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International Impacts of Global Climate Change

Testimony to House Appropriations Subcommittee on Foreign Operations, Export Financing and Related Programs

W. Fulkerson
R. M. Cushman
G. Marland
S. Rayner

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Energy Division

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TESTIMONY TO HOUSE APPROPRIATIONS SUBCOMMITTEE ON FOREIGN OPERATIONS, EXPORT FINANCING AND RELATED PROGRAMS

W. Fulkerson
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OAK RIDGE NATIONAL LABORATORY
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SUMMARY

International impacts of global climate change are those for which the important consequences arise because of national sovereignty. Such impacts could be of two types: (1) migrations across national borders of people, of resources (such as agricultural productivity, or surface water, or natural ecosystems), of effluents, or of patterns of commerce; and (2) changes to the way nations use and manage their resources, particularly fossil fuels and forests, as a consequence of international concern over the global climate. Actions by a few resource-dominant nations may affect the fate of all. These two types of international impacts raise complex equity issues because one nation may perceive itself as gaining at the expense of its neighbors, or it may perceive itself as a victim of the actions of others.

Predicting migrational impacts at the national scale is largely beyond our present scientific capability. There may be net winners and losers, but we can't predict which nations will win or lose and, equally important, which will be perceived to win or lose at the expense of others. We can, however, identify some general characteristics that will render certain nations more vulnerable than others. One is geophysical vulnerability. For example, low-lying nations would face serious consequences if there were a sea-level rise. We can say also that poorer nations are more vulnerable because they are less able to absorb impacts. Rapid economic development of poorer nations, in addition to solving so many other problems including population growth, also may be the best defense against vulnerability to the adverse effect of climate change. The dilemma is that economic growth likely will require increased use of fossil fuels, thus exacerbating global warming (as will deforestation and other land use changes driven by population growth). This dilemma can be solved only by using fossil fuels much more efficiently and economically, which can be a very effective near to midterm strategy, and by substituting nonfossil sources, which will be required in the longer term. Paradoxically then, among the most important of the international impacts of global climate change (or of societal concern about it) are impacts to the energy system. In a sense, the preventive cure has its own impact.

The United States has the opportunity to lead in finding better ways to manage world forest resources more productively, yet sustainable; and in helping to manage the evolution of the world energy system, to make it much more efficient and to move it toward nonfossil sources more rapidly. Global climate change may be the trigger for this evolution. Regardless of global climate, we will reap rewards from developing technologies that use energy more efficiently, developing better non-fossil sources, and finding ways to stimulate their adoption both in the U.S. and in developing nations. The same is true of developing better techniques for managing the forest resources. Might we not take this leadership role as the challenge of the Nineties just as putting a man on the moon was the challenge of the Sixties?

INTERNATIONAL IMPACTS OF GLOBAL CLIMATE CHANGE

Mr. Chairman and Members of the Subcommittee, we are very pleased to have been invited to participate on this panel about the potential impacts of global climate change. First, let me introduce myself and my coauthors of this testimony. I'm Bill Fulkerson, head of the Energy Division at the Oak Ridge National Laboratory. One of the things my division does is assessment of the environmental impacts of energy technology, and we also develop more efficient energy technologies. Bob Cushman is an aquatic ecologist in the Environmental Sciences Division working in the CO_2 Information Analysis and Research Program. Cushman and other Environmental Sciences Division staff currently are assembling a set of critical reviews of the issues involved in relating climate change to resources such as agriculture, forestry, water, marine fisheries, and natural ecosystems. Gregg Marland is also a member of ESD and an expert on global reforestation and fossil-fuel emissions. Steve Rayner is a cultural anthropologist in my division, and he is concerned with techniques of conflict resolution and consensus building in decision making on global environmental issues. So, this testimony represents a truly interdisciplinary perspective.

Two Kinds of International Impacts

What are the international impacts of global climate change? International impacts (as distinct from national impacts or merely the sum of national impacts) are those that arise because of national boundaries; because of the fact that the whole land surface of the globe (except for Antarctica), and parts of the water surface as well, is divided into sovereign nations. Clearly, not all impacts due to climate change are international in scope; only impacts with transboundary consequences. International impacts tend to be much more difficult to manage than purely national ones because they require some degree of international coordination, but since the impacts tend to be a source of conflict between nations, needed coordination is sometimes difficult to achieve.

We distinguish two kinds of international impacts of global climate change. The first arises because climate change has the potential to cause drastic changes in the location and accessibility of resources. Climate change may bring about the relocation across national borders of surface resources such as agricultural productivity, fresh water, fisheries, forests, and other natural ecosystems or particular animal or plant species. Migrations of surface resources or other climate-related changes, such as sea level or temperature, may stimulate large-scale transboundary migrations of people, major shifts in patterns of commerce, and even geographical changes in the sources and destination of industrial effluents. These migrations may have profound consequences for the resources themselves and for the nations involved, particularly if they were to occur rapidly.

The second kind of impact relates to the way nations manage and use their resources because of international concern for the protection of the global commons, particularly the global climate. Such changes in resource use would include particularly the management of fossil fuels and forests. Such concerns may result in disputes among nations about using resources. Because of the geography of these resources, the actions of only a few nations are of paramount importance, and hence, what a few nations do will determine the fate of all. Before biophysical impacts become significant, social stresses deriving from concern about climate change may impact many countries and the way some countries manage their resources. In Table 1 we list some national statistics to

TABLE 1. PRINCIPAL ACTORS: COUNTRIES RANKED BY TOTAL LAND AREA, POPULATION, AREA OF CLOSED FOREST, FLUX OF CARBON FROM LAND USE CHANGE, RECOVERABLE CARBON IN COAL, EMISSIONS OF CO_2 FROM FOSSIL FUEL BURNING, CROPLAND, CEREALS PRODUCTION, AND THREATENED SPECIES

By Total Area

Total Land Area (10^6 ha)	13,081
U.S.S.R	2227
China	933
Canada	922
U.S.A.	917
Brazil	846
Australia	762
India	297
Argentina	274
Algeria	238
Sudan	238
Zaire	227
Saudi Arabia	215
Mexico	192
Indonesia	181
Libya	176

By Population (1987)

Total (10^6)	4,997
China	1085
India	786
U.S.S.R	284
U.S.A.	242
Indonesia	172
Brazil	141
Japan	122
Bangladesh	107
Pakistan	105
Nigeria	102
Mexico	83
Viet Nam	62
W. Germany	61
Italy	57
Philippines	57

By Area of Closed Forest

Total Closed Forest (10^6 ha)	2,845
U.S.S.R	792
Brazil	357
Canada	264
U.S.A.	195
China	125
Indonesia	114
Zaire	106
Peru	70
India	52
Mexico	46
Colombia	46
Bolivia	44
Australia	42
Papau/New Guinea	34
Venezuela	32

By Flux of Carbon from Land Use Change in the Tropics in 1980

Total (10^6 tons C)	1,659
Brazil	336
Indonesia	192
Colombia	123
Ivory Coast	101
Laos	85
Nigeria	59
Philippines	57
Burma	51
Peru	45
Ecuador	40

By Recoverable Carbon in Coal

Total (10^9 ton C)	4,022
U.S.S.R	1601
U.S.A.	955
China	866
Australia	261
W. Germany	103
Poland	50
South Africa	44
India	39
Botswana	36
Great Britain	30

By CO_2 Emissions (1986) from Fossil Fuels

Total (10^6 tons C)	5,374
U.S.A.	1192
U.S.S.R	992
China	532
Japan	246
W. Germany	183
U.K.	164
India	140
Poland	122
Canada	104
France	95
E. Germany	91
Italy	90
S. Africa	75
Mexico	71
Czechoslovakia	64
Australia	60

By Cropland

World (10^6 ha)	1,472
U.S.S.R	232
U.S.A.	190
India	168
China	101
Brazil	75
Australia	47
Canada	46
Argentina	36
Nigeria	31
Turkey	27
Mexico	25
Spain	21
Pakistan	20
Indonesia	20
Thailand	19
France	19

By Cereals Production (1981)

Total (10^6 metric ton)	1,664
U.S.A.	334
China	286
U.S.S.R	167
India	150
Canada	50
France	45
Indonesia	37
Brazil	32
Argentina	31
Mexico	26
Turkey	25
Australia	23
Thailand	23
W. Germany	23
Bangladesh	21

Land use change from Houghton, et al. (1987)
Area and population data from World Resources Institute, 1987
Coal resources data from World Energy Conference
Cereals production data from U.N. 1981 Statistical Yearbook, Statistical Office, UN, NY 1983

By Threatened Species

Mammals		Birds		Reptiles		Plants	
Brazil	42	U.S.	77	Ecuador	36	U.S.	3487
U.S.	39	Brazil	35	Sri Lanka	34	Australia	1967
Australia	32	L. Antilles	29	U.S.	32	South Africa	1144
China	30	Madagascar	29	Mexico	25	India	1113
Peru	30	Australia	28	Colombia	24	Spain	942
Argentina	26	Colombia	28	Venezuela	20	Cuba	845
Colombia	25	Tanzania	27	Brazil	19	Mexico	795
Bolivia	24	Zaire	27	Bahamas	18	Greece	528
Zaire	24	Japan	19	Peru	15	Costa Rica	455
Indonesia	22	Argentina	18	Fr. Guiana	14	Peru	425
				Guyana	14		
				L. Antilles	14		

Source: World Resources 1988-89. World Resources Institute and International Institute for Environment and Development, in collaboration with United Nations Environment Programme. Basic Books, Inc., New York (1988).

Note: totals include island states and territories illustrate that, whereas a few nations are the major actors, virtually all nations become stakeholders if significant climate changes occur.

This second kind of international impact also includes concern over the destruction of unique parts of our natural and historical endowments. These endowments are special to all people, and hence, can be considered parts of the global commons, but they are contained within the borders of one or a few nations. Examples of such natural resources include the Amazon forest or the Galapagos Islands; while unique historical resources are exemplified by the City of Venice, already the subject of a major international campaign to rescue it from the sea.

Winners, Losers, Victims, and Perpetrators

These two kinds of impacts raise complex equity issues because one nation may be perceived as gaining at the expense of its neighbors, or a nation may perceive itself as the victim of the action of other nations. So, the winners and losers aspects of global climate change are exacerbated further by these notions of winning at the expense of others or losing because of the actions of others. Generally, there will be no pure victims or perpetrators. Each victim contributes, however little, to the global climate change, and each perpetrator is likely to be hurt in some way by the consequences of global climate change.

Similarly, there may not be pure winners or losers. A nation may be better off because of one change but worse off because of another; e.g., agricultural productivity might improve at the same time sea flooding of coastal areas increases. Netting out gains and losses is a difficult, maybe impossible, exercise and probably fruitless as well. I think this is the reasoning of our own Senator Albert Gore from Tennessee, who believes that in the long run, at least, there will be no winners, only losers.

Nevertheless, in the short to midterm there may be winners and losers even if in the long term all lose (IIASA, 1988). Furthermore, even if the notion of short to midterm winners and losers is illusory, there is a perception that this will be the case, a perception which cannot be ignored when seeking international consensus on action. The very expectation of winning or losing may alter behavior of nations and, hence, feed back to influence the outcomes. Finally, even if everyone agrees that all will be losers, some may lose more than others.

Presently we cannot predict consequences of global climate change comprehensively or with very much resolution, geographically or temporally. Hence, we cannot say which nations might be net winners or losers. We really don't know. Climatologists generally agree: (1) that global patterns of climate are likely to change on the time scale of several decades due to increasing greenhouse gases, (2) that the global average temperature will rise, and (3) that warming will be greater at the higher latitudes than near the equator.

However, we are not yet in a position to predict with confidence the impacts of these changes on the various nations of the world. It is reasonable to anticipate that the distribution and productivity of resources--for example, agriculture, forests, water, coastal land, fisheries, ecosystems--will be affected. Our time here does not permit a lengthy recitation of the kinds of impacts that have been postulated, such as changes in crop yields, species composition of forests, runoff of rivers, harvest of marine fishes, and so on (e.g., Pearman, 1988, Kates, et al., 1985).

In any event, the state of the science is such that we cannot look decades or centuries into the future to project confidently the mix of impacts, positive or negative, that different countries of the world will experience. For one thing, our climate models cannot yet be used to derive national-scale scenarios of climate change (Grotch, 1988). But maybe even more important, we do not have the scientific tools to simulate how national systems or resources will respond to a climate transition: How will the resources change and migrate? How will the nations interact with each other to manage migrations? What will be the effects of non-climatic factors, such as demographics, social institutions, and technology?

Vulnerabilities and Wealth

Despite this veil of ignorance and uncertainty, we do know some things. We can recognize vulnerabilities of two types:

(1) Vulnerable geographical areas; e.g., warming will lead to sea-level rise which will impact sensitive coastal areas; and

(2) Poorer nations are more vulnerable because they are less able to absorb impacts than nations with greater wealth.

We can contrast the vulnerabilities of the United States and Bangladesh to the gradual sea-level rise, for example. Seawater flooding of a good portion of southern Florida and a quarter of Bangladesh might occur. Preventing the flooding of Florida, or mitigating the effects, is within the economic means of the United States, but the same is not true of Bangladesh. Furthermore, sea flooding of Bangladesh is likely to be an international impact since the population may seek to migrate to other nations. In Bangladesh 9% of the population live in the area that could be inundated by a 1m sea level rise--27% of the population in an area that could be impacted by a 3m rise (Broadus, et al., 1988). It is also worth noting that some scientists have suggested that even the early stages of global warming may lead to an increase in extreme weather events causing tidal surges, thus exacerbating coastal impacts.

There is ample evidence that the aggregate level of health and safety in a nation is directly related to wealth. As Wildavsky (1988) argues, richer is safer because wealth provides the capacity for flexible responses to unwanted risks, especially when precise understanding of that threat is not available or perhaps, not even possible (i.e., surprises) as is the case with global-climate change.

We are led to something of a dilemma or paradox. Rapid economic development by the poorer countries, in addition to solving so many other problems, such as population growth, also may be the best defense against vulnerability to climate change. Economic development depends, however, on increased energy services likely supplied predominantly over the next several decades by fossil fuels, the use of which is a principal driver of climate change (along with deforestation and other regional land-surface changes driven by population growth).

This dilemma only can be resolved by changing the energy system, by providing more energy services with less fossil fuel and by managing the forest resource more productively and stably.

Changing the Energy System and the Management of Forest Resources

These considerations of vulnerability suggest that among the most profound of the international impacts that may occur are changes to the energy system of countries and to land-use practices as well. These changes may occur as a consequence of national concerns for the global climate or as a consequence of international cooperation or pressures. By our description, these are international impacts of the second kind. They are impacts deriving from societal concern about global climate change and the desire to prevent it rather than from the actual climate change itself. The large number of bills introduced in the last session of Congress, and again in this session, attest to the intensity of concern, at least in the United States.

Making major changes in the energy system will have large impacts, and we do know something about winners and losers in this case. If the use of fossil fuel were to be curtailed, all would be losers since fossil fuels are such attractive energy sources, and all nations use them extensively. Fossil fuels supply about 83% of world energy needs. No other energy source is so available, portable, transportable, easy to use at any scale, and inexpensive (so long as environmental costs are external).

We know global warming ultimately depends on decisions about coal, which constitutes most of fossil fuel resources. Deforestation is also an important factor but with much smaller ultimate potential for affecting the global climate. We know most of the coal resources (about 80%) are in three countries: the U.S., the USSR and China (See Table 1). These three countries presently emit 50% of the CO_2 from worldwide fossil fuel use. Almost 50% of CO_2 emissions from deforestation and other land-use changes come primarily from five nations: Brazil, Indonesia, Colombia, Ivory Coast, and Laos. The numbers are much less precisely known for this source, however (Table 1). Thus, most of the action depends on only a few nations. Similar observations can be made about CFC's. The situation with the sources of methane and other greenhouse gases is less well understood.

Although the use of fossil fuel by developing nations, including China, is presently far less than for the industrialized nations, the use is growing at a much faster rate, and the CO_2 emissions of developing nations are increasing proportionately (Fig. 1). If trends of the past 10 years continue, sometime in the first decade of the next century, emissions by the developing nations of the world should exceed those of the OECD nations. They should exceed those of the USSR plus Eastern Europe by early in the 1990's (Fig. 2).

To this situation, let's add one more confounding observation. None of the nonfossil energy technologies, singly or in combination, is presently capable of large-scale displacement of fossil fuels at reasonable costs (including acceptable costs of degradation of the environment, human health, and safety) and without large performance penalties. However, the prospects for developing much more competitive nonfossil technologies seem bright. These range from passively safe nuclear reactors to cheaper photovoltaics, and sustainable and more productive biomass sources (Fulkerson, et al., 1988). Forest management (and more generally land-use management) is linked with the energy system through the use of biomass-for energy, which is still the principal energy source in many developing nations. As Bob Williams will show in his testimony, great opportunities exist for what Williams calls the modernization of the biomass energy source, making it much more

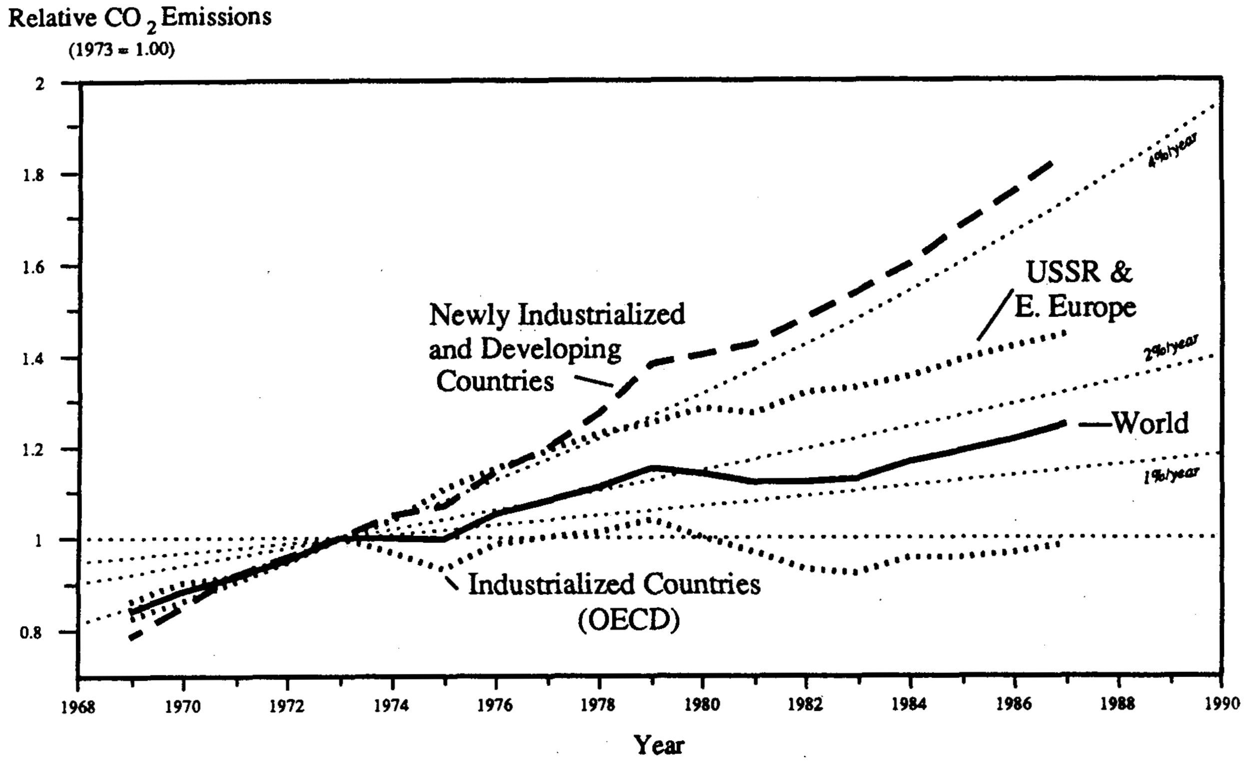

Figure 1. Recend trends in relative CO_2 emissions from fossil fuels for various nation groups, 1968-1987. (Source: Computed from data in *BP Statistical Review of World Energy*, British Petroleum Company, June, 1988. OECD is the Organization for Economic Cooperation and Development.)

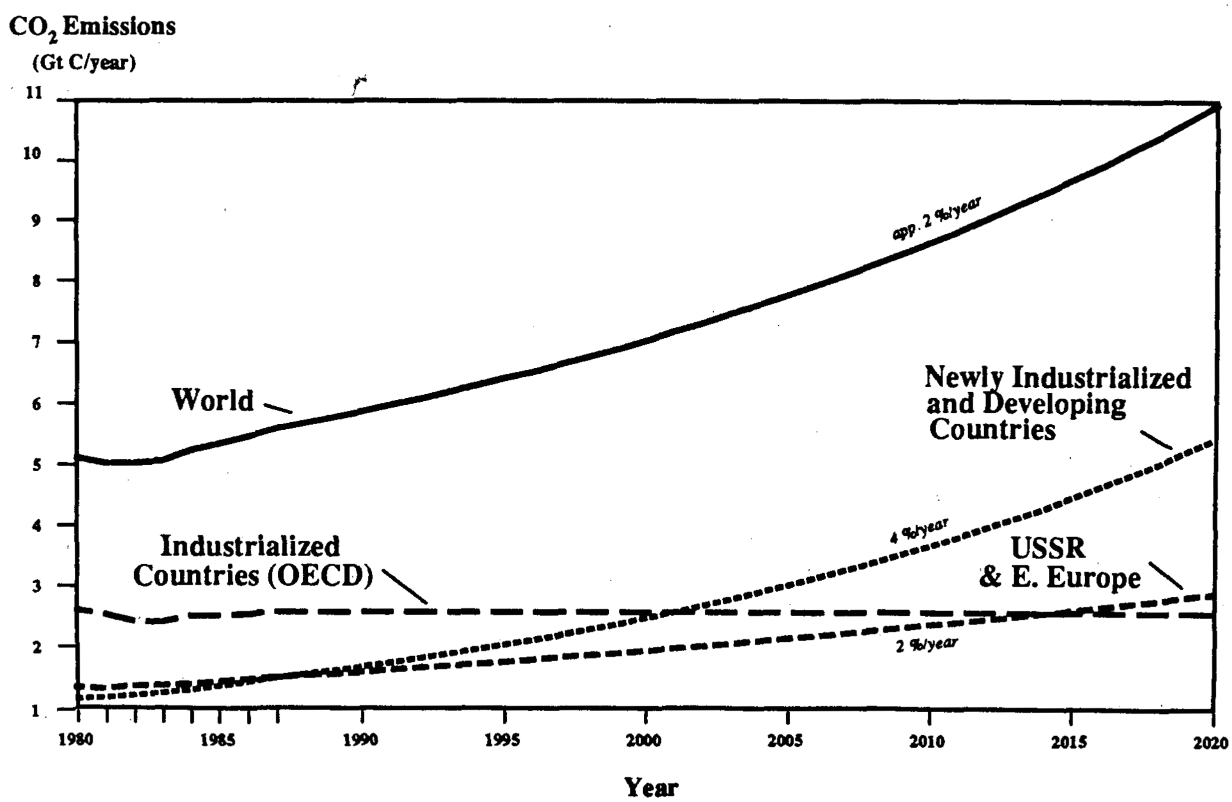

Figure 2. Projected CO_2 emissions from fossil fuel use for various nation groups. These rates represent a range around recent trends. (China is included among the developing country group. OECD is the Organization for Economic Cooperation and Development. See Table 2 for additional data.)

productive with advanced technology. The DOE biomass program, to which the Oak Ridge National Laboratory contributes, is providing some of this needed technology.

The cost of developing these improved nonfossil technologies is the price of our insurance policy against the possible adverse impacts of rapid global climate changes. Furthermore, what will have been lost by paying the insurance, even if adverse impacts turn out to be unimportant? We will have gained technologies that will be useful in any event.

In near term, the next two decades, the principal way to moderate the rate of growth of CO_2 emissions, while at the same time increasing energy services, is by providing those services much more efficiently. This conclusion was expressed in 1981 by Amory Lovins and coworkers (Lovins, et al., 1981). It has been developed further, and quite elegantly, by Jose Goldemberg, Thomas Johansson, Amulya Reddy, and Bob Williams in the book Energy For A Sustainable World (Goldemberg, et al., 1988). Many of the technologies are available. They generally seem to be economically attractive. Even more efficient and higher performance technologies are within near-term reach of advanced industrial nations by further R&D. That the industrialized nations should create the institutional framework and conditions for the rapid transfer of these technologies to developing countries is not merely an ethical imperative based on equity considerations but makes good commercial sense too.

Efficiency improvement, at least to the extent that it is cost effective, should be an attractive strategy for industrialized and developing nations alike, regardless of CO_2. It can reduce stress on oil and gas supplies and also reduce other environmental impacts deriving from energy sources.

We don't know how far efficiency improvement can be carried, however. There are many barriers and market imperfections inhibiting adoption of the improved technologies and policies, even within the United States. The transfer of technologies across national boundaries presents even greater challenges due to major differences in types of skills and resources that are available, as well as variations in political culture that can inhibit communications between decision makers (Gerlach and Rayner, 1988). An urgent matter is learning more about these inhibitions and how to remove them.

For this reason, a Central American Energy Efficiency Initiative recently proposed by Dr. Alvaro Umana, Minister of Natural Resources, Energy, and Mines of Costa Rica, and strongly supported by US AID is a very exciting idea. Under this initiative, the nations of the Central American region would mount a concerted and coordinated effort to improve the efficiency of their energy systems, focusing first on electrical power from generation to end use. The initiative should provide a living prototype from which to learn how more energy-efficient technology can promote economic growth in developing nations. It is a way to test the implementability of the Goldemberg, et al. theories.

This initiative would be mounted in cooperation with the World Bank, regional development banks, and other lending institutions. One challenge for lending institutions will be to find innovative ways to provide capital for many, many small investments by individuals and businesses, encouraging investments in energy-efficient technology based on least life-cycle cost rather than least first cost. The same challenge confronts us in our own U.S. economy, and many of the schemes which have been successful here may be useful in Central America.

In addition, a significant opportunity might be seized by DOE in this initiative. DOE, working with the private sector, can provide technologies tailored to specific needs in the Central American countries. This could be furthered by extending the CORECT[1] idea for renewable energy sources to energy-efficient technology. Such an extension is being discussed in DOE. In short, the role of AID would be to identify technology needs. The role of DOE and the private sector would be to fill technological gaps as required. AID, together with lending institutions, then would design strategies for adoption of better technologies as they become available.

In a larger sense, the United States has the opportunity to be the leader in managing an evolution in the world energy system (starting with our own part of the system, of course): to make it much more efficient and to move it toward nonfossil sources. Global climate change may be the triggering force for the evolution, but developing more efficient and economical technologies and better nonfossil technologies, and finding ways to stimulate their adoption will yield rewards regardless of global climate. By helping lead such a technology evolution, we might improve our balance of trade in the process. This effort to change the energy system and forest management, in ways that are both supportive of economic development and compatible with concerns about the global commons, particularly the global climate, is a challenge worthy of an Apollo-type focus. In these times of large budget deficits, the effort must begin gradually by reinforcing and building on activities already underway by AID, DOE, various lending institutions, and the private sector. Might it not be the challenge of the Nineties? It seems a worthy one. Will we accept it? We hope so.

Thank you Mr. Chairman. I would be pleased to answer questions.

[1] CORECT is the Committee on Renewable Energy Commerce and Trade. It is a multiagency committee with representatives from the private sector with the purpose of encouraging the marketing of U.S. renewable energy technology to developing nations.

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