ESTABLISHING AN INTERNATIONAL ENERGY EFFICIENCY AGENCY: A RESPONSE TO THE THREAT OF GLOBAL CLIMATE CHANGE

BY

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I. The Threat of Global Climate Change

Atmospheric scientists project that given current trends, the concentration of carbon dioxide (CO2) and other greenhouse gases in the earth's atmosphere will more than double and the average temperature of the earth will rise about 2–4 ^{o}C above the pre-industrial level by the middle of the next century [1]. The world would be committed to a further temperature rise due to time delays before an equilibrium temperature is reached. Such rapid increases in temperature could significantly alter rainfall patterns, reduce crop and forest productivity, eliminate species, increase the sea level, damage coastal areas, and displace hundreds of millions of people [2]. Although the timing and magnitude of the impacts are highly uncertain, global climate change due to the greenhouse effect poses a severe threat to the world's ecological and economic systems.

Table 1 lists the man-made causes of the greenhouse effect by activity and pollutant type, given present knowledge. It is estimated that over 55% of global warming is due to energy production and use. In terms of the gases that are causing the greenhouse effect, about half of the effect is due to CO2 emissions. Most of the CO2 entering the atmosphere is caused by the burning of fossil fuels; a smaller part is due to burning of wood and other forms of biomass.

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The U.S. Environmental Protection Agency (EPA) has addressed the issue of what needs to be done in order to stabilize or reduce the concentration of greenhouse gases in the atmosphere. The EPA estimates that the following reductions in annual emissions are necessary [3]:

Carbon dioxide	- 50–80%
Methane	- 10–20%
CFCs	- 75–100%
Nitrous oxide	- 80–85%

Converting all gases to equivalent emissions of carbon (based on their warming potential), these reductions imply cutting present emissions of 12.2 Gigatonnes of carbon equivalent per year (Gt C/yr) to 4.3–6.8 Gt C/yr. Such action would limit the world's "global warming commitment" to approximately 0.1 ^{o}C per decade. Other analyses show that similar reductions in greenhouse gas emissions are necessary in order to significantly reduce potential global warming [4].

Cutting annual CO2 emissions by 50% or more will require profound changes in energy production and use throughout the world. Table 2 presents the trends in CO2 emissions by region during the past 40 years. World CO2 emissions from burning of fossil fuels increased by a factor of 3.6 during 1950–88, representing an average growth rate of 3.5%/yr [5]. During 1980–88, weak economic growth and reductions in energy intensity kept total CO2 emissions by OECD countries nearly constant. But increasing fossil fuel use by developing and Eastern European countries (including the U.S.S.R.) resulted in continued growth in worldwide CO2 emissions. While wealthy industrialized countries have produced the majority of CO2 emissions on a cumulative basis, developing and Eastern European nations currently emit more CO2 from fossil fuel combustion than OECD nations. When deforestation is included, the LDC/EE contribution to global warming is even greater. What is clear from this data is that the threat of climate change must be addressed globally. No one region or group of

countries can stabilize the concentration of greenhouse gases in the atmosphere on its own.

II. International Energy Efficiency Agency: A Response Strategy

Adopting a carbon emissions tax has been suggested as one means of combatting the threat of global warming. The tax could either be high enough to stimulate substantial reductions in fossil fuel use directly [6], or relatively small but still large enough to fund other actions that reduce greenhouse gas emissions [7]. Momentum is building for taxing carbon emissions as part of a broader strategy for slowing climate change. Sweden has already adopted an internal tax of about $160 per ton of carbon emitted, effective in January, 1991 [8]. Brazil has formally endorsed the concept of a worldwide tax on carbon emissions from fossil fuel use [9]. Also, use of a modest worldwide carbon tax to fund actions that slow climate change is gaining support among economists who are concerned about the cost effectiveness of reducing global warming, such as William Nordhaus of Yale University [10].

A worldwide carbon tax of about $8 per metric ton of carbon emitted from burning of fossil fuels has been been suggested as the basis for creating a climate change abatement fund [11]. An $8 per ton carbon tax is equivalent to about $1.00 per barrel of oil, $5.50 per metric ton of coal, and $4.20 per thousand cubic meters of natural gas. A worldwide carbon tax of this magnitude would generate nearly $50 billion in tax revenue per year, based on current levels of fossil fuel use. If the poorest nations are exempt or are subject to a lower tax rate, then total revenue would be reduced somewhat.

The carbon tax would have a minor impact on energy prices. At $8 per ton of carbon, it would raise the total energy bill paid in the U.S. by about 2%, for example [12]. If a significant portion of the revenue from the carbon tax is used to accelerate energy efficiency improvements -- actions that save more money than they

cost [13] -- the tax could have a positive net impact on national economies.

Revenue from the carbon tax could be used to finance a variety of activities to slow or mitigate climate change, including implementing substitutes for ozone-depleting CFCs, research on new technologies for capturing carbon, reforestation and protection of existing forests, energy efficiency programs, development of renewable energy technologies, and agricultural management programs. In this paper, one strategy is presented -- a global energy efficiency campaign implemented through an international energy efficiency agency.

Increasing the efficiency of energy conversion and use is an integral part of a "no regrets" response to the risk of global climate change. For most activities, 25-50% energy savings are possible with the most efficient technologies and practices now commercially available [14]. Improving energy efficiency is economically viable on its own since the value of energy savings usually far exceeds the cost of energy efficiency measures. In Brazil, for example, it is estimated that investing at most $20 billion in electricity conservation measures could result in avoiding around $55 billion of investment in new power plants, transmission lines, and distribution equipment [15]. Improving energy efficiency also provides a host of other benefits including reducing local and regional air pollution and reducing dependence on petroleum imports. Thus, even if global warming turns out to be a minor threat, nations and individuals will not regret having undertaken aggressive energy efficiency improvements.

A worldwide, collaborative effort to improve energy efficiency is desirable for a variety of reasons in addition to the fact that no one nation or region can stabilize the global greenhouse on its own.

1) In OECD nations, energy efficiency efforts are faltering and CO2 emissions are rising once again. U.S. fossil fuel use and CO2 emissions increased over 9% between 1986 and 1989, for example [16]. However, OECD nations must reduce their energy intensities at an unprecedented rate in order to substantially reduce worldwide CO2 emissions during the next 20 years.

2) In developing and Eastern European countries, it is becoming increasingly difficult to finance rapid growth in energy supplies. Increasing efficiency is a way to reduce financing requirements and the risk of energy shortages, without lowering economic growth or standards of living.

3) Given that wealthy nations are the main source of greenhouse gas emissions on a cumulative basis and that emissions per capita in wealthy nations are much greater than in poor nations, developing and Eastern European countries are unlikely to make a strong commitment to alleviating this global environmental threat unless industrialized countries take the lead.

4) The economies of industrialized and developing nations are increasingly interlinked through world trade and the presence of multinational corporations. New energy-efficient processes or goods developed in one country often can be applied throughout the world. It is important to begin improving the efficiency of "world products" such as automobiles, appliances, and lighting technologies through coordinated international efforts.

5) The energy intensity (energy per unit of GDP) of developing and East European countries is approximately 60% greater than that of OECD countries on average [17], and these countries often lack the institutions, technologies, and policies for rapidly improving efficiency. Developing and East European countries could benefit from institutional support, technical assistance, and financing of efficiency improvements. It will be easier for these countries to take advantage of advances in the First World if close international cooperation is occurring.

6) Other benefits such as softening of world oil markets, reducing threats to international security, and reducing acid rain will intensify if nations are working together to improve energy efficiency.

An international energy efficiency campaign should complement but not substitute for national and regional energy efficiency efforts. Individual nations will still need to adopt their own strategies for disseminating energy-efficient technologies and processes, as well as encouraging structural shifts that reduce energy use. An international effort can support national and regional efforts through sharing of information, coordinating and jointly-sponsoring R&D programs, demonstrating technologies as well as policy instruments, offering training or supporting national training programs, establishing uniform testing procedures, developing energy efficiency targets for specific end uses and conversion technologies, and financing of implementation efforts by poor nations. Further details regarding appropriate

international activities are provided below.

An international energy efficiency effort also should complement but not substitute for other mechanisms for reducing the level of greenhouse gases in the atmosphere. A worldwide agreement to reduce the risk of climate change including country-by-country ceilings on CO2 emissions remains the principal goal. National commitments to reduce CO2 emissions are important prior to an international agreement. The existence of a global energy efficiency campaign would help individual nations and the world implement substantial emissions reductions.

International cooperation in energy efficiency already exists at various levels. Among industrialized countries, the International Energy Agency (IEA) conducts studies and sponsors joint R&D or demonstration projects in specific areas. However, energy efficiency activities account for only about 10% of the roughly $16 million annual budget of the IEA. The IEA has no central funds for collaborative R&D or demonstration projects; all funding is provided by member countries [18].

Some industrialized countries are supporting energy efficiency efforts in developing and Eastern European countries through their bilateral assistance programs, but the total funding is only on the order of $50 million per year [19]. Furthermore, the World Bank and other multilateral lending agencies devote a very small fraction of their energy-related lending to energy efficiency improvements [20]. Thus, while some worthwhile activities are occurring, current international cooperation in energy efficiency is piecemeal, small scale, and far from adequate considering the challenge posed by global climate change.

Given that existing institutions are not conducting a comprehensive and aggressive international energy efficiency campaign, starting an International Energy Efficiency Agency (IEEA) is proposed. The IEEA should have a clear mission of supporting local, national, and regional energy efficiency efforts and accelerating

efficiency improvements throughout the world. Where appropriate, existing cooperative programs in energy efficiency could be taken over and greatly expanded through the IEEA. Funding for the IEEA could be provided through the carbon tax either from the outset or once the new agency reaches a substantial size.

A. Scope and Activities

To carry out the proposed mission, the IEEA should concentrate on three broad areas: 1) strengthening energy efficiency efforts in industrialized countries; 2) helping to build capability for implementing energy efficiency improvements in developing and Eastern European countries; 3) providing capital for large-scale energy efficiency investments in developing and Eastern European nations. Although industrialized and developing nations are treated separately in this discussion, the distinction need not be emphasized with the IEEA. The key objective is to have all countries working in a collaborative manner in order to accelerate energy efficiency improvements worldwide.

1. Strengthen Efficiency Efforts in Industrialized Nations

There are many ways in which energy efficiency efforts in industrialized countries could be improved through international cooperation. One way would be to jointly collect, compile, and share information about energy use, the state-of-the-art in energy conserving technologies and processes, R&D efforts, successful (and unsuccessful) policies and programs, planning and regulatory techniques, and the status of implementation in different countries. Data bases and conferences on these subjects could be useful to both industrialized and non-industrialized nations.

Sponsorship of joint R&D and demonstration activities could be another important area of activity. Duplication of effort can be avoided and the results of national R&D efforts can be put to better use if international cooperation occurs. Multi-country research on policies and programs as well as technologies is needed.

Also, relatively expensive, high risk R&D activities of worldwide relevance could be undertaken (e.g., R&D on new industrial processes or vehicles). Special attention should be devoted to potential "leapfrogging" technologies such as use of new materials or microelectronics. The IEA has established institutional and legal precedents for international collaboration in energy efficiency R&D, including safeguards for private companies that participate [21].

At present, different test procedures are used for measuring the efficiency of automobiles, refrigerators, motors, and other equipment in North America, Western Europe, and Eastern Asia. This makes it difficult to compare the efficiency of equipment produced in different regions and to know if products manufactured in one part of the world satisfy the efficiency requirements in another region. Establishing uniform efficiency testing procedures and compiling performance data would facilitate comparison and make it easier to test equipment within multinational companies. If necessary, the resulting performance values could be adjusted to account for local climate and usage patterns when implementing labelling and other programs within each country. Also, conducting efficiency tests using the same methods throughout the world would make it easier for developing countries to adopt minimum efficiency requirements for imported equipment or vary import duties based on equipment efficiency.

Along with establishing uniform test procedures, the IEEA could develop and recommend minimum efficiency targets or requirements for automobiles, appliances, motors, lamps, and other standardized products. International efficiency agreements are needed in part because these products are increasingly developed, produced, and marketed on a global scale. Future trade agreements might limit unilateral actions that could be viewed as restricting free trade. The IEEA could negotiate with equipment manufacturers, encourage manufacturers to accept efficiency targets

voluntarily, and issue model regulations that individual nations would then adopt. Also, the IEEA could discourage manufacturers from maintaining "dual efficiency standards", i.e., producing relatively efficient equipment for one set of countries but inefficient equipment for other (often developing) countries. Efficiency targets also could be developed and recommended for major industrial processes such as production of steel, aluminum, or cement.

Education, training, fellowships, exchanges, and awards are other areas in which an IEEA could play a useful role. Since the number of professionals working in the energy conservation field must greatly expand if efficiency improvements are to occur at unprecedented rates, the IEEA should support education and training (e.g., develop curricula and train local trainers). Exchange programs would be useful since different countries stand out in different areas. For example, with support from the IEEA, Scandanavian experts in constructing superinsulated homes could train or assist home builders and public officials in other countries. Likewise, U.S. experts in utility conservation programs and least-cost utility planning could assist in countries where these activities are just beginning. In addition, the IEEA could recognize individuals, companies, and nations that make outstanding contributions to the worldwide energy efficiency campaign.

2. Assist Developing and Eastern European Countries

Inefficient energy production and use can inhibit economic and social development in developing and Eastern European countries. For many countries, energy imports absorb a large fraction of hard currency. For others, financial resources are no longer available to support energy demand growth of 4% or more per year. Energy shortages and/or excessive investments in capital-intensive energy supply projects can reduce industrial output and the expansion of housing, education, health care, and other critical services. Also, the negative environmental impacts of energy

production and use are of growing concern in LDCs and Eastern Europe. Because of the various problems associated with inefficient energy use, countries such as China and Brazil are striving to reduce their overall energy intensity [22].

The IEEA could help to increase the effectiveness and pace of energy efficiency improvements in developing and Eastern European countries [23]. Since energy conservation opportunities are highly decentralized and are tied to local production patterns and cultural factors, supporting local institutions should be the primary objective of the IEEA with respect to these countries. Education and training is an obvious need -- the IEEA could help to establish, support, and fund energy efficiency training centers in major countries or regions. The IEEA could teach the staff who would be responsible for training industrial energy managers, auditors, conservation program managers, etc. Educating policymakers regarding energy efficiency potential and integrated resource planning is another important need. The IEEA also could support fellowship and exchange programs among LDCs and Eastern European nations, as well as between these countries and industrialized nations.

Technical assistance might include locating and funding of experts who could help to start major energy efficiency programs and centers, or assist in a specific area. For example, the IEEA could provide specialists that are experienced in analyzing or implementing pricing reform, building efficiency standards, industrial cogeneration, or vehicle inspection and maintenance programs. The IEEA could assist with technology development and transfer through co-funding of R&D and demonstration projects, sponsoring product exhibits, encouraging joint ventures, and encouraging multinational companies to adopt state-of-the-art processes and equipment in LDCs and Eastern Europe. Helping countries select energy-efficient industrial processes and energy-efficient technologies also could be useful.

An ongoing U.S.-Soviet collaboration in energy conservation R&D provides an

example of the value of international exchange and assistance. With support from U.S. energy efficiency experts, Soviet researchers are studying energy use in large apartment buildings, developing building temperature control techniques, demonstrating advanced window technologies, integrating energy efficiency opportunities into energy planning, and carrying out various other projects [24]. One part of the collaboration, development and testing of advanced power generating technologies, could benefit all nations.

3. Finance Efficiency Improvements in Developing and Eastern European Countries

As pointed out above, energy efficiency is a sound investment since the value of the energy savings well exceeds the initial cost of the conservation measure. Nonetheless, capital is needed to produce more efficient power plants, buildings, appliances, industrial processes, automobiles, transport systems, etc. throughout developing and Eastern European nations. In terms of its total budget, most of the funds of the IEEA could be devoted to financing of major implementation efforts in these countries.

Consider the following estimate of the potential cost for energy efficiency improvements in these countries. Primary energy consumption in developing countries and Eastern Europe (including the USSR) totalled about 185 EJ (4,400 MTOE) in 1990. If energy consumption grows 4%/yr -- approximately the rate experienced during the past decade and a rate of growth projected by the World Bank [25] -- primary energy use will reach about 405 EJ by 2010. On the other hand, if efficiency improvements and structural shifts reduce the energy growth rate to 2%/yr without lowering economic growth or energy services [26], primary energy use will reach 275 EJ in 2010. This implies nearly one-third less energy consumption in 2010. Assuming efficiency improvements occur linearly, cumulative savings during the 20

year period would equal about 1300 EJ. Based on studies of the cost effectiveness of efficiency improvements in various sectors and countries [27], it is reasonable to assume an average cost of saved energy of $2 per GJ of primary energy savings. Based on this value, $130 billion per year must be invested in energy efficiency measures on average in order to cut primary energy use in 2010 by nearly one-third.

In order to spark energy efficiency improvements on this scale, the IEEA could finance major conservation programs and projects in developing and East European countries. These programs and projects could involve private companies (e.g., financing for energy efficiency improvements in a steel mill), government agencies (e.g., a loan program offered by a national development bank), or utilities (e.g., for improving the efficiency of power generation or end use). Because efficiency improvements are beneficial from a national perspective and because vast efficiency improvements are desired, the IEEA should play a catalytic role -- initiating programs, cost sharing of major projects, and leveraging private and public sector resources. In some countries, extensive program development and technical assistance may be necessary before large sums of money can be effectively invested in energy efficiency.

As a financier, it is suggested that the IEEA provide zero-interest or low-interest loans for major energy efficiency improvements in developing and East European countries. The assistance activities described in the previous subsection would be provided free, however. Concessional financing is necessary because of the financial and institutional barriers inhibiting widespread efficiency improvements in these countries, the urgency of reducing greenhouse gas emissions and the magnitude of reductions that are necessary, and because debt servicing is already a severe burden for many of these countries. Also, recent experience with efforts to phase out production of ozone-depleting CFCs demonstrated that some developing countries will

demand financial subsidies before agreeing to participate in efforts to protect the global environment.

B. Budget, Institutional Issues, and Getting Started

Once it reaches maturity, the IEEA could perhaps spend $10-20 billion per year financing efficiency improvements in developing and Eastern European countries, $1-2 billion per year on institutional development and technical assistance in these countries, and $1-2 billion per year on activities that are primarily OECD-related. Hence, the IEEA might utilize 25-50% of the money in a climate protection fund that is based on an $8 per ton carbon tax. A budget of $12-24 billion per year is consistent with the amount of spending on energy efficiency suggested in a recent report on what might be required to stabilize greenhouse gases [28]. To put this proposed budget in perspective, the World Bank loans about $15 billion per year while all development assistance from OECD to developing countries equals about $50 billion per year [29].

While the proposed IEEA would certainly be a large institution, its budget of $12-24 billion per year would be on the order of 5-10% of desired expenditures on energy efficiency worldwide. The budget for activities devoted mainly to industrialized nations might equal only 1-2% of desired expenditures on efficiency in these countries [30]. Thus, the primary mission of the IEEA would be to stimulate and accelerate "market uptake" of energy efficiency measures throughout the world.

A multi-billion dollar IEEA would need a headquarters, but also should have large branches on each continent. These branches could coordinate activities in their region and work closely with individual countries. While many activities could be decentralized, some activities such as establishing uniform efficiency testing procedures and developing efficiency goals for "world products" should be handled internationally.

Just as individual nations are not waiting for a global agreement before pledging to cut their carbon emissions, it is unnecessary to adopt a worldwide carbon tax or develop unanimous support for the IEEA before beginning. Since it would take a number of years to build up an institution with an annual budget in excess of $10 billion, one or more nations could get the IEEA off the ground. Initial funding could come through individual countries unilaterally adopting a carbon emissions tax or through governmental funding. For example, if Sweden set aside 20% of its carbon tax revenue to help start the IEEA, $30 million would be made available annually. If West Germany adopted an $8 per ton carbon tax and set aside 20% of the revenues for the IEEA, an additional $300 million per year would become available. Unilateral action could pave the way for international adoption of the carbon tax as a global warming accord is negotiated in the next few years.

While one or more countries could fund the start-up of the IEEA, there are a number of reasons for seeking a carbon tax established through an international protocol as the source for permanent funding. First, with a dedicated source of funds decoupled from government budgets, it would be difficult for countries to cut or withdraw funding as political leadership and priorities shift. Second, the IEEA would not compete with national energy conservation programs for funding. Third, an international carbon tax could provide the hundreds of billions of dollars that are necessary to have a significant impact on emissions of carbon dioxide and other greenhouse gases. Fourth, funding the IEEA through a carbon tax gives countries an added incentive to lower their own fossil fuel use. Even though the tax would be small in comparison to energy prices, its sheer existence could trigger other public policies in support of greater energy efficiency.

As outlined here, a large majority of the IEEA's expenditures would go to developing and Eastern European countries. But if a tax on carbon emissions from

fossil fuel use is the funding mechanism, OECD countries would provide about half of the Agency's budget. If the poorest nations are exempt from the tax or are allowed to pay a lower tax, then OECD countries would pay an even larger portion of the total budget.

With this financial flow, why should industrialized nations participate? The answer, in my view, is both obligation and self-interest. The wealthier industrialized nations are responsible for most of the cumulative build-up of greenhouse gases in the atmosphere and emissions per capita are much higher in these countries. Given their disproportionate share of emissions, it is reasonable to ask wealthier nations to pay a disproportionate share of the climate stabilization bill.

The self-interest for industrialized countries relates to the fact that they cannot stabilize the concentration of greenhouse gases in the atmosphere on their own. Developing countries are rapidly increasing fossil fuel use as they build their economies and infrastructure, expand services, and confront other problems. These countries are expected to account for over 75% of the growth in worldwide CO2 emissions in the next few decades [31]. Without extensive technical and financial assistance, energy efficiency may continue to play a limited role in LDCs and Eastern Europe. This in turn would make it difficult if not impossible to stop global warming. Furthermore, aggressive efficiency efforts in LDCs and Eastern Europe will strengthen the economies of these countries and exert downward pressure on world energy prices.

III. Conclusion

Global warming poses a tremendous challenge to mankind since the consequences are uncertain, long-term, and potentially catastrophic. The catastrophic impacts may be unavoidable if we delay action until the uncertainty is resolved. Given this dilemma, it is imperative that the nations of the world work together to minimize the

risk. A worldwide energy efficiency campaign -- led and coordinated by an International Energy Efficiency Agency -- could be a critical component in such an effort. A successful efficiency campaign would increase economic productivity, improve international security, and reduce other environmental problems, in addition to slowing the build-up of greenhouse gases in the atmosphere. It is truly a "no regrets" strategy.

Given the magnitude of the global warming problem and the range of benefits provided by greater energy efficiency, the campaign should be aggressive and large scale. Eventually, the IEEA could equal or surpass the World Bank in size. A small carbon tax would be an adequate and dependable source of funds for the IEEA as well other activities devoted to slowing global warming. The carbon tax also would link the funding base with the objectives of the energy efficiency campaign.

There are many reasons for involving all nations in the implementation as well as funding of a worldwide energy efficiency campaign. The potential for large and cost-effective efficiency improvements exists everywhere, unprecedented rates of energy efficiency improvement are needed, and cooperation should improve national efforts by all countries. Moreover, the benefits of reducing carbon emissions will extend around the world as well as to future generations. By working together, the nations of the world can limit global warming and protect their future.

NOTES AND REFERENCES

1. "Policymakers Summary on the Scientific Assessment of Climate Change", Intergovernmental Panel on Climate Change, WMO/UNEP, June 1990.

2. G.M. Woodwell, "The Effects of Global Warming", in J. Leggett, ed., Global Warming: The Greenpeace Report, Oxford University Press, Oxford, 1990.

3. D.A. Lashof and D.A. Tirpak, eds., "Policy Options for Stabilizing Global Climate", draft report, U.S. Environmental Protection Agency, Washington, DC, Feb. 1989.

4. IPCC, "Policymakers Summary on the Scientific Assessment of Climate Change".

5. G.H. Kats, "Slowing Global Warming and Sustaining Development", Energy Policy, Jan./Feb. 1990, pp. 25-33.

6. W.U. Chandler and A.K. Nicholls, "Assessing Carbon Emissions Control Strategies: A Carbon Tax or a Gasoline Tax?", American Council for an Energy-Efficient Economy, Washington, DC, Feb. 1990.

7. J. Goldemberg, "Energy and Environmental Policies in Developed and Developing Countries", Proceedings of the Conference on Energy and Environment in the 21st Century, Cambridge, MA, March 1990.

8. Sweden has not proposed using revenue from the carbon tax to fund actions to reduce global warming, however. Also, current energy taxes will be reduced by 50% when the carbon tax takes effect, and electric utilities and energy-intensive industries will be exempt from the carbon tax until international agreements for limiting CO2 emissions are concluded.

9. Personal communication with Jose Goldemberg, Secretary of Science and Technology, Government of Brazil, September 1990.

10. W.D. Nordhaus, "Greenhouse Economics", The Economist, July 7, 1990, pp. 21-24.

11. J. Goldemberg, "Energy and Environmental Policies in Developed and Developing Countries".

12. A carbon tax of $8 per ton would cost the U.S. about $12 billion per year. The total energy bill in the U.S. (excluding other taxes) was about $420 billion in 1988. With the rise in oil price caused by the 1990 Persian Gulf crisis, the U.S. will expend well over $500 billion on energy in 1990.

13. H.S. Geller, "National Energy Efficiency Platform: Description and Potential Impacts", American Council for an Energy-Efficient Economy, Washington, DC, July 1989; A.B. Lovins, "The Role of Energy Efficiency", in J. Leggett, ed., Global Warming: The Greenpeace Report, Oxford University Press, Oxford, 1990.

14. J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams, Energy for a Sustainable World, Wiley Eastern Limited, New Delhi,, 1988.

15. H.S. Geller, "Electricity Conservation in Brazil: Status Report and Analysis", American Council for an Energy-Efficient Economy, Washington, DC, Aug. 1990.

16. "Annual Energy Review 1989", DOE/EIA-0384(89), Energy Information Administration, U.S. Department of Energy, Washington, DC, May 1990.

17. J. Goldemberg, "Policy Responses to Global Warming", in J. Leggett, ed., Global Warming: The Greenpeace Report, Oxford University Press, Oxford, 1990.

18. "Joint R&D Projects in Energy Technology", International Energy Agency, Paris, 1990. Also, personal communication with Erich Unterwurzacher, IEA, Paris, September 1990.

19. "Energy Efficiency: Solving the Global Environment and Development Dilemma", draft, U.S. Agency for International Development, Washington, DC, July 1990.

20. J. VanDomelen, "Power to Spare: The World Bank and Electricity Conservation", World Wildlife Fund and The Conservation Foundation, Washington, DC, 1988.

21. IEA, "Joint R&D Projects in Energy Technology".

22. H.S. Geller and D. Zylbersztajn, "Energy Intensity Trends in Brazil", Instituto de Eletrotecnica e Energia, Universidade de Sao Paulo, Sao Paulo, Brazil, October 1990; W.U. Chandler, A.A. Makarov, and Z. Dadi, "Energy for the Soviet Union, Eastern Europe and China", Scientific American 263(3), Sept. 1990, pp. 120-127.

23. Many of the ideas expressed here regarding assistance to developing countries and Eastern Europe are similar to those recently put forward by an ad-hoc working group convened by the U.S. Agency for International Development. See Reference 19.

24. R.H. Socolow, "U.S.-Soviet Collaboration in Energy Conservation: Research and Development Initiatives to Cope with Climate Concerns", Proceedings of the IEA/OECD Expert Seminar on Energy Technologies for Reducing Emissions of Greenhouse Gases, IEA, Paris, April 1989.

25. M. Imram, "Energy Demand Prospects in Developing Countries", paper presented at the IPCC/IES Workshop on Emissions of Greenhouse Gases, London, June 11-13, 1990.

26. Geller, "Electricity Conservation in Brazil"; Chandler et al., "Energy for the Soviet Union, Eastern Europe and China"; A.K.N. Reddy and J. Goldemberg, "Energy for the Developing World", Scientific American 263(3), Sept. 1990, pp. 110-119.

27. The cost of saved energy is the levelized cost of reducing energy consumption, with capital costs levelized (i.e., converted into an annual capital charge) using a real discount rate of 5-10%. Studies indicate that the cost of saved energy for industrial efficiency measures is typically $1.00-2.00/GJ, the cost of saved energy for electricity savings measures is typically around $2.00/GJ ($0.025/kWh), and the cost of saved energy for automobile efficiency measures is around $4.00/GJ. Based on these values, an average cost of saved energy of $2.00/GJ is assumed. See Reddy and Goldemberg, "Energy for the Developing World"; Geller, "Electricity Conservation in Brazil"; Geller, "National Energy Efficiency Platform: Description and Potential Impacts"; M. Ledbetter and M. Ross, "Supply Curves of Conserved Energy for Automobiles", American Council for an Energy-Efficient Economy, Washington, DC, March 1990; R.K. Pachauri, "The Economics of Energy Conservation in Developing Countries", in D.L. Bleviss and V. Lide, editors, Energy Efficiency Strategies for Thailand, University Press of America, 1989.

28. Paper prepared by McKinsey and Company, Inc. for the Ministerial Conference on Atmospheric Pollution and Climate Change, Noordwijk, The Netherlands, Nov. 1989.

29. World Development Report 1990, World Bank and Oxford University Press, Oxford, UK, 1990.

30. These estimates assume a goal of reducing worldwide energy demand growth by 2.5%/yr during the next 20 years. This implies a cumulative energy savings of about 2400 EJ during the 20 year period. If the average levelized cost for efficiency measures is $2 per GJ saved, the total expenditure on efficiency measures would be $4.8 trillion or $240 billion per year on average.

31. Greenhouse Gas Emissions and the Developing Countries: Strategic Options and the U.S.A.I.D. Response", U.S. Agency for International Development, Washington, DC, July 1990.

Table 1

SOURCES OF MAN-MADE GREENHOUSE EFFECT DURING THE 1980s BY ACTIVITY AND GAS TYPE

Activity	(%)	Gas	(%)
Energy use and production	57	CO2	49
CFCs	17	CH4	18
Agriculture	14	CFC-11, 12	14
Land use modification	9	N2O	6
Other industry	3	Other	13

Source: D.A. Lashof and D.A. Tirpak, eds., "Policy Options for Stabilizing Global Climate", draft report, U.S. Environmental Protection Agency, Washington, DC, Feb. 1989.

Table 2

TRENDS IN GLOBAL CARBON EMISSIONS FROM THE COMBUSTION OF FOSSIL FUELS

	FRACTION OF CARBON EMISSIONS (%)			
Region	1950	1965	1980	1988
North America	44.7	32.1	26.7	24.3
USSR and E. Europe	18.0	24.0	24.7	25.2
Western Europe	23.4	20.6	16.5	13.3
Developing Countries	7.1	13.7	20.7	24.9
Japan, Australia, Other	5.9	9.6	11.0	12.4
Total emissions (Gt/yr)	1.62	3.13	5.17	5.89

Source: G.H. Kats, "Slowing Global Warming and Sustaining Development", Energy Policy, Jan./Feb. 1990, pp. 25-33. Also, personal communication with Gregory Kats, Geneva, November 1990.