blocking multilateral agreement on a Uruguay Round package which could significantly expand and improve the operation of international trade rules and boost economic growth worldwide.

To focus just on the environmental implications of excessive agricultural support for a moment, a recent United Nations Food and Agriculture Organization (FAO) study found that unwise and overly generous agricultural subsidies provided by the European Community, produce the following adverse environmental effects:

-- An overuse of chemicals and increased concentration of livestock effluents which pollute and contaminate soil, water, air and food.

-- A deterioration in the quality of soils, water, forests and traditional rural landscapes.

-- A disturbance and reduction of biotypes and wildlife habitats.

-- A reduction in wildlife species and loss of biological and genetic diversity.

Specific examples of these problems cited by the FAO include soil contamination and air pollution from ammonia in animal wastes in certain northern European countries due to concentrated cattle and hog facilities which have responded to subsidies in the livestock sector. In addition, pesticide residues and high nitrate levels in drinking water in many areas of Europe have pushed drinking water contamination levels beyond those recommended by the World Health Organization (WHO) and sometimes past the maximum acceptable levels set by the WHO. Surface and groundwater quality have also fallen for non-drinking uses.

"Among the most disturbing developments," the FAO report noted, "are the growing presence of nitrates and pesticide residues in deep water aquifers; changing of groundwater levels

as a result of irrigation and drainage; contamination of shellfish and other forms of aquatic life; and autrophication of both fresh and marine water bodies from phosphates and nitrates" (in fertilizer).

If it can stay within its budget this year --and currently that is a big if-- the EC will spend about $32 billion (up from about $10 billion in 1985) to encourage the production of agricultural products, a good portion of which it cannot physically consume. To insure that the surpluses generated do not undermine domestic support prices --which are high by any standard-- the Community will spend another $13 billion (up form about $5 billion in 1985) to dump their surpluses on the world market. In shifting its surplus to the world market, the EC will depress world market prices, thereby directly impacting upon the livelihood of millions living in developing countries where governments simply cannot afford to compete with European treasuries to maintain markets.

The Uruguay Round negotiations now underway in Geneva provide an excellent opportunity to re-orient farm policies worldwide. The United States has been strongly advocating the adoption of new international rules which will encourage less trade-distorting --and less environmentally damaging-- forms of agricultural support. Europe, while endorsing the broad principles, balked when the negotiations reached the point where

it was necessary to turn rhetoric into meaningful reduction commitments.

This initiative deserves the support of taxpayers, farmers and environmentalists in Europe, in the United States, and around the world. As a recent World Resources Institute publication points out, "Environmentalists in particular, should recognize that the answer to agriculture's environmental problems is not to tie on more regulations and cross-compliance provisions but to make the fundamental incentives farmers face consistent with the true values of the production systems available to them." Most forms of government support distort market signals, misallocate resources, and seriously retard economic growth especially in developing nations.

Governments need to change the way in which they provide support to agricultural producers. This does not require that governments renounce support to farmers. Agricultural subsidies can be targeted and delivered in less trade distorting ways. This could drastically reduce the fiscal cost of providing farm income support without sacrificing income levels. The Uruguay Round provides us with a once-in-a-lifetime opportunity to make that change in a cooperative and coordinated way.

The available research strongly supports the positive impacts of agricultural trade liberalization on environmental quality, particularly in developing countries where government

policies have more actively encouraged excessive resource use and contributed to an acceleration in environmental degradation. Multilateral agricultural policy reform has important environmental implications for developing countries as well. Income growth is an important precondition for the investments in environmental regulation, as well as the emergence of a larger constituency devoted to improvements in environmental quality. There is abundant evidence that agricultural trade liberalization will stimulate economic growth in the developing world. That growth will generate increased income, providing the resources necessary for expanded environmental protection activities through increased regulation and enforcement.

MEMORANDUM TO ALEX CRISTOFARO

FROM: Al McGartland
Abt Associates, Inc.

SUBJECT: Global Warming Impacts of Agricultural Policy Reform

We have completed our preliminary scoping analysis of the global warming impacts from adopting the U.S. GATT agricultural policy proposals that would eliminate production-distorting subsidies. These results are best used viewed as indicators of the magnitude of the benefits associated with these proposals. Further research is needed to increase the confidence we have in our estimates. We also failed to include several important categories. We did not, for example, consider how farm land that is idled as a result of the GATT would be used. They may be transformed into forests. Similarly, we did not examine the current state of land that would be placed into production.

Our findings are:

- In general Japan, the EC and other Western European countries experience a dramatic decline in farm output. Japan's decreases by 32 percent (value weighted). The EC's production falls by 7 percent and the rest of Western Europe's falls by 13 percent. These reductions result in changes in their agricultural trade balance of roughly $18 billion.

- The changes in energy and fertilizer result in a decrease of 10.5 million tons of CO_2 per year.

- The reduction in Nitrogen fertilizer also reduces N_2O. This reduction is equal to 120,000 tons of N_2O or roughly 3.5 million tons in CO_2 equivalent tons.

- Together, **the total reduction in CO_2 is equal to 14 million tons per year.**

Methodology

Our analysis relies heavily on the USDA report, **How Level is the Playing Field? An Economic Analysis of Agricultural Policy Reforms in Industrial Market Economies**. In this report, USDA provides estimates of the changes in prices and agricultural output of 22 different commodities in 11 regions of the world. We use these changes, along with data on current fertilizer and energy use in the agricultural sectors of the world to predict the change in fertilizer and energy consumption in each of the

11 regions.[1] Next, using results from our analysis of ethanol and global warming, we estimate the change in greenhouse gas emissions that result. Finally, changes in N_2O ar converted to CO_2 equivalents to make comparisons easier.

More detail on this methodology will be available very soon.

Major Assumptions

The most important assumption is that energy and fertilizer consumption in the agricultural sector is linear with output. Therefore, if crop production decreases by 10 percent, we assume that fertilizer and energy consumption will drop by 10 percent as well. Further, much of our baseline data was not crop specific. Therefore, we had to apportion fertilizer and energy consumption to specific crops. This stage of the analysis could benefit from additional work.

The analysis does not consider the effect of pesticides.

We should note that the analysis ignores the fact that a reduction in subsidies would undoubtedly lead to a less intensive agriculture in the industrial world. This shift to a less energy and fertilizer intensive production would also produce global warming benefits.

[1]Date are energy and fertilizer use are found in: Food and Agriculture Organization of the United Nations (FAO), **Fertilizer Yearbook**, vol. 39, 1989, OECD, **Energy Statistics**, 1989 and OECD, **World Energy Statistics and Balances: 1985-1988**, 1990.

Changes in CO2 Emissions in MT

Region	Total Change	Change from Fertilizer Production	Change from Energy Production/ Consumption
U.S.	(1,419)	(600)	(819)
Canada	(300)	(158)	(142)
EEC	(5,524)	(4,115)	(1,409)
Other Western Europe	(2,303)	(1,850)	(453)
Japan	(2,208)	(1,831)	(377)
Australia	327	227	100
New Zealand	136	92	44
Developing Exporters	751	623	128
Total	(10,540)	(7,613)	(2,927)

Note: Changes do not reflect data from the following regions: New Industrialized Asia, and Developing Importers. No changes were observed in the region including Centrally Planned Economies.

This does not include N_2O emissions from Fertilizer use.

14

Tree Planting	9
Acid Rain	17
Total CHA	51
Landfill	44
energy eff.	28

---

1. Doesn't fac for ~~p~~ for sinks
2. Doesn't account for inframarginal changes in agricultural intensity

Faster CFC phaseout Jan 2. 1990

23% below level

excise tax

1994 2000

34 million tn in 2000

7/26/91

Talking Points for Aspen Institute on:

Uncertainty in Source/Sink Measurement

The fact that not all GHGs are perfectly measurable does not warrant omitting them from a comprehensive approach.

- Full accounting is critical. Any actions taken (e.g. fuel switching) need to account for their full effects on net GHG emissions, not just CO2.

- Ignoring GHGs doesn't make them go away. Taking action on CO2 alone, on the ground that other GHGs are unmeasurable, will leave unaddressed the others' contribution to potential climate change.

- Measurement is improving. Many programs are under way, e.g. EPA efforts on CH4 from rice and livestock.

- Compare the cost of obtaining needed information vs. the cost of adopting a flawed policy. Probably cheaper to gather more information than to go ahead with a costly, counterproductive policy.

- Need to provide emitters incentives to invest in needed measurement information. A CO_2-only policy does not; a comprehensive approach does.

- Entrenched resistance. A "stepwise" or "phased" approach -- such as starting with energy CO2 and adding others only when they are deemed sufficiently measurable -- would get stuck at the first step. The initial step would become entrenched, as vested interests arise to block expansion.

- Local variations. A central list of what "counts" for a global stepwise approach implies that the measurability of each gas is uniform worldwide. But measurability of each GHG or source/sink type will vary locally. No single central list makes sense.

- Consider instead a "measurability ladder," assigning levels of credit to levels of measurability. Ladder rungs would be scaled to measurement criteria that apply neutrally to any GHG, source or sink. The more certainty in measurement, the more "credit" the proffered reduction claim would obtain (or the fewer procedural hurdles it would face). This gives emitters the incentive to invest in improving measurement -- so that their emissions measures can climb the "ladder" toward full credit.

SCIENTIFIC AMERICAN July 1990 Volume 263 Number 1

The Great Climate Debate

Greenhouse effect and the prospect of global warming is the subject of scientific and political controversy. Should we take steps now to avoid consequences we cannot foresee?

by Robert M. White

In the waning years of the 10th century, millions braced themselves for the apocalypse, believing that the approaching year 1000 was the very millennium—the end of the heavens and the earth prophesied in the Bible's Book of Revelation. Not surprisingly, the prospect of the impending Day of Wrath terrified normally sane people into rash and (in retrospect) foolish actions. Some gave away all of their possessions; others hastened to do harsh penance for their deeds.

In this final decade of the 20th century, a different kind of apocalypse causes widespread concern. This time the hand of God has been replaced by more visible agents: belching smokestacks, gasoline-powered automobiles, power-generating stations and the voracious destruction of forests, all of which may be turning up the heat on an overburdened environment. Global climate warming, some claim, threatens the very habitability of the planet. Others hold that the predictions of environmental collapse are not well founded and are goading us into hasty political action. Is our planet the "Endangered Earth," as *Time* magazine would have it in its 1988 year-end cover story? Or is it as *Forbes* magazine put it, "The Global Warming Panic: A Classic Case of Overreaction"?

Debate in the media reflects uncertainty among climatologists and geophysicists. Some of the world's eminent authorities on the atmosphere recently hurled verbal brickbats at one another in the pages of the prestigious journal *Science*. Their charges of "junk science" and "science by consensus" reflect the acrimonious nature of the debate within the scientific community. Some members of the National Academy of Sciences, including one of its former presidents, charge that policymakers are being induced to take unwise actions on the basis of uncertain scientific evidence. Set against this view is the recent statement of the Union of Concerned Scientists urging action by the government. It was signed by 52 Nobel laureates and more than 700 members of the NAS.

In spite of the scientific uncertainty, government and nongovernment groups are rushing to outdo one another in urging drastic action now to "stabilize" the global climate. From Washington to Toronto and The Hague, from Cairo to Moscow, international conferences of experts and political leaders have called for action. Soviet President Mikhail S. Gorbachev, President George Bush, British Prime Minister Margaret Thatcher and French President François Mitterand share similar views on the climate-warming issue.

Back home, debate within the Bush administration on how the U.S. government should act is intense. Caught between the urgings for action from the Environmental Protection Agency and Congress and cautions from his science adviser and chief of staff, President Bush called two major conferences to address the issue of climate warming. The first, held in April, brought together the heads of scientific, economic and environmental agencies of many governments. The second will be an initial meeting of governments, scheduled for early 1991, to begin negotiation of an international convention to stabilize global climate.

While there are still doubts in the White House, Congress has been environmentally hyperactive. Many pieces of legislation have been introduced to address the predicted climate warming. Leading the bipartisan effort have been Senator Timothy E. Wirth of Colorado, Senator Al Gore of Tennessee and Congresswoman Claudine Schneider of Rhode Island. Some of this legislation is comprehensive and far-reaching. It offers suggestions for action on the energy, agriculture and transportation fronts as well as for intensified research.

The actions proposed would radically change the most vital functions of human economies. They could include such diverse actions as using energy more efficiently, shifting the fossil-fuel mix from oil and coal to natural gas, relying more heavily on renewable energy sources and using more nuclear and solar energy. Measures could also include implementing reforestation, phasing out use of chlorofluorocarbons (CFC's) and changing agricultural practices.

Policy initiatives of this kind would

ROBERT M. WHITE is president of the National Academy of Engineering. He was formerly chief of the U.S. Weather Bureau and administrator of the National Oceanic and Atmospheric Administration. He has also served as president of both the University Corporation for Atmospheric Research and the American Meteorological Society. In 1979 he was chairman of the first World Climate Conference of the World Meteorological Organization.

alter the technology and economics of energy. Our use of land and water would also need to change. Economic growth in nations dependent on fossil fuels might be slowed. And the problems of arresting the growth of global population would become even more pressing. How can national and international policy formulation be moving so rapidly to address the specter of climate warming when agreement about the science is lacking and the economic and social costs of action have hardly been tallied? At the root of this thinking is a confluence of diverse scientific, economic and environmental forces.

The idea that the actions of humanity might change the composition of the atmosphere and hence the world's climate has deep historical roots. As early as the 1860's, it was suggested that slight changes in atmospheric composition might bring about major variations in climate. Increases in carbon dioxide (CO_2) and other atmospheric trace gases can contribute to what has been called greenhouse warming because these compounds allow the sun's energy to reach the surface of the earth, thereby warming it, while preventing much of that energy from being reradiated to outer space.

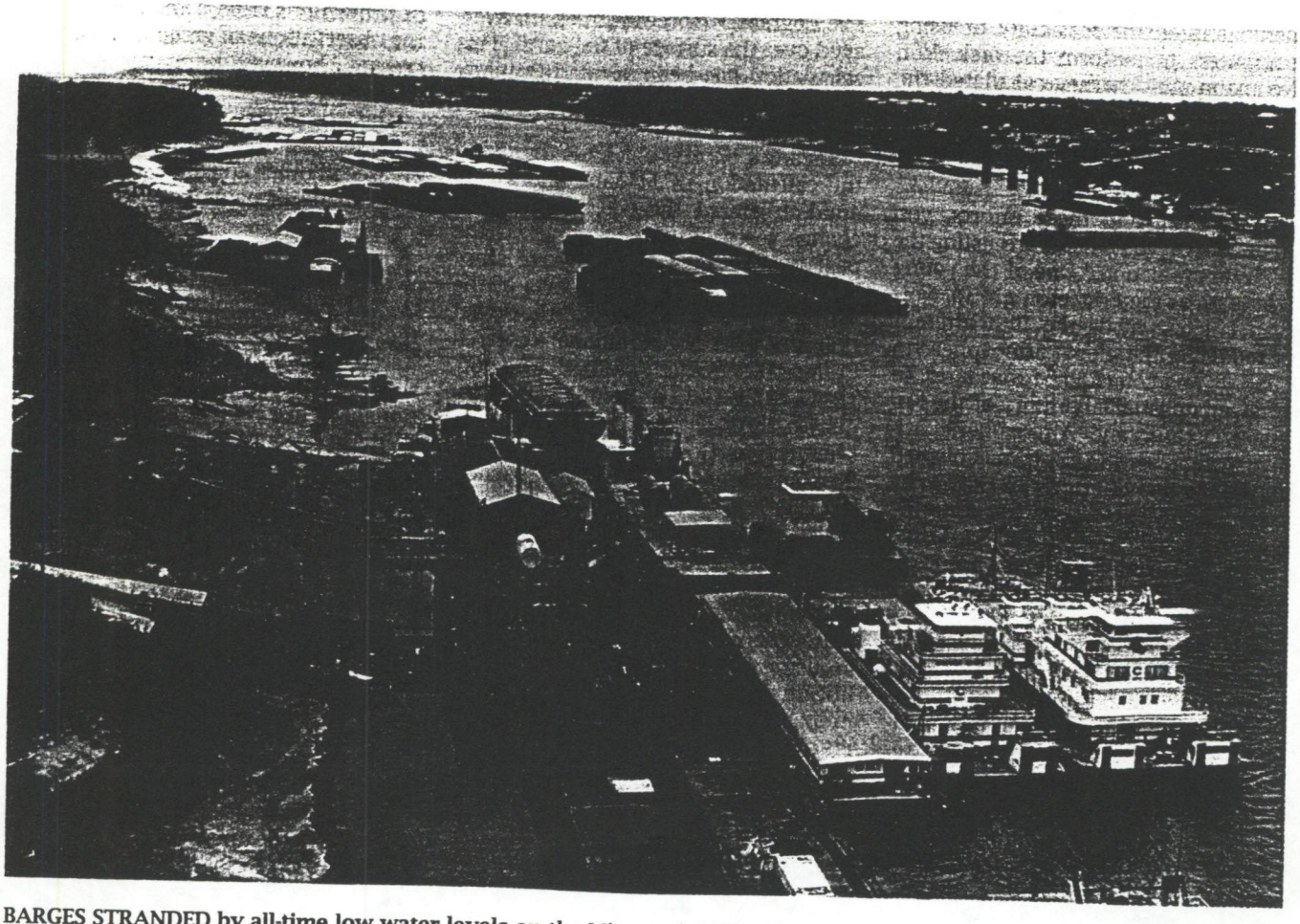
At the end of the 19th century the Swedish scientist Svante A. Arrhenius calculated how changes in carbon dioxide content would affect the temperature at the earth's surface. He estimated that a doubling of carbon dioxide would produce a global warming of about seven to 11 degrees Fahrenheit (four to six degrees Celsius), not too far off modern calculations. Yet it was only with the inception of the International Geophysical Year, a worldwide experiment in 1957 to monitor the global environment, that scientific data validating the increase of carbon dioxide in the atmosphere became available.

Roger Revelle, then director of the Scripps Institution of Oceanography, his colleague Hans E. Suess and C. David Keeling, his student, undertook such measurements. Revelle had long contended that humans were carrying out an unintended geophysical experiment on the atmosphere by burning fossil fuels. Determined to monitor the carbon dioxide content of the atmosphere, he persuaded Keeling to develop the instrumentation.

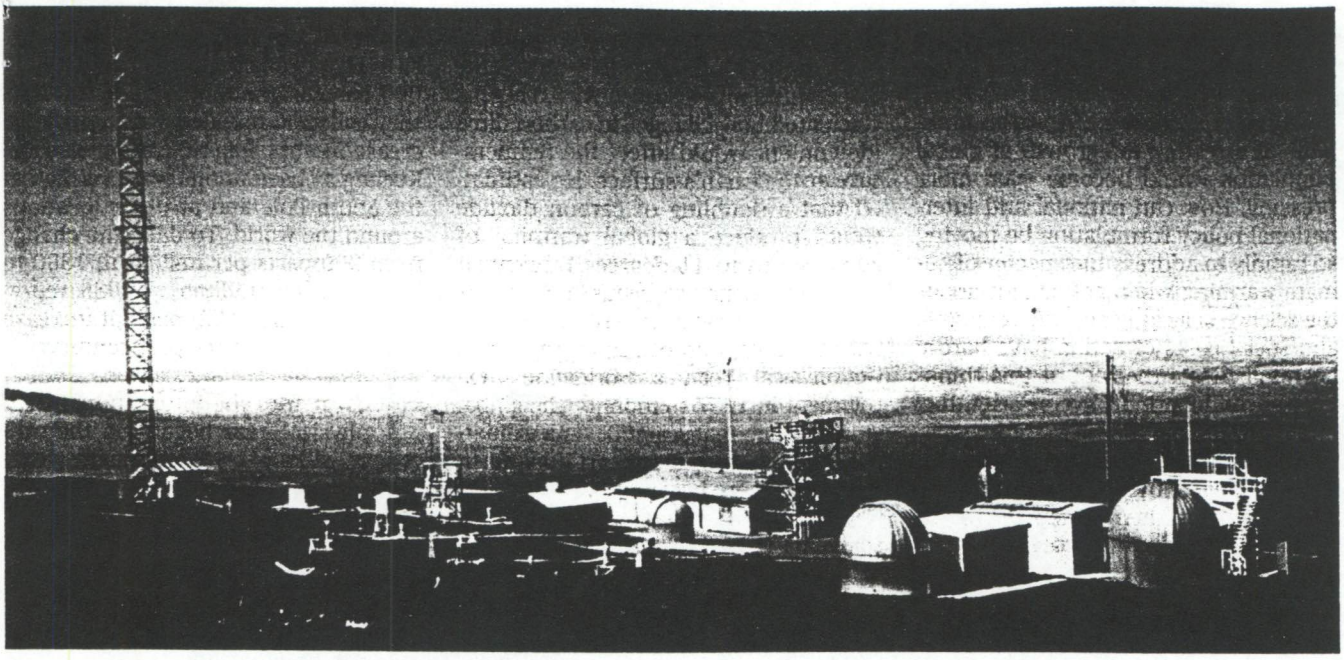
The measuring devices were placed in the Mauna Loa climate observatory in Hawaii at an altitude of about 11,000 feet. Beginning in 1957, the data they collected revealed a systematic increase in atmospheric carbon dioxide. Keeling's observations were verified at the South Pole and at other locations around the world. To date, the change from 290 parts per million in 1880 to 352 parts per million in 1989 represents more than a 20 percent increase over the course of the past century.

Just before the International Geophysical Year began, on the other side of the continent from Scripps, another development key to unraveling the climatic consequences of increasing carbon dioxide emissions was taking place. Under the leadership of the world-famous mathematician John von Neumann at the Institute for Advanced Study in Princeton, N.J., the first attempts were made to represent the atmosphere mathematically on digital computers.

Von Neumann's team of brilliant young scientists was headed by Jule G. Charney. Later known as the father of



BARGES STRANDED by all-time low water levels on the Mississippi River were one effect of the record-breaking drought of 1988. That long, hot summer thrust the greenhouse effect into the public eye and set off the present policy debate.



MAUNA LOA CLIMATE OBSERVATORY in Hawaii is located at about 11,000 feet. Data collected here, beginning in 1957 and continuing through the present, were the first to document a steady increase in atmospheric carbon dioxide levels.

numerical weather prediction and arguably the most important American figure in the transformation of weather prediction from art to science, Charney demonstrated the feasibility of using computers to perform the task. Von Neumann and Charney calculated the first 24-hour weather forecast in 1950 on a primitive digital computer, the ENIAC, maintained by the U.S. Army Signal Corps in New Jersey.

Looking beyond these efforts, von Neumann called climate forecasting the "infinite prediction." One of the young scientists in the Princeton group, Norman Phillips, made the first attempt at modeling the global atmosphere in 1956. It was coincidence that later, in 1963, an unusual laboratory of the National Oceanic and Atmospheric Administration (NOAA) was established on the campus of Princeton University under the leadership of Joseph Smagorinsky, a strong-willed and hard-driving young scientist who had been one of von Neumann's group. The laboratory was totally devoted to the mathematical modeling of the atmosphere using the largest and fastest digital computers available.

Called the Geophysical Fluid Dynamics Laboratory, the center harbored researchers from many nations interested in this new approach to the study of the atmosphere. Among them was a young Japanese scientist, Syukuro Manabe. Modest and retiring but completely dedicated to the work, he developed the first climate model in collaboration with his colleague Richard T. Wetherald in the 1960's. In 1975 they calculated that a doubling of the carbon dioxide content of the atmosphere would produce a global climate warming of about five degrees F (three degrees C), averaged over the surface of the earth. This calculation has been verified in many different laboratories and has not changed substantially.

Keeling's observations, together with the calculation of Manabe and Wetherald, triggered the wave of climate-change research that has marked the past two decades. Studies have since been undertaken in many parts of the world, including Europe and the Soviet Union. In the U.S. the National Research Council conducted studies in 1966, 1977, 1979, 1983 and 1987. These inquiries were chaired by such leading scientists as Gordon J. F. MacDonald, Revelle, Thomas F. Malone, Charney, William A. Nierenberg and economist William D. Nordhaus.

Yet because there were no immediate consequences for human health and no evident manifestation of climate change, the work was slow to arouse political concern. The most politically influential study was the one prepared in 1979 at the request of Frank Press, now president of the NAS, who was then White House science adviser to President Jimmy Carter. It was also in 1979 that the World Meteorological Organization in Geneva, recognizing the potential global significance of the issue, convened the first World Climate Conference.

Gradually, scientific awareness that humanity might actually be causing a planetary disruption began to register in the political world. Although there was much debate over the validity of projections from computer models, the observations of greenhouse-gas increases, however, were precise, well measured and verified in many parts of the world. These were corroborated by additional data that documented increases in other greenhouse gases such as methane, or natural gas, and CFC's.

Meanwhile mathematical-modeling groups in this country had been established not only by the NOAA but also by the National Aeronautics and Space Administration, the Department of Energy and the National Science Foundation. The leaders of these laboratories became the "gurus" of climate warming. Incisive and original in their work, Stephen H. Schneider of the NSF's National Center for Atmospheric Research in Boulder, Colo., and James E. Hansen, the leader of NASA's Goddard Institute for Space Studies, were soon to become frequent witnesses at innumerable congressional committee hearings on the subject.

Although the mathematical models of all the groups yielded similar results, the details of the geographic distribution of climate changes differed from one model to the other. All projected that an increase in carbon dioxide would bring about a gradual warming, but the timing of this warming would depend on the rate of global energy use. They all agreed that

if reasonable assumptions were made about future global energy consumption, it would be around the middle of the next century that the carbon dioxide content of the atmosphere might double.

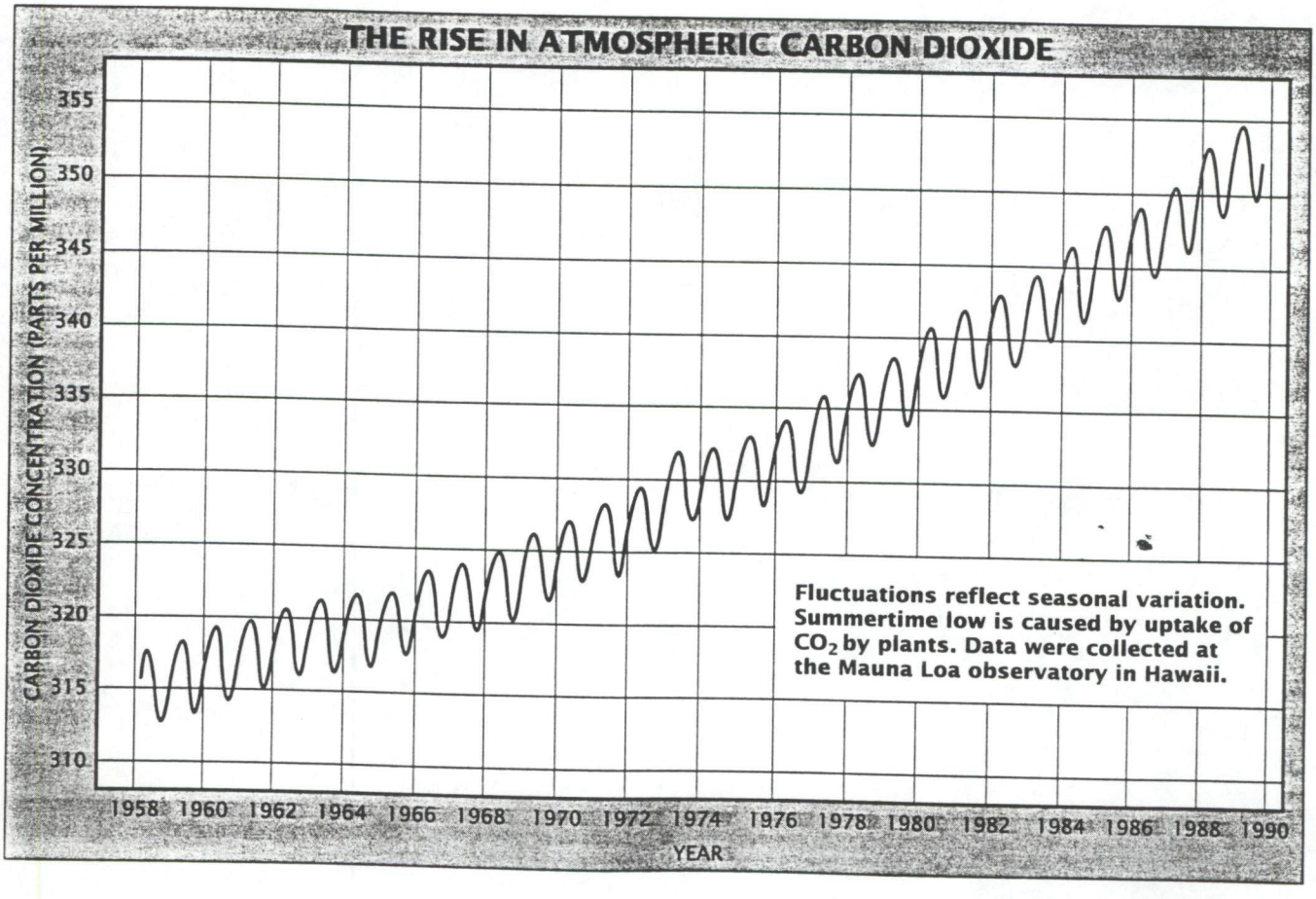
Just how much this doubling of carbon dioxide would increase temperatures, however, varied greatly from model to model. Some predicted as little as a two-degree F (one-degree C) increase, whereas others predicted increases of as much as nine degrees F (five degrees C). The differences in predictions became central elements in the debate about whether the models were sufficiently reliable to warrant policy actions. Further, it made a great difference whether the actual increase was at one or the other end of this range. At the low end, the normal resilience of society would probably be sufficient to accommodate the changed climate. Changes at the high end portended severe disruptions.

These projected temperature changes may appear innocuous because variations of this magnitude are experienced in the normal course of daily and seasonal weather. Their full implications can be appreciated by noting that it took only a two-degree F average decrease in temperatures in Europe to cause the run of several frigid centuries (from the 1400's to the 1800's) known as the Little Ice Age. Nine degrees F is believed to be the difference in temperature that separates the end of the last great ice age 12,000 years ago from the present. Further, the projections indicate that the Northern Hemisphere would experience in just a half century an unprecedented temperature change, 10 to 50 times faster than the change since the last ice age.

Those who are not familiar with mathematical models or the way computers are used to make these projections can be forgiven for being confused—or even annoyed—by the great disparities in the results. Among investigators it is understood that mathematical models are only approximations that attempt to simulate the processes that govern atmospheric behavior. The atmosphere is so complex that it is impossible to represent it in very great detail in these mathematical models. It is possible to represent only certain features and to make assumptions about how the oceans and the atmosphere interact, how the rate at which the oceans take up carbon dioxide varies and how clouds affect the exchange of energy between the earth and the atmosphere. Even the largest computers cannot represent the atmosphere, oceans and land surface in fine detail. Indeed, scientists approximate the conditions in the atmosphere by thinking of it as a set of observations spaced about 500 kilometers apart.

The political calls for action are being played out against the backdrop of that uncertainty. On one side, the view is that if there is a chance that model predictions could be correct, the consequences could be so dire that immediate action to arrest climate change would be imperative. The alternative view, equally cogent, is that commitment to action with vast economic and social consequences is unwarranted in light of both the scientific uncertainty and the absence of knowledge of the economic costs. John H. Sununu, White House chief of staff, in remarks he made at the annual meeting of the National Academy of Engineering in the fall of 1989 gave voice to this position:

> *Although I agree that* [global warming] *is a critical issue, the fact is that the models with which analysis is being done and with which policy is being moved, as good as they may be, still are based on element sizes measured in hundreds of kilometers in length and width, and tens of kilometers in thickness. I suspect that no one who has ever been involved in engineering simulation would feel comfortable making major*



decisions in which the elements were orders of magnitude greater than the details on which they were looking for information. And yet the fact is that we are moving toward binding international policy based on conclusions being drawn by policymakers who have no sense at all of the difference between the levels of confidence they should have and levels of confidence they want to have. A system is not valid just because it gives you the answers you want. And yet so much policy is being made in reaction to that principle.

The solution to the dilemma should be simple: Since the carbon dioxide content of the atmosphere has increased by more than 20 percent over the past century, we ought to be able to detect the climate warming in the global temperature record during the same period. Researchers have sought to do this, but it is a much more difficult task than it first appears. The problem is that climate is always in a state of natural fluctuation. Separating out the changes that are caused by increasing carbon dioxide from the natural changes is tricky scientific business. Moreover, the climatic temperature record is based on scattered and irregular observations not taken specifically for the purposes of determining climatic conditions.

Even so, careful analysis of these temperature records by scientists in the U.S. and in the U.K. sought to detect whether a climate warming has occurred and whether such warming is consistent with the prediction of the models. The prevailing view is that the climatic record over the past century for the entire globe reveals a net increase in temperature ranging from .5 to 1.0 degree F (from .3 to .8 degree C). But set against this conclusion is the disturbing result that similar increases in temperature cannot be detected over the past century in the U.S., where observations are numerous and accurate.

Even if the temperature rise is real, a puzzle remains that workers have been unable to unravel: Is the rise in global temperatures a natural fluctuation or a result of the increase in greenhouse gases? All that can be said is that the observed increase is consistent with the lower end of the temperature increases predicted by the computer models. Consequently, the temperature records, as well as the predictions of mathematical models, provide substance both to those who believe the evidence warrants action now and to those who believe the evidence is still too weak.

The rush to policy action was, I believe, catalyzed by the disastrous drought of the summer of 1988. During this drought, one of the worst on record, the water in the Mississippi River fell so low that navigation was impossible over long stretches, urban water supplies were threatened and crops throughout the grain belt were devastated. Both officials and the public wondered whether this was the greenhouse effect manifest. Indeed, records show that in the U.S. five of the years of the 1980's were among the hottest on record, and the average temperature for the decade as a whole was the warmest since instrumental records have been kept.

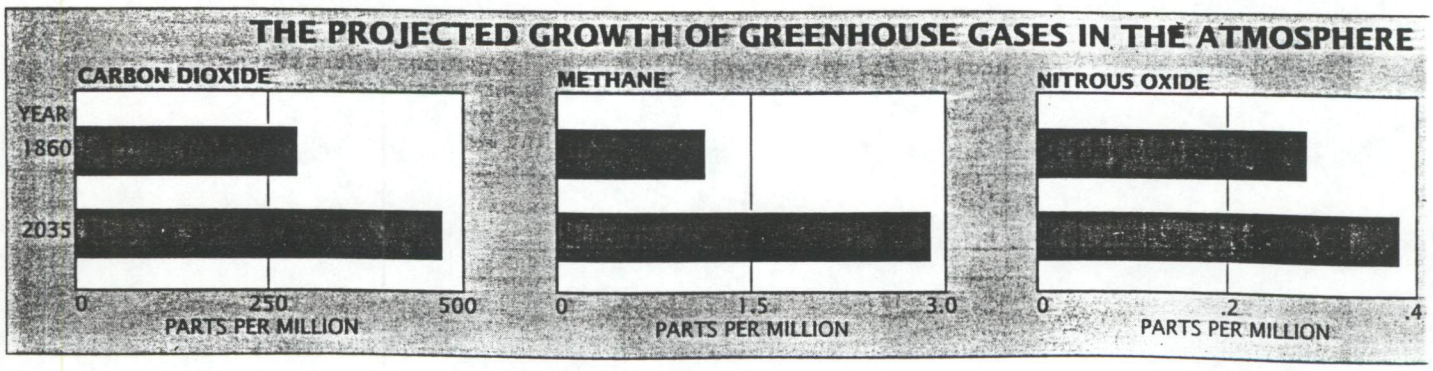
Prompted by heat and drought, congressional hearings addressed the question of whether the greenhouse effect had arrived. These hearings were unremarkable except for a statement by Hansen. When he stated that he was 99 percent certain that the greenhouse warming had begun, as evidenced by the sequence of warm years in the 1980's, the public took notice. His opinion prompted members of Congress to consider whether the prudent course was to move rapidly to legislation aimed at protecting the habitability of the planet from catastrophic consequences.

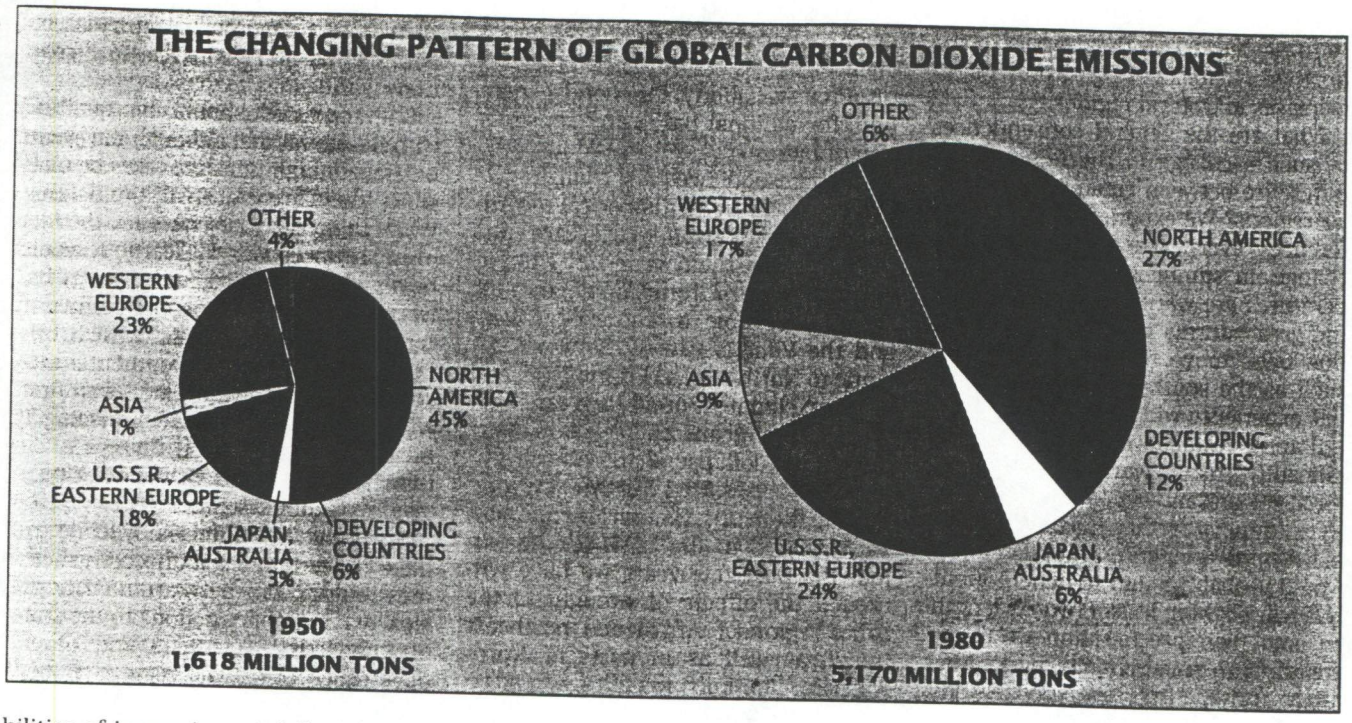
Hearings followed hearings. Both the atmospheric researchers and the more general environmental community began to choose sides on whether immediate policy action was justified. The reaction from environmentalists was quick and vociferous. Several environmental and scientific groups began to advocate international agreements restricting the emissions of greenhouse gases.

At this point, some influential atmospheric researchers, who believed that policy actions were beginning to outrun the scientific evidence, weighed in with their views. Richard S. Lindzen of the Massachusetts Institute of Technology and Jerome Namias of Scripps, the nation's most distinguished long-range weather-forecasting expert, wrote a letter to President Bush urging that no action be taken. Three other members of the NAS, including its former president Frederick Seitz, joined in a report, published under the auspices of the Marshall Institute, calling into question the scientific basis for policy actions. They recommended a major research program in mathematical modeling. They pointed out that there might be alternative explanations for the climate warming that had taken place. Thus, the great climate debate had been joined.

Meteorologists did not look with favor on the prospect of yet another public debate involving their field: they had been proved wrong many times before. As long ago as 1924, Sir Gilbert Walker, then head of the British government's Indian weather service, discerned unusually close connections between rainfall, temperature and pressures in the Pacific Ocean and the Indian subcontinent. Claims were made that the problem of forecasting the Indian monsoon was solved. Were it true, it would have been a great boon to Indian agriculture. But it was soon recognized that the correlations had little predictive power.

Later, in the 1940's and 1950's, widespread claims were made, based on the work of the late Irving Langmuir, Nobel laureate from the General Electric Company, and Vincent J. Schaefer of the State University of New York at Albany, that seeding clouds with dry ice or crystals of silver iodide could bring about an increase in rainfall. Several decades of research into the possi-



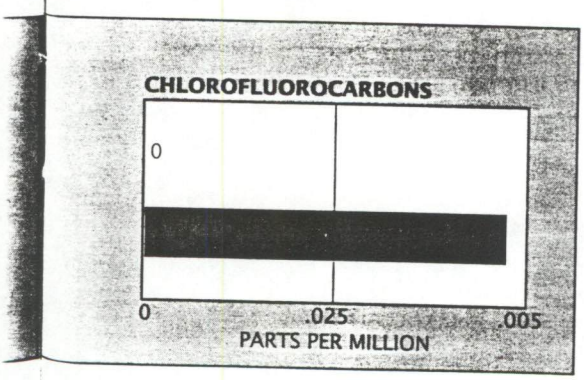


bilities of increasing rainfall, changing the intensity of hurricanes and modifying hailstorms by cloud-seeding techniques proved abortive.

Then, in the early 1980's, it was postulated that dust thrown into the atmosphere by a nuclear exchange between the Soviet Union and the U.S. would result in a "nuclear winter." This idea was deflated by Schneider and his colleague Stanley L. Thompson, who showed with the same models used in the prediction of climate that the "initial nuclear winter hypothesis can now be relegated to a vanishingly low level of probability."

Given this "cry wolf" history, it is not surprising that many meteorologists harbor deep reservations about taking costly actions on the basis of the predictions of a climate warming. But the push for policy has other constituents. Climate warming also unites those who are concerned about biodiversity and species extinction, economic development, human population growth, urban air pollution, acid precipitation and ozone depletion.

Political leaders stimulated by public concerns about environmental deterioration see these issues as important platforms and as springboards to public office. Those interested in increasing the competitiveness of American industry see greater energy efficiency as an important step toward that goal. It also serves the interest of those concerned about U.S. dependence on foreign energy sources. The issue of nuclear power is also underscored. Because fossil fuels are the main source of atmospheric carbon dioxide, strategies for stabilizing climate must envision non-fossil-fuel sources. Here at last is justification that proponents of nuclear power can forcefully advance to support expansion of nuclear power facilities throughout the world.



The issue of global climate warming also offers an opportunity for advancing the "new economic order" long advocated by Third World nations. International action will require technological and economic assistance to such nations if they are to participate in a global effort to reduce atmospheric pollution or arrest deforestation. In fact, the world faces the prospect that the greatest increases in emissions of carbon dioxide will occur in developing countries as their need for economic growth is followed by increased demand for energy.

In like manner, those interested in arresting population growth, especially in the Third World, point out that the climate-warming problem is probably not solvable as long as the number of human beings continues to rise. After all, it is people who consume natural resources and energy and who farm the land. Without population control, prospects for stabilizing the climate and arresting the deterioration of the habitability of the planet are abysmal.

Are the consequences of climate warming to be feared? People experience extremes of temperature in the natural course of events. The fact is that we do not know enough to predict the severity of the consequences. Because the warming would not be uniform over the surface of the earth, it would probably produce both winners and losers among regions and nations. Some parts of the earth would become warmer, some wetter and some drier. It is not possible on the basis of the evidence at hand to predict who would benefit and who would lose in such a global redistribution of so-called climatic resources.

Some aspects of global climate warming would be greatly beneficial in the view of agricultural researchers. Increased carbon dioxide will foster more active photosynthesis and enhance crop growth, to say nothing about the lowered plant requirements for water in a CO_2-enhanced atmosphere. In the words of Jerry D. Mahlman, director of the Geophysical Fluid Dynamics Laboratory, "The things we can say with confidence, the policymakers are not interested in. And the things [they] are interested in, we don't know with confidence."

Models do, however, agree that the polar regions of the world would undergo greater increases in temperature than would the tropics. Some of the projections of temperature increases in polar areas are startling in their magnitude, predicting as much as 18 degrees

F (10 degrees C) on the average in the Northern Hemisphere and only slight increases in tropical regions.

What are the general consequences of such a change in the temperature difference between equatorial and polar regions? We experience similar differences every year as the seasons change. In summer when arctic temperatures are warm, we do not suffer the great storms of winter; precipitation belts move farther north. Areas such as the southwestern part of the U.S. experience very dry conditions.

If arctic regions were to undergo significantly greater warming than equatorial regions and if precipitation belts were to move farther north, countries in the north temperate and polar zones would probably stand to benefit greatly. Their growing season would lengthen, and their precipitation would increase. With suitable soils, agriculture might thrive. These are speculations, however.

Such speculations are formulated in "scenarios" asking the question, What if? Unfortunately, an infinite number of such "what if" questions may be asked. What if the flow of rivers in the American Southwest, already fully utilized, were to be reduced by 20 percent? What if temperatures were to increase in the corn belt and precipitation were to move farther north? What, then, would be the consequences in the U.S. for agriculture, for resource availability, for energy generation, for national parks and conservation of nature?

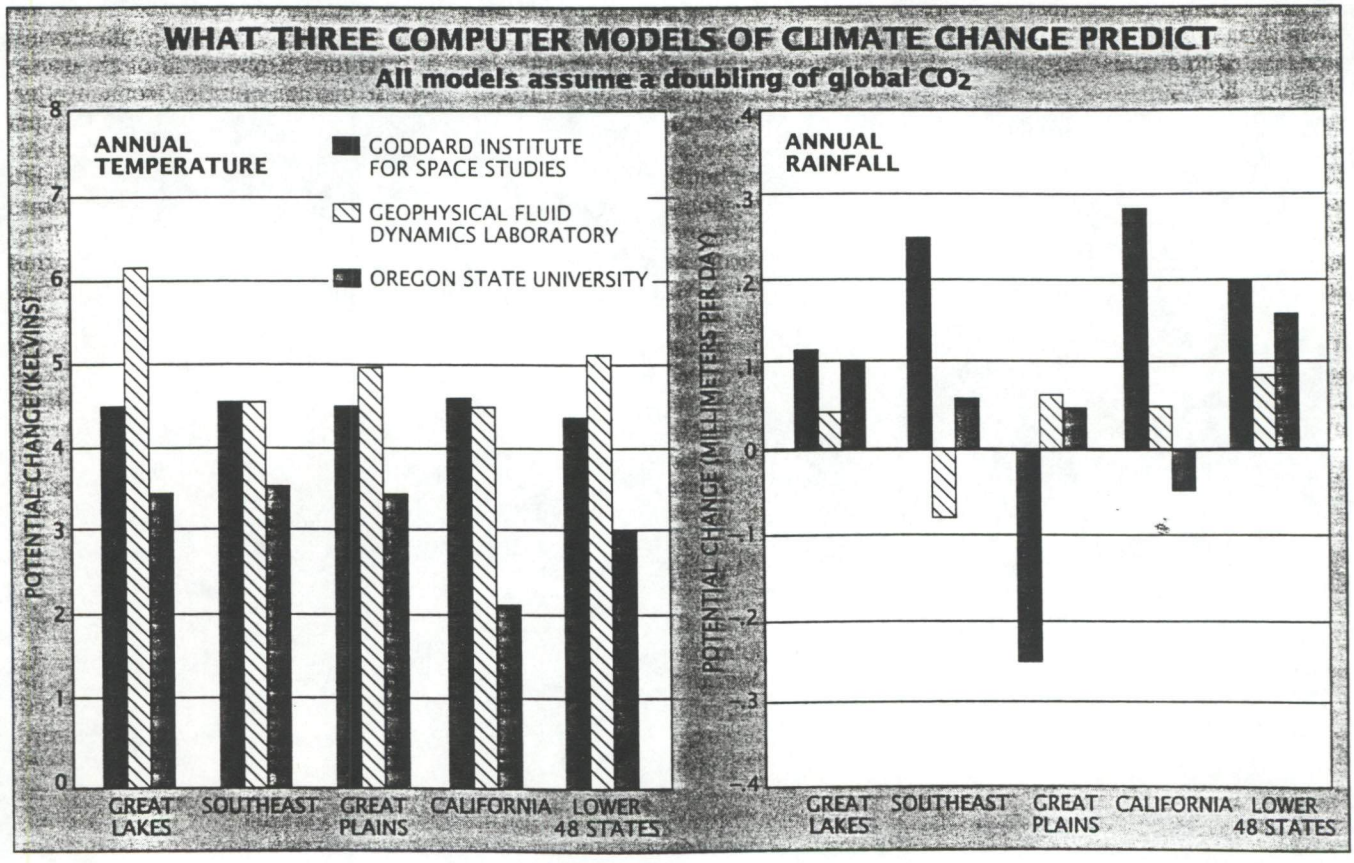
The consequences of changed climates can be seen in historical records going back thousands of years, and we have seen them in recent climatic events. We know, for example, that the Danes were able to settle Greenland and the Vikings to sail the North Atlantic to North America during a period of warm climate around the year 1000. Then a significant change in climate caused the collapse of the Danish settlements, prevented further exploration of the North American continent and ushered in the Little Ice Age. In just the past few years we have witnessed the effects of drought in the Sahel region of Africa and northeast Brazil, as well as in parts of North America.

Such scenarios can suggest apocalyptic possibilities. A recent film in the *Infinite Voyage* television series showed the U.S. Capitol under water as the result of one possible climate-warming scenario. Some foresee vast migrations of people as areas of the world become uninhabitable. Others see threats to national sovereignty and national security. President Gorbachev has stated that ecological security, not military security, will be the principal concern of all nations in the next century as environmental conditions cause disruptions worldwide.

But scenarios should be qualified with the caveat that although the events portrayed might in some cases be plausible, they are not real predictions. What, then, is a wise course in the face of great uncertainty? Clearly, it would be one that recognized uncertainty but would not permit that uncertainty to forestall action. Steps for which other economic and environmental reasons make sense would be taken first, whether or not a climate warming is taking place [see "The Changing Climate," by Stephen H. Schneider; SCIENTIFIC AMERICAN, September, 1989].

Then, as scientific knowledge reduced uncertainties, more costly measures could be taken if warranted, hence closely tying policy actions to the state of knowledge. Scientists and others have called this a "no regrets" policy. In gambling it would be known as "spreading your bets."

A recent report of the Council of Economic Advisers lends weight to this approach. It states that the cost of controlling carbon dioxide emissions and of taking other actions to address climate change would run into hundreds of billions of dollars. Because such reallocations of resources raise the specter of grave economic consequences, we need to be reasonably sure such ac-



tions are worth the cost. Any rational no-regrets policy would foster as one of its prime objectives adequate investment by governments in global monitoring and mathematical modeling to reduce the scientific uncertainties.

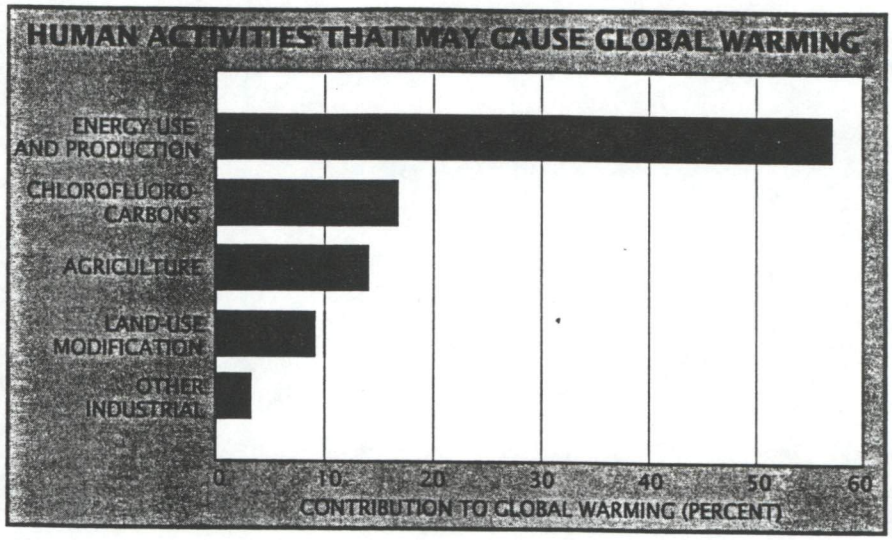
Where might we start? Energy conservation and efficiency along with the phaseout of CFC production would be the first priority for national and international action. Achieving greater energy efficiency justifies itself handily in economic terms. Increased energy efficiency would also ameliorate urban air pollution and acid precipitation. Shifts in the fossil-fuel mix from coal and oil to natural gas could significantly reduce carbon dioxide emissions per thermal unit. Technology is also available for more efficient power generation and for increased gasoline mileage.

Wisdom would also dictate major investments in nonfossil-energy sources. The circumstances favor significant new investments in passively safe, publicly acceptable nuclear power. Further development of forms of solar energy—photovoltaics or biomass, for example—makes good sense. Reforestation and forest preservation constitute a benign policy that yields many ecological and climatic benefits. Research aimed at producing stress- and disease-resistant crops would also be wise.

The public, however, must not be misled. These no-regrets initial policy steps will not solve the climate-warming problem. Their effectiveness will only modestly retard climate warming, and the future may require more drastic actions. No matter what policy actions we take, fully arresting the climate warming just does not seem to be in the cards.

The difficulties of reaching an international agreement on procedures for mitigating climate warming will be difficult and lengthy. The negotiations for the Law of the Sea Treaty provide a good lesson. They consumed 15 years and produced a treaty that the U.S. has yet to sign because of demands by developing nations for significant technology transfer and economic assistance. These issues will be even more complicated and more pervasive in any "Law of the Atmosphere Treaty."

It is likely that humanity will have to adapt to some climate changes. Modes of adaptation by society have not been well studied. Individuals, corporations and communities can adapt to climatic vicissitudes in myriad ways. Farmers can change crops, water use can be regulated and management practices can be altered.



Other modes of adaptation would be needed if climate changes were severe. Sea-level rise, which is one of the predicted concomitants of a climate warming, might inundate low-lying coastal areas and cause salt water to intrude into freshwater bodies. Were this to occur, society would have to decide whether to invest in protective structures along coasts or adapt by changing land-use patterns. The North Sea dikes in the Netherlands are an outstanding example of adaptation to relative rise in sea level.

Some adaptations would take considerable time to implement. If the price of energy were to escalate, energy-efficient habitations would be necessary. Present cities with their great suburban sprawl are not energy efficient, and so we might return to more compact cities. If we chose to maintain agriculture in dry areas, society would need to decide whether to invest in the necessary irrigation systems. In fact, the economic growth of the entire western part of the U.S. has been based on major investments in water storage and transport for irrigation and industrial use.

Fortunately, time may for once be on our side. Governments generally act only when threats become real. They act in the face of military threats or when areas are endangered and destroyed by natural disasters. If the climate changes, the expectation is that it will do so gradually. We should be able to see the initial evidence of coastal inundation in an increasing frequency of high tides and in the undercutting of seacoasts. Climate warming itself should be evident in a rising frequency of heat waves or in other weather anomalies. The effects of a global climate warming are likely to take 30 to 50 years to become serious, and that is a long enough span in which actions to adapt to these changes should be possible.

What of the debate in the atmospheric, environmental and political communities? Our global environment is under attack on many fronts. Climate warming is but one, perhaps the most complex, of these issues. If the changes occurring in our atmosphere are likely to cause consequences, we must understand the problems and promote sensible policies to remedy them. What would be unwise is to lapse into apocalyptic thinking or ostrichlike denial. We like to believe ourselves far more sophisticated, more enlightened, than preceding generations. Until we can calmly and objectively approach our environmental challenges without promoting public hysteria and exciting shortsighted, self-interested reaction, we cannot claim that we are.

FURTHER READING

THERMAL EQUILIBRIUM OF THE ATMOSPHERE WITH A GIVEN DISTRIBUTION OF RELATIVE HUMIDITY. Syukuro Manabe and Richard T. Wetherald in *Journal of Atmospheric Science*, Vol. 24, pages 241-259; May, 1967.

CHANGING CLIMATE: REPORT OF THE CARBON DIOXIDE ASSESSMENT COMMITTEE. National Research Council, Carbon Dioxide Assessment Committee. National Academy Press, 1983.

THE GREENHOUSE EFFECT, CLIMATIC CHANGE, AND ECOSYSTEMS. Edited by Bert Bolin and Bo R. Doos. John Wiley & Sons, Inc., 1986.

GLOBAL TRENDS OF MEASURED SURFACE AIR TEMPERATURE. James Hansen and Sergej Lebedeff in *Journal of Geophysical Research*, Vol. 92, D11, pages 13345-13372; November 20, 1987.

THE GREENHOUSE EFFECT: SCIENCE AND POLICY. Stephen H. Schneider in *Science*, Vol. 243, No. 4892, pages 771-781; February 10, 1989.

Attachment 6

Draft 2/19/92

Major International Environmental Accomplishments, 1989-Present

o Ozone Layer: In June 1990 the U.S. led international efforts to phase-out the production and use of major ozone depleting substances by the year 2000.

-- In response to recent scientific data, President Bush announced in February 1992 that the U.S. would unilaterally accelerate the phase-out to 1995.

o Antarctica*: We reached agreement in October 1991 on an environmental protection protocol to the Antarctic Treaty.

-- The protocol includes measures - most of which were proposed by the U.S. - to address marine pollution, waste disposal, and protection of sensitive areas; it also includes an indefinite moratorium on mining activities in Antarctica.

o Driftnets*: Under a U.S.-led effort, the UNGA in December 1991 approved a resolution calling for a moratorium on the driftnet fishing by the end of 1992.

-- Scientific data gathered under U.S. bilateral research programs with Japan, Korea, and Taiwan demonstrated the highly destructive nature of this fishing practice.

o Acid Rain Agreement: President Bush and Prime Minister Mulroney signed an Air Quality Agreement in March 1991 to resolve long-standing concerns over acid rain. The agreement also establishes a mechanism to address any future air quality issues.

o Mexico Environment: As proposed by Presidents Bush and Salinas, the U.S. and Mexico developed a comprehensive plan to address environmental concerns in the border region.

-- The plan includes measures to deal with hazardous wastes, air and water pollution, enforcement of environmental regulations, and chemical accidents.

-- Mexico will spend $460 million over the next three years to implement border environment projects. The Administration has requested $241 million in FY1993 for implementation of the border plan.

---

* - Note: the Antarctic environment agreement and the driftnet moratorium were listed among the five major environmental accomplishments in Time Magazine's 1991 "Year-in-Review" issue.

- Enterprise for the Americas Initiative: EAI agreements with Bolivia, Jamaica, and Chile in 1991 and 1992 cancelled $263 million in official debt owed to the U.S. In addition, $32.4 million in local currency will be set aside in support of local environment and conservation programs. We expect to reach similar agreements with other Latin American countries.

- Climate Change: The U.S. hosted the first session of U.N. negotiations toward a framework convention on climate change. We hope to sign a convention during the June 1992 U.N. Conference on Environment and Development (UNCED). The U.S. implemented a series of measures that limit greenhouse gas emissions, e.g. National Energy Strategy, Clean Air Act Amendments, and reforestation programs.

- Endangered Species: U.S. efforts in CITES led to a 1989 ban on the trade in elephant ivory; this has helped arrest a serious decline in populations of the African elephant.

  -- The U.S. persuaded Japan to remove its reservation to a CITES ban on the trade in endangered sea turtle products; Japan ended all such trade in April 1991(?).

- Basel Convention: In March 1990 the U.S. signed the Basel Convention, which provides for sound transboundary shipment of hazardous wastes; the Administration has submitted legislation to Congress for implementing the convention.

- East European Environment: In 1989 President Bush announced programs to address the severe pollution problems in Eastern Europe. The U.S. is providing help in reducing air and water pollution and has established a Regional Environment Center in Budapest to assist local efforts.

- Polish Debt: The U.S. granted in 1991 a debt reduction for a debt-for-environment fund supporting environmental projects in Poland.

- Asian Environment: In January 1992 President Bush announced a new program of broadened environmental cooperation with Asian countries, called the U.S.-Asia Environmental Partnership.

- Global Forests: The U.S. called at the 1990 G-7 Summit for negotiations on a global forest convention or agreement; a list of guiding principles on forests are being developed in the context of the June 1992 UNCED.

- Multilateral Development Banks: The U.S. has led efforts in the past several years to ensure that projects supported by multilateral development bank lending are environmentally sound.

- Oil Spills: Pursuant to President Bush's initiative at the 1989 G-7 Summit, the U.S. and 79 other nations agreed in November 1990 to an International Convention on Oil Pollution Preparedness, Response and Cooperation.

- North Pacific Salmon: The U.S., Canada, Russia, and Japan signed an agreement in February 1992 that ended Japan's high-seas salmon fishery, which had contributed to declines in salmon stocks throughout the North Pacific.

- Environmental Research: The U.S. global change research program, funded at over $1 billion per year, comprises over half the world's total research effort in this vital field.

- G-7 "Scorecard": A "scorecard" produced by NGO groups for the July 1991 G-7 Summit rated the U.S. at the top of the G-7 in terms of overall level of environmental protection and efforts in support of the environment.

An Alternative Energy Future

A Joint Industry Study by:

The Alliance to Save Energy
American Gas Association
Solar Energy Industries Association

Peer Reviewers:

Center for Global Climate Change at the University of Maryland
Environmental and Energy Study Institute
Global Climate Change Division of the U.S. Environmental Protection Agency
Natural Resources Defense Council
Worldwatch Institute

April 1992

DIGEST

This study describes a plausible, market-driven energy future for the United States. It shows that a free-market approach to energy use, coupled with reprioritization of research and development and an emphasis on efficiency and clean fuels, can achieve significant reductions in emissions of carbon dioxide (the primary greenhouse gas), other greenhouse gases and criteria air pollutants. This scenario specifically excludes new government intervention in the energy marketplace. In fact, a key assumption underpinning the scenario is the removal of state and local barriers (e.g., mandatory scrubber requirements) to allow market forces to work. This would result a reduction in use of some heavily subsidized energy sources such as coal, and replacing it with natural gas and renewables. Gradually, this market-based approach will alter the nation's energy system.

The study assumes the rapid deployment of new, high-efficiency technologies in all energy markets that results in a stabilization of total energy consumption and a corresponding shift away from high-carbon fuels to natural gas, renewable energies and higher-efficiency equipment. This in turn results in a 12 percent reduction in carbon dioxide emissions by 2010, lower consumer energy bills, an improved balance of trade, and increased employment in domestic energy industries.

The principal specific factors driving the scenario are:

- Continued improvement in efficiency of deployed energy technologies, resulting from competitive forces as well as from reallocated R&D to natural gas, renewables and efficiency technologies;

- The effect of newly-implemented National Appliance Energy Conservation Act (NAECA) standards and other existing standards consistent with expected turnover of equipment and motor vehicles;

- Continued vigorous expansion of Integrated Resource Plans (IRPs) and passage of the IRP portion of National Energy Strategy legislation; and

- Elimination of state and federal legislative and regulatory biases that discourage energy efficiency and encourage the use of carbon-intensive fossil fuels.

The results of this report differ from those of a number of other energy futures because of the factors listed above. Full implementation of NAECA and other efficiency requirements was assumed in this scenario. Other modeling efforts that rely more heavily on econometric equations and price elasticity calculations are unlikely to capture the full impact of these changes. Other energy forecasts, which rely on equations based on

historic trends, do not consider removal of long-standing state and federal biases in their results. In addition, the redirection of federal research, development and deployment programs to efficiency, renewables and natural gas are not considered in other modeling results. This assumption was unique to this project.

It is these factors that account for the differences between standard energy forecasts and this scenario. Thus, this scenario relies on two basic factors: technology and market forces.

TABLE OF CONTENTS

Table of Contents i
List of Tables iv
List of Exhibits vii

CHAPTER 1 : OVERVIEW

Purpose 1:1
Key Characteristics of the Alternative Energy Future Scenario 1:2
Executive Summary 1:8
Greenhouse Gas Emissions 1:8
Criteria Air Pollutant Emissions 1:9
Economic Impact Results 1:10

CHAPTER 2 : ENERGY CONSUMPTION AND SUPPLY

Energy Consumption 2:1
Introduction 2:1
Residential Energy Use 2:1
Commercial Energy Use 2:9
Industrial Energy Use 2:11
Transportation Energy Use 2:17
Electric Utility Energy Use 2:21
Energy Inputs for Electricity Generation 2:27
Total Primary Energy Use 2:27

Natural Gas and Oil Supply 2:35
Introduction 2:35
Success Ratios 2:36
Reserve Additions per Well 2:37
Well Completions 2:38
Natural Gas Reserve Additions 2:38
Petroleum Product Use 2:40

CHAPTER 3 : RENEWABLE ENERGY AND ENERGY EFFICIENCY

Renewable Energy 3:1
Introduction 3:1
Hydroelectric Power 3:4
Solar Energy 3:5
Geothermal Energy 3:6
Biomass Energy 3:7
Wind Power 3:8

TABLE OF CONTENTS (con't)

CHAPTER 3 (con't)

Energy Efficiency 3:9
Introduction 3:9
Residential Sector 3:9
Commercial Sector 3:10
Industrial Sector 3:11
Transportation Sector 3:12
Electric Utility Sector 3:12

CHAPTER 4 : GREENHOUSE GASES

Introduction 4:1
Greenhouse Gas Emissions 4:1
Carbon Dioxide 4:1
Methane 4:3
Other Greenhouse Gases 4:6
Methodology and Assumptions 4:8
Interpretation of Emissions Estimates 4:8
Carbon Dioxide Emissions Estimates 4:8

CHAPTER 5 : CRITERIA AIR POLLUTANTS

Introduction 5:1
Executive Summary 5:1
Methodology 5:3
General 5:3
Stationary Sources 5:3
Mobile Sources 5:4
Analysis Results 5:5
Sulfur Dioxide 5:5
Nitrogen Oxides 5:6
Non-Methane Hydrocarbons 5:7
Carbon Monoxide 5:9
Total Suspended Particulates 5:10

TABLE OF CONTENTS (con't)

CHAPTER 6 : ECONOMIC IMPACTS OF ALTERNATIVE ENERGY FUTURE SCENARIO

Introduction 6:1
Executive Summary 6:2
Data Methodology and Analysis 6:5
Consumer Energy Cost Impacts 6:5
Merchandise Trade Impacts 6:8
Energy Sector and Employment Impacts 6:8

APPENDIX A: INTRODUCTION TO THE A.G.A.-TERA MODELING SYSTEM

APPENDIX B: DETAILED OUTPUT TABLES OF CARBON DIOXIDE EMISSIONS BY SECTOR

APPENDIX C: DETAILED OUTPUT TABLES OF CRITERIA AIR POLLUTANT EMISSIONS BY SECTOR

APPENDIX D: COMPARISON OF ENERGY INTENSITY BY SECTOR UNDER ALTERNATIVE ENERGY USE SCENARIOS

GLOSSARY

LIST OF TABLES

CHAPTER 1

Table 1.1: Total Primary Energy Consumption: Alternative Energy Future 1:3

Table 1.2: Potential Emission Reductions of Alternative Energy Future Scenario 1:10

Table 1.3: Projected Consumer Energy Expenditures and Savings 1:12

CHAPTER 2

Table 2.1: Residential Direct Energy Use 2:2

Table 2.2: Commercial Direct Energy Use 2:9

Table 2.3: Industrial Direct Energy Use 2:13

Table 2.4: Transportation Direct Energy Use 2:18

Table 2.5: Electric Utility Direct Energy Use 2:23

Table 2.6: Energy Inputs for Electricity Generation 2:28

Table 2.7: Total Primary Energy Use 2:30

Table 2.8: Projected Natural Gas Wellhead Price Path 2:36

Table 2.9: Lower-48 Success Ratios 2:37

Table 2.10: Lower-48 Reserve Additions Per Well 2:38

Table 2.11: Lower-48 Well Completions 2:39

Table 2.12: Lower-48 Natural Gas Reserve Additions 2:40

Table 2.13: Petroleum Product Use 2:41

LIST OF TABLES (con't)

CHAPTER 3

Table 3.1: Domestic Energy Resources: Conventional and Renewable . . 3:2

Table 3.2: Growth in Renewable Energy Under the Alternative Energy Future Scenario 3:4

Table 3.3: Summary of Levelized Costs Used for Renewable Technologies 3:8

CHAPTER 4

Table 4.1: Alternative Energy Future: Total U.S. CO_2 Emissions By Fuel Type 4:2

Table 4.2: IPCC Estimate of Sources of Methane Emissions 4:5

Table 4.3: Characteristics of Selected Fossil Fuels 4:9

Table 4.4: CO_2 Emissions from Combustion of Fossil Fuels 4:10

CHAPTER 5

Table 5.1: Potential Emission Reductions of Alternative Energy Case 5:2

CHAPTER 6

Table 6.1: Projected Consumer Energy Expenditures and Savings 6:3

Table 6.2: Residential Energy Consumption and Expenditures 6:6

Table 6.3: Commercial Energy Consumption and Expenditures 6:6

Table 6.4: Industrial Energy Consumption and Expenditures 6:7

Table 6.5: Transportation Energy Consumption and Expenditures 6:7

Table 6.6: Base Case U.S. Oil Consumption, Production and Imports of Crude Oil and Petroleum Products 6:9

LIST OF TABLES (con't)

CHAPTER 6 (con't)

Table 6.7: Alternative Energy Future U.S. Oil Consumption, Production and Imports of Crude Oil and Petroleum Products 6:10

Table 6.8: Impact of Net Imports on the U.S. Merchandise Trade Deficit 6:10

Table 6.9: Incremental Investment Costs for Conservation and Renewable Energy 6:11

Table 6.10: Domestic Energy Industry Annual Revenue Impacts 6:12

Table 6.11: Annual Average National Employment for Coal Mining, Oil and Natural Gas Extraction 6:14

Table 6.12: Domestic Production of Natural Gas, Petroleum and Coal . . . 6:15

Table 6.13: Labor Intensity of Energy Production 6:15

Table 6.14: Employment Impact of Investment in Energy Conservation and Renewables 6:16

Table 6.15: Energy Sector Employment Impacts of the Alternative Energy Future 6:16

LIST OF EXHIBITS

CHAPTER 1

Exhibit 1.1: Total Primary Energy Consumption: 2010 . . . . . 1:3

Exhibit 1.2: Energy Consumption by End-Use Sector: 2010 . . . . . 1:5

Exhibit 1.3: Alternative Energy Future: Electric Utility Energy Consumption 1:6

Exhibit 1.4: Patterns in Natural Gas Marketshare and Total Fossil Fuel-Related Carbon Dioxide Emissions 1:7

Exhibit 1.5: Projected U.S. Criteria Air Pollutant Emissions from Fossil Fuel Use: 2010 . . . . . 1:8

CHAPTER 2

Exhibit 2.1: Residential Direct Energy Use: 1950 through 1990 . . . . . 2:3

Exhibit 2.2: Residential Direct Energy Use: Base Case vs. Alternative Case 2:3

Exhibit 2.3: Residential Energy Use per Household: 1950 through 1990 2:5

Exhibit 2.4: Residential Energy Use per Household: Base Case vs. Alternative Case 2:5

Exhibit 2.5: Residential Energy Use per Dollar of RDPI: 1950 through 1990 . . . . . 2:7

Exhibit 2.6: Residential Energy Use per Dollar of RDPI: Base Case vs. Alternative Case 2:7

Exhibit 2.7: Residential Househeating Use: Base Case vs. Alternative Case 2:8

Exhibit 2.8: Residential Non-Househeating Use: Base Case vs. Alternative Case 2:8

Exhibit 2.9: Commercial Direct Energy Use: 1950 through 1990 . . . . . 2:10

LIST OF EXHIBITS (con't)

CHAPTER 2 (con't)

Exhibit 2.10: Commercial Direct Energy Use: Base Case vs. Alternative Case 2:10

Exhibit 2.11: Commercial Energy Use per Dollar of Commercial GDP: 1950 through 1990 . . . . . 2:12

Exhibit 2.12: Commercial Energy Use per Dollar of Commercial GDP: Base Case vs. Alternative Case 2:12

Exhibit 2.13: Industrial Direct Energy Use: 1950 through 1990 . . . . . 2:14

Exhibit 2.14: Industrial Direct Energy Use: Base Case vs. Alternative Case 2:14

Exhibit 2.15: Industrial Energy Use per Dollar of Industrial GDP: 1950 through 1990 . . . . . 2:16

Exhibit 2.16: Industrial Energy Use per Dollar of Industrial GDP: Base Case vs. Alternative Case 2:16

Exhibit 2.17: Transportation Direct Energy Use: 1950 through 1990 . . . 2:19

Exhibit 2.18: Transportation Direct Energy Use: Base Case vs. Alternative Case 2:19

Exhibit 2.19: Transportation Energy Use per Capita: 1950 through 1990 . . . . . 2:20

Exhibit 2.20: Transportation Energy Use per Capita: Base Case vs. Alternative Case 2:20

Exhibit 2.21: Transportation Energy Use per Dollar of GNP: 1950 through 1990 . . . . . 2:22

Exhibit 2.22: Transportation Energy Use per Dollar of GNP: Base Case vs. Alternative Case 2:22

Exhibit 2.23: Electric Utility Direct Energy Use: 1950 through 1990 . . . . 2:24

LIST OF EXHIBITS (con't)

CHAPTER 2 (con't)

Exhibit 2.24: Electric Utility Direct Energy Use: Base Case vs. Alternative Case 2:24

Exhibit 2.25: Electric Utility Energy Use per Capita: 1950 through 1990 . 2:26

Exhibit 2.26: Electric Utility Energy Use per Capita: Base Case vs. Alternative Case 2:26

Exhibit 2.27: Electric Utility Energy Use per Dollar of GNP: 1950 through 1990 . . . . . 2:29

Exhibit 2.28: Electric Utility Energy Use per Dollar of GNP: Base Case vs. Alternative Case 2:29

Exhibit 2.29: Total Primary Energy Use: 1950 through 1990 . . . . . 2:31

Exhibit 2.30: Total Primary Energy Use: Base Case vs. Alternative Case 2:31

Exhibit 2.31: Total Primary Energy Use per Capita: 1950 through 1990 . . . . . 2:33

Exhibit 2.32: Total Primary Energy Use per Capita: Base Case vs. Alternative Case 2:33

Exhibit 2.33: Total Primary Energy Use per Dollar of GNP: 1950 through 1990 . . . . . 2:34

Exhibit 2.34: Total Primary Energy Use per Dollar of GNP: Base Case vs. Alternative Case 2:34

CHAPTER 3

Exhibit 3.1: Renewable Energy: Contribution to Total U.S. Energy Supply 3:3

CHAPTER 4

Exhibit 4.1: Projected U.S. CO_2 Emissions from Fossil Fuel Use Under Alternative Energy Use Scenarios 4:2

LIST OF EXHIBITS (con't)

CHAPTER 5

Exhibit 5.1: Comparison of Projected Sulfur Dioxide Emissions 5:5

Exhibit 5.2: Comparison of Projected Nitrogen Oxide Emissions 5:7

Exhibit 5.3: Comparison of Projected Non-Methane Hydrocarbon Emissions 5:8

Exhibit 5.4: Comparison of Projected Carbon Monoxide Emissions 5:9

Exhibit 5.5: Comparison of Projected Particulate Matter Emissions 5:11

CHAPTER 1: OVERVIEW

PURPOSE

This is the first joint study to be conducted by the energy-efficiency, renewable energy and natural gas industries. The principal participants include the Alliance to Save Energy, the American Gas Association and the Solar Energy Industries Association, as well as peer reviewers at the Center for Global Climate Change at the University of Maryland, the Environmental and Energy Study Institute, Global Climate Change Division at the U.S. Environmental Protection Agency, the Natural Resources Defense Council and Worldwatch Institute. The energy future examined in this study is not intended to represent the results of the implementation of policies agreed to by the represented industries, but rather an analysis of an energy future that is different than most conventional forecasts.

The purpose of this joint industry study is to:

- develop an energy scenario in the year 2010 that is economically and technologically feasible, and one that is characterized by considerably more energy efficiency, use of renewables and use of natural gas than conventional forecasts;
- estimate key environmental impacts of such a scenario; and
- estimate consumer energy expenditures, direct balance of trade impact, and energy sector employment characteristics.

Although there are many mid- to long-term forecasts of domestic energy markets, most have historically proven inaccurate, providing questionable information on which to base policy. The United States currently faces a number of difficult policy choices in developing a cost-effective national energy strategy that helps simultaneously to achieve the nation's economic, environmental and national security goals. Consequently, it is important to make the best possible mid- to long-term forecasts of the levels and composition of U.S. primary energy demand and supplies under current policies. If U.S. primary energy demand will continue to increase as GDP increases and the U.S. energy supply mix will remain carbon intensive as it is today, we may be faced with difficult trade-offs among the goals of achieving an acceptable level of economic growth, limiting greenhouse gas emissions, and becoming less dependent on foreign oil. If U.S. primary energy demand will not increase as GDP increases and if the supply mix will become less carbon intensive even under current policies, on the other hand, these trade-offs become much more manageable.

We believe that a majority of existing mid- to long-range forecasts make these trade-offs appear more difficult than they really are by failing to accurately reflect the impact of existing market forces and trends on the shape and composition of domestic energy markets. The Alternative Energy Future scenario examined in this report is designed to reflect those market forces and trends. It shows that continued advances in technology and market-driven efficiency improvements and changes in the composition of energy supplies may produce an energy market in 2010 that is very different from those predicted by other studies. Although the projected changes are far-reaching, we believe that they are achievable under current policies unless they are frustrated by regulatory or other barriers.

KEY CHARACTERISTICS OF THE ALTERNATIVE ENERGY FUTURE SCENARIO

Primary Energy Consumption

An important aspect of the energy scenario examined in this study is that primary energy consumption in 2010 will be slightly below levels experienced in 1990 (a decrease of nearly 1.7 percent) despite a 50 percent increase in economic activity (measured in constant 1982 dollars of GNP). Conventional energy outlooks predict various increases in total U.S. primary energy consumption. Exhibit 1.1 compares total projected primary energy consumption for the United States in 2010 under the DOE/EIA Reference Case, the 1992 A.G.A.-TERA Base Case and the Alternative Energy Future scenario examined in this study. As shown, primary energy consumption in 2010 under the Alternative Energy Future scenario is expected to be nearly 13 Quadrillion Btu (quads) below that projected by the A.G.A. Base Case and almost 24 quads below that projected by the U.S. Department of Energy.

Table 1.1 summarizes primary energy consumption by energy source from 1990 through 2010 under the Alternative Energy Future scenario. The Alternative Energy Future scenario projects no net growth in U.S. total primary energy use between 1990 and 2010. By 2010, total primary energy use is projected to stand at 82.3 quads, slightly below the 83.8 quads used in 1990. Oil use is projected to decline from 33.6 quads in 1990 to 25.3 quads in 2010. Coal use is projected to decline from 19.1 quads in 1990 to 14.3 quads in 2010. Nuclear energy and hydroelectric energy are also projected to decline. The use of renewable energy is projected to more than double, to at least 7 quads, within the next two decades under the Alternative Energy Future scenario, which incorporates increased research and development and removal of state and local barriers, but is a "business-as-usual scenario" from the perspective that it assumes no significant new renewable energy incentives.

This study contemplates major actions relative to balancing federal research and development programs, removing state and local biases to the penetration of new renewable, efficiency and natural gas technologies and the enforcement of new appliance minimum efficiency standards. It does not consider significant new policy initiatives. If

Exhibit 1.1

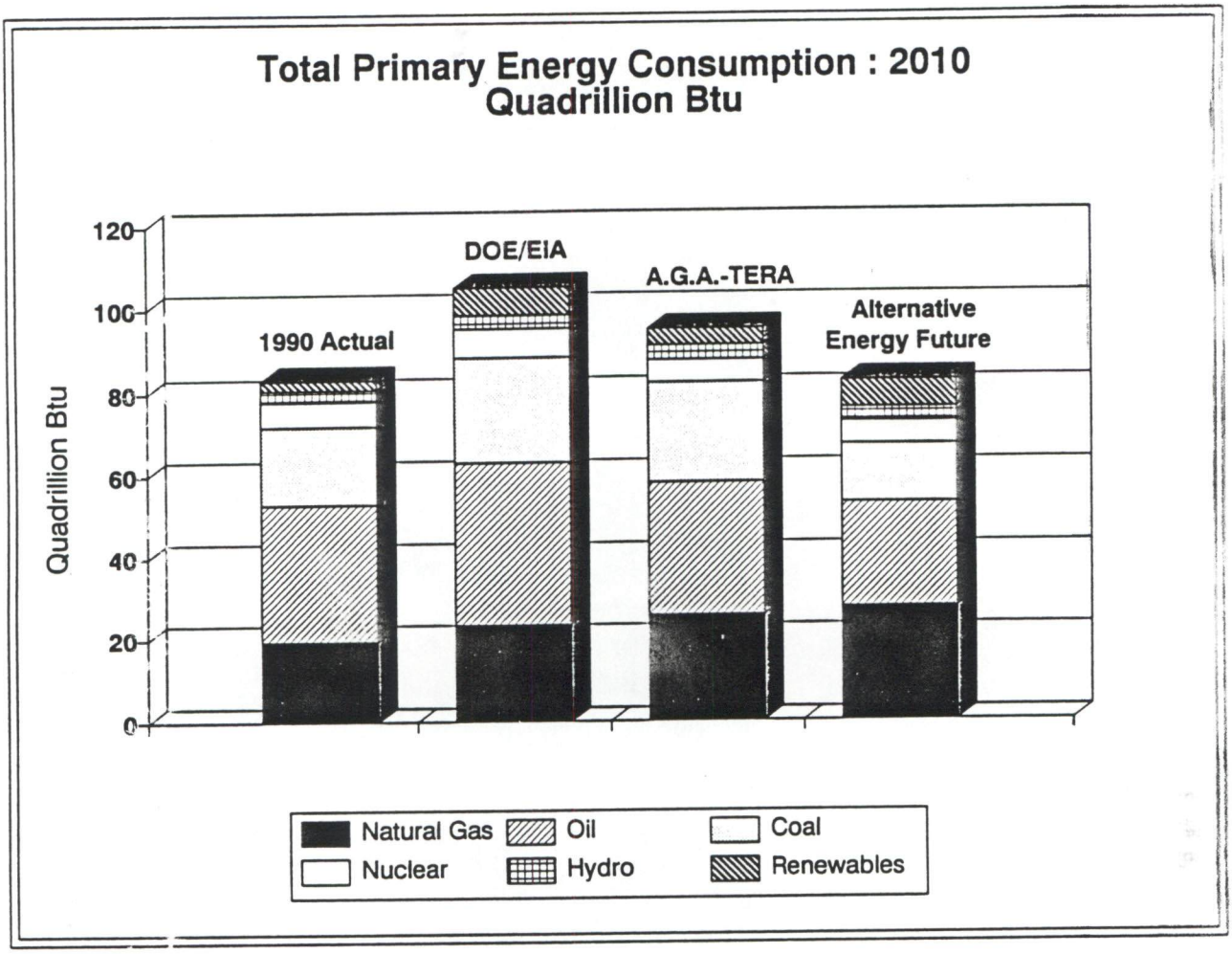


Table 1.1

Total Primary Energy Consumption: Alternative Energy Future (Quadrillion Btu)

	Natural Gas	Petroleum Products	Coal	Nuclear	Hydro	Renew-ables	Total
1990	19.4	33.5	19.1	6.2	2.9	2.6	83.8
1995	20.6	31.6	16.5	7.3	3.4	3.5	82.8
2000	22.2	29.8	14.9	7.2	3.4	4.7	82.2
2005	24.4	27.7	14.7	6.7	3.4	5.8	82.6
2010	27.1	25.3	14.3	5.2	3.4	7.0	82.3

*Totals may not add due to independent rounding.

the federal government were to take a more interventionist role in energy markets, the relative contributions of renewables and energy efficiency would be significantly increased. Additional contributions in these areas would have obvious environmental and balance of trade impacts. It was not the purpose of this report to analyze the cost/benefits of intervention policies. Other reports (America's Energy Choices published by the Union of Concerned Scientists as an example) have analyzed interventionist policies and several of the sponsoring/peer review organizations support a more pro-active approach. This report estimates what the United States can achieve without such policies.

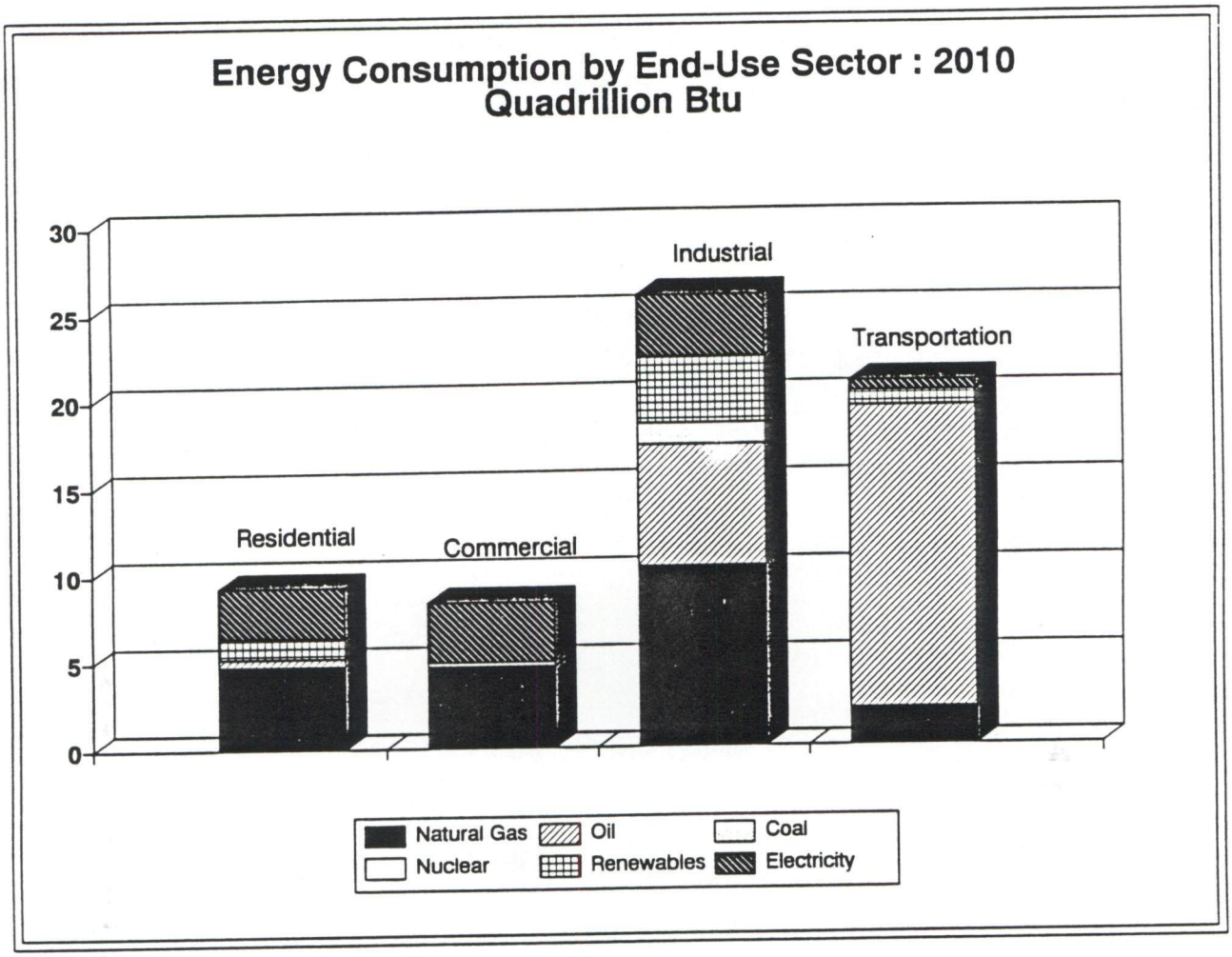
The Alternative Energy Future scenario examined in this study is essentially different than conventional energy forecasts in three areas:

- It incorporates more recent data on regulations and standards for appliance efficiency and conservation measures;
- It assumes removal of market barriers that currently inhibit national energy-economic decisions; and
- It assumes very aggressive market penetration rates for more efficient technologies.

The Alternative Energy Future scenario incorporates the impacts of recent Federal and state regulations, specifically the National Appliance Energy Conservation Act (NAECA) and actions called for under the National Energy Strategy (NES), on the domestic energy markets. Certain NAECA minimum appliance standards become effective in 1992. Exhibit 1.2 on the following page depicts energy consumption by end-use sector under the Alternative Energy Future scenario. Implementation of mandates under NAECA and NES would result in increased energy efficiency across all end-use sectors. The Alternative Energy Future scenario is, therefore, aggressive in its assumptions regarding market penetration of new and more efficient technologies.

Under the Alternative Energy Future scenario, electricity generation would become much more efficient. New gas-fired power plants are projected to consume 7,500 MMBtu per kWh of electricity output -- 31 percent more efficient than the average of about 10,900 MMBtu per kWh in 1990. New coal-fired power plants would consume 8,500 MMBtu per kWh of electricity output -- 18 percent more efficient than the average of approximately 10,400 MMBtu per kWh in 1990.

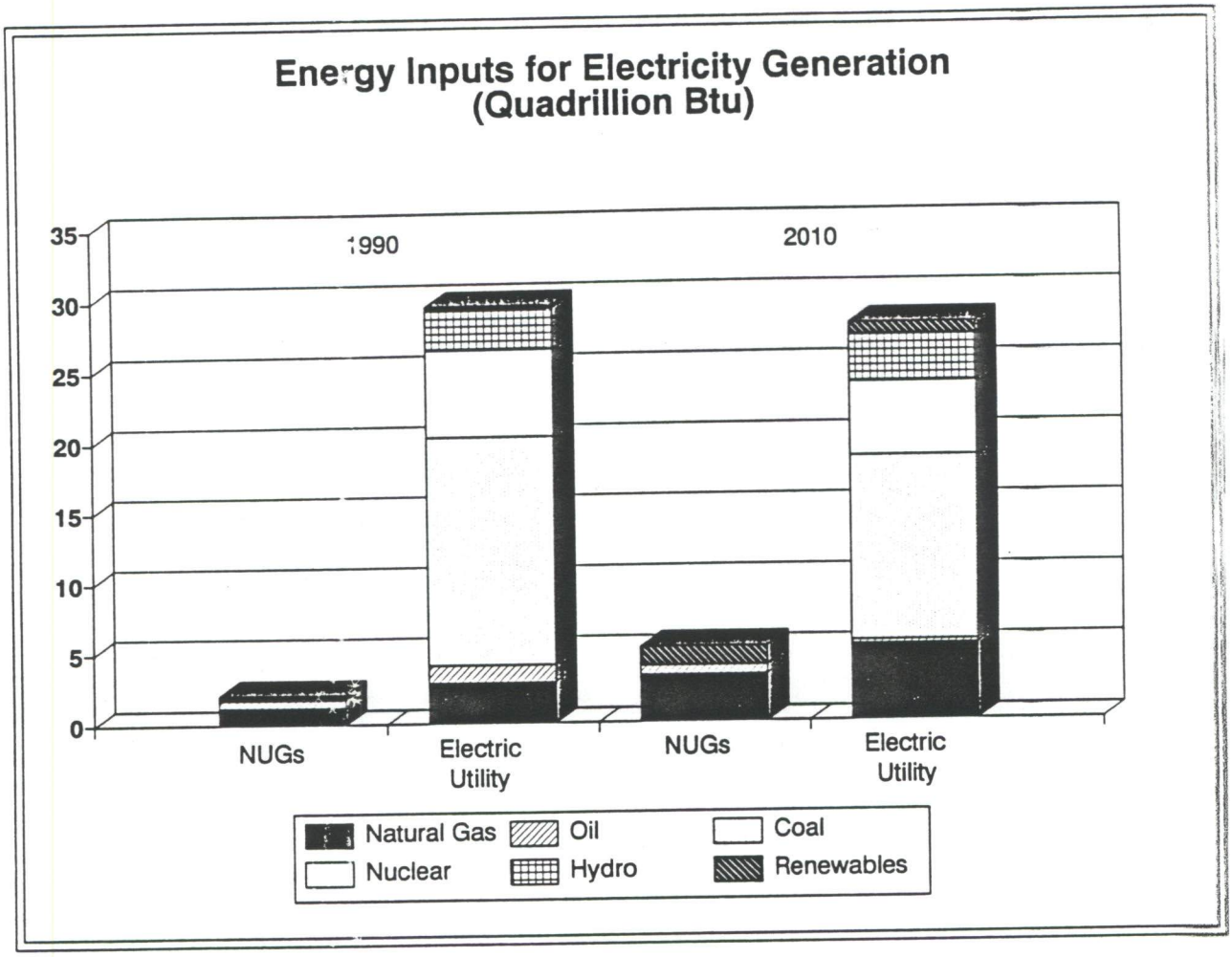
Exhibit 1.2



Additions to electric utility generating capacity are assumed to be evenly divided between gas-fired and coal-fired power plants. For this to happen, existing policies favoring coal (such as mandatory state scrubber rules for acid rain compliance) are assumed to be dismantled. Coal-fired electric utility power plant capacity is expected to decrease nearly 33 percent (compared with the 1992 A.G.A.-TERA Base Case) by 2010, with coal-fired capacity of 319 GW in 2010. This is equivalent to eliminating construction of 294 coal-fired power plants of 500 MW and deactivating 20 existing plants of that same size.

Gas-fired electric utility power plant capacity is projected to reach 157 GW in 2010, up from about 122 GW in 1990. Total electric utility power plant capacity, under the Alternative Energy Future scenario, is expected to decrease nearly 32 GW from 1990 falling to 712 GW of capacity by 2010. This is equivalent to eliminating construction of about 530 power plants of 500 MW capacity and deactivating 63 existing plants of that same size. Exhibit 1.3 below summarizes projected energy inputs for electricity generation, for NUGs and electric utilities, under the Alternative Energy Future scenario.

Exhibit 1.3



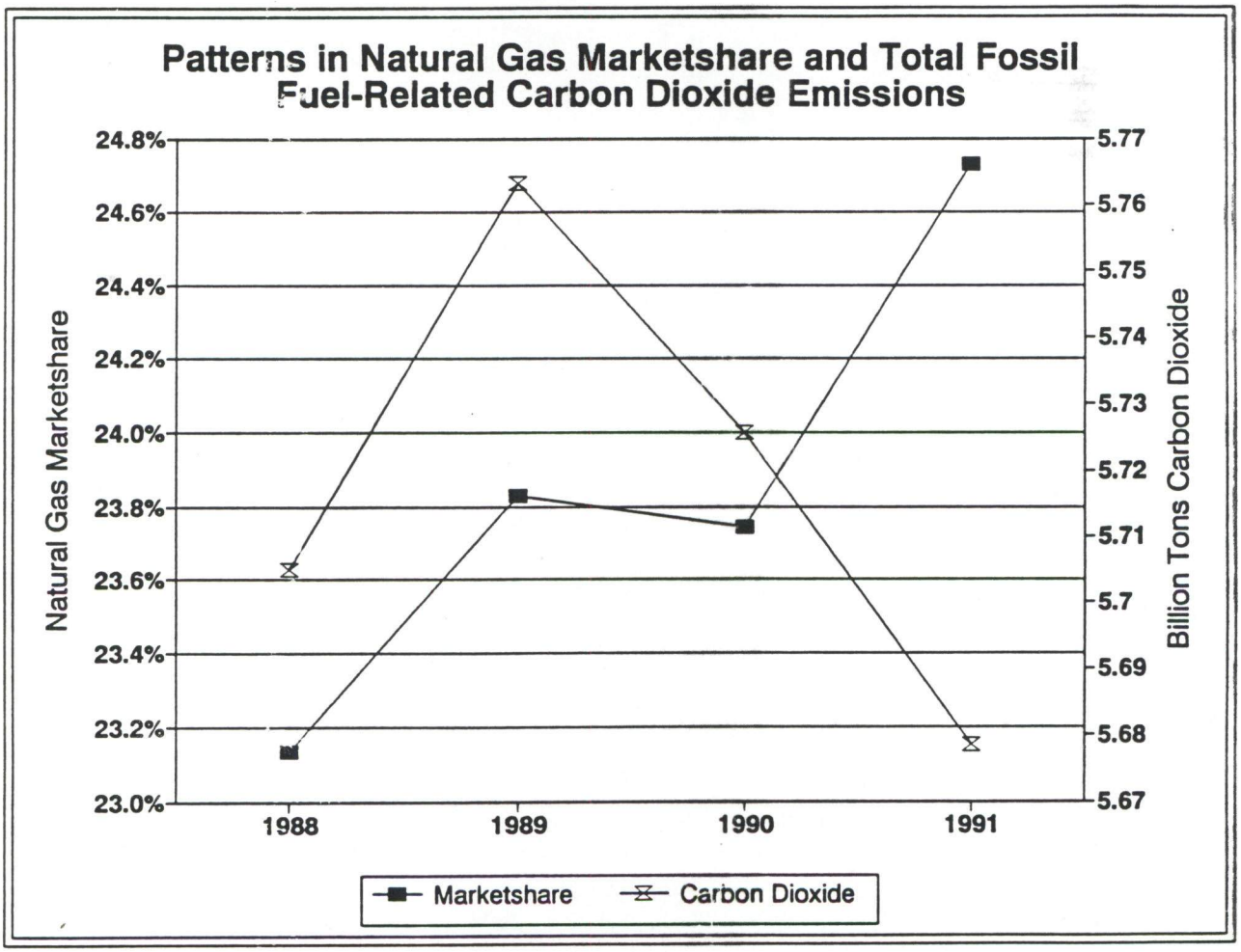
In the transportation sector, the overall average efficiency for cars, buses and trucks is projected to improve 42 percent from 1990, reaching 23 MPG by 2010. By 2010, natural gas vehicles would account for about 12 percent of automobile and light truck energy use in the transportation sector. Electric vehicles would account for about 5 percent of automobile and light truck energy use by 2010. In aggregate, natural gas and electric vehicles total 24 million by 2010 in the Alternative Energy Future scenario -- 11 percent of the total projected vehicle population -- versus 8 million vehicles in the Base Case scenario. Other alternative-fuel vehicles would account for about 8 percent of energy use by automobiles and light trucks by 2010 under the Alternative Energy Future scenario.

In recent years, there has been a modest change in the composition of fossil fuel consumption in this country. As discussed in detail in Chapter 6, there have also been measurable improvements in energy efficiency and renewable energy across all end-use sectors. In addition, renewable energy represents a high-growth set of industries, many

of which have advanced technologically to commercial readiness. Renewable electric power generation (excluding hydropower) increased three-fold between 1982 and 1988. Demand-side applications of photovoltaics, solar water heating, and solar industrial process heat hardly existed in the 1970s but have offset the equivalent of over 1,500 megawatts. Total renewable energy generation has been predicted by renewable and environmental organizations to more than quadruple in the next two decades, without significant energy policy changes.[1] While the exact energy picture in 2010 as described in the following chapters is one of several possible outcomes, the likelihood that recent trends, particularly in increased energy efficiency and renewable energy, will continue is high.

From 1988 through 1991, for example, fossil fuel consumption remained relatively stable at nearly 72 quads. Total primary energy consumption remained at approximately 80 quads over the same period. Natural gas increased its market share of total energy consumption (including nuclear and renewables) from roughly 23 percent in 1988 to slightly more than 25 percent in 1991. Over this same period, fossil fuel-related carbon dioxide emissions have declined. Exhibit 1.4 below depicts this relationship between natural gas' market share and carbon dioxide emissions.

Exhibit 1.4



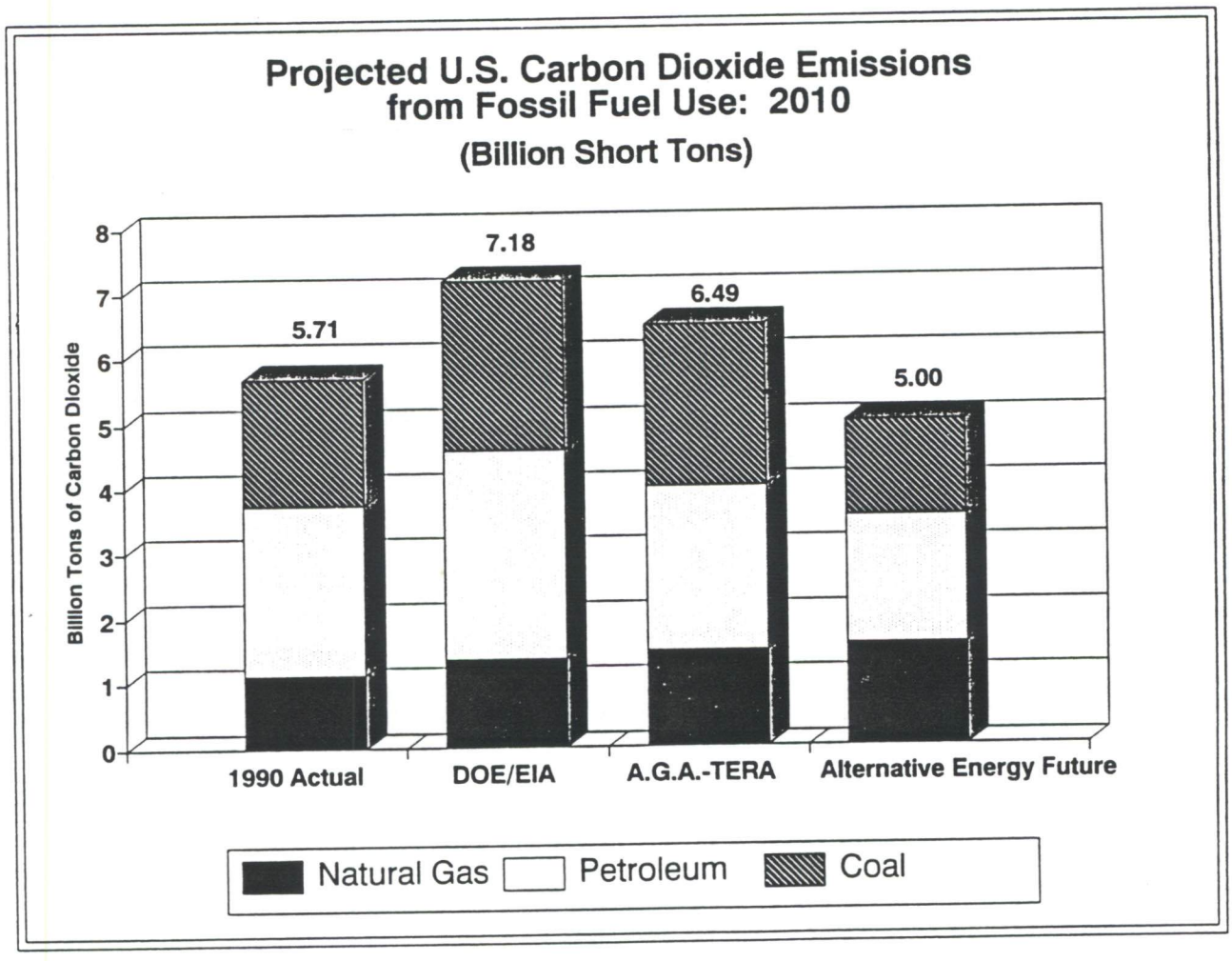
EXECUTIVE SUMMARY

Under the Alternative Energy Future analyzed in this study, substantial environmental benefits would be achieved with little net direct effect on economic health and employment in the energy industries. Emissions of greenhouse gases would decline significantly from current levels and criteria air pollutant emissions would be considerably below conventional projections. This is possible through economically and technologically feasible measures that increase efficiencies in the production and consumption of energy, and the adoption of conservation measures across end-use sectors.

Greenhouse Gas Emissions

Exhibit 1.5 shows the Alternative Energy Future scenario's projected level of carbon dioxide emissions by fuel type through 2010 compared with the 1992 **A**merican **G**as **A**ssociation's **T**otal **E**nergy Resource **A**nalysis (A.G.A.-TERA) model Base Case and the 1992 Department of Energy's Energy Information Administration's (DOE/EIA) Reference Case, two more conventional energy forecasts. Throughout this report, except where noted, all references to the Base Case are to the 1992 A.G.A.-TERA Base Case.

Exhibit 1.5



Typically, conventional energy forecasts project increasing levels of carbon dioxide emissions from fossil fuel use over the projection period. For example, increases in CO_2 emissions range from 14 to 26 percent over 1990 levels under the Base Case and the DOE/EIA Reference Case, respectively. U.S. carbon dioxide emissions from fossil fuel use would decrease to 5.0 billion short tons by 2010 under the Alternative Energy Future scenario. This would represent over a 12 percent **decline from 1990 carbon dioxide emissions levels.**

Although not quantitatively estimated in this study, fossil fuel-related methane and nitrous oxide emissions under the Alternative Energy Future scenario are expected to decrease, perhaps significantly. Any potential increases in methane due to increased natural gas consumption are expected to be more than offset by significant decreases in petroleum and coal consumption. Fossil fuel-related nitrous oxide emissions are also projected to decline as a result of increased natural gas consumption coupled with substantial declines in coal and petroleum products consumption.

Criteria Air Pollutant Emissions

The aggregate emission reduction in the year 2010 of criteria air pollutants, specifically sulfur dioxide, nitrogen oxides, non-methane hydrocarbons, carbon monoxide and total suspended particulates, of the Alternative Energy Future scenario relative to the Base Case scenario would be over 10.2 million tons for the five air pollutants analyzed. Reductions of each of the individual pollutants range from 1.1 to 3.5 million tons per year by the end of the forecast period. (See Table 1.2)

- Nitrogen oxide (NO_x) emissions of the Alternative Case would be 24 percent lower (3.4 million tons per year) than in the Base Case. About 80 percent of the NO_x reduction is attributable to coal-fired electricity generating plants: both from the reduced utilization of these units due to reduced electricity demand, as well as the substitution of lower NO_x-emitting gas-fired combined-cycle plants for coal-fired plants.

- Sulfur dioxide (SO_2) emissions of the Alternative Case would be 1.1 million tons less than the Base Case in 2010 -- a reduction of roughly 8 percent. Approximately 60 percent of the SO_2 reduction is attributable to conversions to natural gas or conservation in oil-fired plants. No incremental reduction is projected for coal-fired electric utility plants -- SO_2 emissions of these plants are projected to drop from 15.6 million tons per year to 8.1 million tons per year as a result of the acid rain provisions of the Clean Air Act Amendments, regardless of the scenario employed. However, the reductions may be achieved in a more economic fashion under the Alternative Energy Future scenario which relies more on fuel switching and conservation than capital-intensive scrubbers.

- An additional reduction in non-methane hydrocarbon (NMHC) emissions of 1.2 million tons per year is achievable via the Alternative Case. This incremental

7 percent reduction is attributable to the substitution of natural gas, electric and other alternative-fuel vehicles for gasoline vehicles. Despite the fact that nearly half of all NMHC emissions come from stationary sources, most future reductions will come from vehicles, as stationary sources are already tightly controlled, and further control of these sources would be very costly.

- Carbon monoxide (CO) emissions will drop sharply over the forecast period due to tighter vehicular emission standards, enhanced inspection and maintenance programs, the use of oxygenated fuels and the expanded use of natural gas and other alternative-fuel vehicles. Alternative Energy Case CO emissions drop from the current level of 66.1 million tons per year to 39.8 million by 2010 -- 3.5 million tons below the projected Base Case level.

- Total suspended particulate (TSP) emissions of the Alternative Energy Case are projected to fall by 1 million tons more -- over 50 percent more -- than the Base Case reduction for the forecast period. This 1 million ton reduction is equally attributable to conservation and switching to natural gas in coal-fired boilers and to vehicular conversions from gasoline to clean alternative fuels.

Table 1.2

Potential Emission Reductions of Alternative Energy Future Scenario (Thousands of Tons Per Year)

	SO_2	NO_x	TSP	CO	NMHC
1995	200	834	157	1073	186
2000	440	1713	378	1938	266
2005	760	2443	692	2379	1012
2010	1095	3433	1017	3464	1237

Economic Impact Results

As a result of the increased marketshare for natural gas and the increased penetration of conservation technology, all sectors would experience reductions in the cost of purchasing energy in the Alternative Energy Future scenario compared with the Base Case. The magnitude of the savings would increase over time as overall energy prices increased and conservation saved additional energy. **The following comparisons of energy expenditures are made between scenarios, not in terms of the change from 1992 levels.**

- In the year 2010, total energy expenditures would be nearly 19 percent lower in the Alternative Energy Future scenario than in the Base Case. Total energy expenditures, projected to be $736.2 billion (1992 dollars) in the Base Case, would fall to $599.2 billion (1992 dollars) in the Alternative Energy Future scenario. Energy users would save $137.0 billion (1992 dollars) in energy bills as a result. (See Table 1.3)

  - In the Alternative Energy Future scenario, residential energy bills would decline from the Base Case level by $41.2 billion (1992 dollars) or 24 percent in 2010.

  - Commercial sector energy costs in 2010 would decline by 19 percent from the projected Base Case level thereby saving commercial establishments $29.0 billion (1992 dollars) in energy expenditures.

  - The cost of energy purchased by industrial customers compared with the Base Case projection would also decline in the Alternative Energy Future scenario by 19 percent. As a result, U.S. industry would reduce its energy expenditures by $28.8 billion (1992 dollars).

  - Transportation energy costs are projected to decline by 14 percent from the Base Case level thereby saving $38 billion (1992 dollars) in expenditures.

The Alternative Energy Future scenario would improve the U.S. merchandise trade deficit relative to the Base Case. The primary source of this improvement would be the reduction in the dependence on foreign oil. As noted in subsequent chapters, the Alternative Energy Future scenario not only constrains the growth of petroleum product demand but also projects a smaller decline in domestic production of oil than in the Base Case due to increased drilling activity and improved productivity.

- As a result of increased reliance on foreign oil and increases in the world oil price, the Base Case projects that the cost of net oil imports (expressed in constant 1992 dollars) would grow from $45.5 billion in 1991 to $123.3 billion in 2010. The growth represents a 171 percent increase (in real terms) in this major drag on the U.S. economy.

  - The net imports of oil in the Base Case are projected to grow from 6.6 million barrels per day in 1991 to nearly 11.3 million barrels per day in 2010.

- By comparison, the Alternative Energy Future scenario projects that the net expenditures for crude oil and petroleum products imports would increase by a still alarming 78 percent from $45.5 billion in 1991 to $80.9 billion in 2010 expressed in constant 1992 dollars. Nonetheless, by 2010 the Alternative Energy Future scenario projects a $42.4 billion (1992 dollar) improvement in the

petroleum component of the merchandise trade deficit compared with the Base Case.

- The net imports of oil projected in the Alternative Energy Future scenario are stabilized at less than 8 million barrels per day. The growth in the petroleum merchandise trade deficit is a function of the projected increase in world oil prices.

- In addition, the development of energy conservation and renewable energy technologies should allow U.S. industry to compete more effectively for the growing world market for energy development and energy conservation services. Estimates developed by the U.S. Agency for International Development project a world market of between $8 billion to $17 billion annually for energy efficiency technologies and services alone. The majority of U.S.-manufactured renewable energy products and services are currently exported, at levels exceeding $150 million each year, with a market potential of several billion dollars.

Table 1.3

Projected Consumer Energy Expenditures and Savings
(Energy Bills Only)
(Billions of 1992 Dollars)

	2000 Base Case	2000 Alternative Energy Future	2000 Consumer Energy Savings
Residential	$143.2	$126.0	$17.2
Commercial	110.0	99.7	10.3
Industrial	111.6	101.0	10.6
Transportation	214.3	184.4	29.9
TOTAL	$579.1	$511.1	$68.0
	2010	2010	2010
Residential	$169.0	$127.8	$41.2
Commercial	149.9	120.9	27.9
Industrial	152.8	124.0	28.8
Transportation	264.5	226.5	38.0
TOTAL	$736.2	$599.2	$137

The Alternative Energy Future scenario implies a significant restructuring of the nation's energy industry. When the incremental conservation and renewable investment expenditures are combined with the restructured domestic energy production revenues, the total annual revenues received by domestic companies for energy and energy services is reduced but not by as much as consumer energy expenditures.

- In the Base Case in 2010, consumers are projected to pay $602.9 billion (1992 dollars) for domestically-produced energy.
  - Total energy bills are projected to be $736.2 billion, which includes $123.3 billion for imported oil and $10 billion for imported natural gas.
- In the Alternative Energy Future scenario in 2010, consumers are projected to pay $518.3 billion for domestic energy. But in order to achieve the conservation improvements embedded in the scenario, consumers are projected to invest nearly $43 billion on incremental conservation and renewable technologies in 2010.
- As a result, the total revenue received by domestic energy producers, including producers of "conservation energy" and renewable energy, is projected to be $551.4 billion. This represents a decline of $51.5 billion or less than 9 percent of the domestic energy industry revenues projected in the Base Case.

Because of the labor-intensive nature of energy conservation and renewable energy, total employment in energy production and service industries in the United States may actually increase.

- Total energy sector employment in the Alternative Energy Future scenario is projected to increase by more than 82,000 jobs in 2000.
  - Domestic natural gas and oil production jobs are projected to increase by over 15,000 jobs above Base Case levels.
  - Coal production jobs are projected to decline by 24,000 compared with the Base Case.
  - Over 90,000 new jobs in the conservation and renewable energy sector are projected to be created.
- By 2010, the rate of job growth is projected to accelerate. The Alternative Energy Future scenario projects a net increase of more than 175,000 jobs in the energy sector above the Base Case level.

- Natural gas and oil production employment is projected to increase by more than 25,000 jobs.

- Coal production employment would continue to decline, losing more than 44,000 jobs compared with the Base Case.

- Energy conservation services and renewable energy are projected to become major employers in the U.S. economy by 2010, with more than 190,000 jobs created above the Base Case levels.

Chapter Notes

1. The Union of Concerned Scientists, America's Energy Choices: Investing in a Strong Economy and a Clean Environment, Cambridge, Massachusetts, 1991.

ONE HUNDRED SECOND CONGRESS

JOHN D. DINGELL, MICHIGAN, CHAIRMAN

JAMES H. SCHEUER, NEW YORK
HENRY A. WAXMAN, CALIFORNIA
PHILIP R. SHARP, INDIANA
EDWARD J. MARKEY, MASSACHUSETTS
AL SWIFT, WASHINGTON
CARDISS COLLINS, ILLINOIS
MIKE SYNAR, OKLAHOMA
W.J. "BILLY" TAUZIN, LOUISIANA
RON WYDEN, OREGON
RALPH M. HALL, TEXAS
DENNIS E. ECKART, OHIO
BILL RICHARDSON, NEW MEXICO
JIM SLATTERY, KANSAS
GERRY SIKORSKI, MINNESOTA
JOHN BRYANT, TEXAS
RICK BOUCHER, VIRGINIA
JIM COOPER, TENNESSEE
TERRY L. BRUCE, ILLINOIS
J. ROY ROWLAND, GEORGIA
THOMAS J. MANTON, NEW YORK
EDOLPHUS TOWNS, NEW YORK
C. THOMAS McMILLEN, MARYLAND
GERRY E. STUDDS, MASSACHUSETTS
PETER H. KOSTMAYER, PENNSYLVANIA
RICHARD H. LEHMAN, CALIFORNIA
CLAUDE HARRIS, ALABAMA

NORMAN F. LENT, NEW YORK
CARLOS J. MOORHEAD, CALIFORNIA
MATTHEW J. RINALDO, NEW JERSEY
WILLIAM E. DANNEMEYER, CALIFORNIA
DON RITTER, PENNSYLVANIA
THOMAS J. BLILEY, JR., VIRGINIA
JACK FIELDS, TEXAS
MICHAEL G. OXLEY, OHIO
MICHAEL BILIRAKIS, FLORIDA
DAN SCHAEFER, COLORADO
JOE BARTON, TEXAS
SONNY CALLAHAN, ALABAMA
ALEX McMILLAN, NORTH CAROLINA
J. DENNIS HASTERT, ILLINOIS
CLYDE C. HOLLOWAY, LOUISIANA
FRED UPTON, MICHIGAN

JOHN S. ORLANDO, CHIEF OF STAFF
ALAN J. ROTH, CHIEF COUNSEL

U.S. House of Representatives
Committee on Energy and Commerce
Room 2125, Rayburn House Office Building
Washington, DC 20515-6115

FAX COVER SHEET

DATE: 5/8

TO: Boyden Gray

FROM: Dave Finnegan

FAX NUMBER 456-6279

NUMBER OF PAGES (INCLUDING COVER) 2

COMMENTS:

If there are any problems with the transmission, please call (202) 225-3147.

45279

Draft Resolution 2

The Committee,

Recalling General Assembly resolutions 45/212 of 21 December 1989 and 46/169 of 19 December 1991,

Convinced that the problem of climate change cannot be resolved without adequate cooperation among members of the international community,

Having agreed upon and adopted the text of the United Nations Convention on Climate Change, 1992,

1. Calls upon all States and regional economic integration organizations entitled to do so to sign the Convention during the United Nations Conference on Environment and Development in Rio de Janeiro or at the earliest subsequent opportunity and thereafter to ratify, accept, approve or accede to the Convention;

2. Urges all such States and regional economic integration organizations, pending the entry into force of the Convention, to adopt policies and measures consistent with the provisions of the Convention, including support for relevant international programmes, and report thereon to the interim secretariat at the earliest date.

April 2, 1992

NOTE

TO: Distribution

FROM: Jonathan Wiener

The Arizona Journal of International & Comparative Law is publishing a set of articles on global environmental change following a symposium at which Dick Stewart was a keynote speaker, and has asked us to submit an article explaining the "comprehensive approach." We have updated and elaborated our 1990 article on this subject (which received interagency review) to take account of new scientific findings and to address questions raised since that time. A copy is attached for your review; if you have any comments, I would appreciate them as soon as possible, no later than Thursday April 9, since the journal has put us on a very tight time schedule. Thank you very much.

4.2.92 **DRAFT -- DO NOT QUOTE OR DISTRIBUTE**
For Univ. of Ariz. Jrnl. of Int'l & Comparative Law (June 1992)

THE COMPREHENSIVE APPROACH TO GLOBAL CLIMATE POLICY: ISSUES OF DESIGN AND PRACTICALITY

Richard B. Stewart[1]
Jonathan B. Wiener[2]

The atmosphere is a global commons.[3] Unabated use of the commons as a dumping ground for greenhouse gases (GHGs) could eventually produce significant, perhaps unacceptable environmental changes.[4] Yet actions to limit emissions significantly are likely to entail large costs.[5] In the absence of a common regime for limiting use of the atmospheric commons, no nation will have an adequate incentive to limit its own use, because it will have no assurance that others will do likewise. Its solitary control efforts would do relatively little to avert warming, and its

---

[1] Visiting Professor of Law, Georgetown University Law Center; former Assistant Attorney General for Environment & Natural Resources, US Dept. of Justice, 1989-91.

[2] J.D. 1987, Harvard Law School; A.B. 1984, Harvard College; currently Policy Counsel, Office of Science & Technology Policy, Washington D.C. The authors' views are their own and do not necessarily reflect the views of the U.S. government.

[3] It is a true "global commons" in the economic sense, see T. C. Schelling, "Economic Responses to Global Warming: Prospects for Cooperative Approaches," in Rudiger Dornbusch & James M. Poterba, eds., Global Warming: Economic Policy Responses at 198 (1991); the term is not used in the technical meaning of international law.

[4] This paper addresses the optimal design of policy to respond to climate change in the event such action is warranted based on its costs and benefits. It does not attempt to resolve the question of what level of emissions limitation, if any, is justified. Hence the illustrative point is simply that unlimited emissions could entail damages worth preventing. On the possible impacts of greenhouse gas emissions on climate, see generally J.T. Houghton, G.J.Jenkins & J.J.Ephraums, eds., The Intergovernmental Panel on Climate Change (IPCC) Scientific Assessment (1990).

[5] See, e.g., US Interagency Task Force, The Economics of Long-Term Climate Change (Sept. 1990); William Nordhaus, "How Much Should we Invest in Preserving Our Current Climate?" unpub. paper, Yale University (Sept. 1991). But see National Academy of Sciences, Policy Implications of Greenhouse Warming 47-63 (1991) (some options could be at low cost or small net savings).

citizens and industries would incur a potentially serious economic disadvantage relative to others.

Some nations are already taking measures or setting policies to limit GHGs.[6] There is also discussion of a regional initiative within the European Community (EC).[7] These measures, however, are driven in major part by concerns relating to energy independence, economic efficiency, or environmental problems other than global climate change.

The current negotiations for a global climate convention may yield a framework convention that calls for national strategies to address climate issues and a system for tracking progress in achieving them. This decentralized, "bottom-up" approach is likely to endure for some period of time. If continued research shows no great threat from GHG emissions, the costs of more drastic measures will have been avoided.[8] But if continued scientific research

---

[6] E.g., Swedish CO2 tax [cite]; German Federal Ministry for the Environment, "Comparative Analysis of the CO2 Reduction Potentials and Proposed Actions Specified in the Reports Presented by the Enquete Commission on 'Preventive Measures to Protect the Earth's Atmosphere' and in the Decisions Adopted by the German Federal Government" (1992) (imagine that in German); America's Climate Change Strategy: An Action Agenda (Feb. 1991); "US Statement on Commitments," presented at the Fifth Session of the Intergovernmental Negotiating Committee on a Framework Convention on Climate Change, New York (Feb. 27, 1992).

[7] David Lascelles, "A Mission to Make the Polluters Pay," Financial Times (London), Jan. 28, 1992, at , col. 1; "Commission Asked to Make Formal Proposal on Energy Tax to Address Climate Change," BNA Int'l Env't Reptr.: Current Report 670 (Dec. 18, 1991).

[8] There are considerable uncertainties about the magnitude, timing and regional pattern of any such change, see Houghton et al., The IPCC Scientific Assessment, supra n. at xii. Recent findings suggest that any anthropogenic warming effect may be more gradual than previously believed because some gases (CFCs and NOx), formerly thought to be contributing over 25% of enhanced radiative forcing, may be having no net effect. See IPCC 1992 Supplement 20, 29 (Feb. 1992). In addition, any near-term effect may be less stressful than previously predicted, because the observed slight warming that has occurred over the past several decades -- still within the range of natural variation, id. at 29 -- has occurred almost completely at night and in the winter, rather than increasing extreme temperatures. Id. at 27; Thomas Karl et al., "Global Warming: Evidence for Asymmetric Diurnal Temperature Change," Geophysical Research Letters (Dec. 1991).

Still, very rapid warming, or warming that leads to unpleasant

shows that there is a serious, near-term global warming threat warranting more aggressive action to limit concentrations of GHGs in the atmosphere, agreement on joint measures to protect the commons would be necessary. These measures would have to limit net GHG emissions into the commons, determine how entitlements to this limited use of the commons will be allocated, and provide some form of compliance assurances. In short, what would be required is the creation of some form of property regime for the commons.

The scope of these common measures is a question of critical importance. The incentive effects associated with different policy designs can profoundly affect the cost and effectiveness of environmental protection measures. Policy design issues are too often ignored in the rush to "do something," because policymakers tend to focus on snapshot evidence of a current symptom of a problem, rather than on its full scope and on the dynamic incentive effects of different policy designs. Both economics and ecology teach that complex, integrated systems like societies and ecosystems deserve comprehensive attention. When policy formulations hastily target one of many interrelated variables, they often ignore lower-cost options to achieve better results, and produce unintended side-effects that can confound the best-intended policy.

Nowhere is the importance of the choice between "piecemeal" and "comprehensive" policy designs more evident than in the context of potential climate change. Anthropogenic activities affect both sources and sinks of several greenhouse gases (GHGs), including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), HCFCs and HFCs, the precursors of tropospheric ozone and of CO2, including VOCs, NOx, and CO, and others. CO2 emissions represent the largest single current contribution to potential global climate change, accounting for over half of the radiative forcing effect of all GHGs. Most proposals for limitations of GHGs have been restricted to fossil fuel CO2 emissions, or to CO2 emissions from the energy and transportation sectors. This "piecemeal" approach, however, ignores other sources of CO2 and all of the other GHGs. It also ignores GHG sinks, such as forests, whose destruction releases GHGs and whose expansion reduces net GHG emissions.

Two years ago, the Bush administration proposed a comprehensive approach to global climate research and policy that

---

"surprises" such as strong positive feedbacks or reversals of ocean currents, see Stephen H. Schneider, "The Changing Climate," Scientific American (Sept. 1989) at 78-79, could entail unexpected "catastrophes" that significantly increase the damages to societies and ecosystems, see Schelling, supra n. , at 204.

embraced all GHGs, their sources and sinks.[9] The United States argued that a comprehensive approach was far superior, on both economic and environmental grounds, to a piecemeal approach directed at only a part of the problem, such as CO2 emissions. Initial reactions to this position ranged from skepticism to hostility. Doubts were expressed about the practicality of a comprehensive approach. In addition, the proposal was seen by many as an excuse for inaction and delay. Those impatient for an early agreement on GHG limitations pressed for a convention controlling CO2 fossil fuel emissions.

Today, the environmental and economic logic of the comprehensive approach is finding increasing favor among nations currently negotiating a global climate framework agreement and within the international environmental policy community. Nonetheless, doubts about its practicality remain. This essay advocates the comprehensive approach. It first explains what it is and how it would be implemented. It then explains its environmental and economic benefits, and the ways in which it will enhance the likelihood of international agreement on measures to limit GHGs by establishing a level playing field among nations and reducing the cost of achieving limitations. Next, the essay considers the practical scientific and institutional problems in implementing a comprehensive approach. Finally, it discusses how a comprehensive approach could be combined with international trading of net GHG emission reduction credits. Such a trading system would further reduce the costs of achieving reductions in net GHG emissions and stimulate the development of a decentralized, effective means of transferring capital and technology from industrialized countries (ICs) to developing countries (DCs).

I. THE COMPREHENSIVE APPROACH

The essence of the comprehensive approach is twofold: full accounting of all anthropogenic influences on the environment; and flexibility to take the most cost-effective actions to address those influences. The first element finds its intellectual heritage in multimedia and lifecycle assessments of environmental impacts, ecology, and systems analysis; the second element, in market-based incentive approaches to environmental policy. The comprehensive approach holds that any measures to address global climate issues -- whether scientific research on the causes and consequences of global climate change, projections of future net

---

[9] See US Submission to IPCC Working Group III, Dec. 29, 1989; US Papers prepared for an IPCC/WGIII Seminar on the Comprehensive and Emissions Trading Approaches to Environmental Policy, Washington DC, Feb. 3, 1990; Task Force on the Comprehensive Approach to Climate Change, A Comprehensive Approach to Addressing Potential Climate Change (U.S. Department of Justice, Feb. 1991).

GHG emissions trends, technology assessment, R&D, policy analysis regarding the means and costs of limiting net GHG emissions, or national plans or international agreements to limit GHGs -- should address the full environmental problem of concern: net emissions (sources and sinks) of all GHGs.

There are several anthroprogenic GHGs whose emissions contribute to global warming. They vary in their instantaneous radiative forcing (heat-trapping) ability, reactivity, and residence time in the atmosphere. The instantaneous radiative forcing potential of a molecule of CO2 is quite weak compared to that of the other GHGs.[10] But CO2 is by far the most voluminous of anthropogenic GHG emissions, and also has a relatively long residence time in the atmosphere -- in excess of 100 years. Taken together these attributes can be used to construct a time-integrated measure of the impact of a CO2 molecule on the climate, called its "global warming potential" (GWP). Although there is uncertainty about rates of sink uptake of CO2 and thus about CO2 residence time, and also about the indirect chemical reactions of other GHGS, the per-molecule GWP of CO2 remains much less than that of other GHGs, even of short-lived GHGs like CH4.[11] Based on total anthropogenic contributions, net emissions of CO2 from fossil fuel combustion and other sources (such as deforestation) account for over half[12] and perhaps over two thirds[13] of the GWP of current anthropogenic GHG emissions.

The next most important GHG is methane (CH4), which has about 58 times more instantaneous radiative forcing potential per kilogram than CO2,[14] but a residence time of only about 11 years.[15] Methane emissions represent about 20% of the GWP of current GHG emissions. The next most significant GHG is N2O, with a direct per molecule radiative forcing effect over 200 times greater than CO2 and an atmospheric residence time of about 150

---

[10] IPCC 1992 Supplement, supra, at 20-22.

[11] Id. at 21; World Meteorological Ass'n, Scientific Assessment of Ozone Depletion: 1991 (preprint Dec. 17, 1991) at ch. 7, tab. 7-2.

[12] Houghton et al., supra n. , at xx.

[13] Based on the new finding that CFCs, formerly thought to contribute 25% of current additions to forcing, may play no net role. See IPCC 1992 Supplement, supra n. , at 20, 29.

[14] Houghton, et al. supra n. , tab. 2.3.

[15] IPCC 1992 Supplement, supra n. , at 13.

years.[16] It represents about 8% of total current GHG GWP.

These calculations of GWP are based on several simplifying assumptions that tend to overstate, perhaps significantly, the relative importance of CO2. These include the use of a model of the carbon cycle that omits important CO2 sinks and thus overstates the lifetime of CO2.[17] Another factor is the "saturation effect": these GWPs are calculated in the current atmosphere, but as GHG concentrations rise in the future, the relative impact of additional CO2 will diminish faster than the relative impact of other GHGs, hence increasing the importance of other GHGs relative to CO2.[18]

Until recently, it had been thought that CFCs, which destroy the upper stratospheric ozone layer, causing increased amounts of damaging ultraviolet radiation to reach the earth, were also a major GHG, second only to CO2 in total GWP. The direct radiative forcing effect of CFCs is extremely powerful -- several thousand times that of CO2 on a per molecule basis -- and many of the CFCs have relatively long residence times.[19] However, recent advances in scientific knowledge focusing on the indirect reactive effects of CFC emissions have found that CFCs deplete ozone in the lower as well as the upper stratosphere, and that lower stratosphere ozone reductions have a significant cooling effect that roughly offsets the warming effect from CFC radiative forcing.[20] This new finding suggests that CFCs in the aggregate have no net GWP.[21] The GWP of different CFCs varies, however; and the HCFCs and HFCs, which were developed to replace CFCs in industrial uses and which dissipate lower in the atmosphere before reaching stratospheric ozone, may have significant GWP.

Other trace gases of concern include CO, NOx, and VOCs, which

---

[16] Houghton et al., supra n. , at tab. 2.3, 2.8.

[17] See IPCC, 1992 Supplement, supra n. , at 19.

[18] Id. at 21.

[19] Houghton et al., supra n. , at tab. 2.8.

[20] These findings were first widely reported in World Meteorological Organization (WMO), "Executive Summary: Scientific Assessment of Stratospheric Ozone, 1991" (22 Oct. 1991). These findings have stimulated research into the indirect effects of other GHGs, particularly CH4, NOx, and other tropospheric ozone precursors. There is currently considerable uncertainty regarding these indirect effects. See WMO, Scientific Assessment of Ozone Depletion: 1991 (preprint Dec. 17, 1991), at 7.9-7.15.

[21] See IPCC 1992 Supplement, supra n. , at 20.

as a result of atmospheric reactions form tropospheric ozone. CO and VOCs also result in the atmospheric formation of CO2.[22] The indirect effects of NOx, CO and VOCs are highly dependent on local atmospheric conditions, however, making a rigorous GWP calculation difficult.[23]

The GHGs are generated by numerous sources, including human ("anthropogenic") activities, other biological activities, and non-biological processes. Among the anthropogenic sources of trace gases are virtually every sector of human activity, including mining, energy generation, transportation, agriculture, forestry, waste disposal, industry, building and residential services, and others. Biogenic sources are similarly diverse. Meanwhile, CO2 is removed from the atmosphere by "sinks" such as trees, grasses, and other vegetation; phytoplankton; and ocean mixing. Other GHGs are removed by chemical reactions. Table 1 shows a summary of GHG sources and sinks.

A key to developing a comprehensive approach is the creation and subsequent refinement of an index to compare the environmental effects of different GHG emissions and sinks. If one uses no explicit index, one must still choose which emissions to limit most by some system of objective or subjective priorities. A quantitative index simply makes the relative environmental impact of the gases explicit, as an aid to decisionmaking.

The most basic index would compare the instantaneous radiative forcing effect of different GHGs, in units equivalent to the effect of a molecule or kilogram of CO2. For example, because a kg. of methane (CH4) has 58 times the instantaneous radiative forcing effect of a kg. of CO2, it would have an index value of 58. More sophisticated indices of global warming potential (GWP) have already been developed to take into account differences among GHGs in residence time and their indirect effects on climate due to atmospheric reactions. In the most recent IPCC index, for example, CH4 has a "direct" GWP component 11 times that of CO2, and an additional (additive) "indirect" GWP component somewhere between 5 and 15 times that of CO2, for an aggregate GWP in the range of 16-26.[24] As the discussion above explained, CFCs in the aggregate may have a direct GWP component 3000-7000 times larger than that of CO2, but their "indirect" effect on lower stratospheric ozone may lower their net GWP to about zero.

Since each GHG has impacts on the environment that go beyond

---

[22] Houghton, et al., supra n. , at tab. 2.8.

[23] See IPCC, 1992 Supplement, supra n. , at 22.

[24] Based on data and discussion in WMO (Dec. 17, 1991), supra, ch. 7.

warming, and the point of a comprehensive approach is to minimize net environmental risk for each action or investment, a more complete index (or set of indices) would ideally include not only GWP but other environmental effects. These include ultraviolet-induced damage due to ozone depletion,[25] the enhanced photosynthetic productivity and water use efficiency of trees and most crop plants resulting from higher levels of CO2 in the atmosphere,[26] and toxicity.[27] If policy were made without accounting for these impacts, it could inadvertently reduce risks associated with GWP but increase other risks.[28]

---

[25] Just such an index of "ozone depletion potential" (ODP) has been developed and used in the Montreal Protocol phaseout of CFCs. See WMO (Dec. 17, 1991), supra n. , ch. 6.

[26] The direct effects of CO2 demonstrated in actual field tests (as compared to the computer models used to predict future climate) are impressive, showing 30-60% gains in productivity for members of the "C3" plant group that make up 80% of the world's food supply. See IPCC Impacts Assessment (1990), p. 2.5; Bert G. Drake & P.W. Leadley, "Canopy photosynthesis of crops and native plant communities exposed to long-term elevated CO2," 14 Plant, Cell and Env't 853 (1991); Norman Rosenberg, et al., "From Climate and CO2 Enrichment to Evapotranspiration," in Paul Waggoner, ed., Climate Change and U.S. Water Resources 151-75 (1990). But cf. F. Bazzaz and E. Fajer, "Plant Growth in a CO2-Rich World," Scientific American (Jan. 1992) (cautioning against optimism on direct effects of CO2).

[27] E.g., CO and perhaps certain HCFCs are toxic.

[28] Effects of the local production processes that lead to these emissions -- such as the energy fuel cycles that emit GHGs and alternative fuel cycles -- could potentially be included in this suggested index. See Scott Barrett, "Economic Instruments for Climate Change Policy," in Responding to Climate Change: Selected Economic Issues 51, 68 (OECD 1991). We believe, however, that such a step would be undesirable in the context of global policy. First, those effects are not directly related to the GHG molecules themselves; restricting emissions of a GHG might or might not reduce other risks or other emissions from the fuel cycle. This is an empirical matter that depends on the particular policy design and technological responses. Although a CO2-only tax might reduce SO2 emissions, see Barrett, supra at 68, restricting SO2 in the past has increased, not decreased, solid waste and CO2 emissions. See Worldwatch Institute, State of the World 1990 111 (1990); Daniel J. Dudek, Alice LeBlanc & Peter Miller, "SO2 and CO2: Consistent Policymaking in a Greenhouse," EDF, New York, Jan. 1990. Similarly, as we illustrate below, restricting CO2 alone could increase emissions of CH4. Multiple emissions cannot be assumed to vary in lockstep with each other. Second, those other fuel system

In order to determine the effects of human activity on global climate, one must also have information about net emissions (source emissions less sink uptake) of the various GHGs resulting from human activity. This information would of course be needed for any policy that sought to affect concentrations of the several GHGs. Limits on net GHG emissions can only be achieved by correlative changes in activities that produce such emissions. Where direct monitoring of emissions is infeasible, as it usually is, emissions factors could be developed to relate given amounts of source or sink activity, or raw materials inputs, to net emissions. For example, today CO2 emissions are measured not at the smokestack, but by calculating the carbon input incorporated in different fuels and adjusting for different combustion efficiencies. Similarly, an acre of rice paddy of a given type could be assigned an emissions factor based on the amount of methane that it emits.[29] Similar measures could be developed for various forms of energy consumption, pollution, agricultural practices, forest management and so forth. Uptake factors could likewise be developed for sinks. For example, an acre of a given type of forest would be assigned a value based on the amount of carbon that it stores. Technical and policy analysis would assess the extent to which various changes in human activity could most cheaply and effectively reduce net GHG emissions.

A hypothetical international agreement to limit net GHG emissions that followed the comprehensive approach would allow each nation to assemble actions that address net GHG emissions. If the agreement contained a performance goal, it would set for each signatory nation an emissions trajectory (e.g. X% reduction by year Y) or an allowance of net GHG emissions, expressed in CO2 equivalents. In order to stay within this limit, each nation would have the flexibility to limit different GHG sources and to expand (or reduce destruction of) different GHG sinks, so long as it did not exceed its total limit. The GWP index for different gases, direct monitoring, and emissions factors linking source and sink activities with net GHG emissions would provide the foundation for

---

risks -- which may indeed be more worthy of concern than climate change -- could be addressed and internalized by local or national policy: they do not raise issues of emissions into a global commons (nor, for that matter, does the local toxicity of the GHGs themselves). It is precisely on this reasoning that experts are urging state public utility commissions to internalize local but not global externalities in their environmental planning "adders." See Alan Krupnick, "Environmental Costing for Electrical Utilities," presentation at the Project '88/Round II Workshop, March 12, 1992, Washington DC.

[29] Emissions factors for agriculture are complicated by dependence on rainfall, nutrient supply, and other local factors.

an auditing system of accounting for net emissions in order to determine compliance with allowance limitation agreements.

The utility of the comprehensive approach, of course, is not limited to the design of policies to limit net GHG emissions. It can be used to design research strategies to improve understanding of all relevant gases, sources, sinks, and source/sink processes; to develop monitoring systems to calculate relevant atmospheric concentrations and net emissions for all relevant gases by nation, source and sink, or sector; to calculate the effect on net emissions of all gases of current or proposed technologies and practices; to generate "report cards" calculating the effect on net emissions of current national policy actions; to analyze the impact on net emissions of proposed policy actions; and to define the criteria for providing financial and technical assistance to achieve GHG limitations in developing countries.

The Montreal Protocol on Substances That Deplete the Ozone Layer provide an important precedent for use of a comprehensive approach to deal with degradation of the global atmospheric commons. Parties to the Protocol agree to limit and then reduce their production (and their imports, exports, and consumption) of two groups of designated chemical substances that deplete stratospheric ozone. Each one of these substances is assigned an "Ozone Depleting Potential" (ODP), based on the comparative contribution of an additional unit of that substance to ozone depletion. Rather than require each nation to achieve specific percentage reductions in each ozone-depleting substance, signatory nations are required to achieve an overall limitation on production of each group of substances. Compliance with the overall limitation is determined by multiplying the production of each substance in a group by its ozone-depleting index number.
An analogous approach to GHG climate change would assign each nation a phasedown schedule for net GHG emissions expressed in CO2-equivalents. Compliance with the limitation would be determined by multiplying net emissions of each GHG by its CO2-equivalent GWP index value.

II. THE ADVANTAGES OF A COMPREHENSIVE APPROACH

A. Environmental Advantages

The comprehensive approach has a simple ecological logic: the policy response to an environmental problem should be as broad as the sources of the problem. By ignoring important sources of the problem, a piecemeal approach neglects important opportunities to solve it. Moreover, a piecemeal approach tends to be self defeating because its effort to solve one source of the problem has the effect of intensifying other, neglected sources of the problem by driving economic activity into sectors and technologies not subject to emissions limitations.

The history of pollution control in the United States illustrates the self defeating character of a piecemeal approach to environmental problems. Early federal regulation focused on air pollution. Industry reacted by disposing of residuals in the water rather than the air. When a far-reaching system of water pollution control was adopted, facilities dumped residuals on the land. Not until many years later was an effective system of controls on toxic waste treatment, storage,and disposal enacted. In the interim, the problem of toxic waste contamination of ground and groundwater was aggravated. Even now, requiring scrubbers to remove sulphur from the air creates sludge solid wastes that must be disposed of in another medium.[30] Like squeezing one end of a balloon, this piecemeal, media-by-media approach to pollution control simply shifted a substantial part of the problem elsewhere.[31]

A piecemeal approach to GHG limitations would have a similar self-defeating character. If only CO2 emissions were subject to limitations, economic activity could tend to shift to activities that generated other GHGs not subject to limitation or to activities that destroy sinks. For example, a system of controls limited to CO2 emissions would encourage fuel switching in the energy sector from coal to natural gas, because combustion of natural gas produces just over half as much CO2 per unit of energy

---

[30] Reducing SO2 emissions 10 million tons per year through scrubbing would generate 45 million tons per year of sludge -- about 1/3 the current total municipal solid waste volume in the U.S. See Winston Harrington, Acid Rain: A Primer (RFF, 1989) at 16.

[31] See Lakshman Guruswamy, "The Case for Integrated Pollution Control," 54 Law & Contemp. Probs. 41 (1991) and sources cited in id. at 41, nn. 2-3.

produced than does coal.[32] But increased natural gas combustion brings CH_4 leakage from natural gas mining and transmission systems (pipelines and local distribution networks). Because CH_4 is about 20 times more potent a GHG per unit than CO_2, about a 6% rate of CH_4 leakage from natural gas systems would negate all of the CO_2-related radiative forcing avoided by switching from coal to natural gas.[33] Natural gas flowing from the former Soviet Republics into the EC would leave in its wake CH_4 leaks ranging from 4 to 10%,[34] the average would quite likely be 6% or higher.[35] Even in an industrialized country like the U.K., the CH_4 leakage rate of pipelines is estimated to range between 1-11%,[36] with a conservative best estimate of the national average falling between 5.3% and 10.8%.[37] These leakage rates are large enough that an EC tax on CO_2 could actually boost a net increase in potential global warming.[38]

Similarly, use of biomass-based ethanol as a replacement for gasoline would lower CO2 but could simultaneously increase N20, if expanded corn farming to produce ethanol feedstock made heavy use of fertilizers, a major N2O source. Corn is one of the most nitrogen-fertilizer-intensive crops grown today. Biomass to produce the ethanol might be grown on lands cleared of forests,

---

[32] See Henning Rodhe, "A Comparison of Various Gases to the Greenhouse Effect," 248 Science 1217, 1218 (1990).

[33] Rodhe, supra n. .

[34] Victor I. Rabchuck and Nicolay I. Ilkevich, Siberian Energy Institute, USSR Academy of Sciences, "A Study of Methane Leakage in the Soviet Natural Gas Supply System," paper prepared for Batelle Pacific Northwest Laboratory (May 1991).

[35] Kathleen B. Hogan, John S. Hoffman and Anne M. Thompson, "Methane on the Greenhouse Agenda," 354 Nature 182, 182 (21 Nov. 1991).

[36] Max K. Wallis, "Leaking Gas in the Greenhouse," 354 Nature 428 (12 Dec. 1991).

[37] C. Mitchell, J. Sweet and T. Jackson, "A Study of Leakage from the UK Natural Gas Distribution System," 18 Energy Policy 809-818 (Nov. 1990). This conservative estimate did not even include leakage from sources other than service pipelines, such as connections at wellhead and point of distribution.

[38] This issue is often omitted from estimates of the effect of EC policies on net GHG emissions. E.g., McKinsey & Co., "Towards Reduced Greenhouse Gas Emissions in the European Communities and the United States," Jan. 1992, omits this issue.

forfeiting a sink to gain the alternative fuel.[39]

These are simply two examples of the many environmentally self-defeating displacements that a piecemeal approach would produce. What is perhaps even more worrisome is the array of unanticipated, complex tradeoffs that seem bound to occur if we tinker with one aspect of the GHG system without taking into account the effect on the system as a whole. By contrast, a comprehensive approach would account for all the environmental effects of alternatives, forcing decision makers to focus on those measures that yield the greatest net overall environmental benefits.

Finally, the comprehensive approach offers greater flexibility to respond to new information. The science of climate will evolve. The significant new scientific insights revealed in the fall of 1991 regarding the indirect effect of CFCs on lower-stratosphere ozone illustrate the importance of flexibility. New findings also indicate that sulfur aerosols produced by fossil fuel combustion have an important cooling effect on the lower atmosphere, offsetting some of the warming effect of the CO2 produced by such combustion.[40] By constantly renewing attention to all the important factors, a comprehensive approach keeps policymakers from targeting policy at one aspect of the issue only to discover later that the target has moved.

B. Economic Advantages

Another lesson from the history of environmental policy in the United States is that piecemeal approaches which regulate only a part of a problem are substantially more costly than those that allow greater flexibility and expand control opportunities. Prior to the 1990 Clean Air amendments, US policy for dealing with sulfur dioxide emissions focused on sulfur emissions from new sources and required at least partial use of scrubbers from all such sources. Under the acid rain provisions of the 1990 Clean Air Act, ambitious sulfur control requirements are extended to all utility sources. But sources are allowed the flexibility to achieve reductions in any way they choose -- whether through use of scrubbers, low-sulfur coal, new combustion technologies, or reduced electricity generation due to conservation and demand-management techniques. Moreover, sources that reduce sulfur emissions further than they

---

[39] If the biomass were sustainably harvested and if it sequestered as much CO2 as the forest (including its root and soil matter), no net carbon would be lost on the sink side, and the biomass would still offset combustion of fossil fuel.

[40] IPCC 1992 Supplement, supra n. , at 20-21.

are required may sell their excess reductions to others who find it more difficult or costly to achieve reductions. The flexibility afforded by this approach is projected to save billions of dollars compared to an approach imposing specific, uniform controls.[41]

The comprehensive approach affords nations similar flexibility in limiting net GHG emissions by allowing them to choose among all GHGs, their sources and sinks, in meeting GWP limitation obligations. Because of the heterogeneity of GHG limitation opportunities and costs in different nations, the comprehensive approach should yield large cost savings compared to a piecemeal approach that requires uniform controls for each gas or sink. Different nations have very different portfolios of GHGs and sinks. For example, US CO2 emissions are over six times greater, in terms of GWP, than US methane emissions. In India, by contrast, methane emissions are twice as large a share as CO2 emissions.[42] More importantly, the marginal costs of net GHG limitations within a nation will vary considerably across different gases, their sources and sinks. These sector-by-sector marginal costs will also vary among nations. A comprehensive approach allows each nation the flexibility to select that combination of GHG source and sink controls that is least economically and socially costly in achieving overall GWP limitations.

What is best for one nation will not necessarily be best for another. Depending on relative marginal costs, one nation might focus more of its energies on limiting CO2 emissions from the energy sector, another on limiting methane emissions from agriculture, a third might stress afforestation, and a fourth, concentrate on reductions in pollution that cause tropospheric (low-atmosphere) ozone. A piecemeal approach that requires each nation to achieve specific, uniform levels of control for each gas or sink ignores these variations in national GHG inventories and control costs, and is bound to increase substantially the cost of achieving a given level of limitation of GWP. The excessive costs of a piecemeal approach will be even greater if controls are targeted on particular sectors or if "best available technology" requirements are imposed.

The superior cost-effectiveness of a comprehensive approach is important because the long-term costs of significant limitations on

---

[41] Economic Report of the President (1990) at 194-95; US National Acid Precipitation Assessment Program (NAPAP), 1990 Integrated Assessment Report (Nov. 1991) at 433, 510.

[42] Data from US EPA/OPPE (1990).

net GHG emissions could be large.[43] The amount of savings from using a cost-effective approach can be commensurately large. The cost savings associated with the flexibility offered by the comprehensive approach to address all GHG sources and sinks, rather than being compelled to obtain all reductions out of energy sector CO2 alone, could be quite dramatic: in the US, for example, to achieve an equivalent goal (defined in GWP) could cost as much as 90% less under the comprehensive approach than under the energy-CO2-only approach.[44]

In particular, a CO2-only approach would ignore some of the most promising, lower-cost opportunities for reducing net GHG emissions. For example, reducing CH_4 leakage itself may be a cost-effective means to reduce contributions to potential warming.[45] CH_4 is itself the product being transported and sold in natural gas systems, providing an economic incentive to capture fugitive CH_4

---

[43] See, e.g., Bradley et al. (DOE Sept. 1991), infra; Bruniaux, et al. (OECD June 1991), infra; US Interagency Task Force, The Economics of Long-Term Global Climate Change (CEA/DOE: Sept. 1990); Economic Report of the President (Feb. 1990).

[44] As an illustration, DOE estimates that to reduce US energy-sector CO2 emissions by 20% from 1990 levels by 2010, using a tax on the carbon content of fossil fuels, would require a tax of $539 per metric ton of carbon put in place after 1990 and would impose a total economic cost of $128 billion per year in 2010. To reduce US net GHG emissions from the energy sector by the same degree, using a GWP-weighted tax on fossil fuels, would require a tax of $180 per metric ton of carbon-equivalent and would impose a total economic cost of only about $30 billion per year in 2010. See Richard A. Bradley, Edward C. Watts & Edward R. Williams, Limiting Net Greenhouse Gas Emissions in the United States, Volume II: Energy Responses at 8.10-8.12, (US Dept. of Energy, Office of Environmental Analysis, Sept. 1991). Hence even when constrained to act only within the energy sector, broadening from CO2 to all GHGs reduces costs by about 75%. Broadening beyond the energy sector to a full net GHG emissions approach reduces costs further: applying the GWP tax and in addition allowing a refund for reforestation activities that sequester CO2 would lower the total cost in 2010 to about $6-10 billion -- over 90% less than the CO2-only, energy-only policy. Id. at 8.12. Note that these figures should be taken only to illustrate the likely range of cost savings, since they depend in part upon the IPCC's 1990 GWP figures, which are being recalculated.

[45] E.g., Rabchuk and Ilkevich, supra n. at 12, calculate that recovering 1/2 to 2/3 of the gas leaking from main pipelines in Russia would cost about 50-90% of the cost of equivalent new production.

emissions,[46] but leakage will persist where energy markets are not competitive or where the cost of capture exceeds the revenue that the capturer can gain from the recovered CH_4. Leakage from landfills, coalbeds, and ruminant animals might also be recovered for use as fuel, or otherwise reduced.[47]

C. Promoting the Likelihood of International Agreement

Reaching international agreement on GHG limitations will be difficult because of differing national interests.[48] Some nations, such as low-lying island and coastal nations or nations in Africa already threatened by decertification, may feel more immediately and severely threatened by global climate change than others. Nations where little temperature change is expected to occur,[49] or where the costs of adaptation would be small,[50] may have little incentive to limit emissions. Meanwhile, the burdens of different types of GHG limitations will be different in different nations. Countries like the US and Canada with low population densities who rely heavily on fossil fuels, and the OPEC nations who sell such fuels, would probably be disproportionately burdened by limitations on CO2 emissions. Nations that rely on forest clearing to feed their populations or generate export income would be disproportionately burdened by specific controls on reductions of CO2 sinks. Nations relying heavily on agriculture would be affected, in differing degrees, by limitations on N2O and CH4 emissions.

Faced with controls that would limit their economic development, the developing countries (DCs) will likely argue that there should be no (immediate) application of limitations to them, and that the industrialized nations have already "filled up the

---

[46] Hogan, Hoffman & Thompson, supra n. , at 181.

[47] Id.

[48] See James K. Sebenius, "Negotiating a Regime to Control Globasl Warming," in Greenhouse Warming: Negotiating a Global Regime (World Resources Institute, Jan. 1991).

[49] Relatively less temperature change is expected in the tropics, perhaps disinclining tropical nations to limiting emissions. William R. Cline, "Comments," in Dornbusch & Poterba, supra n. , at 225-26.

[50] Industrialized countries may face small costs from gradual warming. See William D. Nordhaus, "Economic Approaches to Global Warming," in Dornbusch & Poterba, supra n. , at 40-44; Schelling, in id., at 201-02.

global commons" with more than their fair share of GHGs.

These differing interests are likely to be reflected in the various equity arguments advanced by different nations in the negotiations over the structure of a limitations agreement. Some will emphasize current emissions as a starting point. Others will argue that the right to emit should be allocated by population, by development needs, or by energy efficiency. No single principle will win assent. Any agreement will be the product of tough bargaining, compromise, and convergence among different allocative principles.[51]

Use of a comprehensive approach in any GHG limitations agreement would advance the chances of an agreement, for two reasons. First, the superior cost effectiveness of a comprehensive approach will lower aggregate compliance costs compared to a piecemeal approach. By reducing the social and economic burdens of limiting GHGs, it should make all parties more willing to incur limitation obligations.

Second, a comprehensive approach establishes a level playing field among all nations at the table. Because of the differences among nations noted above, a piecemeal approach inevitably favors some nations while disproportionately burdening others. Nations who would be penalized by a proposed piecemeal measure will resist its adoption because of the distributional inequity involved and fears that the relative international competitiveness of its industry will suffer. A comprehensive approach provides a more equitable "level playing field" that does not favor some nations relative to others. It is therefore likely to increase the chances of international agreement on GHG limitations.

III. PRACTICAL CHALLENGES IN IMPLEMENTING A COMPREHENSIVE APPROACH

The initial reaction in the international community to the Bush administration's advocacy of a comprehensive approach was generally, though not uniformly negative. Because a comprehensive approach would involve more complexities and uncertainties than an approach limited to fossil-based CO2 emissions, and because it would take time to resolve these problems, many saw the proposed comprehensive approach as a smokescreen for inaction and delay. Today, there is growing recognition of the environmental and economic advantages of a comprehensive approach. Even many of those advocating early binding agreement on targets and timetables

---

[51] See generally ---- Chapman & ----- Drennan, "Equity and Effectiveness of Possible Carbon Dioxide Treaty Proposals," 8 Contemp. Pol. Issues no. 3, 16 (1990).

for limiting GHG emissions now advocate a comprehensive approach.[52]

A. Addressing practical challenges

Faced with current difficulties in measuring all the various GHG emissions sources and sinks, some have urged a "phased comprehensive" approach: agreement on fossil CO2 limitations now, and "later" enlargement of this agreement to include other gases and sinks as knowledge and monitoring capacities improve.[53] Based on todays' knowledge, technology, and data bases, it probably would be administratively easier to implement a limitations agreement restricted to fossil CO2 emissions than a comprehensive agreement. Our capacity to monitor fossil-based CO2 emissions from the important activity sectors -- energy, transportation, and industry -- is far better deployed than our capacity to monitor CO2 sinks, or emissions of many of the other GHGs. Many current studies confine themselves to energy policy alone simply for the reason that, in the words of one of the more candid analysts, "[t]his focus suggests itself because the necessary quantitative data for a least-cost analysis are far more developed in the case of energy than for other major sources of greenhouse gases."[54]

But this is not sufficient justification for pressing forward with an immediate piecemeal agreement on CO2 emissions. First, if one is truly concerned about the potential for climate change from anthropogenic GHGs, adopting a CO2-only approach is no solution: ignoring the hard-to-measure gases will not make them go away.

Second, looking ahead, a piecemeal CO2-only policy would provide to develop a no encouragement to the additional research

---

[52] E.g. Norway, Canada, Australia.

[53] One commentator has argued that waiting to take any action until every emission of every GHG is precisely measurable would be a "compulsive comprehensive approach." This caricature is instructive, but no one has made this proposal. Meanwhile the proposal billed as "phased comprehensive" under which we "proceed gas-by-gas, starting with energy sector CO2 and address the other GHGs 'later,'" is really "costume comprehensive." "Later" is undefined, illusory and fails to grasp the real policy problems and dynamic incentive implications. As we argue below, the practical middle ground is to establish a framework for full accounting and for cost-effective actions that is coextensive with the broad scope of the environmental issue, and that provides appropriate incentives for improved measurement.

[54] F. Krause, et al. Energy Policy in the Greenhouse (1989) Vol. One, I.1-3.

work that is needed. By placing no policy value on non-CO2 emissions, it offers no reward to those who develop means to monitor and control non-CO2 gases. This monitoring work will be needed if only to be able to predict future emissions and concentrations. The design of the comprehensive approach, by contrast, ensures that the incentives for research into the key unknowns are provided. Measuring many GHG emissions will not be easy. But it is not beyond our reach, if we focus current research efforts to support a comprehensive approach. Indeed, the IPCC and many countries, including the US, are rapidly moving ahead to perform this research, following a comprehensive agenda.

Third, the important issue is not what is administratively "feasible" today, but whether the costs of proceeding with a flawed piecemeal policy design are less than the costs of doing the necessary groundwork to develop a comprehensive approach. The serious defects of piecemeal environmental policy design, summarized above, suggests that pursuing such a policy may even worsen climate risks -- hardly a solution that environmental advocates should espouse.

Fourth, piecemeal approaches tend to entrench themselves by favoring certain nations and economic interests that develop a vested stake in their perpetuation. Experience shows that, once adopted, piecemeal initiatives rarely evolve into a comprehensive strategy. Those interests that are competitively favored by piecemeal approaches block changes that would reduce this advantage. As a result, U.S. environmental regulatory policy, which started down a piecemeal path over twenty years ago, remains largely piecemeal today, resulting in serious economic efficiencies and competitive distortions. For example, the Prevention of Significant Deterioration provisions of the Clean Air Act limit industrial development in many "cleaner" regions of the United States, often without substantial environmental justification. But modification of the PSD provisions is opposed by political representatives from "dirty" regions, who fear that their removal will lead industry to migrate to the cleaner regions.[55]

This experience is ignored by those who argue that a piecemeal approach should be adopted initially, and expanded into a comprehensive approach later on. Those nations that were favored by the initial piecemeal measures would resist development of a more comprehensive approach that would treat all nations with an even hand. The resulting entrenchment of a piecemeal approach would produce incomplete environmental protection and serious economic distortions and inefficiencies. It is accordingly essential to insist that a comprehensive approach be adopted from the start, rather than beginning with a defective design that will perpetuate itself.

---

[55] See Peter Pashigian, "Environmental Regulation: Whose Self-Interests are being Protected?" 23 Economic Inquiry 551 (1986).

Fifth, there is in any event unlikely to be any broad international agreement on CO2-only limitations in the near future. One of the major obstacles to such an agreement is that a CO2-only approach would disproportionately penalize some nations or groups of nations, such as the United States and the OPEC nations. And a CO2-only approach misses much of the environmental variable of interest, namely net GHG emissions. The adoption of a comprehensive approach is likely to be a necessary (though not sufficient) condition of any far-reaching international agreement on GHG limitations.

Sixth, as explained more fully below, one can design a comprehensive approach in ways that takes due account of gaps in our knowledge respecting some GHGs, sources and sinks, while simultaneously providing incentives to close those gaps. These gaps principally concern two items: the development of a GWP Index, and the development of reliable monitoring and data collection capacity to measure the impact of various source and sink activities on net GHG emissions.

B. Developing a GWP Index

The development of a GWP index will be a process of international scientific consensus. The extent of international scientific exchange and collaboration fostered by the IPCC, and the extent of convergence on common assessments of GHG issues, has been remarkable. The United States is currently spending well over $1 billion annually on global climate research,[56] and the other nations of the world are together spending a like amount.[57] At this level of effort, it should be possible to develop a reliable GWP index by the time that a binding international agreement on quantitative GHG limitations is a realistic possibility.

Difficulties are undoubtedly presented by the estimation of atmospheric residence time. Because of gaps in knowledge regarding sink removal and recycling rates and atmospheric reactions, there is uncertainty about exact residence time for key GHGs. These uncertainties seem to be greatest for CO2, which cycles in and out of the atmosphere every few years and is not actually "retired" into the deep ocean or soil matter for over 100 years. Relative residence time has important policy implications, for it is presumptively more valuable, all other things being equal, to limit emissions of a GHG with a long residence time as compared with one that has a shorter residence time, because the longer-lived gas

---

[56] See US Government Printing Office, Our Changing Planet: The FY 1992 US Global Change Research Program, A Supplement to the US President's FY 1992 Budget (1991).

[57] ??

will contribute to the global warming effect for a longer number of years.[58] But how much weight should be given to this factor? Is reduction of one GWP unit of a GHG with a 100 year residence time equivalent to reduction of 10 units of a gas with a 10 year residence time?

A related issue has to do with the "time horizon" over which the GWP is calculated. On conventional economic analysis, adverse effects occurring 100 years from now should be discounted much more steeply than effects occurring ten years from now.[59] Presumably the relative damage of a unit of warming 100 years from now will be less than the same unit of warming today, because we will have learned better ways to adapt, and will have more resources with which to do so, in the future. An alternative to straightforward annual discounting is to use a fixed time horizon in constructing an index, taking into account only the radiative forcing exerted during that time horizon. The longer the time horizon, the greater the relative weight given to longer-lived gases. The IPCC is using time horizons of 20, 50, 100, 200 and 500 years. The choice among these is, however, primarily a question of policy rather than science. A shorter time horizon (higher discount rate) reflects greater concern over the short-term rate of warming, whereas a longer time horizon (lower discount rate) reflects greater concern over ultimate equilibrium temperature levels.[60]

A third difficulty is presented by differences in GHG reactivities and other atmospheric interactions that indirectly affect global climate. Reactions are important sinks for some GHGs, such as methane (CH4). Other gases, such as NOx, CO, and VOCs are precursor gases; they react in the atmosphere to form tropospheric ozone, which exerts a radiative forcing effect although they do not. Hence, their GWP is indirect. NOx and CH4 have other indirect effects that are being intensively studied. For example, CH4 reacts in the atmosphere to produce tropospheric ozone, stratospheric water vapor, and CO2. The difficulties in estimating the "indirect" component of the CH4 GWP are being aggressively pursued, and may be substantially resolved by the time this article is published.

Significant and rapid progress is being made in resolving the

---

[58] A further consideration is reversibility. An erroneous underestimate of the severity of global climate warming is harder to reverse if the gases being emitted are relatively long-lived.

[59] See Daniel Lashof and Dilip Ahuja, "Relative Warming Potentials of Greenhouse Gas Emissions," 344 Nature 529 (April 5, 1990).

[60] This feature of the time horizons is well recognized by the scientific community. See WMO, supra (Dec. 17, 1991), at 7.4-7.5.

relevant uncertainties. There is no reason to suppose that a workable GWP index for all GHGs cannot be developed by the time that a broad international agreement on GHG limitations is likely. Moreover, absolute precision is not needed for practical use. Just as "uncertainty is no excuse for inaction," the existence of some residual uncertainty is not a sufficient justification for restricting a limitations agreement to a single gas, such as CO2. Such a policy would, in effect, establish a GWP index that implicitly assigns a weight of zero to all other GHGs. This error is far greater than any that would be made in including them. Some weighing system, implicit or explicit, is inevitable in any policy response to GHG emissions. It is preferable that the weighing be made explicit, and that the relevant science be pushed forward to make that weighing as accurate as practicable.

Nor is a different conclusion warranted by recent scientific developments that indicate that CFCs in the aggregate may have no net effect on global temperature. Removing CFCs from the analysis makes CO2 relatively more important, but it simultaneously increases in the same proportion the importance of the remaining GHGs, including methane, N20, and the HCFCs being developed to replace CFCs because of concerns about ozone depletion. Accordingly, use of a comprehensive approach is as important as ever. In addition, if CFCs have no net warming effect, then net GHG emissions during the past decade were about 25% lower in GWP than previously thought. Because the pressures on the commons have been less severe than we thought, the case for immediately pushing forward with a piecemeal approach is weakened.[61]

Finally, as detailed above, eventually it would be desirable to include environmental effects other than GWP in the construction of a more complete GHG index, in order that policy measures be directed at all of the environmental effects of concern. Ignoring those other effects could reduce overall well-being by restricting GWP but also forfeiting other benefits or exacerbating other ills.

C. Measuring Net Emissions

In order to implement and verify compliance with any emissions limitation agreement, one needs reliable methods for estimating the amount of net GHGs resulting from various activities. It will generally not be feasible to measure emissions of GHGs directly. As is so often the case in environmental regulation, policy measures must be addressed to variables that are proxies or surrogates for the environmental agent of ultimate interest. Even in the case of fossil-based CO2 emissions,

---

[61] On the other hand, the GWP reductions that had been expected to result from the phase-out of CFCs are no longer in prospect.

emissions are indirectly calculated on the basis of the carbon content of fuel and combustion characteristics, although the methodology and data involved are highly reliable. Because of existing regulatory controls on emissions of VOC, HC, and NOx, their emissions can be monitored with considerable reliability, at least in the industrialized countries. HCFC production can also be determined fairly easily. But the necessary methodology and data are far less well developed for emissions of methane and nitrous oxides, for emissions of CO2 from deforestation and land use, and for CO2 sink uptake and storage.

In order to close this gap, emission factors should be developed. Take, for example, methane. Leaks from natural gas pipelines can be estimated without great difficulty. But diffuse, non-point sources present much greater difficulties. For example, methane emissions from an acre of a given type of rice paddy or a cow of a given type with a given feed could be measured. These measurements could be used to construct a factor index that allows one to calculate emissions from a rice farm of given size or a herd of given numbers. In order to develop the data base needed to use this index, one must inventory the amounts of different types of rice paddies or cattle and feed. Similar steps must be taken to develop indices and data bases for N2O emissions and for different types of sinks. For example, the capacity of different types of forests to store carbon differs substantially, depending on the soil and terrain, species, survival rate, and local climate.[62] These differences must be embodied in workable emissions factors and reflected in inventories.[63]

Substantial work on solving these problems is already underway. A comprehensive understanding, at the earliest feasible time, of the sources and emissions rates of all GHGs and of uptake by different GHG sinks is needed for reasons independent of the scope of any international agreement limiting net GHG emissions. The development of accurate global climate models and sound policy analysis requires an accurate determination of existing baselines and future emissions trends. A better understanding of net emissions and source-sink balances is also needed in order to reduce uncertainty regarding atmospheric residence times and thereby develop a more accurate index of the comparative GWP of different GHGs. The likely emergence of a "national strategies"

---

[62] See M. Harmon, W. Ferrell, & J. Franklin, "Effects on Carbon Storage of Conversion of Old Growth Forests to Young Forests," 247 Science 699 (Feb. 9, 1990).

[63] Work on methane emissions factors and emissions measurement has progressed considerably in the past two years. See Hogan, Hoffman & Thompson, supra; IPCC, Methane Emissions and Opportunities for Control (Sept. 1990); IPCC, Methane Emissions Reduction Opportunities Report (forthcoming 1992).

approach in an initial framework GHG convention will provide a further impetus to the development of better techniques and data to measure net GHG emissions resulting from different human activities.

As in the case of GWP indices, perfection is not necessary. It is far better to use somewhat rough but workable emissions factors and data rather that to ignore significant components of the GHG problem entirely. To the extent that substantial deficiencies in the development of indices or in data remain if and when an international agreement on binding quantitative emissions limitations is in prospect, the resulting uncertainties can be handled by conservative accounting methods. A nation claiming credit for limitations on activities that emit GHGs or for sink expansion would receive credit towards compliance with its emission limitation obligations only to the extent of net CO2-equivalent emission reductions found, by an international process of scientific consensus such as that created under the framework convention, to be adequately verified by method and data. For example, if estimations of methane emissions from rice paddies have an estimated error of plus or minus 50%, one might give less than full credit for the limitation claimed, discounting it by 25% or even 50%.

This "discount" approach would give those nations, and those relevant industries, who have an interest in claiming credit for such emissions reduction measures a powerful incentive to accelerate the research and data collection needed to resolve the uncertainty and receive full credit. Of course, all emissions factors and data banks would have to be revised in light of ongoing advances in scientific knowledge. But the alternative -- a "phased" approach in which the international community determines that CO2 reductions alone will receive credit until some later date at which other GHGs will be recognized -- is counterproductive. In addition to the danger of entrenchment, as discussed above, such an approach provides no incentive for improved measurement of the ignored GHGS.

In addition, a climate change convention should establish a process for collection by an international body of self-reported data on the activities of nations in limiting GHG sources or reducing or enhancing sinks. This inventory will be necessary in order to analyze global emissions trends and their relation to climate change. They will also provide publicity that will encourage signatory states to adhere to their obligations. Ideally, these reports should be audited through on-site inspections, satellite observation or other methods of remote sensing, and other techniques, although the use of such techniques by an international authority will be controversial.

IV. INTERNATIONAL EMISSIONS TRADING

Assuming an international agreement to limit net GHG emissions on a comprehensive basis, there are a variety of policy instruments that could be used domestically within any given nation to achieve its obligations. These include command-and-control regulations, government ownership or management of relevant resources, charges and taxes, tradeable allowances, and various forms of subsidies. Nations should have the flexibility to use whatever combination of instruments they wish in order to meet their obligations.[64] There is, however, increasing interest in the use of economic instruments to deal with environmental problems generally and GHG emissions in particular.[65] The United States has already successfully used tradeable emissions allowances to deal with several environmental problems.[66] It is gearing up to apply emissions trading on a broad scale to reduce sulfur emissions[67]; this program will also have the indirect benefit of reducing CO2 emissions.[68] The European Community is considering a carbon tax to reduce fossil-based CO2 emissions.[69]

---

[64] The use of some policies, e.g. subsidies, may be limited for trade policy reasons.

[65] See, e.g., Robert Hahn & Robert Stavins, "Incentive-Based Environmental Regulation: A New Era from An Old Idea?", 18 Ecol. L. Q. 1 (1991); Robert Stavins, "Harnessing Market Forces to Protect the Environment," Env't, Jan.-Feb. 1989 at 5 (summarizing Project '88); Richard B. Stewart, "Controlling Environmental Risks Through Economic Incentives," 13 Colum. J. Envtl. L. 153 (1988); Thomas Tietenberg, "Economic Instruments for Environmental Regulation," 6 Oxford Rev. Econ. Policy 17 (1990).

[66] See Stewart, "Controlling Environmental Risks Through Economic Incentives," supra; Robert Hahn & Gordon Hester, "Marketable Permits: Lessons From Theory and Practice," 16 Ecol. L. Q. 361 (1989); Daniel J. Dudek, Richard B. Stewart & Jonathan B. Wiener, "Environmental Policy for Eastern Europe: Market-Based versus Technology-Based Approaches," 17 Colum. J. Envtl. L. 501 (1992).

[67] Clean Air Act Amendments of 1990, Title IV, codified at 42 U.S.C. { 7651. See Economic Report of the President (1990) at 193-97; Daniel J. Dudek, "Emissions Trading: Environmental Perestroika or Flimflam?", Electricity J. Nov. 1989.

[68] By allowing firms the flexibility to adopt the cheapest measns to reduce SO2, the act will encourage energy conservation. See Dudek, LeBlanc & Miller, supra.

[69] See text accompanying n. , supra.

In the international context, the advantages of a comprehensive approach can be most fully realized if any agreement on GHG limitations allows different nations or facilities in different nations the flexibility to invest in GHG reductions wherever in the world those investments are most cost-effective. This flexibility would minimize the cost of any global effort to limit emissions while directing investments to their most valuable uses. Since GHG emissions mix globally in the atmosphere, what matters is the change in the net global flux of GHGs, and not where reductions are obtained. A kilogram of GHG emissions avoided in Poland or India is as climatologically relevant as a kilogram avoided in Paris or Indiana.[70] Yet the cost of avoidance may vary widely, so that an investment in the least-cost location would deliver much more emissions reduction than the same investment elsewhere.

A. Types of trading: formal and informal

The benefits of flexibility could be captured through "formal" or "informal" trading mechanisms. If an agreement establishes quantitative limits on each nation's net GHG emissions, the agreement could in effect give each nation an allowance of emissions up to the limit. A "formal" trading system would allow a nation with unused allowances, or firms within such nations, to sell those allowances outright to other nations or to firms in other nations. This system would enable emissions-reducing projects to be undertaken where they are most cost-effective. If the international agreement contains no overarching quantitative limits but an obligation on nations to develop national strategies to limit net GHG emissions, a kind of "informal emissions trading"[71] could be allowed: through "cooperative arrangements"[72]

---

[70] There is thus no significant risk of local "hotspots" in the GHG context, as there might be in trading emissions of, say, a toxic pollutant. In the toxics example, flexible location of reductions might in theory lead to bunching all the emissions at a very few locations, at which local toxicity levels might cross a threshold that might increase damages beyond the aggregate maximum goal. The major GHGs are probably less vulnerable to this problem than any of the several pollutants already regulated using emissions trading (e.g. lead, SO2), though certain minor GHGs that also happen to be local pollutants (e.g. CO, NOx) might pose hotspot issues.

[71] See Jonathan B. Wiener, "The Comprehensive Approach, Greenhouse Taxes, and Informal Emissions Trading," OECD Workshop Papers on GHG Emissions Trading and Taxes (forthcoming 1992).

[72] US Submission to INC Climate, March 15, 1991, at 4, 5.

or "joint implementation,"[73] nations could invest in overseas net emissions limitation efforts as part of their national strategies. In both the "informal" and "formal" cases, these investments or allowances could be expressed in carbon equivalents using an index like GWP.

B. How trades could occur

These international investment arrangements would be wholly voluntary. Consenting adult nations would fashion agreements to meet their mutual interests. For example, the United States might offer to provide capital and technology to Brazil for the construction of a plant for manufacture of energy-efficient refrigerators. The refrigerators manufactured by the plant would reduce Brazil's emissions of CO2 below what they otherwise would be, freeing up net GHG emission allowances that it would otherwise have had to use. In return Brazil could offer to give a portion of those unused allowances to the US. The amount would be agreed between the US and Brazil. The US could then use these allowances to cover US emissions that would be more costly to control than investing in energy efficient refrigerators in Brazil.[74] Similarly, the US and Brazil could enter into an agreement in which the US would assist in the conservation of Brazilian CO2 sinks, in return for an agreed portion of the emissions credits thereby generated. In like fashion, other countries where the cost of limiting emissions is high, such as Japan, could invest in projects in countries where the marginal cost is low, such as China. The investor country could receive emissions allowances; the host country would receive new resources and technologies.

If the right to trade were extended beyond nations to domestic entities, a U.S. firm could, for example, provide the capital and technology for such a plant to a firm in Brazil and receive allowances as compensation. The US firm could use the allowances to cover its own emissions or, more likely, sell them for cash to another U.S. firm or a firm elsewhere in the world to cover that firm's emissions. Such trades would effectively create a market in greenhouse emission allowances. Firms for which net GHG emissions reductions are relatively cheap would reduce net emissions and sell allowances. Firms for which reductions were relatively costly would buy allowances. The extension of trading to firms as well as nations would substantially increase economic efficiency and stimulate environment-friendly technological innovation by creating a worldwide market in GHG limitation opportunities.

---

[73] Norwegian proposal at INC-III, Nairobi, Sept. 1991.

[74] This example is elaborated in James T.B. Tripp & Daniel J. Dudek, "Comments of the Environmental Defense Fund on the IPCC Working Group III Economic Measures Paper," Jan. 1990.

An important precedent for voluntary international trading is found in the amended Montreal Protocol, which provides (under the label of "industrial rationalization") for some CFC production trading among producers in different nations with the concurrence of the governments involved.[75] One might expect that informal international trading would initially begin on a bilateral or regional basis, such as US-Canada[76] or within the European Community. Trades might also be made a feature of bilateral assistance agreements and debt-for-nature swaps. As experience with trading grew, one could expect the gradual development of a worldwide market and the emergence of a stock exchange system of trading.[77]

C. Advantages of trading

A trading system would have several important virtues. First, it would markedly reduce the costs of achieving a given level of net GHG limitation. Without trading, each nation can invest in emissions limitations only within its own borders. In effect, each nation must be self-sufficient in the industry of limiting emissions. Under emissions trading, however, it can invest in GHG reductions anywhere in the world, just as today nations can purchase other products in a world market and are rarely self-sufficient in major industries. The cost reductions provided by the opportunity to trade could be substantial, because the marginal cost of avoiding a unit of GHG emissions varies widely across countries.

A recent OECD study, for example, found that in order for every country in the world to reduce CO2 emissions 20% from its 1990 levels by 2020, countries would have to impose widely different taxes: a tax in 2020 of about $950 per ton of carbon in the OECD-Pacific region (Japan, Australia and New Zealand); about $210 in OECD-Europe and OECD-North America (the US and Canada);

---

[75]

[76] US EPA and Environment Canada are conducting a joint study of emissions reduction opportunities that could be pursued in concert.

[77] In the US, the Chicago Board of Trade has indicated interest in offering a futures market for sulfur dioxide emissions reduction credits created pursuant to the sulfur trading provisions of the 1990 Clean Air Act Amendments. The New York Mercantile Exchange has expressed interest in hosting a current SO2 credits market. See "Efficient-Markets Pollution," Wall St. J., March 2, 1992, at A12, col. 1.

about $100 in the USSR area; and only about $60 in China.[78] This spread in costs indicates that it is much more expensive to achieve equivalent emissions limitations in some places (e.g., Japan) than in others (e.g., China). Allowing international trading would enable high-cost countries to invest in areas where the cost of avoiding emissions is lower, reducing the overall global cost. In the OECD model, allowing trade reduces the average global tax in 2020 from $215 per ton of carbon to $152,[79] and global economic welfare falls by only 1% instead of the 1.75% drop estimated to occur from the CO2 limitation without international trading.[80] The flexibility to invest internationally thus achieves about a 40% reduction in total economic cost.[81]

Second, trading would enhance the chances of a broad international agreement on limitations by further lowering the costs of achieving a given level of limitations. It would also ameliorate one of the largest obstacles to securing such an agreement: the simultaneous insistence by the developing countries (DCs) that they need high GHG allowances in order to industrialize, and resistance by the ICs to any limits on their emissions that entail high compliance costs. By reducing ICs' compliance costs by expanding the portfolio of limitation opportunities, trading should make ICs willing to give DCs a relatively larger initial allocation of allowances.

Third, trading would help address a central problem: in the decades ahead the greatest potential increases in GHG emissions will occur in the DCs, as they strive to industrialize. Already the divergence in emissions growth is striking: from 1975-85, CO2 emissions grew barely at all in OECD countries while they grew at over 5% per year in China and over 2% per year elsewhere.[82] While CO2 emissions are projected to grow at about 1% per year in the OECD from 1990-2020, they are projected to grow at about 2.2%-4.7%

---

[78] J.M. Burniaux, J.P.Martin, G.Nicoletti & J. Oliveira Martins, "The Costs of Policies to Reduce Global Emissions of CO2: Initial Simulation Results with Green," Working Paper No. 103, Dept. of Economics & Statistics, Organization for Economic Cooperation & Development (OECD) (Paris 1991), at 26-30 & table 6.

[79] Id. at 34-36.

[80] Id. at 10 (using household real income as a measure of economic welfare).

[81] As a reference point, recall that the opportunity to trade SO2 reduction credits in the US acid rain program, an extremely important cost-cutting measure, is projected to cut costs by about one-quarter. See n. & accompanying text, supra.

[82] See Bruniaux, et al., supra n. , at 27, table 5.

per year in China and 2.2%-3.5% elsewhere over the same period.[83] Key DCs such as India and China have enormous coal reserves that they want to use for industrialization. Meanwhile, the deforestation contributing 10-30% of net GHG emissions is occurring almost wholly in DCs.[84]

In this context, limiting emissions in the ICs alone would not make much of a dent in future global net GHG emissions. Yet DCs do not want to restrain their economic growth. In order to continue growing on a path that does not entail high GHG emissions of the sort experienced by current ICs, a flow of capital and technology from the ICs will be required to help the DCs "leapfrog" to a low-emissions development path. It is therefore unsurprising that DCs are demanding, as a condition for signing a GHG limitations agreement, substantial transfers of capital and technology from the ICs. Pressing further, DCs tend to demand technology on a "concessional" or "noncommercial" basis, not conditioned on emissions limitations, and a central fund from which DCs could draw financial resources.

An emissions trading system could provide a more effective and efficient way to transfer capital and technology from the ICs to the DCs, on a mutually voluntary basis, to the benefit of both. Since the growth in emissions is likely to occur in DCs and the marginal cost of achieving reductions is lower in DCs, under an emissions limitation agreement there would be an incentive for ICs to invest in emissions-avoiding projects in DCs. This mechanism would mean both lower cost to the ICs to achieve their emissions limitation and a flow of resources and technology to DCs. The OECD modelling exercise described above showed just this result: allowing international emissions trading cut total costs by 40%, with especially large savings in the OECD-Pacific countries, while generating a revenue flow to China of about $60 billion by 2020.[85] Under an agreement calling for "national strategies" and allowing "informal trading" as described above, ICs would similarly be likely to invest some resources in emissions-avoiding projects in DCs.

International trading could also be used under a limitations

---

[83] Id. (summarizing projections by OECD, Manne & Richels, Edmonds-Reilly, and IEA).

[84] IPCC Response Strategies (1990).

[85] See Bruniaux, supra n. , at 10-11, 34-36. Several ICs are already engaged in "technology cooperation" efforts with DCs as a part of the ICs' strategies for dealing with net GHG emissions. E.g., US "Technology Cooperation Related to Global Climate Change: A Selected Inventory" (Dec. 1991).

agreement restricted to a given GHG, such as fossil-based CO2.[86] But the cost savings from trading and the potential of trades to provide needed transfers of capital and technology to the LDCs are maximized under a comprehensive approach.

D. Challenges in implementing trading

It is often pointed out that emissions trading would require accurate monitoring of net emissions. That is of course true, but accurate monitoring will be required in order to secure compliance with any agreed-on limitations, regardless of whether trading is allowed. The additional administrative task that trading would entail is the eventual development of a registry to keep track of trades and make sure that existing inventories are consistent with the record of trades. If domestic entities are allowed to trade as well as nations, accounts must initially be kept at the national level, and then balanced on the international level. The additional administrative cost of establishing such a global "green" SEC should, however, be substantially less than the cost savings and other benefits obtained by trading, and might be funded through a nominal charge levied on trades.

The design of a trading system must accommodate special concerns of the DCs that the as the trading market operated, developed nations might "buy up" most of their allowances, condemning them to perpetual underdevelopment. This concern could be addressed by making allowances only leasable, by limiting their duration, or by limiting the percentage of any nation's allowances that may be leased. But it seems economically unlikely, since the allowances would be sought by a variety of competing ICs and could carry a significant price tag. If it is a real concern, some thought might be given to international rules of antitrust (a prospect that could implicate other commodities in international trade as well).

Perhaps more difficult is the concern expressed that, even if the trading market were competitive, future generations of DC citizens might be "sold out" by unscrupulous DC governing regimes who would take the profits from underpriced allowance sales and exit the scene. This concern besets the entire future of countries for which it is relevant, and it is hard to see how the addition of GHG emissions trading would decidedly worsen the problem. Moreover, corrupt leaders (in any country) could sell out their populations at the bargaining table on the initial climate agreement itself. But the simple answer to this concern is to make the allowances leasable, say for one-year or five-year increments,

---

[86] See Daniel J. Dudek & Alice M. LeBlanc, "Offsetting New CO2 Emissions: A Rational First Greenhouse Policy Step," 8 Contemp. Policy Issues 29 (July 1990).

so that the DC would not irrevocably lose ownership over its allowances each time they are traded in the marketplace.

E. Emissions taxes as an alternative

Emission charges or taxes are another form of economic instrument that could be used to achieve cost-effective reduction of net GHG emissions in conjunction with a comprehensive approach. The GWP index and emission indices could be used to impose a CO2 equivalent tax on all GHGs, sources and sinks. However, a tax set at levels that would provide significant incentives for substantial GHG limitations would generate enormous revenues. There appears to be little prospect that nations would give an international authority control over such revenues.

An alternative, now being explored within the European Community, is for each nation to impose such a tax in a multilaterally coordinated fashion, but for each to collect and keep the revenues itself. An immediate problem, not raised by tradeable allowances, is the need to set tax rates that are equivalent across widely different domestic tax structures and economies. A second problem is that in the context of an international GHG limitations agreement, many nations may prefer to use domestic instruments other than taxes or charges in order to achieve the emission limitations that they have agreed to. These alternatives include regulation, tradeable emission rights, and central state control of relevant resources. An internationally uniform tax or charge would greatly restrict national choice. A system of international trading, on the other hand, would not restrict choice among domestic instruments. Still, some homogeneity among nations in the choice of domestic instruments could be desirable (though not required) under emissions trading: the advantages of international trading would be maximized if subnational entities as well as nations are allowed to trade. The ability of subnational entities to trade internationally would be greatly enhanced if a nation adopted internal trading as well.

In principle, a tax approach and a tradeable allowances approach can be economically equivalent. If both policies are set to achieve the same emissions result, the price of an emissions allowance on the allowance trading market would be identical to the marginal tax rate on emissions. But there are likely to be some notable differences in practice. For example, if the marginal cost function is not precisely known, a quantity limit could unintentionally push the economy past a point of rapidly rising marginal costs, imposing higher total cost on society than initially deemed warranted. A tax approach may provide some security against this cost-side risk; but a tax would pose the countervailing risk of inadequately discouraging emissions, for example if the price elasticity of demand for emissions-related

goods and services were inaccurately estimated.[87] Which risk of error is more important to avoid depends on one's view of the social costs and social benefits of trying to prevent potential global warming.

There are common issues that must be faced under a tradeable allowances, tax, or performance-based regulatory approach. Issues of monitoring emissions and determining baseline emissions would arise with all approaches, since verifying the emissions level from each emitter would be critical to enforcing allowance limits, proper tax payments, or regulatory compliance. Issues of allocating emissions are relevant to every approach; tradeable allowances only makes the allocation decision explicit, whereas it is implicit in every other type of limitations policy. For example, requiring all nations to stabilize (or reduce) emissions would implicitly allocate existing emissions to existing emitters in proportion to their historical output, hence "grandfathering" their current entitlement. Imposing a tax on all current emissions implicitly burdens all emissions without any "grandfathered" entitlements. A tradeable allowance approach is open to a variety of allocation schemes, including grandfathered distribution or auction. In this way the allowance approach enables efficiency (least cost) and equity (distribution) to be separable. Finally, revenue is not a unique feature of tax approaches; allowances can be sold, leased or auctioned by the government in the first instance to generate revenue.

---

[87] See Weitzman, "Prices vs. Quantities," 41 Rev. Econ. Studies 477 (1974); Wallace E. Oates & Paul R. Portney, "Thinking About Policies for the Containment of Global Warming," RFF draft (Aug. 1991); Wallace E. Oates, "Pollution Charges as a Source of Public Revenues," paper for Egon Sohmen Foundation Conference on "Economic Evolution and Environmental Concerns" (July 1991).

CONCLUSION

A comprehensive approach to GHG issues is the only scientifically, environmentally, and economically sound strategy. Its adoption will increase the likelihood of successful negotiation of a broad international agreement on GHG emissions. During the next decade, the development of national strategies to deal with GHG emissions under the aegis of a framework convention seems most likely. The framework convention on climate change should mandate a "net GHG emissions" approach to these national strategies. Each nation would develop an inventory of its net GHG emissions, analyze future trends on a "business as usual" assumption, develop plans for limiting net GHG emissions, and develop a tracking system to determine progress. Second, the framework convention should mandate that any future protocol for binding limitations on GHGs (if any) would be similarly comprehensive.

Third, it should guarantee some form of credit or recognition for steps taken now that limit emissions, to be counted towards binding obligations if they are ever adopted. Such an "advance assurance" of a comprehensive approach would give nations the confidence to invest appropriately in limiting GHGs other than CO2, or in protecting and expanding sinks. Moreover, it would unleash the full panoply of "no regrets" actions[88] -- actions warranted for other reasons that also limit net GHG emissions[89] -- some of which nations might be holding in abeyance lest their early deployment forfeit credit against a future baseline for binding GHG reductions. Nations might then move forward with ideas they already know would be to their benefit, but are waiting in the wings until GHG credit is assured, perhaps including removing policies that spur excess deforestation,[90] internalizing the costs

---

[88] See Robert M. White, "The Great Climate Debate," 263 Scientific American no. 1 (July 1990) at 36, 41-43.

[89] See Council on Environmental Quality, ed., United States of America National Report to the UN Conference on Environment & Development 215 & n.23 (1992).

[90] See Robert Repetto, "The Forest for the Trees? Government Policies and the Misuse of Forest Resources," World Resources Institute (1988) (slowing tropical deforestation would be economically beneficial for local governments as well as environmentally beneficial, but perverse government policies continue to spur forest clearing); Robert N. Stavins & Adam B. Jaffe, "Unintended Impacts of Public Investments on Private Decisions: The Depletion of Forested Wetlands," 80 Am. Econ. Rev. 337 (1990) (similar for United States forests).

of energy systems and reducing energy subsidies,[91] reducing agricultural subsidies,[92] and making more rational use of water resources.[93]

Guaranteeing that the convention and its progeny take a comprehensive approach would itself be a "no regrets" strategy, as it would catalyze the research effort into GHG measurement that is needed if only to understand and predict future anthropogenic contributions to radiative forcing. It would mobilize development of a workable GWP (or other GHG index), emissions factors and inventory data banks for determining net emissions from various source and sink activities. These tools would be useful in predicting future radiative forcing, in making local technology choices, and in identifying opportunities for national strategy investments. If a binding agreement on quantitative limitations becomes ripe, a comprehensive approach would also be ready to implement with attendant cost savings and environmental benefits. These steps will enable the international response to GHGs and potential climate change to proceed on the only sound foundation: a comprehensive one.

---

[91] See Krupnick presentation, supra; Bruniaux et al., OECD "GREEN" Model (forthcoming 1992); Harold M. Hubbard, "The Real Cost of Energy," 264 Scientific American 36 (April 1991) (internalizing costs can improve economic efficiency).

[92]

[93]

Table 1

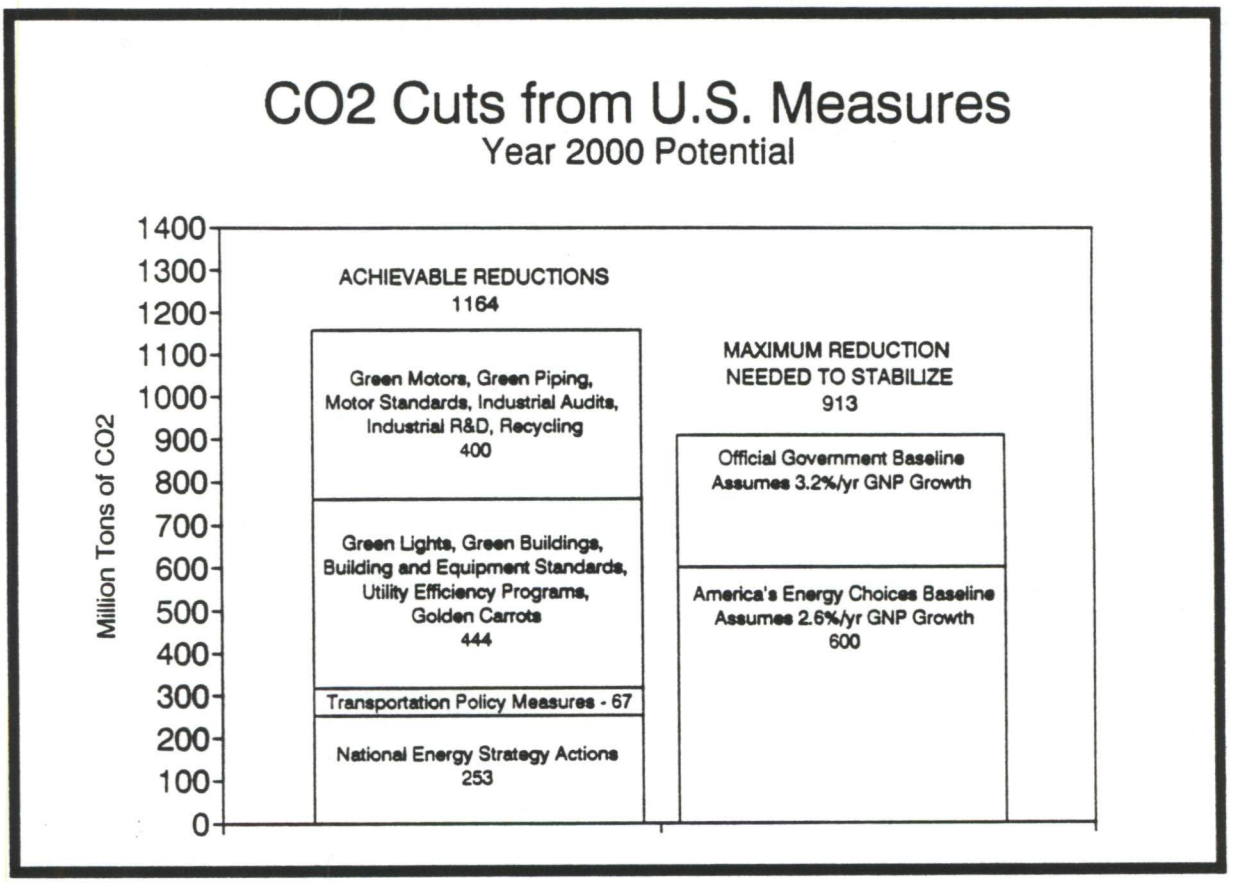
Selected Sources & Sinks Subject to Human Influence

Gas	Sources	Sinks
Carbon dioxide (CO2)	Fossil fuel combustion Land clearing Biomass combustion	Ocean biota & storage Forests Soils Grasses
Methane (CH4)	Livestock: enteric fermentation, wastes Rice cultivation Wetlands Landfills Natural gas extraction, transmission, distribution Coal mining Biomass combustion	Atmospheric OH interaction Soil removal
Nitrous oxide (N2O)	Agricultural fertilizers Land clearing Biomass combustion	Soil removal
Halocarbons (CFCs and related)	Refrigerants Aerosol propellants Foam blowing agents Solvents, cleaning agents Fire retardants	Recapturing and destroying existing supplies
Tropospheric Ozone (O3)	Precursors: CH4, CO, VOCs, in the presence of NOx Transport of strat. O3 into troposphere	Halocarbon depletion
Carbon monoxide (CO)	Fossil fuel combustion Biomass combustion Precursors: CH4, VOCs	Atmospheric OH interaction
Nitrogen Oxides (NOx)	Fossil fuel combustion Biomass combustion Agriculture	
Volatile Organic Compounds (VOCs)	Fossil fuel combustion Biomass combustion Industrial processes	Atmospheric OH interaction
Sulfur oxides (SOx)	Fossil fuel combustion Biomass combustion	Deposition

A CLIMATE FOR INVESTMENT

How the U.S. Can Stabilize CO_2 Emissions Through Profitable Measures the White House Already Supports

Daniel A. Lashof
David D. Doniger



Natural Resources Defense Council
March 19, 1992

EXECUTIVE SUMMARY

The United States has brought negotiations over an international treaty to curb the greenhouse effect to the brink of failure. After five rounds of treaty talks, the United States remains the only wealthy industrial nation unwilling to sign a climate treaty with a commitment, as a first step, to stabilize greenhouse gas emissions at 1990 levels by the year 2000. The treaty is to be signed at the "Earth Summit" in Rio de Janeiro this June.

Near the close of the last round of negotiations, the Bush Administration announced a four-page list of *New U.S. Measures to Mitigate Climate Change*. The document states that these are "measures the United States has begun to take" in various areas which will reduce emissions of carbon dioxide (CO_2) and other greenhouse gases. The Administration did not provide an estimate of the effect of the announced measures, although one was promised before May. The Administration continued to reject a legal commitment to stabilize CO_2.

The Natural Resources Defense Council (NRDC) has analyzed the CO_2 emission reductions that can be achieved by effectively implementing a portion of the measures on the U.S. list. NRDC's analysis shows that --

- The U.S. could stabilize CO_2 emissions at 1990 levels by 2000 through these measures, even using unrealistically optimistic economic growth assumptions.

- The measures would enable the U.S. to stabilize CO_2 emissions <u>at a profit</u>.

Our analysis shows that the total of reductions achievable by these measures, more than 1.1 billion tons of carbon dioxide, comfortably exceeds the growth projected in any of the baseline scenarios. In fact, if a reasonable baseline estimate of 600 million tons of CO_2 growth is used, then these measures could result in <u>reducing</u> total U.S. CO_2 emissions in the year 2000 by 10 percent below 1990 levels.

The emission reductions result from the Administration's National Energy Strategy (253 million tons), transportation policy measures (67 million tons), building efficiency measures (444 million tons), and industrial efficiency measures (400 million tons).

The Administration should have no fear of agreeing -- and has no excuse for <u>not</u> agreeing -- to a legally binding obligation to stabilize CO_2. Such a commitment is needed to secure an effective international treaty and to ensure effective domestic implementation of these measures. If the United States fails to commit to the minimal step of stabilizing CO_2 emissions, even in the light of clear evidence that it is profitable for the country, the Bush Administration will have irresponsibly undermined global progress toward protecting the Earth.

INTRODUCTION

The United States has brought international negotiations over a treaty to curb the greenhouse effect to the brink of failure.

After five rounds of treaty talks, the United States remains the only wealthy industrial nation unwilling to sign a climate treaty with a commitment, as a first step, to stabilize greenhouse gas emissions at 1990 levels by the year 2000. All other industrial nations -- the countries of the European Community (EC) and the European Free Trade Agreement (EFTA), Japan, Canada, Australia, and New Zealand -- are ready to sign such an agreement at the "Earth Summit" in Rio de Janeiro in June. The most specific proposal, from the European Community, would require stabilizing emissions of carbon dioxide (CO_2), the principal greenhouse gas, at 1990 levels by 2000.

A binding legal commitment to emissions stabilization is essential to the success of these talks. As Jean Ripert, the chairman of the negotiations, stated on February 28: "If there is to be a breakthrough in these negotiations, it will come when there is agreement on a formula reflecting an unambiguous commitment gradually bringing the greenhouse gas emissions of the industrialized countries under control." Unless the U.S. changes its position well before the last meetings in April and early May, the climate treaty negotiations will fail.

Near the close of the last round of negotiations, the Bush Administration announced a four-page list of *New U.S. Measures to Mitigate Climate Change*. The document states that these are "measures the United States has begun to take" in various areas which will reduce emissions of CO_2 and other greenhouse gases. The Administration did not provide an estimate of the effect of the announced measures, although one was promised before May. The Administration continued to reject a legal commitment to stabilize CO_2.

Issuing the list of measures (and an accompanying promise of limited funds to assist developing countries) represented a sign of movement. But the Administration must take the further step of agreeing to a binding stabilization commitment in order to avoid scuttling the climate treaty talks.

In this study, the Natural Resources Defense Council (NRDC) has analyzed the CO_2 emission reductions achievable through the U.S. list of measures. NRDC's analysis shows that these measures would easily permit the U.S. to stabilize CO_2, at a profit. NRDC's analysis is based on Department of Energy (DOE) documents, the *America's*

Energy Choices report, co-authored by NRDC and three other organizations, and data and analysis performed in preparation of that report.[1]

For this reason, the Administration should have no fear of agreeing -- and has no excuse for not agreeing -- to a legally binding obligation to stabilize CO_2.

The analysis is presented in three steps. First we discuss baseline projections of CO_2 emissions. Expected growth in CO_2 emissions determines the hurdle that must be cleared in order to achieve given stabilization or reduction requirements. Next we account for the CO_2 emission reductions that DOE projects for the National Energy Strategy. Finally, we examine the additional CO_2 emission reductions that can be achieved by implementing the most important elements of the Administration's list of "new measures."

BASELINE EMISSIONS

In determining what is necessary to stabilize carbon dioxide emissions, the first question is how much would emissions increase under "business-as-usual" or "baseline" conditions. While such projections are uncertain, government and private analyses can be used to indicate the range of emissions growth to be expected, and the range of emissions reductions that would be needed.

In the National Energy Strategy (NES), the U.S. Department of Energy projected emissions increases as follows. The NES "Current Policy Base Case" shows U.S. energy-related CO_2 emissions rising from 5254 million tons in 1990 to 6167 million tons in 2000. This would be an increase of 913 million tons.[2] This scenario is based on a highly optimistic assumption, dictated by the Council of Economic Advisors, that U.S. gross national product (GNP) will grow at an annual rate of 3.5% between 1990 and 1995, and that average GNP growth from 1990 to 2000 will be 3.2% per year. The NES base case also assumes that the output of energy-intensive industries, such as steel, aluminum, and cement, will grow at almost the same rate as GNP.

Most economic authorities consider this GNP growth estimate to be unrealistically high. In preparation of our report, *America's Energy Choices*, we used a GNP growth estimate drawn from DOE's *1990 Annual Energy Outlook*. There DOE estimated that

---

[1] *America's Energy Choices: Investing in a Strong Economy and a Clean Environment*, Natural Resources Defense Council, Alliance to Save Energy, American Council for an Energy-Efficient Economy, and Union of Concerned Scientists (1991).

[2] Figures are in short tons of carbon dioxide. These values include the conversion of energy-related carbon monoxide emissions to carbon dioxide in the atmosphere. DOE figures for CO reported as CO_2-equivalents were converted to actual CO_2 assuming that DOE had used a Global Warming Potential of 3 for CO.

GNP growth would average 2.6% per year from 1988 to 2000. Our report also assumed that, consistent with current trends, GNP growth will be led by the manufacturing-and-finishing and service sectors, with slower growth in the energy-intensive industries. In the Reference Case for *America's Energy Choices*, CO_2 emissions are projected to grow by 690 million tons from 1988 to 2000, or about 600 million tons between 1990 and 2000.[3]

CO_2 REDUCTIONS FROM THE NATIONAL ENERGY STRATEGY

The Department of Energy (DOE) projects that implementation of the NES will reduce CO_2 emissions in the year 2000 by a total of **253 million tons.** According to DOE, these reductions can be attributed to five categories of NES actions in roughly equal proportions:[4]

- Integrated resource planning (IRP) and energy efficiency research and development (R&D). Utility IRP (or least-cost planning) programs are designed to evaluate energy efficiency and electricity generation options on an equal footing in order to select the least-cost options. DOE plans to double its expenditures, from $3 million in 1991 to $6 million in 1993, on analytical support for states that are implementing utility IRP activities. DOE projects that the fraction of U.S. electricity generating capacity subject to significant IRP implementation will increase from 23% in 1991 to 89% by 2000. Similarly, DOE is expanding its support for R&D on building energy technologies and is taking steps to implement an Executive Order directing a 20% reduction in the use of energy in Federal buildings and facilities by the year 2000.

- Alternative fuels and vehicle efficiency. DOE's calculation for the NES includes the effect of greater use of alternative fuels and oxygenated compounds in gasoline, which will be required to comply with the 1990 Clean Air Act amendments. DOE also has a program to reduce the cost

---

[3] The National Energy Strategy's Technical Annex 2 also gives results for an alternative baseline with "low" economic growth, averaging 2.7% per year from 1990 to 2000. This projection gives an increase in CO_2 emissions between our Reference Case and the NES's Current Policy Base Case, with growth of 707 million tons from 1990 to 2000.

[4] In its report on *Limiting Net Greenhouse Gas Emissions in the United States*, DOE provides a breakdown of the fraction of greenhouse gas reductions resulting from different elements of the NES as follows:

Energy Efficiency and IRP	21%
Transportation R&D and Alternative Fueled Vehicles	20%
Municipal Solid Waste to Energy Conversion	18%
Natural Gas Reform	19%
Others	22%

Assuming that the same proportions apply to CO_2 itself, the five categories listed are responsible for CO_2 emission reductions of 53, 51, 46, 48, and 56 million tons respectively.

of producing ethanol from woody biomass, to develop advanced batteries for electric and hybrid vehicles, and to develop more efficient automobile engines and other components.

- Energy production from municipal solid waste. DOE's calculation for the NES projects 16 gigawatts (GW) of additional waste-to-energy capacity by 2000 compared to the baseline. This could include electricity generated from landfill gas as well as waste-burning facilities.

- Expanded use of natural gas. DOE projects increased reliance on natural gas as a result of regulatory reforms that make it easier to obtain permits for natural gas pipelines and expanded natural gas R&D.

- Other measures. Other programs that contribute to the year 2000 CO_2 reductions attributed to the NES include increased electricity generating efficiency in fossil-fuel-fired power plants as well as expanded use of renewable energy sources.

While much of the credit for the CO_2 reductions attributed to the NES should be given to actions that were already underway, such as state-level utility regulatory reform and the 1990 Amendments to the Clean Air Act, the reductions themselves nevertheless represent a significant change from baseline projections.

CO_2 REDUCTIONS FROM ADOPTED OR ANNOUNCED MEASURES

If effectively implemented, additional measures on the list recently announced by the Administration have the potential to stimulate large additional CO_2 reductions through profitable energy efficiency improvements. NRDC's estimate of this potential is based on the detailed technical analysis conducted for the *America's Energy Choices* study.

The CO_2 reduction potential detailed below accounts for interactions between the individual measures and the reductions included for the NES. Interactions between measures are captured by modeling the overall impact of technology packages applied to specific building types or industries. We avoided double counting the actions under the NES by subtracting from our estimates the reductions attributed to the energy efficiency and IRP measures and the transportation R&D measures already covered in the NES.

CO_2 Reductions from Transportation Policy Measures

Measures that have been announced or adopted for reducing transportation emissions include:

- The Surface Transportation Act enacted last year, which levels the playing field for federal support of highways versus public transportation systems.

- The Clean Air Act, which provides for states or regions to adopt transportation demand management measures as part of plans for achieving air quality standards.

- Raising the limit on tax-free transit passes provided by employers and other steps to equalize incentives to use transit compared with driving.

Based on experience with such strategies in a number of cities, *America's Energy Choices* estimated that measures of this type could reduce year 2000 vehicle miles travelled by 6%, yielding CO_2 reductions of **67 million tons.** This adds to the CO_2 reductions from the NES from alternative fuels and vehicle efficiency R&D.

CO_2 Reductions from Building Efficiency Improvements

The announced measures for increasing energy efficiency in buildings include:

- EPA's Green Lights and Green Buildings programs which encourage building owners to identify and implement cost-effective efficiency improvements.

- DOE's building, appliance, and equipments standards, which set minimum energy efficiency performance levels. The Senate and House energy bills establish minimum energy efficiency requirements for most new buildings. The bills also include standards for lamps, commercial heating and air conditioning systems, and showerheads. DOE is already required to set standards for most residential appliances.

- EPA's Golden Carrot refrigerator program, which is an example of the Golden Carrot concept in which utilities, equipment manufacturers, and the government cooperate to establish incentives for the introduction of equipment that is much more efficient than the minimum performance standards.

- Expansion of utility integrated resource planning and energy efficiency programs. Many states, including California, New York, and

Massachusetts, have adopted utility regulatory reforms which make energy efficiency investments as profitable as investments in additional electricity generation. The Senate and House energy bills would require that all states consider adopting such reforms.

The potential impact of these measures is enormous. *America's Energy Choices* documents that the applications of cost-effective state-of-the-art energy efficiency techniques would reduce building energy consumption by 37 to 87 percent, depending on the type of building. For example, energy use in office buildings could be cut by 70% and energy use in existing single family homes with gas heat could be cut by 64%.

All together more than 60 individual technical improvements were analyzed, including high efficiency lighting, electronic thermostats, better windows, increased insulation levels, more efficient heating systems, and more efficient appliances. All of the selected measures save money over their lifetimes because the higher initial investments are offset by lower operating costs.

Given the rate of new construction and remodelling and the average lifetime of appliances and other equipment, we estimate that effective implementation of the measures described above could stimulate the adoption of state-of-the-art technology in about 40% of the U.S. building stock by the year 2000. This results in CO_2 savings of 470 million tons.

Emission reductions of 53 million tons have already been included for actions to promote energy efficiency and integrated resource planning as part of the overall CO_2 reductions from the NES. Assuming that half of the NES efficiency savings come in buildings and the other half are in industry, we subtract 26 million tons to avoid double-counting the NES actions.[5] The additional CO_2 reduction from building efficiency improvements is thus **444 million tons.**

CO_2 Reductions from Industrial Efficiency Improvements

The announced measures for increasing energy efficiency in industry include:

- Electric motor standards, which set minimum efficiency levels for new motors. The Senate and House energy bills set standards for a variety of electric motors.

- EPA's Green Motors program, which will encourage industries to identify and implement cost effective improvements to motor drive systems. System

[5] Although we had to make an arbitrary assumption to apportion the NES savings between buildings and industry, this does not affect the total savings when all measures are included.

improvements, including variable speed drives and better matching of motor size to load requirements can greatly expand savings compared to standards for new motors alone.

- EPA's Green Piping program, which will encourage industries to identify and implement cost-effective piping insulation levels and other measures to conserve process heat.

- DOE's energy audit program, under which energy audits will be made available to small and medium sized industrial firms.

- DOE's industrial R&D program, which focuses on developing improvements for energy-intensive processes.

- Recycling, encouraged by the Resource Conservation and Recovery Act, reduces the need to process virgin materials, and thus substantially reduces industrial energy requirements.

Our estimates of industrial efficiency potential are again based on research for *America's Energy Choices*. Electricity efficiency improvements, which account for about half of our industrial CO_2 reduction estimate, are derived from an Electric Power Research Institute (EPRI) study. We assume savings equal to 50% of EPRI's higher estimate of the cost-effective potential for 2000. The bulk of these savings come from motor system improvements.[6]

Fuel savings estimates are based on a variety of sources, including a series of industry-specific reports prepared for DOE. Although our assumptions vary from industry to industry, they are equivalent to roughly 50% adoption of state-of-the-art technology by 2000. This figure is somewhat higher than in buildings because of the more rapid replacement of industrial equipment. The total CO_2 emission reductions estimated for both electricity- and fuel-use efficiency improvements is 427 million tons in 2000. Subtracting 27 million tons assumed to be included in the NES savings, we obtain a net additional CO_2 reduction of **400 million tons**.

---

[6] Electric Power Research Institute, *Efficient Electricity Use: Estimates of Maximum Energy Savings*, March 1990 (EPRI CU-6747). Our estimate is much more conservative than the analysis conducted by the Rocky Mountain Institute in The State of the Art: Drivepower, *COMPETITEK*, April 1989.

Additional Measures

A number of additional measures have been adopted or announced for which we have not attempted to project CO_2 reductions. These include EPA's Green Computers and Office Equipment program, vehicle Inspection and Maintenance programs mandated by the Clean Air Act, DOE research and development on high performance aircraft engines and heavy truck efficiency improvements, and the development of a high-speed rail network.

There are also measures that can help further reduce total net greenhouse gas emissions, such as tree planting programs, capturing landfill methane, capturing coal-seam methane, and reducing nitrous oxide emissions from nylon production. We do not include estimates of the potential for these measures because emission reductions from such sources would be extremely difficult to verify at this time. For this reason, such measures should be undertaken as an additional program distinct from reducing direct CO_2 emissions from the energy sector.

MEASURES THAT SHOULD BE ADDED TO THE U.S. LIST

While the list of measures discussed above is more than sufficient to stabilize CO_2 emissions at 1990 levels by the year 2000, additional measures should also be adopted in order to achieve the substantial CO_2 reductions needed to stabilize the climate system. With these additional measures a 20% reduction in CO_2 emissions could be achieved by 2000. These measures also have additional benefits beyond curbing global warming.

Increased CAFE Standards

Increasing CAFE standards for automobiles and light trucks would add substantial additional CO_2 reductions as well as increasing America's energy security and reducing other environmental impacts of oil development. If new car efficiency gradually increased to 40 miles per gallon by 2000, CO_2 emissions would be reduced by 101 million tons in 2000, with much greater reductions in later years as the vehicle fleet turns over. This value accounts for the prior reduction in vehicle miles driven, as discussed above. Assuming that 30 million tons of the NES transportation CO_2 reduction comes from efficiency improvements (with the rest coming from alternative fuels), the net additional CO_2 reduction in 2000 would be **71 million tons.**

Tax Reform

The bulk of federal taxes are assessed on personal and corporate income, and thus discourage employment and investment. Shifting part of this tax burden to pollution by phasing in a tax on fossil fuels in proportion to their carbon contents would simultaneously stimulate economic growth and reduce CO_2 emissions. For example, an EPA-sponsored study found that a tax reaching $24 per ton of carbon in 2000 ($6.50 per ton of CO_2) could reduce CO_2 emissions in that year by more than 15% from baseline levels while increasing economic growth. If this 15% cut is applied after accounting for all the reductions discussed above (to avoid double counting) then the additional CO_2 reduction in 2000 would be **740 million tons.**

THE NEED FOR A LEGALLY BINDING COMMITMENT TO CO_2 STABILIZATION

This analysis has shown that the U.S. could easily stabilize CO_2 emissions at 1990 levels by 2000, at a profit, by implementing just some of the energy efficiency measures that the Administration listed during the last round of climate negotiations. As a result, the Administration should have no reason to fear making a binding legal commitment to CO_2 stabilization.

Such a commitment is needed not only to secure an effective international treaty, but also to ensure effective domestic implementation of the measures discussed here. Despite the fact that these measures will save the U.S. money, their implementation will not take place by itself. Past experience has shown that there will be bureaucratic and budgetary obstacles in government, as well as special interest opposition from industries that can be expected to delay and water down the effectiveness of these measures. An overarching legal obligation to achieve CO_2 stabilization is critical to giving government the motivation and the means to override these obstacles.

For instance, the Department of Energy is already legally required to issue efficiency standards for nine important household appliances, ranging from water heaters to room air conditioners. Despite the fact that these standards will save consumers money, DOE is running almost two years behind the statutory schedule for issuing them.[7] The delay in achieving energy savings from just these appliances will cause CO_2 emissions in the years 2000 to be approximately 0.4% higher than they would have been with timely government action.

---

[7] The National Appliance Energy Conservation Act required DOE to promulgate the final rule for these products by January 1, 1992. As of March 1992 DOE had not yet issued the Notice of Proposed Rulemaking. Given the Administrative lead time required to turn a proposed rule into a final rule, promulgation of the final rule will most likely be at least two years late. As the statute requires a three-year period between issuance of a rule and its effective date, each day's delay in issuing the rule translates into a delay in implementation.

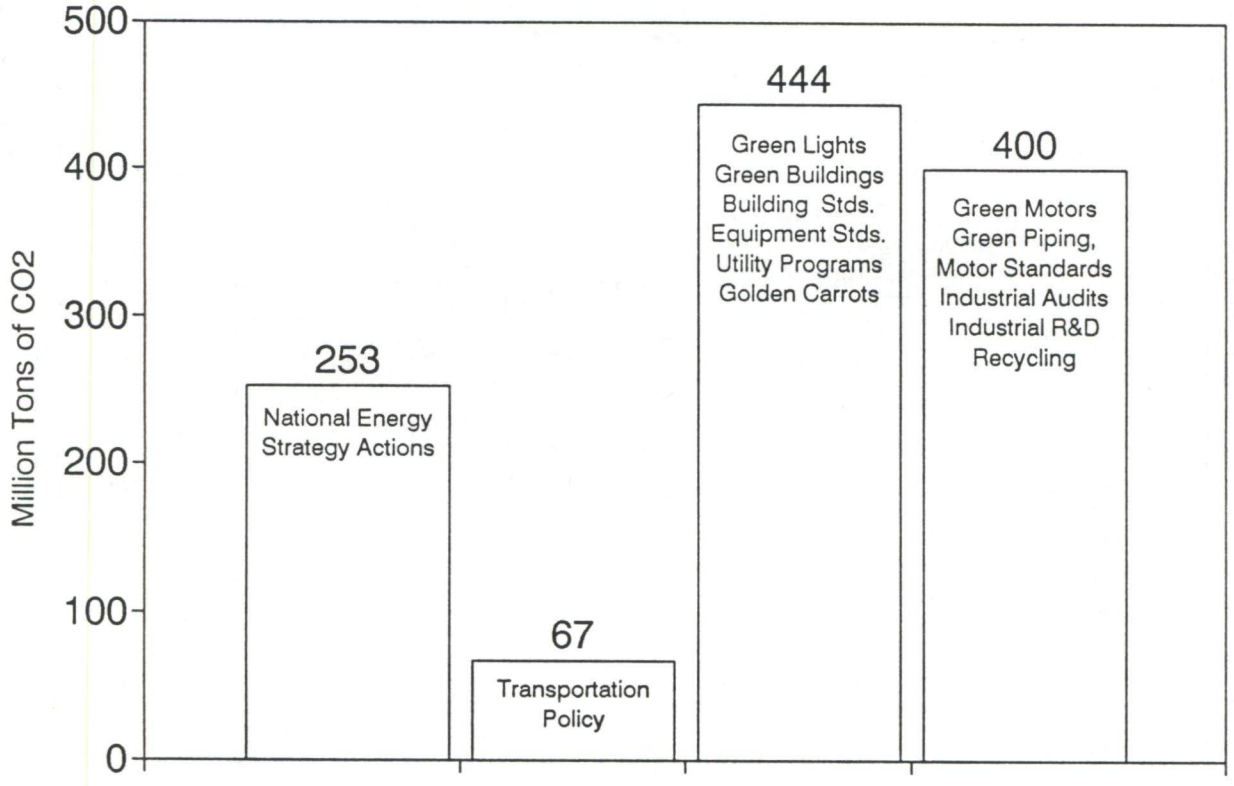
Adequate funding and commitment to the voluntary initiatives is equally important. The EPA Green Lights program works by offering the private sector advice, expertise, and recognition on a company-by-company basis. The program operates on a budgetary shoestring, however. The population of potential participants among the nation's companies, public institutions, and non-profit organizations is far larger than EPA's small program can reach. Follow-on programs such as Green Motors, Buildings, Pipes, and Computers are as yet unbudgeted and unstaffed.

In some instances, special interest industries oppose energy efficiency measures despite the fact that they would save consumers money. For example, some utilities continue to fight integrated resource planning (IRP), or least-cost planning, even though a dollar of profit earned from selling efficiency is just as good as a dollar earned from adding new energy production capacity. Just recently, during Congressional consideration of the pending energy legislation, the National Association of Home Builders opposed proposals for mandatory energy standards for new home construction. The energy savings from well insulated housing would more than pay back the extra cost of construction. But home builders, with their eye only on the up-front purchase price, oppose such standards even though they make housing more affordable.

Without a binding obligation for the nation to stabilize CO_2 emissions, bureaucracy, budgetary problems, and special interests will continue to hamstring implementation of the measures the Administration has identified. That is why the legal obligation is so important. It would give government and industry both the reason and the means to cut through these obstacles to fully implementing these measures. It would ensure that standards are issued and other necessary actions are taken in a timely manner, with the eye on profitability to consumers overall rather than just on special interest considerations. And coupled with a commitment to further negotiations toward subsequent emission reductions, it would give both industry and government strong incentives to turn their ingenuity to identifying further opportunities to continue cutting CO_2 at a profit.

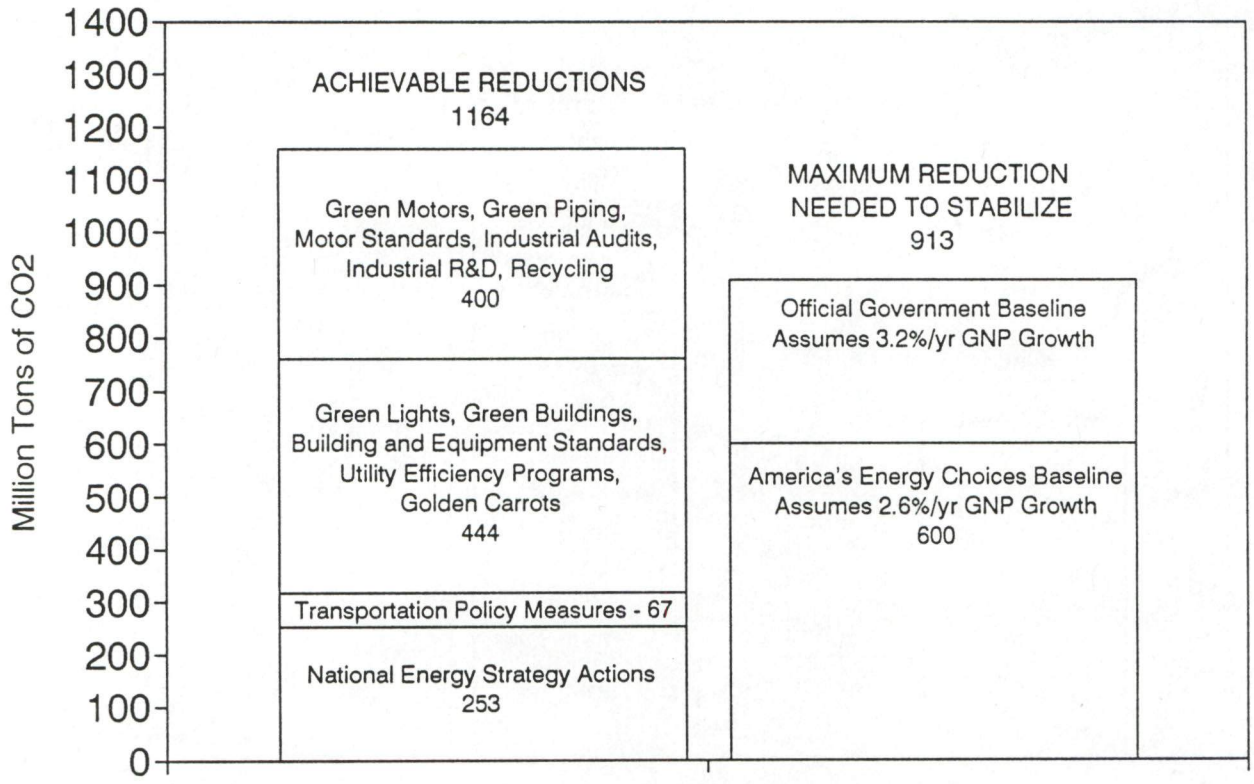
CO2 Cuts from U.S. Measures

Year 2000 Potential



CO2 Cuts from U.S. Measures

Year 2000 Potential



Fax Cover Sheet

U.S.EPA

Office of Policy Analysis

Fax# (202) 260-6405

Tel# _____

To: Jonathan Wiener

Fax# _____

From: Alex Cristofaro

Comments:

Computerized version to follow in 5 minutes

Pages to follow: 4

Jonathan:

Check it out. France & Germany don't produce as much CO_2 per GDP as the U.S., but ~~they~~ their imports of manufactured goods "embody" much more carbon than ours!!

Alex

Source

National Carbon Intensities, 1950-85
Metric Tonnes per $million GDP ($80)

Country	1950	1960	1970	1980	1985	(50-85)	(60-85)	(70-85)
U.S.	71.4	60.0	60.1	48.5	40.1	-43.8%	-33.1%	-33.3%
Canada	57.7	48.5	50.0	42.5	35.4	-38.6%	-27.0%	-29.2%
France	42.8	36.6	32.3	25.4	18.9	-55.9%	-48.4%	-41.6%
W. Germany	70.0	51.4	44.5	34.5	28.3	-59.5%	-44.8%	-36.3%
Italy	12.6	18.5	28.9	25.1	23.1	82.6%	24.3%	-20.3%
U.K.	68.3	61.6	49.9	35.7	30.9	-54.8%	-49.8%	-38.1%
Spain	19.9	18.1	20.4	23.8	20.8	4.7%	14.9%	2.1%
Japan	30.0	30.3	35.3	26.9	22.3	-25.7%	-26.5%	-36.9%
Australia	42.1	45.3	42.4	45.1	42.8	1.6%	-5.4%	1.1%
India	12.0	14.3	16.9	22.6	23.4	95.2%	63.5%	38.6%
U.S.S.R.	52.5	62.6	57.9	59.9	56.5	7.7%	-9.8%	-2.3%
Poland	57.5	65.8	65.5	70.4	67.1	16.6%	2.0%	2.5%
China	9.2	44.2	24.8	24.7	20.4	120.6%	53.9%	-17.8%

The Embodiment of Carbon in Imports of Manufactured Products:

Implications for International Agreements on Greenhouse Gas Emissions

A collaborative project between the Organization for Economic Cooperation and Development (OECD), the International Energy Agency (IEA), the US Congressional Office of Technology Assessment (OTA), and the US Environmental Protection Agency (EPA).

Prepared by Andrew W. Wyckoff and Joseph M. Roop, consultants.

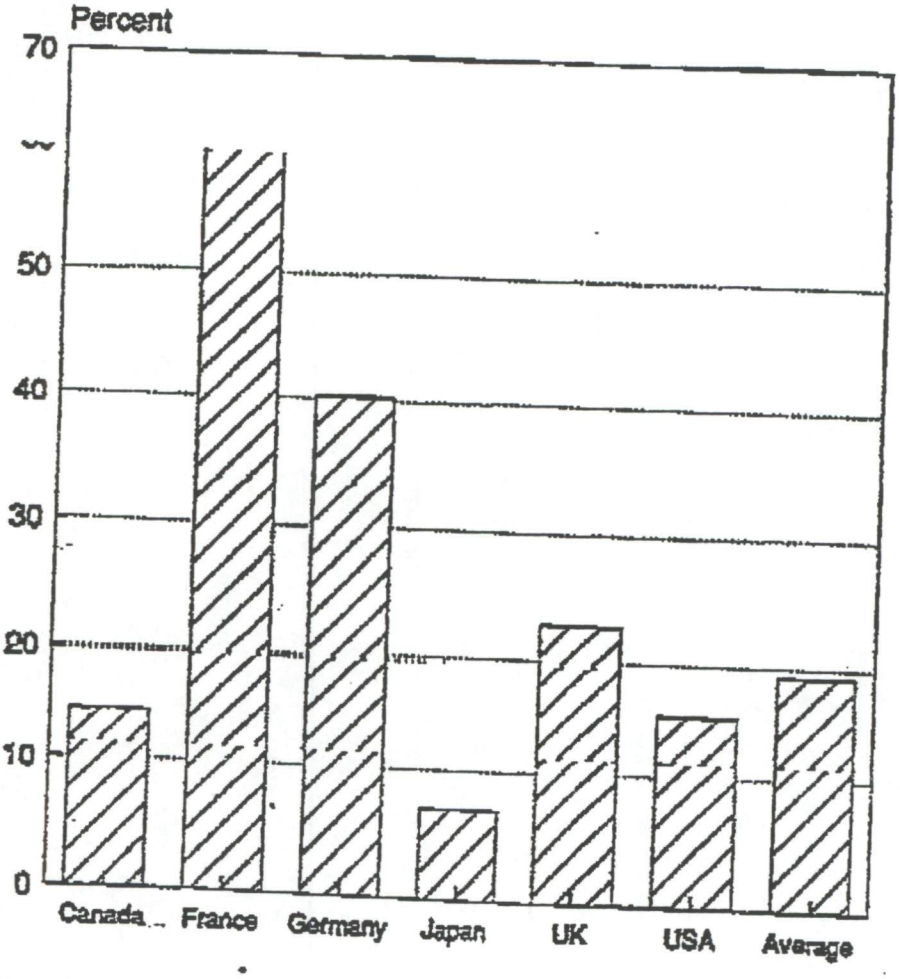
DRAFT

Preliminary version: do not cite without permission.

January 1992

Figure I

The Percentage of Carbon Embodiment in Imports* to Total Industrial Carbon Production



* All Manufactured Goods except refined petroleum products.

11. Table 1 indicates that the carbon embodied in a country's imports of manufactured goods tends to come from a neighbour -- a reflection of patterns of trade. Most of the carbon embodied in imports to Canada come from the US, for France it is Germany and the rest-of-the-OECD (RoO), for Germany it is France and RoO; for the UK, most of its carbon embodied in imports come from France, Germany, and the RoO. In Japan, the bulk of the carbon embodiment comes from the US and the rest-of-the-world, presumably other Asian countries. In the US, the origin of the carbon embodied in imports is more diverse, with significant amounts coming from Canada, Japan, the RoO, and the rest-of-the-world. As the last line in Table 1 indicates, the sources of carbon-intensive products are diverse and relatively evenly distributed across the six countries in the analysis.

[Official Use -- Not for Distribution]

ISSUES AND OPTIONS ON CLIMATE

Table of Contents

(1) Overview of US Approach
(2) US National Strategy
(3) Options Urged by Others
    A. Stabilizing net GHGs
    B. Moderating the rate of warming
    C. Stabilizing CO2 per capita
    D. Emissions per GDP
(4) Funding and Technology Cooperation: Alternatives to a Central Fund

(1) OVERVIEW OF US APPROACH

- National strategies comprised of concrete actions, not targets & timetables
- Weigh costs and benefits of policy options
- Comprehensive approach (net GHG emissions, including sources & sinks in all sectors), not CO2 only or energy sector only
- Technology cooperation (mutually voluntary investment arrangements), not mandatory or concessional transfer
- Allow cooperative international arrangements to limit net emissions (informal emissions trading), not solely domestic actions
- Sound global change science and economics; substantial research

(2) U.S. NATIONAL STRATEGY

National strategies to take actions to limit net greenhouse gas emissions has been the US position: we will commit to developing a strategy comprised of concrete actions, but not an overarching emissions target. Each nation would retain flexibility on what actions to include in its national strategy.

Pros:

- Preserves policy flexibility
- Avoids committing the country to an emissions outcome in a future year, when it is difficult to say (a) where the economy would be at a certain point and hence how hard it would be to achieve the limit; and (b) what is the scientifically appropriate emissions outcome..
- If a robust strategy is unveiled, would show the US is serious and is taking real, concrete measures (unlike other countries with announced targets).
- Some initial, low-cost steps would be warranted even in the face of the great uncertainties in predicting future climate. [Nordhaus 1991.]
- Employs "comprehensive approach," accounting for net greenhouse gas (GHG) emissions and seeking to address them on the basis of overall cost-effectiveness.

- While some insist on targets, some other countries are coming around to our view that a national strategies approach is best for the framework convention.

But: difficult to make this approach credible without a revised US national strategy for State to shop around.

Fleshing out the US National Strategy:

- Bob Reinstein says right now he needs just a list of actions, with a ballpark assessment of each action as "major" "modest" or "minor," not hard numbers (though hard numbers will be needed in the future.)

- Under such an approach, the US would identify **specific, concrete actions** that contribute to limiting net emissions. The US took a first cut at such a strategy in its **"Action Agenda"** (Feb. 1991).

- We are now preparing a **new, revised set of actions** that might constitute a national strategy. CEA, DOE, EPA, USDA and others are participating in this effort. These actions would include:

  - **Energy Supply and Conservation:**

    -- The National Energy Strategy (NES) -- a broad set of programs addressing energy supply (e.g. clean coal technology, renewables, natural gas), end use conservation, integrated resource planning (IRP), transportation efficiency, alternative vehicle fuels, Clean Air Act reforms, DOE appliance standards
    -- Green Lights, Green Piping, and other 'Green' programs
    -- Coal mine methane recovery

  - **Industrial conservation:**

    -- EPA Landfill regulations and methane recovery
    -- EPA Pollution Prevention Strategy
    -- Phaseout of CFCs and HCFCs (depends on GWPs used)

  - **Forestry and Agriculture:**

    -- America The Beautiful tree planting program
    -- Conservation Reserve Program
    -- Livestock methane recovery (ruminance, wastes)

  - **US International Cooperative Activities:**

    -- Bilateral activities, e.g. energy efficiency, methane recovery, renewable energy sources
    -- Multilateral activities
    -- Private sector activities

Some difficulties are still being worked out to mesh analyses from different agencies to assemble a consistent picture, and an analysis of the aggregate effect on forecasted emissions is not yet available. As noted, at present Reinstein needs only a list with ballpark categories.

(3) OPTIONS URGED BY OTHERS

A. "Stabilization of net GHGs".

Pros:

- Could show US commitment to overall action (assuming that is desirable). Key issue is when and at what level.
- If agreed as nonbinding soft goal, with date and level left open, could show commitment without binding US to a scientifically and economically unsound timetable.
- Based on comprehensive approach (net GHGs).
- If the US will probably get to stabilization at some date in the not-too-distant future anyhow (based on forecasts and the effect of new actions), why not get credit for our actions? Key issue is how sure we are we won't be overcommitting ourselves.

Cons:

- Would be acceding to EC's position on targets, which we have long resisted on scientific and economic grounds.

- Recent scientific findings do not favor adopting a stabilization goal now. The scientific case for near-term emissions stabilization may be less persuasive today than it was a year ago:

    - CFCs are now realized to generate little or no net radiative forcing. [WMO/UNEP, Scientific Assessment of Stratospheric Ozone Depletion: 1991.] That would mean there is **25% less radiative forcing** being added to the climate system, and consequently the level of expected anthropogenic climate change will be substantially smaller.

    - More generally, the last 10 years have been an (unfinished) exercise in grasping the **physics** uncertainties of climate science: solar effects, cloud dynamics, ocean-atmosphere thermal exchange. Now we are **entering a new period of chemistry uncertainties** of great importance: e.g. hydroxyl reactions, aerosol properties, urban soup interactions, altitudinal and latitudinal dependencies.

    - Delaying stabilization action by 10 years would change realized and equilibrium warming in 2050 **barely at all.** [Schlesinger & Jiang, Nature, 1991.]

    - Empirical observations show that **all** of the warming in the last 40 years has occurred as a rise in minimum temperatures -- **nighttime and wintertime** -- not in maximum temperatures. [Karl, NOAA, 1991.] Instead of

increasing climate variance and stresses, warming is likely to dampen extremes, smooth out variance and **reduce stress,** such as reducing crop freezes.

- Evidence is mounting that **CO2 has important beneficial effects** on plant growth. Field studies (not computer models) show that doubling the CO_2 concentration of the atmosphere from 300 ppm. to 600 ppm. is estimated to **increase plant growth by 30-60% or more** through greater photosynthesis, as well as improve plants' resistance to drought. The CO_2 enrichment effect is **especially beneficial for the plants that make up 80% of world food supply** -- including wheat, rice, barley, legumes -- **and for all trees.** [Idso & Kimball, 1991; Drake, 1991; IPCC Impacts Assessment, 1990.] Indeed, the combination of CO_2 enrichment and rising temperature boosts productivity even more: doubling CO_2 concentrations raises the optimum temperature for photosynthesis in C3 plants by about 4-6^{o}C. [IPCC 1990.] Models of the combined effect of warming and CO_2 enrichment show <u>in</u>creased overall crop yields. [EPA 1990; Parry 1988.]

  This may simply argue for giving beneficial weight to CO2 in any GHG Index used to aggregate emissions across gases.

B. <u>Moderating **the rate of warming**</u>.

Pros:

- The long-term objective of the convention will be to prevent adverse effects of the level of climate change; the intermediate goal should therefore attend to any nearer-term abrupt changes in climate.

- If warming is gradual and anticipated, adaptation may occur. But **ecosystems and impoverished societies may be especially vulnerable to rapid** or abrupt (potentially nonlinear) changes in climate. [NAS, Adaptation Panel, 1991.]

- As a policy matter, attention to moderating the rate of warming would entail **more balanced attention to all the greenhouse gases, especially potent but shorter-lived methane (CH4)**, which yields especially strong near-term increases in forcing. Reductions in potent CH4 emissions would more immediately reduce the rapid accumulation of forcing in the atmosphere. [Hogan, Hoffman & Thompson, 1991.]

- Attention to the rate of change would also entail **more attention to the rapid growth in emissions from developing**

countries. While OECD emissions growth has been nearly flat in the last 15 years, emissions of CO2 from energy use developing countries -- not including deforestation -- have grown almost 2.5% per year. [Marland, 1989.]

Cons:
- o Requires some incremental emissions limitations now.
- o Hard to estimate likelihood of "abrupt" changes or impacts.

C. "Stabilization of CO2 per capita"

Pros:
- o US could achieve it more easily than Europe because US population is growing faster.

Cons **to focusing on CO2 alone.**

- o It would violate the sound, longstanding, and successful US policy to take a "comprehensive approach." This policy is environmentally and economically sensible. And more and more countries are endorsing it -- even the EC now gives it lip service.

- o It would be **environmentally unwise**, since the issue of environmental concern is net change in greenhouse gases added to atmosphere, not one gas or sector per se.

  - o Focusing solely on CO2 emissions is a **dangerously narrow, piecemeal approach** that could have counter-productive **side effects.**

  - o For example, the EC may approved in the near future a **CO2 tax.** In response to the tax, Europe would most likely **switch from burning coal to burning natural gas,** which emits less CO2 per BTU and would be charged a lower tax. The EC is looking to Russia for natural gas to accomplish this fuel switching. Such fuel switching would reduce CO_2 emitted in combustion **but increase CH_4,** a more potent greenhouse gas, through leakage from natural gas systems. A **6 percent CH_4 leakage rate would offset all the reduction in radiative forcing achieved by coal-to-gas CO_2 savings,** and EC natural gas imports from Russia would carry with them CH_4 leaks of **4-10 percent -- enough to threaten a net increase in potential global warming!**

  - o High CH4 leakage occurs even in some of the EC nations themselves. In the **U.K.,** the leakage rate is estimated

from **1-11** percent, suggesting that a CO_2-only limit there could offset or increase net potential warming.

- The European obsession with CO2 despite the likely increase in CH4 emissions shows that Europe **isn't really serious about preventing global warming.** They seem to be interested in less in climate protection and more in **GNP protection: how to "game" the system** to help the EC compete with the US and Japan, where controls on CO2 would be more expensive.

- Focusing only on CO2 would also be **economically unwise**, as it would ignore strategies addressed at other greenhouse gases can be more **cost-effective.**

  - **Reducing CH4 leakage from natural gas pipelines, coalbeds and landfills** may be highly cost-effective means to reduce contributions to potential warming. These sources, which could be reduced at potential profits because the recovered gas could be used as fuel, together emit **over 100 Tg** of CH4 per year -- enough to reduce total CH4 emissions to the level of CH4 removal every year (hence stopping growth in atmospheric CH4 concentrations!). [Hogan, Hoffman & Thompson, 1991.]

  - **Reducing agricultural subsidies** in Europe would have important effects on emissions of methane (CH4), nitrous oxide (N2O), and CO2. Europe will spend $44 billion in direct subsidies in 1992, plus $85 billion paid by consumers as higher food prices. That is over 4 times US subsidies and 3 times US consumer costs. [Wall. St. Journal, 1/13/92.] Removing the EC's corn, wheat and sugar subsidies would avoid tens of millions of tons of CO2-equivalent N2O and CH4 emissions per year. [EPA analysis, 1992.]

  - **Reducing livestock emissions of CH4** could also be cost-effective. Bovine somatotropin (BST) reduces the production of methane in cows by about 15% per litre of milk. BST has been identified by the IPCC as a key measure to reduce global methane emissions. BST produced from genetically engineered bacteria has been approved for use in the US, but, without any evidence of health risk, meat and milk from BST-treated cows have been refused by the EC.

- Focusing only on gross CO2 **ignores CO2 sinks.** At least we should say "net CO2." Otherwise heavy deforestation will

not be counted in the stabilization goal -- exempting important contributors like Brazil -- and there will be no incentive to reduce deforestation. Cost-effective afforestation options, such as the America the Beautiful tree planting program, would be precluded.

Cons to a **"per capita"** standard.

- Although the growth of US emissions per capita is lower than that of the EC -- basically because population in the US is growing faster than in the EC -- the current level of emissions per capita is much higher in the US (5 tons of CO2 per capita per year) than in the EC (between 1 and 3 tons) (Japan is at 2 tons). Once we agree to a per capita standard, the EC will not stop at stabilization of emissions per capita at each country's current level, but will demand stabilization at a specific uniform level -- just as France proposed in 1990 that all countries stabilize at 2 tons of CO2 per capita per year.

- The picture is even worse with respect to the developing countries, where emissions per capita are very low and growth in emissions per capita is even lower. A per capita standard would basically mean no emissions restraint in developing countries. No wonder developing countries have been arguing in favor of such a standard, claiming that each inhabitant of the planet has a right to emit a certain amount of CO2!

- Stabilizing per capita emissions worldwide would mean that emissions simply rise with population. That would mean doubling emissions by around mid-century. This might not be an environmentally sound goal if global warming is thought to be a problem.

D. "Emissions per GNP"

A better measure of performance is **emissions per useful product. Americans may emit more, but they also produce more value for the world economy** [from CEA/DOE 1990]:

Country	CO2 per GNP (kg/$, 1986)
Japan	0.16
France	0.17
Italy	0.19
W. Germany	0.25
U.S.A.	0.28
Canada	0.29
Australia	0.32
U.K.	0.33
Mexico	0.49
India	0.64
Poland	1.60
China	1.76

(Caution: numbers for emissions per GNP in any one year are vulnerable to annual changes in exchange rates and emissions.)

- And these CO2/GNP figures **exclude CO2 "embodied" in the imports of products** consumed by different countries. Though US production involves more CO2 than France or Germany, it consumes goods from abroad that use far less [from Wyckoff & Roop, 1992, for EPA/IEA]:

Country	% of Carbon Embodiment in Imports
Japan	7
Canada	14
U.S.A.	16
U.K.	23
Germany	40
France	60

Hence on a full-consumption basis [which has not yet been calculated], net CO2 emissions per consumption may look quite different from CO2 per output.

- Another key measure is the **trend in emissions per GNP over time: how countries have improved their carbon efficiency.** The US looks quite good on this scale [from EPA/OPPE, using IEA data]:

Country	% Change in CO2 per GDP over period		
	1950-85	1960-85	1970-85
France	-55.9	-48.4	-41.6
U.K.	-54.8	-49.8	-38.1
Japan	-25.7	-26.5	-36.9
W. Germany	-59.5	-44.8	-36.3
U.S.A.	-43.8	-33.1	-33.3
Canada	-38.6	-27.0	-29.2
Italy	82.6	24.3	-20.3
China	120.6	53.9	-17.8
USSR	7.7	-9.8	-2.3
Australia	1.6	-5.4	1.1
Spain	4.7	14.9	2.1
Poland	16.6	2.0	2.5
India	95.2	63.5	38.6

- This also demonstrates that **future emissions growth is likely to be remarkably high in developing countries, given their rapidly growing economies and rising rates of emissions per GNP.**

(4) FUNDING AND TECHNOLOGY COOPERATION: Alternatives to Centralized Funds

Giving to a central fund has disadvantages:

- The central fund decides how the money is spent, not our government.
- Funds are spent on management of the fund itself.
- The fund has no built-in incentive to finance the most cost-effective, concrete projects. It has other bureaucratic incentives.

A better approach could be for the US to champion what it has already endorsed in technical terms: **a global investment strategy, based on market principles of free trade and voluntary cooperative arrangements,** that will **ensure a real and murtually desirable investment flow to serious, cost-effective projects worldwide.** In the exposition of national strategies to limit net greenhouse gas emissions, each nation should be able to include bilateral, multilateral or regional **"cooperative arrangements"** with other countries that limit net emissions.

- The United States has endorsed this concept, among other places, in its written submission to the Climate INC on March 15, 1991, in its May 1991 Principles for a Global Forests Agreement, and in its intervention at the fourth INC session in Geneva, December 1991.

- For example, in the Climate agreement, each nation could include in its "national strategy" both domestic actions to limit net GHG emissions and actions taken overseas through "cooperative arrangements" with other nations. (If it is important to quantify and allocate the net emissions reductions thereby achieved, the investor nation and the host nation would measure the reduction according to sound emissions accounting procedures and apportion it between them according to their mutually voluntary arrangement.)

- The U.S. has already begun to publicize its significant **"Technology Cooperation"** activities with other countries, in which U.S. agencies invest abroad in projects that also limit net GHG emissions or could assist in adaptation to potential climate change. In particular, the U.S. published "Technology Cooperation Related to Global Climate Change: A Selected Inventory" in December 1991, and will host a symposium on the topic during the negotiating session in February 1992 in New York.

- **U.S. debt-for-forest exchanges** are another example of the market-based approach. They relax debt burdens and spur forest protection at the same time. We are already negotiating exchanges with interest on U.S. public debt under the President's **Enterprise for the Americas Initiative.** Jamaica, Chile and Bolivia have already negotiated framework agreements to set the stage for such swaps.

- Global environmental issues warrant global, cooperative responses. For example, since GHG emissions mix globally and have global effects, it is the aggregate global net emissions that are of environmental interest. Limitations achieved anywhere on the globe are equally significant (with some qualifications for certain gases, which can be addressed through technical translation factors). Nations therefore ought to have the flexibility to pursue limitation projects wherever they are most cost-effective.

  Similarly, the biodiversity and carbon storage benefits of forest conservation are shared globally, and any investment worldwide should be credited.

[Some other countries have proposed complex and encumbered versions of the "cooperative arrangements" idea, dubbing it "joint implementation." These variants contain much with which the U.S. can agree, but also elements that are potentially at odds with U.S. policy. For example, Norway has helpfully articulated the rationale for joint implementation, but has also linked joint implementation to a uniform emissions target & timetable for greenhouse gases. Germany has implied that joint arrangements could be undertaken only with countries that are members of a regional group like the EC (excluding developing countries and Eastern Europe).]

But the basic notion of "cooperative arrangements," unfettered by other provisions, is sound and practical. Such **cooperative arrangements would offer several important advantages:**

- Consenting adult nations could exercise the **flexibility** to achieve emissions limits or forest/biodiversity conservation in concert.

- This flexibility would **improve the cost-effectiveness** of any efforts under national strategies, by enabling countries to find and invest in the most effective, least costly projects worldwide.

- Such international cooperative arrangements would serve as a **decentralized, market-based vehicle for investments** in countries offering low-cost emissions limitation or forest conservation opportunities. Potential recipients would compete to offer projects yielding the most at the least cost; potential investors would compete to offer the best financial and technical assistance. **Both investors and host countries would gain** -- or else choose not to engage in such arrangements, which would necessarily be voluntary market transactions.

- Since cost-effective opportunities are especially likely to be found in **developing countries and Eastern Europe**, an investment flow to those areas could be expected.

    - (Indeed, the U.S. approach contemplates investments in developing and Eastern European countries, whereas the German/EC limited version would preclude investment there. This could be a major point to attract developing country support of the US approach.)

- While **limiting global net emissions and conserving global forests,** cooperative investments would confer a **cost saving** to countries (most likely industrialized countries like the U.S.) where such efforts would be more expensive. For example, a U.S. national strategy to limit net GHG emissions could be achieved at less cost if the U.S. could invest in projects abroad with a lower marginal cost of abatement than in the U.S.

- Investor nations could also hope to gain **new markets for key technologies**, e.g. energy supply and conservation technologies, biotechnologies, and agricultural and forestry technologies. Japan, for example, has announced its intention to spread its environmental technologies worldwide, and is already the site of the UN Environment Program Technology Institute.

- This **market-based vehicle** would be an **alternative to concessional funding through centralized funds.** It would:

    - rebut calls for gratuitous wealth transfers unaffiliated with emissions reductions or forest conservation, by promising real investments
    - ensure any money is well spent, by tying real investments to real environmental protection projects

- employ existing institutions for bilateral and multilateral investment and assistance
- expend no additional resources on administration of a central fund
- retain ultimate authority over spending and selection of projects in national hands, rather than releasing large sums to an international institution for it to spend

U.S. Department of Justice

Environment and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

February 7, 1992

MEMORANDUM

TO: Alex Cristofaro - EPA
Howard Gruenspecht/Abe Haspel - DOE
Norm Hartness - OMB
Jeff Holmstead - WHC
Nancy Maynard - OSTP
Dan Reifsnyder/Stephanie Kinney - State
Ray Squitieri - CEA

FROM: Jonathan Wiener

SUBJECT: OECD Workshop Paper

As I wrote you on January 7, 1992, OECD has asked to publish an outline of my remarks at the July 1991 OECD Workshop on Greenhouse Gas Emissions Trading in a set of papers from the Emissions Trading workshop and a similar workshop on Taxes/Fees for Greenhouse Gases held in November.

Thank you for your comments on the January 7 version of the attached outline, which I have now forwarded to Tom Jones at OECD for publication in the set of papers presented at the OECD Workshop. Each paper published by OECD will of course only represent the personal views of the invited expert and not governmental views, but I appreciate your having commented on the attached, which is much improved as a result. Thank you very much.

THE COMPREHENSIVE APPROACH, GREENHOUSE TAXES, AND INFORMAL EMISSIONS TRADING [1]

Jonathan B. Wiener[2]

Version of 7 Feb. 1992

INTRODUCTION

Most discussion of greenhouse gas (GHG) limitation policies has focused on a "carbon tax" that would apply only to the carbon content of fossil fuels. On both environmental and economic grounds, a more "comprehensive approach" to any such tax would be preferable.[3] The environmental issue of concern is net contributions to potential environmental change, not emissions of one gas per se. Such a tax should therefore apply to all GHG emissions, denominated in terms of the relative contribution of each gas to climate change (e.g. carbon-equivalent units). A "CO_2-only" tax could inadvertently reduce CO_2 emissions but simultaneously increase emissions of other GHGs like methane; and a CO_2-only policy would preclude attention to more cost-effective actions aimed at other GHGs. And any such tax should apply to net rather than gross emissions, providing incentives for conservation of GHG sinks.[4]

Meanwhile, the notion of an international tax on GHGs raises serious questions of implementation and workability. Domestically imposed taxes may solve some of the implementation problems that could frustrate an international tax, but domestic taxes imposed in only a few countries could shift emissions geographically, and significant domestic taxes are unlikely to be adopted because of the distorting effects on competitiveness they could entail.

If measures to limit net GHG emissions are indeed warranted -- a critical question, beyond the scope of this outline, that can only be answered by careful cost-benefit analysis of the optimal level and timing of such measures -- alternatives to taxes may be worth considering. In particular, an approach calling for national strategies and allowing nations the flexibility to incorporate in those strategies emissions-limiting activities undertaken abroad as well as at home (a kind of "informal trading" of emissions reductions) might be a superior implementation tool.[5]

ADVANTAGES OF A COMPREHENSIVE APPROACH

-- The variable of interest is the net effect on the environment, such as potential to change the climate, and is not emissions of one gas per se.

-- There is a great variety of sources and sinks of several GHGs, in virtually every sector of human activity. See Table 1.

-- Energy sector CO_2 is not the whole story. The IPCC estimated that CO_2 contributed 55 percent of global radiative forcing in the 1980s.[6] Of that 55%, about 10-20 percentage points were due to land clearing with the remaining 35-45 percentage points due to energy use.[7]

-- CO_2 is the weakest Greenhouse Gas (GHG) per unit. On an incremental basis, reducing emissions by one unit of CO_2 prevents much less radiative forcing than reducing emissions by one unit of methane (CH_4) or other GHGs. See Table 2.

-- A "comprehensive" approach -- encompassing all GHGs, sources and sinks -- would be environmentally and economically superior to a "piecemeal" focus on one GHG or sector. Any taxes or emissions limits should be denominated in terms of net GHGs rather than CO_2 alone. An index of the relative contribution of each GHG to climate change impacts, or to an intermediate proxy of atmospheric effects, could be used to aggregate across GHGs.

Environmental Advantages of a Comprehensive Approach

-- Traditional environmental policies have been beset by counterproductive "shifts" of emissions:

    -- Cross-media: restricting emissions to one medium, e.g. air, can simply shift the residual to another medium, e.g. land or water. For example, requiring scrubbers to remove sulphur from the air creates sludge solid wastes that must be disposed of in another medium.[8]
    -- Cross-pollutant: e.g., requiring SO_2 scrubbers can yield increased CO_2 emissions[9]; requiring low-NOx burners can yield increased CO or particulate emissions.

-- Climate policy is much more complex, addressing numerous GHGs, sources and sinks in every area of human activity. Tackling climate change is like tackling several traditional environmental issues at once, including air pollution, energy use, agriculture, and industrial chemicals. With

this very complex set of activities, there is a high likelihood of unexpected problems and side effects if narrow policy approaches are chosen. This complexity offers endless catacombs through which "shifts" may occur.

-- Shifts and Unintended Side Effects. A "piecemeal" policy focusing on CO_2 alone could induce "shifts" to activities that emit other GHGs. Examples:

  -- Shifts across GHGs:

    -- All projections forecast that a tax or fee imposed on CO_2 emissions would spur major fuel switching from coal to natural gas. For example, the European Community (EC) is looking (in part) to Russia for natural gas to accomplish fuel switching under a contemplated EC CO_2 tax.

    -- This would reduce CO_2 emitted in combustion but increase CH_4, a more potent GHG, through leakage from natural gas systems. About a 6 percent CH_4 leakage rate would be needed to offset all the reduction in radiative forcing achieved by coal-to-gas CO_2 savings.[10]

    -- In Russia the average CH_4 leakage rate is high enough (4-10 percent) that an EC policy to replace coal with natural gas from that area would threaten a net increase in radiative forcing.[11]

    -- High leakage occurs even in industrialized economies. In the U.K., the leakage rate is estimated to be from 1-11 percent,[12] suggesting that a CO_2-only limit there could offset or increase net radiative forcing. In Australia, the reported 3 percent gas leakage rate would offset about half of the CO_2-related reduction in radiative forcing.[13] Worldwide, the average leakage rate is variously estimated at 2-4 percent[14] and 6-9 percent.[15]

    -- Reducing methane leakage may be a cost-effective means to reduce contributions to radiative forcing, but a policy aimed only at CO_2 provides no such incentive.

  -- Shifts across sectors: If ethanol is encouraged as a replacement for gasoline, it could lower net total fuel cycle CO_2 (if produced using biomass energy rather than fossil fuel energy)[16] but could increase N_2O: ethanol derived from corn farming, a heavy user of nitrogen fertilizers, could be a significant source of N_2O.

- -- Shifts across issues: Replacing CFCs with HCFCs and HFCs could lower ozone depletion potential (ODP) but increase global warming potential (GWP) per unit of industrial output.[17]

-- Flexibility to respond to new information. The science of climate evolves. Significant new scientific insights were revealed in the fall of 1991:

  - -- CFCs act to deplete lower-stratosphere ozone and thereby indirectly cool the lower atmosphere; and
  - -- the lower atmosphere chemistry of other trace gases is complex and interdependent.[18]

  New findings are also indicating that

  - -- sulfur aerosols play a significant role in cooling the lower atmosphere; and
  - -- the carbon cycle includes a large terrestrial sink removing CO_2 from the atmosphere more rapidly than scenarios of emissions have assumed.[19]

  In the face of this changing picture, a comprehensive approach helps avoid "putting all our eggs in one basket." By constantly renewing attention to all the important factors, it keeps policymakers from targeting policy at one aspect of the issue only to discover later that the target has moved.

Economic Advantages of a Comprehensive Approach

-- Nations' portfolios of GHG emissions vary widely, as do their economic systems and social and cultural values.

-- CO_2 reductions may be the least costly option for reducing GHGs in one nation, but not in other. The least-cost option to limit radiative forcing will probably be different in each nation.

-- A least-cost result is promoted by allowing each nation the flexibility to choose its optimum mix of policies for addressing all GHGs.

Dealing with Uncertainty in Source/Sink Measurement

-- Not all the sources and sinks of all GHGs are always easy to measure. Does this mean a comprehensive approach cannot be used? No.

-- Ignoring GHGs doesn't make them go away. A policy limiting CO_2 alone would leave untouched the climate effects of other GHGs.

-- Often the primary need is not measurement of every element of total baseline emissions, but measuring the emissions reductions achieved by specific projects or programs. The latter is typically much more practical. For example, the total size of each source of methane (e.g. livestock, gas leaks, rice) contributing to the total global source is not known with certainty. But from the annual change in atmospheric methane concentrations, we do know the amount by which the total source exceeds the total sink. Hence we can readily assess the contribution of specific, measurable emissions reductions efforts to slowing the rise in concentrations.[20]

-- Much work is being done now to improve the measurement of all GHG sources and sinks. Indeed, because all of these gases may affect the climate, accurate predictions of future climate change -- even without policy measures to limit emissions -- require scientists to improve these measurements.

-- The question is not whether there is "enough" information, but whether the cost of obtaining needed information for sound policy is worth the benefits of avoiding flawed policy. It is most likely to be cheaper to gather more information than to go ahead with a costly, environmentally counterproductive emissions control policy.

-- Policy needs to provide emitters incentives to invest in obtaining the needed measurement information. A CO_2-only policy does not provide such incentives, but a comprehensive approach would.

-- A "phased comprehensive" approach -- such as starting with energy CO_2 emissions in an international agreement, and voting to add other GHGs and sectors only when they are deemed sufficiently measurable -- would not be adequate.

  -- It could easily get stuck at the first step. The initial step would become entrenched as vested interests arise to block expansion to cover all GHGs, sources and sinks.

  -- A central list of what "counts" for a global phased approach assumes that the measurability of each gas is uniform worldwide. But measurability of each GHG or source/sink type will vary locally. For example, CH_4 emissions from gas pipelines or coalbeds in some countries could be more measurable than net CO_2 emissions from fuelwood combustion.

  -- Categorically excluding a gas or source from the agreement offers no incentive to emitters to improve measurement capabilities.

  -- As explained above, often the primary issue for policy purposes is the ability to measure the change in net emissions achieved by reduction efforts, not to measure every piece of the current baseline.

  -- A better approach is to encompass all net GHG emissions reductions efforts but count them according to their measurability, or, put another way, discount them according to the uncertainty of measurement. A "measurability ladder" could be drawn up to assign accounting value according to levels of measurability; each "rung" of the ladder would correspond to a degree of measurability defined by criteria that apply neutrally to any GHG, source or sink. Emitters would then have the incentive to invest in improving measurement -- so that their emissions limitation projects could "climb the ladder" toward full credit.

TAXES/FEES: IMPLEMENTATION ISSUES

Issues Concerning Implementation of International Taxes/Fees

If any restrictions on emissions are warranted, in theory the same outcome could be produced by either a tax or a tradeable quantity allowance system. The price of an emissions allowance on the allowance trading market would be identical to the marginal tax rate on emissions if both policies are set to achieve the same emissions result.

But there are likely to be some notable differences in practice. For example, if the marginal cost function is not precisely known, a quantity limit could unintentionally push the economy past a point of rapidly rising marginal cost, imposing higher total cost on society than initially deemed warranted. A tax approach may provide some security against this risk. But a tax would pose the countervailing risk of inadequately (or excessively) discouraging emissions, for example if the price elasticity of demand for emissions-related goods and services were inaccurately estimated.[21] Which risk is more important to avoid depends on the social marginal costs and social marginal benefits of preventing warming.

At the same time, some problems would be common to both price and quantity restrictions on emissions. The selection of the level at which to set the restriction would be analytically difficult and highly contentious in both cases. Similar issues of monitoring emissions and determining baseline emissions would also arise with price-based as with quantity-based limitations, since knowing the emissions level from each emitter would be critical to enforcing proper tax payments (and since knowing the overall emissions level and elasticity would be important to predicting the tax revenue likely to be raised).

In addition, a worldwide tax imposed through a central international authority raises serious implementation issues that would not arise under a tradeable allowance system:[22]

-- What central authority would administer and enforce the tax? How much sovereignty would nation-states have to cede to such an authority? What kind of centralized bureaucracy would be able to oversee and tax all nations' energy, industry, agriculture, and forestry activities?

-- How would the tax rate be set? If the tax turned out to be an excessive (or an inadequate) disincentive to emissions, who would have authority to change the rate?

-- How would the tax be set to provide equivalent incentive signals in different countries with widely varying economic

systems, incomes, emissions portfolios, and pre-existing domestic tax/subsidy regimes?

-- What would be done with the pot of revenues generated by the tax? Who would handle the money and on what terms would it be redistributed? What share of the funds would be needed to pay for the central bureaucracy?

Of course, a formalized quantity-based limitation that allowed international trading could confront some analogous difficulties:

-- setting the total quantity of emissions;

-- revising this amount if it proved to be inappropriately high or low;

-- allocating targets or allowances among countries[23];

-- initially issuing allowances for free or at a price, and if the latter, deciding what to do with the revenues.

Problems with Non-Uniform Domestic Limitations Policies

One alternative to a centralized tax that has been suggested is a multilateral agreement to undertake parallel domestic taxes in each signatory state. The efficacy of such a system of multiple domestic taxes would depend on, among other things, the breadth of their coverage of potential emitters, and their uniformity or complementarity across emitters.

-- Coverage of potential emitters would need to be broad; otherwise emissions-intensive activities could move from areas subject to a tax to areas not subject to a tax.

  -- Rapid growth in developing country emissions means a tax imposed only in the OECD would only slightly affect global emissions. Since 1976, energy sector CO_2 emissions in the OECD have grown only slightly, while non-OECD emissions have grown at about 2.5 percent per year. At these growth rates, acting alone the OECD countries would have to eliminate more than 100 percent of their CO_2 emissions to reduce global emissions by 20 percent by 2000.[24]

  -- If only a few countries taxed their energy GHG emissions, reducing their consumption of fossil fuels, world prices of those fuels would fall[25]; reduced prices would lead to increased consumption in other nations where taxes on GHG emissions were not in place.

Depending on the relative price elasticities of demand and the relative emissions per unit fuel consumed, the emissions increase resulting from this increased consumption could partially or significantly offset the reduced emissions achieved in the taxing countries.

-- Over the slightly longer term, restrictions by the subgroup of emitters could be offset as industries using high-emitting technologies were increasingly relocated in non-taxing areas and their products imported back into the taxing countries.

-- Meanwhile, taxes (or other limitations policies) that vary significantly across emitters could distort competitiveness among trade partners and rivals. If so, such unilateral or patchwork policies are unlikely to be imposed, or unlikely to be very significant.

-- Furthermore, an agreement requiring every nation to impose a domestic tax would unduly inhibit the choice of policy measures within each nation. Even if all agreed on taking action to limit emissions, some might prefer using quantity-based emissions limits while others prefer using price-based limits; and still others might take different routes, such as government-funded tree planting, or technology development incentives, or reduction in certain subsidies, or negotiated voluntary actions by businesses; or some mix of several policy instruments.[26]

-- Of course, the concerns described above about incomplete coverage of emitters would be equally relevant to quantity-based restrictions on energy emissions imposed in an incomplete set of countries. The global distribution of emissions counsels that action to limit emissions, if any is warranted, would need to be taken on a coordinated global basis by many or even all emitting nations.

INFORMAL EMISSIONS TRADING: "COOPERATIVE ARRANGEMENTS" AS AN ALTERNATIVE TO FORMAL TRADING

An oft-mentioned option for enabling international flexibility while achieving GHG emissions reductions is "emissions trading," in which parties can reallocate their emissions reductions among each other so long as the aggregate reduction is achieved.[27] But this discussion generally assumes creation of a formal trading system, with precise allowances or permits issued by a central agency, and with an aggregate limit (or "target") imposed on emissions. Such a system is hard to envision occurring internationally in the near future, though nations could adopt it domestically to implement national emissions reductions. And the desirability of formal allowance trading under a target depends upon the desirability of an aggregate global target, a larger and fundamental question beyond the scope of this outline.

The great benefits of emissions trading -- flexibility, cost savings, improved environmental performance through conservation and innovation, and investment flows to the most cost-effective opportunities -- can still be incorporated into a climate change agreement that does not include a global target. Under an agreement that calls on each nation to adopt a "national strategy" of its own formulation, nations could undertake "cooperative arrangements," also called "informal emissions trading," to invest in the most cost-effective emissions reduction opportunities worldwide.[28] Allowing "cooperative arrangements" has been suggested by the U.S.[29] The same idea lies at the core of the more complicated (and potentially more cumbersome) proposals that some countries have made using the term "Joint Implementation."[30] The concept could build on and institutionalize existing cooperative efforts like Technology Cooperation and debt-for-nature exchanges.

In its most basic and most practical form, "cooperative arrangements" would involve:

-- Under its "national strategy," each nation could include both domestic actions and investments made overseas through "cooperative arrangements" with other nations.

-- Overseas GHG limitations would be apportioned between the investor nation and the host nation according to the terms of their mutually voluntary arrangement, following sound principles of emissions accounting.

-- Consenting adult nations could thus engage in "informal" emissions trading, improving the cost-effectiveness of any GHG abatement efforts without the need for full-blown formalized allowance systems.

-- Countries would have an incentive to find and invest in the least-cost and most effective opportunities, worldwide, for any net emissions limitations.

-- Such international "cooperative arrangements" would serve as a decentralized, market-based vehicle for flows of investment to low-cost emissions limitation opportunities. Potential recipients would compete to offer projects yielding the most GHG reductions at the least cost; potential investors would compete to offer the best financial and technical assistance. Both investors and host countries would gain -- or else choose not to engage in such arrangements, which would necessarily be voluntary market transactions.

-- Since cost-effective opportunities are especially likely to be found in developing countries and Eastern Europe, one would expect an investment flow to those areas, and a simultaneous cost saving to countries where emissions limitations would be more expensive. In this way investors and recipients would both benefit while emissions are limited.

-- This market-based vehicle could be an alternative to centralized funds. It would
    -- employ existing institutions for bilateral and multilateral investment and assistance;
    -- ensure any money is well spent, by tying real investments to real environmental protection projects;
    -- expend no additional resources on administration of a central fund.

REFERENCES

Dudek, Daniel J. (1987). "Marketable Instruments for Managing Global Atmospheric Problems." Economic Frontiers in Environmental Policy, Annual Meeting of the Western Economics Association. Vancouver, British Columbia. July 7-11, 1987.

Dudek, Daniel J. (1990). "A Short Discussion of Greenhouse Gas Trading." Prepared for Climate Action Network Meeting, Stockholm, Sweden, August 31 - September 1.

Dudek, Daniel J. (1990b). "International Trading in Greenhouse Gas Permits." Policy Paper prepared for Project 88 -- Round II, Environmental Defense Fund, New York, July.

Dudek, Daniel J., LeBlanc, Alice M., and Miller, Peter (1990). "SO2 and CO2: Consistent Policymaking in a Greenhouse," Environmental Defense Fund, New York, January.

Grubb, Michael (1989). The Greenhouse Effect: Negotiating Targets. London: Royal Institute of International Affairs.

Falk, Jim and Brownlow, Andrew (1989). The Greenhouse Challenge (Penguin Books Australia).

Harrington, Winston (1989). "Acid Rain: Science and Policy: A Primer," Resources for the Future, Washington, D.C.

Hogan, Kathleen, Hoffman, John, and Thompson, Ann (1991). "Methane on the Greenhouse Agenda," Nature, vol. 354, pp. 181-82 (21 November).

IPCC (1990). First Assessment Report, including Scientific Assessment, Impacts Assessment, and Response Strategies.

IPCC (1990b). Response Strategies Working Group, "Methane Emissions and Opportunities for Control," coordinated by Japan Environment Agency and U.S. EPA (September).

IPCC/OECD (1990). Papers from the "Seminar on Financial and Economic Measures As a Response to Climate Change," Paris (26-27 April).

IPCC (1992). Supplement Science Assessment, press release following meeting in Guangzhou, Chine (15 January).

Oates, Wallace E. (1991). "Pollution Charges as a Source of Public Revenues," paper for Egon Sohmen Foundation Conference on "Economic Evolution and Environmental Concerns" (July).

Rabchuk, Victor I. and Ilkevich, Nicolay I. (1991). "A Study of Methane Leakage in the Soviet Natural Gas Supply System," Siberian Energy Institute paper prepared for Battelle Pacific Northwest Laboratory (May).

Rodhe, Henning (1990). "A Comparison of the Contribution of Various Gases to the Greenhouse Effect." Science, vol. 248, pp. 1217-19.

Stewart, Richard B. and Wiener, Jonathan B. (1990). "A Comprehensive Approach to Climate Change," American Enterprise, vol. 1, no. 6, pp. 75-80 (November-December).

Swisher, Joel N. and Masters, Gilbert N. (1989). "International Carbon Emission Offsets: A Tradeable Currency for Climate Protection Services." Stanford University.

Tans, P. Tans, I. Fung, & T. Takahashi (1990). "Observational Constraints on the Global Atmospheric CO2 Budget," Science, vol. 247, p. 1431 (23 March).

U.S. Interagency Task Force (1990). The Economics of Long-Term Global Climate Change: A Preliminary Assessment (U.S. Dept. of Energy, OPPA, DOE/PE-0096P, September).

U.S. Interagency Task Force on the Comprehensive Approach (1991). A Comprehensive Approach to Addressing Potential Climate Change (U.S. Dept. of Justice, February).

Wallis, Max K. (1991). "Leaking Gas in the Greenhouse," Nature, vol. 354, p. 428 (12 December).

Wiener, Jonathan B. (forthcoming 1992). "Risk Tradeoffs in Global Environmental Policy," in J. Graham, ed., Weighing the Risks: Risk Tradeoffs in Public Policy, Harvard Center for Risk Analysis.

WMO (1991). World Meteorological Organization/United Nations Environment Program, Scientific Assessment of Ozone Depletion: 1991 (Preprint: December 17).

Wolff, George T. and Frosch, Robert A. (1991). "Impact of Alternative Fuels on Vehicle Emissions of Greenhouse Gases," paper 91-128.5 presented at Air & Waste Management Ass'n Annual Meeting, Vancouver (June).

Table 1

Selected Sources & Sinks Subject to Human Influence

Gas	Sources	Sinks
Carbon dioxide (CO_2)	Fossil fuel combustion Land clearing Biomass combustion	Ocean biota & storage Forests Soils Grasses
Methane (CH_4)	Livestock: enteric fermentation, wastes Rice cultivation Wetlands Landfills Natural gas extraction, venting, transmission, distribution Coal mining Biomass combustion	Atmospheric OH interaction Soil removal
Nitrous oxide (N_2O)	Agricultural fertilizers Land clearing Biomass combustion	Soil removal
Halocarbons (CFCs and related)	Refrigerants Aerosol propellants Foam blowing agents Solvents, cleaning agents Fire retardants	Recapturing and destroying existing supplies
Tropospheric Ozone (O_3)	Precursors: CH4, CO, VOCs, in the presence of NOx Transport of strat. O3 into troposphere	Halocarbon depletion
Carbon monoxide (CO)	Fossil fuel combustion Biomass combustion Precursors: CH4, VOCs	Atmospheric OH interaction
Nitrogen Oxides (NOx)	Fossil fuel combustion Biomass combustion Agriculture	
Volatile Organic Compounds (VOCs)	Fossil fuel combustion Biomass combustion Industrial processes	Atmospheric OH interaction
Aerosols/sulfates (e.g. SO_2)	Fossil fuel combustion	Atmospheric interactions

Table 2

Former IPCC "Global Warming Potential" (GWP) Indices*

Gas	Instantaneous radiative forcing per kg (rel. to CO_2)	Atmospheric residence years (estimated)	Relative radiative forcing potential over years		
			20	100	500
CO_2	1	120	1	1	1
CH_4**	58	10	63	21	9
N_2O	206	150	270	290	190
CFC-11	3970	60	4500	3500	1500
CFC-12	5750	130	7100	7300	4500
HCFC-22	5440	15	4100	1500	510
CFC-113	3710	90	4500	4200	2100
CFC-114	4710	200	6000	6900	5500
CFC-115	4130	400	5500	6900	7400
HCFC-123	2860	1.6	310	85	29
HCFC-124	3480	6.6	1500	430	150
HFC-125	4920	28	4700	2500	860
HFC-134a	4130	16	3200	1200	420
HCFC-141b	2900	8	1500	440	150
HCFC-142b	4470	19	3700	1600	540
HFC-143a	4100	41	4500	2900	1000
HFC-152a	4390	1.7	510	140	47

Source: IPCC Scientific Assessment, 1990, Tables 2.3, 2.8.

*The GWPs are being revised in light of new scientific information presented by the WMO (1991) and IPCC (1992) and currently under review in the IPCC. For example, the indirect component of the GWP of CH_4 is being recalculated, a newly understood indirect component for CFCs is being incorporated, and the lifetime of CO_2 is being reviewed in light of new understanding of the carbon cycle.

**Including indirect effects of CH_4 on tropospheric O_3, CO_2, and stratospheric H_2O. WMO (1991), p. 7.5, reports that the direct component of this value is understated due to a typographical error in IPCC (1990).

ENDNOTES

1. Outline presented to the OECD Workshop on Taxes/Fees for Greenhouse Gases, Paris, November 5-6, 1991.

2. Special Assistant to the Assistant Attorney General, Environment & Natural Resources Division, U.S.Department of Justice. The views expressed are the author's and do not necessarily reflect those of the U.S. Department of Justice or the U.S. Government.

3. The "comprehensive approach" is articulated in U.S. Interagency Task Force on the Comprehensive Approach (1991); and Stewart & Wiener (1990).

4. Of course, any such tax or other restriction, whether on CO_2 or on all GHGs, and whether domestic or international, needs to be warranted on cost-benefit grounds as well. That topic is beyond the scope of this paper, which is limited to addressing cost-effectiveness and implementation concerns.

5. Pros and cons of GHG taxes and trading approaches are explored more fully in IPCC/OECD (1990), in particular in the U.S. paper submitted to that seminar.

6. IPCC Scientific Assessment, Policymakers' Summary, p. xx (1990). These shares may be revised in light of new scientific information presented by the WMO/UNEP Stratospheric Ozone Assessment Panel in October 1991 and being reviewed by the IPCC in early 1992.

7. IPCC Response Strategies, Policymakers' Summary, Table 1 p. xxxii (1990).

8. Reducing SO2 emissions 10 million tons per year through scrubbing would generate 45 million tons per year of sludge -- about 1/3 the current total municipal solid waste volume in the U.S. Harrington (1989), p. 16.

9. Dudek, LeBlanc, and Miller, (1990).

10. Rodhe (1990). This figure is derived using a 100-year index value of CH_4 = 20 relative to CO_2 (on a mass basis). The IPCC had estimated this index value at 21, see Table 2. The index is currently being recalculated by the IPCC. The "direct" component of the index value for CH_4 will likely be increased "substantially" by the new analysis, to 11, but the "indirect" component remains under review as of this writing. See WMO (1991), pp. 7.5-7.6, Table 7-2.

11. Rabchuk and Ilkevich (1991).

12. Wallis (1991).

13. Falk and Brownlow (1989), p. 270.

14. IPCC (1990b), p. 34.

15. Wallis (1990), citing Crutzen, P.J., Nature vol. 350, pp. 380-81 (1991).

16. Wolff and Frosch (1991).

17. Wiener (forthcoming 1992). Such a shift is likely if (as suggested by the new UNEP/WMO Ozone Assessment Panel findings) the direct warming effect of CFCs is offset by the indirect cooling effect of their depletion of lower stratosphere ozone, but HCFCs/HFCs pose only a direct warming risk and have no indirect cooling effect. This also depends on the ratio at which HCFCs/HFCs are substituted for CFCs in actual usage.

18. WMO/UNEP (1991).

19. IPCC (1992); Tans et al. (1990).

20. Hogan, Hoffman & Thompson (1991).

21. Oates (1991).

22. Further discussion may be found in the U.S. paper submitted to IPCC/OECD (1990).

23. The allocation problem arises whenever a quantity-based restriction on emissions is imposed, whether or not trading is allowed. Without trading, the allocation problem is implicit in the quantity standard articulated (e.g. requiring "reductions to a certain uniform level" would have very different allocation effects from requiring "reductions by a certain uniform percentage"), and is typically highly contentious. With trading, allowance allocation is explicit, and its economic impact can be moderated through subsequent opportunities to trade.

24. U.S. Interagency Task Force (1990).

25. Assuming no offsetting reduction in fuel supply.

26. An agreement calling for nations to adopt "national strategies" would afford this important flexibility.

27. E.g., Dudek (1987, 1990, 1990b); Grubb (1989); Swisher & Masters (1989).

28. U.S. Paper submitted to IPCC/OECD (1990); Stewart and Wiener (1990); U.S. Interagency Task Force on the Comprehensive Approach (1991).

29. U.S. Submission to the INC-Climate, March 15, 1991, pp. 4-5; U.S. Intervention at the Fourth Session of the INC-Climate, Geneva, December 1991.

30. Norway's submission to the Intergovernmental Negotiating Committee (INC) on a Framework Convention on Climate Change at its Nairobi session in September 1991; Germany's remarks at the INC session in Geneva in December 1991.