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OFFSETTING NEW CO₂ EMISSIONS: A RATIONAL
FIRST GREENHOUSE POLICY STEP

DANIEL J. DUDEK AND ALICE LEBLANC

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OFFSETTING NEW CO₂ EMISSIONS: A RATIONAL FIRST GREENHOUSE POLICY STEP

DANIEL J. DUDEK and ALICE LeBLANC*

This paper describes and assesses a policy to slow the increase of carbon dioxide (CO₂) emissions in the atmosphere. Policy governing new CO₂ sources would either prevent emissions, procure compensating emissions reductions, or sequester emissions in sinks. The paper uses electric power plants to demonstrate the mechanics of the policy and the control or offset choices. Offset options include scrubbing, fuel switching, investments in energy conservation and efficiency, and afforestation.

Costs per ton of CO₂ sequestered range from \$1.35 for planting shade trees to \$59.41 for scrubbing. All options except scrubbing cost less than \$11.00, and the median cost is around \$6.00 per ton removed. Planting trees on erodible cropland in conjunction with the Conservation Reserve Program combines the goals of reduced erosion, surplus agricultural production, and greenhouse warming. This policy is a first sane step toward reducing the accumulation of greenhouse gases. Having an international framework for managing emissions is most desirable. In the interim, however, the United States can demonstrate environmental leadership, generate substantial conservation benefits, and spark ingenuity in searching for alternatives, broadening the options, and lowering the ultimate costs of reducing CO₂ emissions.

I. INTRODUCTION

This past year, public attention has focused on the portent of global change. Concerning depletion of the stratospheric ozone layer, an international consensus was developed and an agreement to restrict the production of chlorofluorocarbons (CFCs) was achieved. The huge seasonal ozone depletions over the Antarctic continent demonstrated visibly the human capacity for altering the biosphere dramatically. As awareness of this problem has increased, recognition of CFCs' dual role as both ozone depleters and greenhouse gases also has developed. The unusual weather patterns of summer 1988 created crisis conditions for many weather-sensitive

*Senior Economist and Staff Economist, respectively, Environmental Defense Fund. An earlier version of this paper was presented at the Western Economic Association International 64th Annual Conference, Lake Tahoe, Nev., June 21, 1989, in a session organized by Darwin C. Hall, California State University, Long Beach. The research in this paper was supported by the Joyce Foundation. The authors have benefited from the assistance of Joshua Foster, an intern at the University of Massachusetts, Amherst, in preparing this report. However, the authors retain complete responsibility for the report's contents.

sectors of the economy. Drought affected much of the Midwest and Great Plains regions of the United States, and this severely reduced crop yields. The western states were ravaged by forest fires, and this increased the drought's devastation and added to the emissions of carbon dioxide (CO₂)—the single most important greenhouse gas.

These events, coupled with recent scientific assessments presented at Villach, Austria (UNEP, 1988), at Toronto (WMO, 1989), and before the Senate Committee on Energy and Natural Resources (U.S. GPO, 1988), have prompted policy makers to assess governments' appropriate response. Examples of legislative initiatives in 1989 addressing global warming are S. 2667 introduced by Senator Wirth with several co-sponsors and S. 2666 introduced by Senators Stafford and Baucus and others. Many observers recognize the importance of improving energy efficiency and reducing fossil fuel combustion. Ultimate goals for fossil fuel reduction have been set at roughly 50 percent so as to stabilize the atmosphere.¹ However, most policy initiatives remain in the planning or research stages.

Some global warming policies would steer society toward different energy choices through changes in incentives. Others would accelerate research and development so as to avoid future catastrophes. The policy debate currently is focused on the best mix of strategies. The policy that this paper discusses would begin the long process of slowing greenhouse gas emissions and averting some of the warming by requiring CO₂ offsets for new fossil-fueled electricity generation. This would stimulate the development and use of CO₂ reservoirs and low-CO₂-emitting energy technologies, and it would encourage conservation and other measures to reduce CO₂ emissions.

II. GREENHOUSE POLICIES

Managing the greenhouse problem is best conceived in stages. The first task is to slow the rapid growth of emissions in the atmosphere. For some greenhouse gases, such as CFCs, this began in January 1990 when the Montreal Protocol went into effect. For others, such as the CO₂ produced from fossil fuel combustion, one can expect no reduction in emissions growth given the underlying demand for energy. Investments in energy conservation have allowed the U.S. economy to grow significantly while keeping total energy consumption virtually flat over the 1973-1987 period (Hatsopoulos et al., 1988). However, real energy prices also have fallen and have diminished the discipline of the high prices. The mix of fuels used in energy

1. An international conference, "The Changing Atmosphere: Implications for Global Security," brought scientists together in Toronto during June 1988. The consensus was that a 20 percent reduction in fossil fuel combustion would be both desirable and attainable by the year 2005. That same meeting also addressed the 50 percent goal. In the Environmental Protection Agency's (EPA) report to Congress of February 1989 entitled "Policy Options for Stabilizing Global Climate," the EPA states that a 50-80 percent reduction in anthropogenic emissions of CO₂ would be required so as to stabilize atmospheric concentrations at current levels.

production is another critical determinant of emissions. For example, when natural gas is combusted, it emits 26 percent less CO₂ than does residual fuel oil and 43 percent less CO₂ than does coal (per Btu) (Department of Energy Carbon Dioxide Analysis Center, 1989). Many conventional energy analysts forecast an increasing reliance on coal beyond its current 24 percent share of the U.S. energy market (Villagran, 1989).

One way to slow emissions growth and still allow growth in energy production is requiring all new CO₂ sources to offset their emissions—i.e., new CO₂ sources would have to find compensating CO₂ emission reductions elsewhere. Initially, this approach could be feasible if applied to stationary sources, which account for close to 70 percent of total CO₂ emissions in the United States. Fossil fuel-burning electricity-generating utilities account for more than one-half the CO₂ emissions of stationary sources, or about 35 percent of total U.S. CO₂ emissions (U.S. DOE, 1989).

III. OFFSETS

One could generate offsets in a variety of ways. An offset policy requires only that the form of CO₂ compensation be certified, permanent, and enforceable. For example, investments in energy conservation would reduce energy demand, fossil fuel burning, and emissions. Such offsetting investments need not be limited to the service region of an individual utility. If energy conservation investments are more effective in northern regions, then one might exploit these opportunities first. Cogeneration frequently improves the efficiency of energy use and could help obtain CO₂ reductions. Estimates of the electricity that cogeneration will produce during the year 2000 range from 187 billion to 262 billion kilowatt hours (kWh) (RCG/Hagler Bailly, 1989). If this cogeneration replaces coal-fired electric utilities with a mix of coal- and gas-fired cogeneration units, then approximately 110-154 million tons of CO₂ reductions are realized. The higher estimate is more likely to occur if Congress enacts a flexible emissions trading program for acid rain control (Dudek et al., 1990).

One also could make investments in mass transit options so as to reduce mobile sources of CO₂, but these options would likely be expensive. A cheaper opportunity would be expanding van pooling. One could induce appliance or auto manufacturers to improve efficiency by allowing them to generate offsets or requiring them to purchase offsets if average efficiency fell below a pre-set standard. Scrubbing CO₂ emissions from stack gases and then disposing the CO₂ also would constitute an offset. Afforestation, particularly of retired agricultural lands, is another possibility. The following sub-sections describe and analyze the feasibility of several potential offset options. All examples presume an offset ratio of 1-to-1, but one could implement any ratio. In particular, if the effectiveness of an offset option is uncertain, then one would desire offsets greater than 1-to-1.

A. Biomass Offsets

Of all the greenhouse gases emitted to the atmosphere, only CO₂ can be readily removed. Some have suggested the widespread planting of trees as one means of removing CO₂ from the atmosphere and storing it as carbon in the biomass of the forest (Dyson, 1976). Sequestering 5 gigatons of carbon from the atmosphere each year—an amount roughly equal to current annual world emissions—would require between 1.3 billion and 1.7 billion acres of new plantation forests (Marland, 1988). By comparison, the total land area of the United States is 2.3 billion acres.

If one doubled the productivity of existing forests, then the same result could be achieved from existing forests through increased uptake of CO₂. One would have to achieve these increases through genetic improvements, management, and fertilization. Existing studies of using trees to control the greenhouse problem demonstrate the lack of technical or physical barriers to use large-scale biomass offsets. Expanding forested area would produce offsetting reductions of CO₂. Joint investments would be possible between utilities and timber companies or the Forest Service. The Conservation Reserve Program (CRP), created by the Food Security Act of 1985, offers another opportunity, particularly since it is under legislative review for reauthorization.

1. The Conservation Reserve Program

The CRP is intended to remove highly erodible agricultural land from production. Private landowners offer to convert targeted cropland to non-crop vegetative uses in exchange for annual government payments for 10 years. In addition, the government will subsidize up to 50 percent of the cost of establishing approved conservation practices. The program's goals include 40–45 million acres of cropland under contract in the reserve by 1990 of which one-eighth was to be forested.² One bill—S. 1521, introduced June 23, 1987, by Senator Nunn and others—would increase these figures to 55–65 million acres.

Offsetting new CO₂ emissions by increasing afforested CRP land would facilitate attaining both the CRP's conservation objectives and a slowing of CO₂ emissions growth. In addition, offset expenditures would raise the effective cost of building new power plants, and this would make energy efficiency investments relatively more attractive.

2. Feasibility of Biomass Offsets

Table 1 presents the CO₂ emissions resulting from new electric power generation expected to come on stream from 1987 to 1996 as well as the

2. Total acreage contracted under the CRP increased to 33.9 million acres during the ninth signup during summer 1989. The CRP will be under review as Congress moves toward a new farm bill in 1990.

TABLE 1

Planned Coal- and Oil-Fired Electric Generating Capacity Increase Through 1996

Year	Coal-Fired		Oil-Fired		Acres (millions)
	Megawatts	CO ₂ (million tons)	Megawatts	CO ₂ (million tons)	
1987	3,513	20.2	14	0.05	1.4-3.2
1988	2,194	12.6	13	0.04	0.8-2.0
1989	1,834	10.6			0.7-1.7
1991	3,961	22.2			1.5-3.5
1992	2,503	14.4	130	0.4	1.0-2.4
1993	750	4.3	180	0.6	0.3-0.8
1994	2,983	17.2	770	2.6	1.3-3.1
1995	1,600	9.2	538	1.0	0.7-1.8
1996	3,405	19.6	935	3.1	1.5-3.6
Total	22,643	130.2	2,580	8.6	9.3-22.1

Note: Acreage is for offsets required for total CO₂ emissions by new oil- and coal-fired electricity-generating utilities.

Source: Planned electric generating capacity increases are from the North American Electric Reliability Council (1987).

acreage of new mixed hardwood forests required for offsets.³ (Planned coal- and oil-fired generating stations were taken from the 1987 Reliability Assessment published by the North American Electric Reliability Council.⁴) Plants were assumed to operate at capacity rates of 65 percent for new coal plants and 49 percent for new oil-fired plants. The CO₂ emissions rates used were 202 pounds of CO₂ per mmBtu for coal and 156 pounds of CO₂ per mmBtu for oil.⁵

The authors assessed the feasibility of afforestation by examining the literature on uptake rates for different tree species. Estimates of uptake fall within a wide range since few studies have attempted to measure the total carbon storage potential for different species, soils, and climates. This deficiency results partly from the fact that silviculturalists and forest managers

3. Mixed hardwoods were chosen for these calculations because their average carbon fixation rate is close to the average for all species and because their range of carbon fixation rates is also representative of all species. Variation in acreage reflects variation in both uptake rates of different species and cropland soil conditions for different regions of the country.

4. Planned new gas-fired units were not included. They also contribute CO₂ emissions, though at a lower rate.

5. Estimates were provided by the Department of Energy Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn. The calculations in this paper also assume an average utility heat rate of 10,000 Btu per kWh.

have been interested largely in only stemwood or merchantable timber production. However, carbon also is stored in root systems and as detritus and soil carbon. Johnson and Sharpe (1983) estimated ratios of merchantable stemwood to total stemwood in detailed plot studies in Virginia: The ratios ranged from 2.1 to 5.0 and had a mean value of 2.7. On this basis alone, studies inferring carbon fixation rates from typical Forest Service data on merchantable biomass would underestimate total fixation substantially. Supporting these estimates is research indicating that up to 25 percent of tree biomass is stored in roots and that below-ground storage is inversely related to site quality (Keyes and Grier, 1981). Some ecologists have estimated that as much as two-thirds of the carbon stored in terrestrial ecosystems is in soils (Post et al., 1982).

Other studies (Cooper, 1983) have concluded that carbon fixation rates also vary by management objective. For example, the usual forest management objectives of cutting either to maximize profit or to maximize the annual increment of biomass—i.e., maximum sustained yield—produce only one-third as much stored carbon as do management regimes maximizing storage.

Estimates for carbon fixation rates in the United States were obtained from USDA forest service data (Moulton and Richards, 1990). Average carbon fixation rates for a 40 year period were provided by species, geographic region, and soil type. Average values were calculated for wet and dry cropland for all regions of the country. Ranges reflect variation in regions and for wet and dry cropland. Acreage estimates in table 1 were derived using a range of 6.3 to 15.0 tons per acre per year offset by mixed hardwoods such as oak, ash, cherry and maple.

Table 2 presents the acreages of various tree species required to offset the emissions of the planned electrical generating stations. Total acreages vary from 7.6 million to 42.0 million acres depending on the rate of fixation. Because any offset program most likely would employ a range of species in different locations, an average estimate of roughly 13.5 million acres for all species on cropland is quite reasonable. This figure is 34 percent of the CRP's 1990 acreage goal of 40 million acres and is only 23 percent of Senator Nunn's proposed CRP expansion. In addition, President Bush, in his 1990 State of the Union message, called for a program to increase the nation's tree cover by a billion trees per year for the next 10 years.

3. CRP Offset Program Costs

If one assumes tree planting at \$150 per acre and \$25 per acre fertilization costs, then 13.5 million acres of trees would cost roughly \$2.4 billion to establish. Rental payments would be \$100 per acre per year, or a total of about \$1.35 billion per year. Under the CRP, the U.S. Department of Agriculture (USDA) has contributed on average \$50 per acre per year to rental payments. The USDA pays up to one-half the cost of establishing the pro-

TABLE 2
Cropland Variation by Tree Species

Years	CO ₂ (million tons)	Trees (millions of acres)			
		Mixed Hardwoods	Loblolly Pine	Spruce	All Species
1987-1996	138.9	9.3-22.1	10.8-15.7	7.6-10.2	7.6-42.0

Source: Moulton & Richards, U.S.D.A. Forest Service, 1990.

protective vegetation. As of May 1989, the average USDA cost share for tree establishment was \$38.20 per acre.

If one assumes a capital cost of \$910,000 per megawatt for fossil fuel utilities as the Department of Energy (DOE) has estimated, then the total cost of the power plants in table 1 is \$23.2 billion. Offsetting with reforestation would amount to roughly a 10 percent increase in capital costs. If the USDA continued to pick up its average establishment cost share, then a utility's establishment cost would drop to approximately \$137 per acre. Utilities' total program establishment costs would be about \$1.85 billion, or roughly 8.0 percent of capital costs. Annual rental payments would drop to \$675 million per year, or 0.49 cents per kilowatt hour, if CRP rental payments of \$50 per acre were continued. (This assumes continuing the CRP beyond its current 10-year authorization.)

Some researchers have suggested a fixation rate of 24-32 tons per acre per year as an attainable goal for genetic research for some species (Strauss and Wright, 1990). As fixation rates improve, acreage requirements and costs decline. Table 3 shows the variation in utility costs depending on both tree species and cost sharing and assuming average cropland fixation rates for each species. Establishment costs would range between \$1.15 billion and \$2.45 billion. On a per-kilowatt-hour basis, total costs would fall by between 0.36 and 1.1 cents.⁶ Clearly, an offset program would provide substantial incentives for private investment in genetically improving the fixation rates of trees. The average annual costs per ton of sequestered CO₂ range from \$3.48 to \$10.67 depending on the tree type and cost share option (see table 3). These cost estimates take no account of revenues that could be generated

6. All costs are expressed in 1985 dollars. Establishment costs consist of planting and fertilizing and are spread over a 50-year period at an interest rate of 8.5 percent. Rental costs are assumed to remain constant at \$100 per year (in 1985 dollars). One obtains average annual costs per ton by adding total rental payments to the stream of establishment cost payments (deflated by an assumed inflation rate) and then dividing by total metric tons of CO₂ sequestered over the 50-year period.

TABLE 3
Utility Cost Variations by Tree Species and Program

	Trees			
	Mixed Hardwoods	Loblolly Pine	Spruce	All Species Average
Average Acres (millions)	14.0	12.1	8.4	13.5
Establishment Cost—No USDA Cost Share (billions)	2.45	2.12	1.47	2.36
Average Cost per kWh	0.0110	0.0096	0.0068	0.0106
Average Annual Cost per Ton CO ₂	10.67	9.30	6.64	10.31
Establishment Cost—USDA Continues Cost Share (billions)	1.92	1.66	1.15	1.85
Average Cost per kWh	0.0057	0.0049	0.0036	0.0056
Average Annual Cost per Ton CO ₂	5.49	4.81	3.48	5.31

Note: Dollar amounts are in 1985 dollars.

from harvesting. Any CO₂ losses due to harvesting would have to be compensated. Individual regional economies could benefit from more widespread afforestation.

B. Biomass Energy Plantation Offsets

Trees produced in an intensive plantation style of cultivation also could serve as biomass energy source. If biomass from energy plantations is used instead of fossil fuel for new electricity generation, CO₂ emissions are offset. In the plantation rotation system, newly planted trees sequester an amount of CO₂ equivalent to that emitted by the combustion of the harvested trees.

Dramatic increases in productivity of Douglas fir (26 percent) and loblolly pine (more than 100 percent) have been documented (Farnum et al., 1983). However, widespread conversion of existing forested areas—rather than cropland or other unforested land—to biomass plantations could increase the net flux of carbon to the atmosphere (Cropper and Ewel, 1987). This could occur if the older trees, which store relatively large amounts of carbon, are harvested for uses that do not replace the burning of fossil fuels but ultimately are combusted and release their stored carbon as emissions. From an ecological viewpoint, such wholesale conversions to monoculture could be disas-

trous. Fortunately, current economic evaluations of this energy source tend to favor cropland conversion since land preparation costs are dramatically less.

Since the energy crisis of the early 1970s, substantial research has focused on evaluating the potential to supply the nation's energy demand from biomass. Generating electricity through the use of gas turbines fired by gasified biomass has yet to be demonstrated commercially but should cost less than conventional coal-fired electricity generation in developing countries and should be competitive in most of the United States. Advances in coal gasification for use in gas turbines are applicable to biomass. Using cultivated biomass as an energy source not only would provide an offset but would help reverse deforestation in developing countries (Williams, 1989). An offset policy, such as the one outlined in this paper, would provide incentives for developing innovative technology such as the gas turbine powered by gasified biomass.

Results from the Department of Energy's research program indicate that plantation management could sequester carbon at an average cost of around \$8.16 per ton of CO₂ (Strauss and Wright, 1990). This cost could decrease in the near future due to the potential for genetically engineered improvement in the carbon fixation rate. These cost figures are for the plantation and its operation only. They do not include harvest and transportation costs and do not take into account the value of the biomass as fuel.

C. Energy Conservation Offsets

The use of energy conservation investments to reduce energy demand and thus avoid constructing new expensive generating capacity is well known. The authors pooled data on program costs of conservation measures in the Midwest, Pacific Northwest, and New York State so as to derive a national conservation cost curve (Dudek et al., 1990). If one utilizes the most cost-effective conservation measures, then a reduction of 138.90 million tons of CO₂—the amount required annually to offset the planned new utility emissions—would cost on average \$5.73 per ton. Costs of the conservation programs selected range from 0.1 to 1.0 cents per kilowatt hour saved.

These conservation investments also would reduce the underlying demand for new generating stations and the demand for offsets. Utility avoided costs from conservation measures include the cost of new capacity. In addition, one also can consider fuel cost an avoided cost from a social viewpoint. When one includes avoided costs, the net costs per ton of emissions prevented would be negative. The offset policy should increase demand for energy conservation investments. Any offset policy will likely result in a mix of options actually selected, and conservation will be one such option.

Over the years, researchers have assembled a wide variety of energy conservation investments and their costs. Some energy conservation investments

combine demand reduction and sequestering. For example, some researchers have suggested planting shade trees around homes so as to reduce air conditioning demand. This option has been estimated to cost between \$1.35 and \$6.74 per ton of prevented CO₂ (Rosenfeld et al., 1988).

D. Scrubbing and Disposal

Another possibility for offsets would be the more conventional approach of treating emissions at the source through scrubbing stack gases. The most economically promising scrubbing technology consists of an absorption and stripping process using monoethanolamine (MEA) (Albanese and Steinberg, 1980).

The critical determinant of cost and feasibility is the disposal method. Disposal options primarily involve deep ocean discharge in either solid, liquid, or gaseous form. At a 90 percent removal level, one can expect power-generating costs to double for a modern, coal-fired, 200-megawatt plant. At an average electricity cost of 60 mills per kWh, this results in a cost of \$59.41 per ton of CO₂ removed. Clearly, these estimates are beyond those for alternative offset options. In addition, no certain method exists for storing the CO₂ in the large quantities generated to keep it from re-entering the atmosphere. Even ocean disposal has technical and ecological uncertainties (Steinberg, 1989).

However, one can expect technological change, induced partly by policies such as an offset requirement, as evidenced by new developments in scrubbing technology (*Chemical Marketing Reporter*, 1988).

E. Fuel Switching

Fuel switching could result in reduction of emissions from utilities. On a mmBtu basis, the combustion of natural gas results in fewer emissions than does the combustion of either coal or residual fuel oil, and the burning of residual fuel oil results in fewer emissions than does the burning of coal. The cost of switching depends on the relative prices of the fuels and the cost of equipment changes.

Switching from residual fuel oil to natural gas could be a cost-effective way to reduce emissions. The cost of equipment change is not significant in most cases and prices of the two fuels are forecast to remain relatively close over the next 15 years. Over the period 1995-2005, based on estimates of future prices of natural gas and residual fuel oil (GRI, 1989) and of total consumption of oil by utilities (ICF, 1989a), switching from residual fuel oil to natural gas by utilities in the 31 eastern states could result in an average yearly reduction of 46.3 million tons of CO₂ at an average cost of \$4.48 per ton reduced (Dudek et al., 1990).

Switching from residual fuel oil to natural gas not only would reduce CO₂ emissions but also would reduce sulfur dioxide (SO₂) emissions. The sulfur

content of oil that utilities burn varies: Resulting emissions are in the range of 0.2–2.8 pounds per mmBtu. Natural gas, however, is generally free of SO₂ emissions. Switching from oil to gas, as described above, also would result in an average yearly reduction of 228,900 tons of SO₂. If the acid rain legislation that the Bush administration has proposed is passed, then one can expect the value of a permit for one ton of SO₂ emissions to be worth more than \$700 by the year 2000 (ICF, 1989b). Clearly, an offset policy for emissions would reinforce the acid rain legislation by providing incentives for switching to cleaner fuels.

IV. CONCLUSIONS

The offset policy that this paper has described generally is applicable to all sources of greenhouse gas emissions. Policy measures to slow the continued accumulation of greenhouse gases currently are available. As table 4 indicates, these options range in cost from \$1.35 to \$59.41 per ton of CO₂ removed. For a new 200-megawatt coal-burning electric power plant requiring total offsets, this would add 0.1–6.0 cents per kWh with a median increase of about 0.7 cents per kWh. If one assumes an average cost per kWh of 6 cents, then the percentage increase in electricity costs ranges from 2 to 100 percent with a median increase of 12 percent. These cost estimates are calculated as a percent of electricity costs of new generation capacity. When offset costs are blended with the cost of total electricity generation by the utility requiring the new capacity, they would be substantially lower as a percent of a rate increase to customers. These cost estimates do not account for the value—often substantial—of other benefits deriving from the offset policies. These include the harvesting of trees for commercial uses, the use of biomass for fuel, avoided costs from conservation, and SO₂ reduction from fuel switching.

Emissions from planned fossil fuel-burning power plants have been used as an example to demonstrate the offset policy. However, one could include mobile sources as well. Auto manufacturers voluntarily could improve fleet fuel efficiency beyond the regulatory requirement. One could translate these fuel efficiency improvements into present-value terms through the use of actuarial methods and then sell them as offsets. Appliance efficiency improvements would provide a similar opportunity.

The final question: What do these offsets achieve? The cumulative outputs of the proposed new plants would account for less than 3 percent of total U.S. emissions. Because the problem is the growth rate of emissions, one must begin to chip away at the problem as opportunities arise—particularly when one can combine several public policy objectives. A single, cheap technical solution to the greenhouse problem does not likely exist. Rather, progress probably will come one small step at a time. Some of these small steps can be marginal policy changes but, when summed, can have a potent effect in reducing greenhouse gas emissions. These estimates seem small but

TABLE 4
Costs of CO₂ Offset Options

Option	Cost per Ton CO ₂
Trees With CRP Contribution	\$3.48-\$5.49
Trees Without CRP Contribution	\$6.64-\$10.67
Biomass Plantation	\$8.16
CO ₂ Scrubbing and Disposal	\$59.41
Shade Trees	\$1.35-\$6.74
Conservation	\$5.73
Fuel Switching (oil to gas)	\$4.48

are based only on the direct offsets and not on any additional conservation that the increased energy production costs induce. The policy would produce incentives to reduce emissions requiring offsets, to develop and deploy less intensive energy technologies, and to exploit carbon sinks. Further, retiring agricultural lands also would generate greenhouse gas emission savings from foregone agricultural operations if one elects the CRP option.

Linking an offset program with the CRP also answers the thorny question of the CRP's fate after the 10-year contracts expire. The history with similar land retirement programs indicates a general failure to follow through. Previous efforts aimed at creating a soil bank proved to be temporary as congressional support waned. An offset policy could provide permanence to the CRP and could secure lasting environmental benefits by providing a stream of income beyond the 10-year life of the program for forested acreage. And finally, offsets would stimulate the search for new and cheaper ways to eliminate emissions—a pressing national priority.

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MARKETABLE INSTRUMENTS FOR MANAGING GLOBAL ATMOSPHERIC PROBLEMS

DRAFT

by

Daniel J. Dudek

ENVIRONMENTAL DEFENSE FUND
257 Park Avenue South
New York, New York 10010

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ABSTRACT

Environmental policy interest has become more sharply focused on global atmospheric pollution problems in recent years. Two problems, stratospheric ozone depletion and climate change, have been the subject of intense international discussion. In the case of ozone, an international control strategy developed under the auspices of the United Nations Environment Programme (UNEP) is about to be signed in Canada this September. The agreement will impose international restrictions on the production of chlorofluorocarbons (CFCs) and provide for continuing international collaboration on scientific research and monitoring. Climate change, caused by the greenhouse effect of radiatively active trace gases, is the subject of a variety of international meetings designed to establish the foundation for a similar international convention.

However, little attention has been devoted to implementation. In the case of CFCs, negotiations have concentrated on which ozone-depleting chemicals to control and the size of reductions in production. Some details such as trading among the class of regulated compounds have been introduced, but critical issues concerning international trade and the potential for local monopolistic rents have been ignored. In particular, the issue of how global aggregate reductions will be achieved has remained undecided. Will each signatory be required to comply with the reduction schedule or can differential control effort and trading occur? Market-based initiatives such as transferable permits specifically address the problems of guaranteeing market access and promoting efficiency in resource allocation.

Marketable permits for ozone depleters and greenhouse gases are policy instruments which have great potential in the solution of global atmospheric problems. While substantial uncertainty concerning the efficacy of international cooperation in the solution of such problems remains, recent progress toward the development of a protocol to control CFCs is hopeful. In this light, additional research on the design of transferable rights and their associated markets is critical. However, problems with the implementation of emissions trading programs in the United States and challenges by environmentalists may limit their usefulness. Implementing these methods will require greater advocacy by economists and others with a stake in environmental policy.

INTRODUCTION TO GLOBAL ATMOSPHERIC PROBLEMS

In recent years, air quality management efforts have shifted to transboundary problems of increasing geographic scope. Two global issues which are receiving substantial international attention are stratospheric ozone depletion and climate change. The challenge of designing rational environmental management programs for these transboundary problems is compounded by the diversity of separate national interests and the distribution of expected net benefits.

A. Stratospheric Ozone Depletion

The scientific hypothesis describing the catalysis of ozone, an unstable isotope of oxygen, was first published in 1974. This work presented the chemical life cycle of a class of compounds known as chlorofluorocarbons (CFCs) which are highly stable with low toxicity, desirable thermodynamic properties, and wide commercial application. The tremendous stability of these compounds allows them to cumulate in the troposphere for decades and ultimately migrate to the lower stratosphere where they are finally photodissociated. The released chlorine then catalyzes a set of chain reactions which very efficiently destroy ozone. The important human consequence from all this chemistry is an increase in the penetration of ultraviolet radiation to the surface of the earth. Scientists have recently revealed smoking gun evidence of observations of theoretically predicted by-products from these reactions in the vast seasonal depletion termed the Antarctic Ozone Hole. CFCs emissions have been growing at annual rates ranging from 5 - 25 percent.

B. Climate Change

The problem of climate change is linked to that of ozone depletion through atmospheric chemistry and physics. CFCs are also radiatively active trace gases which absorb infrared radiation in the troposphere preventing it from escaping back into space. The heat balance of the earth is thus altered affecting both the rate of chemical reactions in the atmosphere and the basic processes governing climate. Within the next century, scientists expect that we will experience a rise in temperature equivalent to the change associated with the last ice age. The result will be an increase in the global average temperature and most importantly changes in climate. These changes -- temperature, precipitation patterns, storm intensity, and sea level rise -- will be differentially distributed with the greatest effects in the mid to high latitudes. Due to the long lags in response times in the interaction between the atmosphere and the oceans, the climate problem is one of timing and ultimate magnitude. Other gases involved in the problem include CO₂, methane, and N₂O.

CO₂ has been increasing in concentration in the atmosphere by 0.5% per year and is expected to account for over

half of the coming warming. The CO₂ problem requires an understanding of the sources, sinks, and fluxes which govern the global carbon cycle in order to understand the possibilities for intervention. Of particular current interest is the role of tropical rainforests in the global carbon cycle. Is deforestation an important source of CO₂? Are forests important sinks for CO₂?

C. Conceptual Modeling

Each of these problems could be very neatly cast as a problem in optimal control where the objective is to optimize resource use over time subject to physical system constraints. In the case of the stratospheric ozone layer, the problem is to manage the time profile of emissions of ozone-depleting chemicals into the atmosphere so as to minimize both control costs and damages. The state variable of interest is the depletion of ozone while controls are the rates of emission of the various chemicals. Since these compounds are very long-lived, on the order of a hundred years, the problem is one of managing a fund pollutant for which natural renewal of the state is barely nonzero.

In the case of carbon dioxide, or the wider collection of greenhouse gases, the state variable is the atmospheric concentration of the constituent of interest. For ease in exposition, this paper will focus on CO₂ as the major source of greenhouse warming. The control problem is significantly more complex for CO₂ since there are multiple reservoirs of carbon. In fact, the problem can be viewed as one of optimally managing the fluxes of carbon between these reservoirs (Nordhaus, 1979). The major carbon reservoirs are the atmosphere, oceans, fresh water, terrestrial biota, and rocks (geologic strata).

While fluxes occur between each of these reservoirs, there are only a few susceptible to human manipulation. Of primary significance is the extraction of fossil fuel resources from the rock reservoir and their combustion for energy production with subsequent release of CO₂ to the atmosphere. The remaining fluxes of interest are exchanges between the atmosphere and the oceans and changes involving terrestrial biota. In the latter case, deforestation and the removal of forest biomass by burning are fluxes of CO₂ to the atmosphere that are susceptible to control. Although the theoretical possibility exists to inject CO₂ into the deep oceans (>2000 meters of depth) for long-term carbon disposal, neither engineering nor economic feasibility analyses have been performed. Albanese and Steinberg discuss potential control technologies.

Melillo and Gosz describe the carbon budget for the atmosphere as a simple mass balance equation.

$$AC = FF + LU - OU - TEU \quad [1]$$

In their formulation, the two source terms which account for

loadings are fossil fuel combustion (FF) and changes in land use (LU) (e.g. forest to agriculture). The sink terms represent net ocean uptake (OU) and net terrestrial ecosystem uptake (TEU). The size of these flows has been estimated as 5200 Tg C/yr (tera grams of carbon per year) from fossil fuel combustion, 2600 Tg C/yr from land use changes, 2100 Tg C/yr net ocean uptake, and 3000 Tg C/yr uptake by plants. These flows net out to a 2700 Tg C/yr accumulation in the atmosphere (AC). As Mellilo and Gosz point out, this is not an isolated system, but rather one which must be assessed in the context of the other major geochemical cycles -- nitrogen, phosphorus, and sulphur. For example, they estimate that the inadvertent fertilization of forest ecosystems by nitrogenous combustion by-products could stimulate an additional 300 Tg C/yr in forest biomass.

This simple mass balance relation describes the limits of our ability to intervene in the carbon cycle to compensate for atmospheric accumulation. Controls would operate on both sources and sinks. Sources could be suppressed through improved efficiency, substitution to non- or lower polluting alternatives, or the application of traditional pollution control technology. The main research emphasis has been placed on fossil fuels and non-carbon energy sources. However, even simple carbon budgets for alternative fuels or combustion technologies have yet to be calculated. Sinks could be stimulated and expanded. The main prospect would be the expansion of forested area. However, the resource requirements for a decentralized forestation approach would be enormous. Seidel and Keyes estimate that a land area equal to the continent of Europe planted in American sycamores would be required to sequester about 50 years of CO₂ emissions in current annual terms. The precise contribution of tropical rainforests has not been assessed. However, Whittaker and Likens have estimated that tropical rainforests hold approximately 42% of all carbon locked up in terrestrial vegetation.

Each of these global atmospheric problems have similar attributes. They both involve time horizons of the century scale, highly diffuse emission sources, and marked distributional consequences. The dominant polluters have been the industrialized economies. However, as growth proceeds in the less developed world, emissions, particularly of CO₂, are expected to overtake those from the developed nations. The greenhouse problem with its intimate connection to energy use seems less amenable to cooperative international action. Chlorofluorocarbons, on the other hand, while widely commercialized, are produced by fewer than 20 firms. Further, these chemicals are not a generally critical input like energy.

II. Costs of Global Atmospheric Change

No comprehensive assessment of the costs of either of these global atmospheric problems has been produced. The U.S. Environmental Protection Agency (EPA) has generated a risk assessment of stratospheric ozone depletion for its Science

Advisory Board. However, this document is still in draft form and much of the information is limited in its usefulness to conduct a benefit-cost analysis. For example, although there is a known negative relationship between crop yields and increasing doses of UV-B, only one field study of one cultivar of soybeans has been conducted (Teramura). Four crop year experiments which simulated an ozone depletion of 25% resulted in yield decreases of up to 20-25%. However, no attempt was made to assess either the effect of adjustments in cultural practice or the economic significance of such changes.

While active research to empirically estimate damages is underway, it is nonetheless possible to characterize their nature and expected distribution. Of particular importance is the spatial distribution of damages. For both of these problems, effects will increase with latitude. Consequently, the developed nations in the high latitudes are expected to experience the greatest damages. For example, a globally averaged ozone depletion of 2% would correspond to a 8.25% depletion at 60 degrees north latitude, the approximate location of Oslo (Stordal and Isaksen). Climate change for large land masses like the United States are also expected to exhibit east-west variations. For example, Manabe and Wetherald predict mid-continental reductions in soil moisture ranging up to 50%.

A. Stratospheric Ozone Depletion

1. Health Effects of UV-B Radiation
 - nonmelanoma and melanoma skin cancer
 - immune system suppression
 - ocular damage
 - cataracts
 - increased exposure to increased air pollutants (in particular, tropospheric ozone)
2. Agricultural Effects of UV-B Radiation
 - crop yield reductions through disruption of photosynthesis
 - changes in competitive balance between plant species
3. Fisheries Effects of UV-B Radiation
 - phytoplankton mortality
 - larval sensitivity
 - changes in species diversity
 - impacts on endangered species
 - reductions in commercial catch
4. Materials Damages from UV-B Radiation
 - brittleness in elastomers

A summary of these effects and appropriate scientific references is presented in Dudek and Oppenheimer.

B. Climate Change

1. Health Effects

- temperature thresholds and increased mortality
- increased flood severity
- increased frequency and intensity of severe weather

Recent research has reported the potential for increased tropical storm intensity. Emmanuel estimates a 40 -50% increase in destructive power from the increased surface temperature of the oceans under a doubled CO2 atmosphere.

Farber recently estimated the value of wind damage reduced by coastal wetlands in Louisiana. Present values ranged between \$7 and \$23 per acre depending upon whether an 8% or 3% discount rate were applied. He notes that winds accounted for only 5.4% of total property damage from coastal storms. Damages in his sample ranged from \$3.3 to \$122 million (1985). Increases in storm intensity could thus produce significant damage increases.

2. Agricultural Effects

Dudek (1987b), in a limited experiment with a nonlinear programming model of U.S. agriculture, estimated the cost of climate change to the agricultural sector from an effective doubling of CO2 to have an undiscounted value of approximately \$7 billion dollars (1982). In that simulation, both production technology and demand were held constant so as to evaluate the ceteris paribus response of the U.S. agricultural economy to a doubled CO2 environment. Depending upon the future state of technologic advance, export market conditions, and the nature of adaptive responses, actual costs to the agricultural sector could be significantly different. Since the transient path of the economic system to that doubled CO2 condition is not known, it is not presently possible to estimate the average annual cost to agriculture.

3. Materials Damages

Also at risk is extensive coastal infrastructure and investment. It is well-known that the coastal regions of the United States contain very high population concentrations as well as very high property values. It is also well-known that water expands when it is heated and that as the temperature increases from the greenhouse effect, coastal areas will be inundated by the rising sea. Hoffman, et al predict a probable sea level rise between 144 and 217 cm for a global warming of 2.3 to 7.0 degrees Celsius.

Several case studies of the impact of sea level on coastal communities have been completed (Barth and Titus). Case study analyses produced damage estimates ranging from 15 to 1,065 million 1980 dollars in Charleston, South Carolina and from 10 to 360 million dollars for Galveston, Texas. The estimates

varied with the scenario for sea rise and the discount rate. For Charleston, the estimated damages would amount to losses of between 1% and 20% of total net economic services in the region. In the Galveston economy, losses were estimated to account for between 0.2% and 3.6% of the net product of the area.

The total net stock of federal, state, and local nonresidential capital stock is estimated to be worth between 2.2 and 2.6 trillion 1985 dollars (Boskin, et al). Total private capital stock is several times larger and while only a small fraction would be at risk from sea level rise, the value of these threatened assets may still be substantial as the case studies demonstrate.

Several studies have attempted to estimate the magnitude of the economic consequences of climate change. Nordhaus (1982) concluded that the economic effects of a doubled CO2 atmosphere would range between a cost of 12% and a benefit equal to 5% of global GNP. Cutting an equally broad swath, Laurmann estimated the costs of a changing climate as primarily the costs of spatial adjustment of economic activity. He concludes that these costs would be on the order of 3% of gross world product.

III. Policies for Managing the Global Airshed

A. Proposals

1. International Conventions

a. cake-cutting exercises

In March of 1985, the Vienna Convention for the Protection of Stratospheric Ozone was signed. While the negotiating nations agreed that the problem was significant enough to warrant coordinated international action, they could not agree what that response should be. A separate set of technical workshops and negotiations sponsored by the United Nations Environment Programme (UNEP) has been on-going for the past 18 months in an effort to develop a protocol, the operative component of the Vienna Convention. At this time, negotiating states have agreed to first freeze production of CFCs and then ultimately to reduce their manufacture by up to 50%.

While this negotiated process offers promise for more rational management of global common property resources, it also has significant shortcomings. In the CFC debates, the less developed countries (LDCs) have had a minor role. CFC use globally currently averages about 0.17 kg per person. In the United States in contrast, per capita use is estimated to be greater than 1.2 kg per person in recent years. Many LDCs have per capita rates of use significantly less than 0.1 kg per capita. Small wonder then that most of these nations feel that this a problem for the developed nations to solve.

Several proposals have been advanced to provide LDCs with a separate compliance track for the protocol. The protocol, in its current form, envisions phased reductions in the availability of ozone-depleting chemicals. Participating nations would certify their compliance in reducing production or consumption according to the negotiated schedule. However, percentage reductions would be onerous for low use nations to achieve. Consequently, those proposals that have addressed the LDC problem would exempt them from these reductions either allowing growth in use up to a limit or up to the point of equality with global average use. These equity adjustments have been designed to allow market access by LDCs, ease compliance burdens, create incentives for participation, and to allow economic development.

However, growth in LDC use of CFCs and in emissions of CO₂ are central to the policy questions at hand. None of the proposals on the table for CFC control adequately address this problem. The operation of this protocol will be critical evidence to those evaluating the feasibility and desirability of collaborating to control greenhouse gases. Fortunately, most of the implementation issues concerning the control of CFCs lie ahead.

2. Market Initiatives

a. emission fees or taxes

Emission fees have been suggested as one approach to managing both CO₂ (Nordhaus) and CFCs (Miller and Mintzer). While fees are completely congruent with the problems' dynamic aspect and possess a direct empirical analog in the form of costates, implementing an international fee system is non-trivial. Major institutional problems involving collection, certification, and ultimate disbursement exist. From the recent stratospheric ozone negotiations, it is clear that any cooperative control strategy must allow separate national implementation. In effect, this means that signatories would be given targets and goals, but not a specific mechanism for attainment. Individual nations could use fees to meet their reduction quotas, but this process would create problems of verification of compliance with the international schedule, uncertainty among firms while the "correct" fee level was being discovered, and trade distortions reflecting differences in national control strategies or fee levels (Dudek, 1987a).

b. marketable permits

1). CFCs

Marketable permits for CFCs were first proposed by EPA in an advanced notice of public rule-making in February of 1980. The agency was poorly prepared for the negative reaction which greeted its proposal. No attempt was made to market the concept to industry and the proposal was withdrawn. EPA is currently operating under the terms of a consent decree which requires a proposal for further regulation of CFCs by August of 1988. This is another opportunity for marketable permits. The largest

issues looming include who would be allowed to own such permits, the costs of administration, and accommodating new entrants.

2). CO2

Marketable permit schemes are desirable for CO2 management because:

- a. they handle the distributional problems explicitly while allowing the possibility for efficient allocations to emerge
- b. they would induce active management of carbon sinks which would generate valuable credits.

The former advantage stems from the incentive that some permit designs would offer to LDCs to cooperate in a global agreement. The latter advantage for marketable permits creates the possibility that another global commons problem, i.e. tropical deforestation, could be linked with positive net benefits. Tropical deforestation raises at least two significant environmental issues -- biological diversity and the role of forests in the biosphere. Considerable research and attention has been devoted to species diversity and the critical role of tropical rainforests as habitat. Substantially less attention has been paid to the role of such forests in the maintenance of our life support system, the biosphere. An extreme view of the forest conceives it as a standing stock of biomass chiefly composed of carbon. Deforestation, particularly by burning, releases this carbon into the atmosphere in the form of carbon dioxide. The rest of the world is also discharging huge amounts of carbon dioxide into the troposphere as a result of fossil fuel use.

The mid to high latitude regions contain many of the world's developed economies which also act as bankers to the world economy. Of particular interest is the role that these developed economies play in financing the economic development of the less developed countries, the main repositories of the world's tropical forest resources. Much has been written about the third world debt crisis. In its essence, interest rate increases and poor economic performance in the world economy coupled with questionable loan practices created circumstances under which debtor nations found that they could no longer service their obligations. This has threatened the solvency of major banking institutions in the developed world, created additional pressures for quick payoff resource exploitation, and prevented more orderly investment in economic development.

There is a possible mutuality of interest between developed and less developed nations that could focus on tropical forests as the nexus between the climate change and debt problems. The role of tropical forests in the carbon budget of the biosphere must be assessed as a first step. Some research has been developed in this area. The contribution of tropical forest maintenance to delaying the climate warming could be determined and translated into an economic value which measures the

magnitude of damages avoided. These estimates could be compared with the debt service obligations of those nations with significant forest resources. Payment schedules and amounts could be recomputed on the basis of the values of forests to the developed nations. It is not expected that the values estimated will be large enough to offset all outstanding debt obligations. However, it is hoped that they would be sufficiently great to stimulate interest in a debt for forests swap. This kind of intermediate exchange experience could help to lay the foundation for wider trading between nations for the purpose of managing global atmospheric environmental problems. Alternatively, if we were in an active market for permits for CO₂, then nations with large healthy tropical forest ecosystems could gain carbon credits. These presumably valuable permits could then be transferred to a debt holder or sold to an international broker.

The problems in initiating this type of debt swap, if economically feasible, are primarily institutional. Who would hold the rights to tropical forest development? Would a separate debt holding entity similar to that set up by the Japanese have to be created? Could new debt instruments backed by tropical forest assets be issued and successfully marketed?

IV. Conclusions

A. Importance of Learning

Experience in the implementation of a policy is a very important test of its practicality. Transferable rights have great potential application for the management of global atmospheric problems like stratospheric ozone depletion and climate change. However, examples of successful transferable permit systems are rare. Those that have been developed in air quality are modest (approximately \$50 million per year) and limited in scope of trade (almost all have been intra-firm as opposed to inter-firm trades). The conclusion is that there are few examples of transferable rights applied to environmental problems. Why?

B. The profession and advocacy of market methods

Economic approaches to the solution of atmospheric environmental problems have been controversial. For example, one of the most promising policy instruments to be developed is the notion of trading in pollution rights (Dales). These ideas have come closest to implementation in the case of that loose collection of policies described as emissions trading. However, emissions trading has not fulfilled its theoretical promise. The policy was initiated in response to the dilemma posed by nonattainment. EPA was faced with a large number (>50) SMSA's which were not in compliance with regulations written under the mandates of the Clean Air Act. Under the rules, EPA would have to deny permits for additional sources which would effectively stymie economic development and it would have to impose federal funding sanctions. Neither of these responses were likely to be

politically palatable. Emissions trading offered a path out of this dangerous conundrum.

Emissions trading was a natural show piece for the Reagan administration's regulatory reform agenda. In their haste to implement reform, a number of questionable trades were approved by EPA. These became the object of litigation by certain environmental groups. They have had mixed results in the courts. However, this litigation and the precedents that it has established have poisoned environmentalists against the emissions trading. Legislative proposals in the Senate to amend the Clean Air Act would ban emissions trading in nonattainment areas.

Economists have not been diligent in working to implement the policy prescriptions that they propose. Emissions trading is an excellent case in point. Problems with implementing economic management approaches to environmental issues are:

1. incongruous and unreasonable assumptions
2. measurement problems in environmental issues
3. sophisticated methodologies
4. poor ethical reputation of economists
5. inadequate attention to equity impacts.

Wiley has argued that these 5 problems "constitute a significant barrier to the use of economic criteria in environmental regulations".

Environmentalists have mistrusted transferable rights as "licenses to pollute" and contributed to the problems that these policies have experienced. For example, under some emissions trading schemes, emissions credits are granted only to the first applicant proposing a credit based upon a new technology. Once approved, the new technology then becomes the mandated standard for all other firms. This extreme form of technology forcing blunts the incentive to innovate new pollution control technologies. In particular, it chokes off the market in emissions credits and perpetuates the efficiency losses associated with uniform treatment standards. The continuing spate of litigation over the program has produced a significant aura of uncertainty over its future. The success of markets in allocating pollution discharges depends upon security in tenure in the rights (credits) created by the firms' investments of capital and ingenuity.

Economists need to overcome their inherent biases against advocacy and become active on behalf of the advantages that economic criteria as applied to resource and environmental management offer.

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**A SHORT DISCUSSION OF
GREENHOUSE GAS TRADING**

Daniel J. Dudek

Environmental Defense Fund
New York, New York

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1 Emissions Trading Concept

This paper will develop both an argument for the use of greenhouse gas permit trading as well as a strategy for its implementation. The argument for permit trading is based upon the assets of the policy itself and not upon a comparison with other policy instruments. For a comparison of marketable permits with alternative instruments see Dudek (1987). The focus in this paper is on implementation. As such, marketable permits for greenhouse gases can be seen as a natural outcome of the evolution of market-based environmental policy experiences in the U.S. The transition from emissions trading in nonattainment areas to national SO₂ trading through lead rights trading among refiners and transferable production permits for CFCs is very clear.

In the international context, the primary gains from trading include:

- 1) powerful incentives for extra reductions
- 2) stimulus to technical change and innovation
- 3) creation of a mechanism for international transfer of reductions reducing the burden of any individual emissions limit
- 4) consistency with any national control program

International trading in greenhouse gases would build directly upon the successful model of the Montreal Protocol. The administrative apparatus required to implement trading is no different than that required to track CFC production for example. The administrative requirements to track and monitor any greenhouse gas protocol will be very similar. The definition of control obligations within the Montreal Protocol include the tracking of exports and imports as well as conversion factors between different CFCs to account for differences in ozone depletion potential. The Montreal Protocol allows provisions which allow for the economic rationalization of production which by any other name is trading. International greenhouse gas trading would function in a like manner.

2 Short History of Emissions Trading

Emissions trading is actually a generic term for a collection of flexible air pollution policies created to overcome the conflicts produced by the failure to meet air quality goals in urban areas in the U.S. in the late 70's. The EPA's final emissions trading policy includes provisions for bubbling, offsetting, and netting. Tietenberg (1985) provides an excellent overview of the development of these policy reforms for the management of air emissions. Over time, these basic concepts have been applied to a wider number of pollutants and circumstances. Emissions trading is ideally suited for the management of transboundary pollutants such as acid rain.

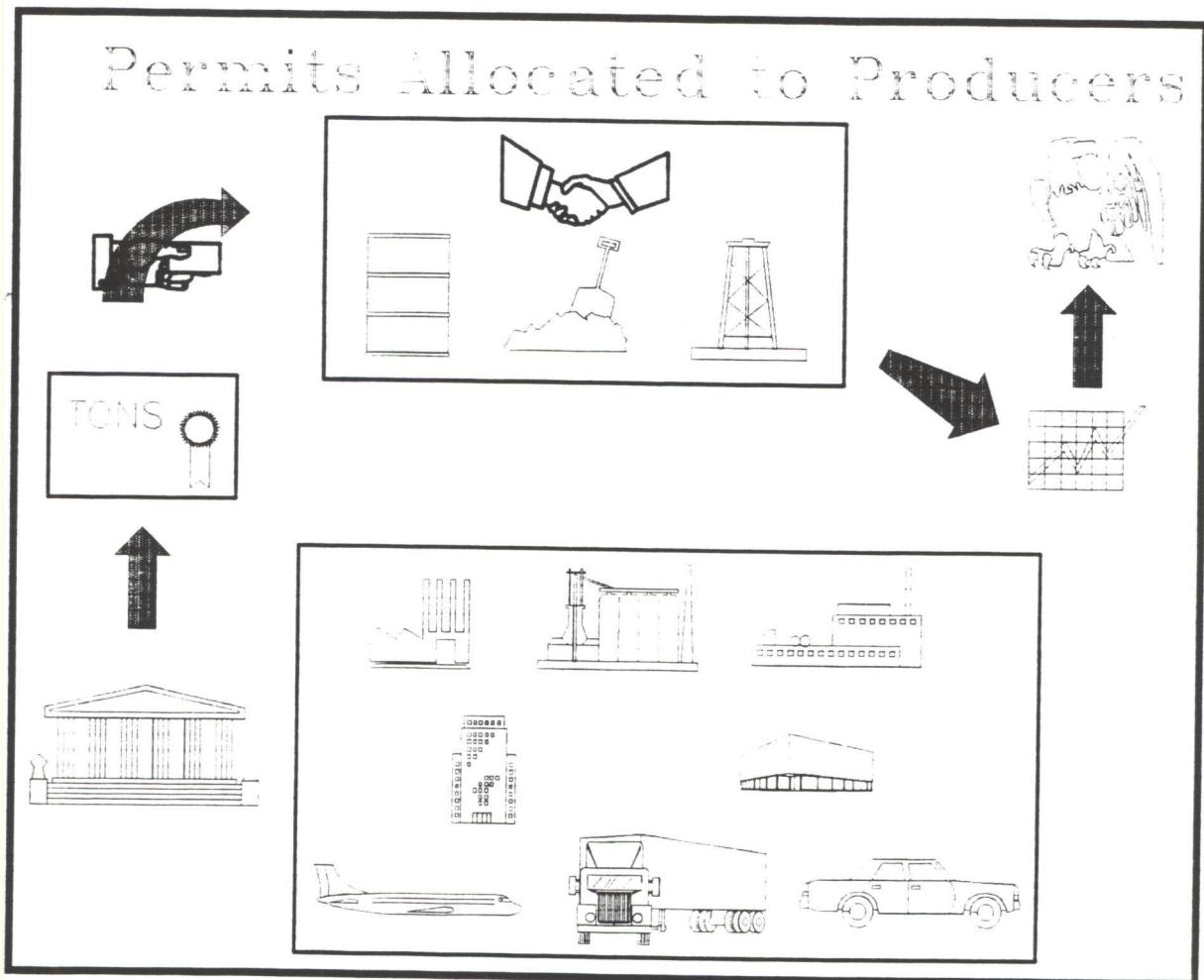
The concept of emissions trading is based on the premise that pollution reductions can be accelerated if polluters are allowed to optimize pollution control investments. The evidence from the experience with trading clearly shows significant cost savings for emitters (Dudek and Palmisano, 1988). The environmental account has been more hotly disputed however. Both Hahn and Hester (1986) and Liroff (1986) in their reviews of the performance of netting and bubbling respectively observed no significant deterioration in air quality. Dudek *et al* (1990) identified significant CO₂ reduction benefits from an acid rain emissions trading program. Cost-effective SO₂ control investments could eliminate between 5.4-6.0% of expected utility CO₂ emissions over the decade 1995-2005.

The system operates quite simply. Polluters are assigned a baseline for each emissions source which establishes the initial conditions from which reductions can be assessed. Baselines are established by regulation by the appropriate air quality management authority. The polluter must meet the minimum standards in force for each pollutant at each source. However, these regulatory obligations can be met by overcontrolling at another emissions point and transferring the overcontrol. The flexibility

capture and destruction of banked CFCs and halons would also be a valuable source of reductions as would the recovery of coalbed methane. In both designs the control point for compliance is the fossil fuel producer who would be required to turn in a sufficient quantity of permits to cover annual production.

End users would perceive the program in economic terms much as a tax on carbon, i.e. they would face higher energy prices. In fact, users would be offered energy at two prices -- one price with the permit bundled in and another with the permit to be supplied by the fuel purchaser. Buyers would evaluate the costs of generating new permits versus the price differentials charged by the energy producers.

As indicated above, the permit program, although behaving somewhat as a tax policy in effect, would nonetheless differ in at least two critical aspects. First, the "tax" would be determined by the market in permits, i.e. by the decisions of private actors rather than through legislative or bureaucratic means. Second, sinks are encouraged.



3.2.1 Technology Transfer

A major benefit is that such a system provides manufacturers with an economic incentive to develop and use technology that uses fossil fuel energy more efficiently than national regulations (promulgated to be consistent with an international allocation formula) alone would provide or that relies on renewable sources of energy. It could also provide large industrial or commercial users of energy systems with incentives to make efficiency investments. The reason for this is that such a manufacturer may be able to sell (or large users may be able to earn credits) based on this added efficiency. The ability to sell CO₂ emission credits produces economic value for the more efficient technology. Internationally, a potential benefit of a trading program is that, if properly designed, it could promote transfer of energy efficient technologies from highly industrialized to less developed countries.

To simplify this illustration, let us look at how an international agreement could affect the energy efficiency of, initially, one major appliance, namely, refrigerators, and, then, a broader range of fossil fuel energy systems. Furthermore, by way of illustration, let us assume that the industrialized countries of the world are required by such an international agreement to reduce their emissions of CO₂ by prescribed amounts annually or in multi-year phases, that countries with high rates of forest loss would have to reduce their rates of CO₂ growth modestly and that many developing countries, such as India and China, with very low but growing per capita rates of CO₂ emissions would be authorized to increase those rates modestly for some period of time. The CO₂ control/reduction schedule should be pre-announced both in the convention/protocol and each national program so that firms and government agencies can plan and make their investments accordingly.

For the U.S., or any other industrialized country, to meet internationally prescribed CO₂ reduction goals, it would have to consider a range of strategies, including adoption of progressively more stringent energy efficiency standards for vehicles, building heating, ventilation and air conditioning (HVAC) and lighting systems and major appliances (CHVAC), such as refrigerators. Under the National Appliance Energy Conservation Amendments of 1988, the U.S. Department of Energy (DOE) has the authority to promulgate energy efficiency standards for many household appliances, including refrigerators. DOE has in fact recently promulgated new energy efficiency standards for refrigerators and freezers to take effect January 1, 1993, 54 Fed. Reg. 47916 (Friday, Nov. 17, 1989). In announcing these new rules, DOE has claimed that they will improve overall refrigerator/freezer energy efficiencies by 25% compared to products on the market today. Each nation could translate CO₂ emission controls into percentage improvements in energy efficiency for all industrial sectors.

To take advantage of a trading program, the DOE standard-setting program for appliances such as refrigerators could be revised along the lines of the Department of Transportation's Corporate Average Fuel Efficiency (CAFE) standard-setting program for automobiles. A car manufacturer complies with the applicable CAFE standard if the average fuel economy of its entire fleet sold in a given year meets the mandated fuel efficiency level. Energy efficiency standards for refrigerators could be similarly set so that the average refrigerator made and sold by a manufacturer complied with the standard in effect in a given year.

Under a trading program, a manufacturer (or importer of a foreign-made refrigerator) that produced and sold in the U.S. refrigerators the average energy efficiency of which was better than the applicable product standard could obtain energy efficiency (surrogates for CO₂ emission) credits. These can be statistically translated into CO₂ equivalents using average

To give a more concrete example, let us assume that western European countries or the European Community (EC) as a whole would have to reduce CO₂ emissions annually by rates or amounts prescribed in an international convention/protocol. Those rates may be different from those applicable to the U.S. The EC could establish efficiency standards for refrigerators and freezers. The efficiency standards in force in those countries or throughout the EC in any particular year might be different from those in the U.S., in part reflecting differences in applicable national goals or, within those countries or groupings, differences in allocating responsibilities for meeting national goals among different sectors of their economies.

With a bilateral agreement in place, a manufacturer of refrigerators/freezers selling in both the North American and western European markets might produce and sell appliances which on average were not as efficient as required in one market but more efficient than required in another market. That manufacturer would be eligible for credits in the latter market (i.e., the market where the appliances were sold). It could then use those credits to compensate for its failure to meet the applicable standard in the former market. Or, pursuant to contract, a more energy efficient manufacturer in the latter market could sell or transfer credits to a manufacturer in the former market.

This discussion has been limited to manufacturers of refrigerators and freezers to present a concrete example of how a bilateral credit transfer system could operate. As with any national program, such a bilateral arrangement could be designed to cover other appliances or all energy-consuming systems. Under such an arrangement, energy efficiency baselines for such systems would be set by the participating countries. Those baselines could be modified in accordance with a prescribed schedule. Energy efficiency or equivalent CO₂ emission credits could be traded, bought or sold amongst all manufacturers/importers of such systems. The arrangement would set forth the procedures for monitoring, certification of credits, reporting of transfers and enforcement. It could also authorize participation in the market for credits by third parties. If planting of trees as a sink of CO₂ were included in the national program, the energy efficiency credits would have to be denominated in CO₂ equivalents as well.

Such bilateral agreements expand the universe of manufacturers who could benefit from the investment and flexibility provided by such trading arrangements. CO₂ concentrations in the atmosphere are a function of global loadings and are not affected by the geographic distribution of individual sources. The fact, therefore, that one industrial country emits a smaller total load in a given year than an international convention/protocol prescribes while another country emits a concomitantly larger total load as a result of trading among those countries is irrelevant in terms of environmental protection.

Bi-lateral or international agreements that authorize trading of energy efficiency/CO₂ emission credits between an industrialized country, and a developing country, are also possible. A major objective here would be to design the international allocation system so that firms that decided to take advantage of the trading program would indirectly be contributing to the kinds of technology transfer and financing goals described in the Report of the Second Session of IPCC Working Group III/Response Strategies Working Group, Geneva, 2-6 October 1989, in particular, "Implementation Measures on Technology Development and Transfer Measures" and "Implementation Measures on Financial Measures."

As a general proposition, the tougher the CO₂ reduction goals that industrialized countries must meet, the more their manufacturing firms should be inclined to look for such joint venture opportunities in less developed countries as a source of credits. In addition, so long as developing countries face constraints on the rate of growth of their CO₂ emissions, firms there have an incentive to enter into such joint or contractual arrangements as well.

4 Application to CO₂

The primary advantages of using marketable permits were distilled recently in the process of the IPCC discussions concerning response policies. Those identified included:

- flexibility
 - direct control of emission levels
 - efficiency in pollution control
 - mechanism for trading among different greenhouse gases
 - incentives for development of non- or low polluting technologies.
- (Working paper by Bertram et al. For IPCC/WG3-II/Doc 3)

In addition, permits would decentralized pollution control decision-making commensurate with the numbers of sources involved. An international CO₂ (or greenhouse gas) trading program also can accommodate a variety of separate national implementation strategies and policies. No nation would be compelled to achieve its control obligations through trading. Lastly, by linking sources and sinks in one comprehensive strategy, an explicit mechanism of self-interest is established between along the often divisive North and South axis.

4.1 Sink Stimulus

CO₂ trading is likely to produce the same proliferation in supply options as generated in the deregulation of the financial services industry. The huge variety of precisely tailored investment vehicles available in the current market are likely to be mirrored in the CO₂ (or greenhouse gas) permit markets. After all, a CO₂ trading program would create a new form of environmental currency. One direct effect would be the stimulus to develop sinks as well as source reductions.

Since tropical forests are a major sink for carbon and their burning or destruction at current rates constitutes some 15% of global CO₂ loadings, the question is how an international agreement can promote the retardation of the destruction or the re-establishment of any forests and whether a trading program can facilitate attainment of those goals.

The destruction and burning of tropical forests in countries such as Brazil and Indonesia contribute a significant fraction of their CO₂ budgets. Thus, if such countries allocated their CO₂ emissions targets proportionately to the forest sector and fossil fuel sectors, Indonesia would have to take steps to prevent increases in the destruction of its forests; Brazil would have to implement a program to decrease the rate of loss of its forests by 2% per year.

If tropical forest acres can be converted into CO₂ and energy efficiency equivalents, countries like Brazil and Indonesia might find it economically attractive, as well as environmentally sound, to retard the destruction of their forests even faster or to implement restoration programs where, in the process, they can earn CO₂ credits which their own industry could use or which they could sell to foreign firms or governments. Those countries in turn could use the revenues from the sale of such credits to finance programs to retard forest loss. A trading program authorized under an international convention/protocol could

credit certification program was viable and accurate. Since a country might have an incentive to inflate its eligibility for credits, this international agency would need additional resources to assure reliable national reporting of information and valid credit issuance programs.

A trading system can also help to assure the integrity of any system of emissions limits. As industrial enterprises -- or even governments -- attempt to comply with CO₂ limits, technical or economic factors will inevitably prevent some from complying at some times. Without a trading system, a variance system (formal or simply by non-enforcement) will inevitably develop. A formal system will in turn require technical or economic criteria for evaluating variance requests and bureaucracies to apply those criteria. Inevitably also, those bureaucracies may not discipline needed economic enterprises for the sake of what may appear "temporary" violations of CO₂ limits. The problem could lead to distrust between nations and diminishing willingness to make needed sacrifices. By allowing dischargers the flexibility of choice in reduction decisions and the ability to bank extra reductions, there is no credible justification for violation of emissions limits.

A trading system should eliminate the need for variances by allowing industries and nations that cannot comply with limits to purchase credits. No criteria would be necessary to evaluate variance requests, and the sole task for bureaucracies would be the registration and verification of the transfer. Enforcement officials would not need to negotiate complex compliance orders, but simply to order the purchase of credits. Enforcement could also be more credible because the purchase of credits should often be less draconian than shutdown of enterprises. In addition, the failure of some enterprises to comply with initially set limits should always be matched by compensating reductions. And because a market mechanism will replace bureaucratic judgment, those enterprises that do not comply with initial limits should do so because of real economic needs not political influence.

5.1 The Offset Program

One of the first direct implementation steps for CO₂ trading is an offset requirement for new CO₂ sources. This is a program which the major industrialized nations should undertake unilaterally as a first rational step toward the significant reductions required. It is a minimalist step which can be established now without any regulatory lag or lead-in. Major new sources would include new fossil fueled electric generating stations, new industrial boilers, and cogeneration facilities selling power into regional electricity grids. Such a program would:

- * begin reduction of accumulation of greenhouse gases in the atmosphere
- * establish administrative mechanisms to facilitate trading
- * stimulate private market development of CO₂ reducing technologies.

The heart of the program is the ability to create and transfer CO₂ credits. Any CO₂ reduction meeting the certification requirement would constitute a legitimate CO₂ credit available for offset. The program would create explicit procedures for the certification of several identified offset credit sources. In addition, these procedures would allow any source to receive credit for CO₂ reductions for any such reductions that can be demonstrated to have been explicitly created for this program and which constitute CO₂ reductions that would have normally been emissions.

there is no price ceiling and the systems do not necessarily diverge. As indicated in the discussion on alternative designs, when permits are issued to fossil fuel producers, the tradeable permit program would appear to fossil fuel users in the form of increased energy prices. In this sense, the transferrable permit program behaves exactly like the carbon tax except for one crucial difference. Under the permit system, the level of the tax is set by the market and varies continually depending upon market conditions and not upon political or bureaucratic whim.

International greenhouse gas permit trading has several critical advantages unmatched by alternative policy options. First, marketable permits would provide the greatest spur to innovation in both low polluting technologies, emission control options, and pollutant sinks. This substantial economic incentive for forest protection is an important and often overlooked feature of any greenhouse policy. Providing the option of producing additional permits over time through forest management changes lessens the impact of greenhouse gas control on economic performance. Permits also provide an explicit mechanism for reallocating scarce resources, namely CO₂ permits, over time and space. Certainly fixed international obligations could be periodically renegotiated, but it is difficult to imagine that such a process could even begin to approach the efficiency of a genuine global market. Lastly, a system of marketable permits provides all parties with a relatively simple means of determining performance. The sum of permits transferred to control authorities at any one point in time measures total emissions.

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**INTERNATIONAL TRADING
IN
GREENHOUSE GAS PERMITS**

Policy Paper Prepared
for

Project 88 -- Round II

Daniel J. Dudek

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1 Background

In recent years, air quality management efforts have shifted to transboundary problems of increasing geographic scope. Two global issues which are receiving substantial international attention are stratospheric ozone depletion and climate change. The challenge of designing rational environmental management programs for these transboundary problems is compounded by the diversity of separate national interests and the distribution of expected net benefits.

Each of these global atmospheric pollution problems could be very neatly cast as a problem in optimal control where the objective is to optimize resource use over time subject to physical system constraints. In the case of carbon dioxide, or the wider collection of greenhouse gases, the state variable is the atmospheric concentration of the constituent of interest. A commonly articulated objective function would be to minimize costs over time subject to limits on global average temperature changes¹. For ease in exposition, this paper will focus on CO₂ as the major source of greenhouse warming. The control problem is complex for CO₂ since there are multiple reservoirs of carbon. In fact, the problem can be viewed as one of optimally managing the fluxes of carbon between these reservoirs (Nordhaus, 1979). The major carbon reservoirs are the atmosphere, oceans, fresh water, terrestrial biota, and rocks (geologic strata).

While fluxes occur between each of these reservoirs, there are only a few susceptible to human manipulation. Of primary significance is the extraction of fossil fuel resources from the rock reservoir and their combustion for energy production with subsequent release of CO₂ to the atmosphere. The remaining fluxes of interest are exchanges between the atmosphere and the oceans and changes involving terrestrial biota. In the latter case, deforestation and the removal of forest biomass by burning are fluxes of CO₂ to the atmosphere that are susceptible to control. Although the theoretical possibility exists to inject CO₂ into the deep oceans (>2000 meters of depth) for long-term carbon disposal, neither engineering nor economic feasibility analyses have been performed. Albanese and Steinberg discuss potential CO₂ control technologies.

1.1 The Problem of Climatic Changes

Trace gases like carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and chlorofluorocarbons (CFCs) absorb infrared radiation preventing its escape into space. This heat trapping affects both the rate and nature of critical chemical reactions in the atmosphere such as those governing stratospheric ozone depletion and the basic processes governing climate. The result is an increase in temperature similar to that which occurs in a greenhouse, but producing climate changes unprecedented for their speed of occurrence. Within the next century, scientists expect that we will experience a rise in temperature equivalent to the change associated with the last ice age in the range of 5-15 degrees Fahrenheit. These changes -- temperature, precipitation patterns, storm intensity, and sea level rise -- will be differentially distributed with the greatest changes in the mid to high latitudes. The most serious effects are likely to fall on nations with poor resources and currently faltering economies

¹ Temperature changes are useful system limits since they can be estimated from the capacity of sensitive or valuable ecosystems to adjust. For example, limits of 1° C per century might allow forests to migrate without investment.

such as those in the Sahel region of Africa. Due to the long lags in response times in the interaction between the atmosphere and the oceans, the climate problem is one of timing and ultimate magnitude. The prospect for human societies and natural ecosystems is adaptation under a continually changing climate.

CO₂ has been increasing in concentration in the atmosphere by 0.5% per year and is expected to account for over half of the coming warming. The CO₂ problem requires an understanding of the sources, sinks, and fluxes which govern the global carbon cycle in order to understand the possibilities for intervention. Of particular current interest is the role of tropical rainforests in the global carbon cycle.

1.1.1 Sources and Sinks

Melillo and Gosz describe the carbon budget for the atmosphere as a simple mass balance equation.

$$AC = FF + LU - OU - TEU$$

[1]

In their formulation, the two source terms which account for loadings are fossil fuel combustion (FF) and changes in land use (LU) (e.g. forest to agriculture). The sink terms represent net ocean uptake (OU) and net terrestrial ecosystem uptake (TEU). The size of these flows has been estimated as 5200 Tg C/yr (tera grams of carbon per year) from fossil fuel combustion, 2600 Tg C/yr from land use changes, 2100 Tg C/yr net ocean uptake, and 3000 Tg C/yr uptake by plants. These flows net out to a 2700 Tg C/yr accumulation in the atmosphere (AC). As Melillo and Gosz point out, this is not an isolated system, but rather one which must be assessed in the context of the other major geochemical cycles -- nitrogen, phosphorus, and sulphur. For example, they estimate that the inadvertent fertilization of forest ecosystems by nitrogenous combustion by-products could stimulate an additional 300 Tg C/yr in forest biomass.

This simple mass balance relation describes the limits of our ability to intervene in the carbon cycle to compensate for atmospheric accumulation. Controls would operate on both sources and sinks. Sources could be suppressed through improved efficiency, substitution to non- or lower polluting alternatives, or the application of traditional pollution control technology. The main research emphasis has been placed on fossil fuels and non-carbon energy sources. However, even simple carbon budgets for alternative fuels or combustion technologies have yet to be calculated. Sinks could be stimulated and expanded. The main sink prospects would be the expansion of forested area although some have suggested the stimulation of marine plant biomass. However, the resource requirements for a decentralized forestation approach would be enormous. Seidel and Keyes estimate that a land area equal to the continent of Europe planted in American sycamores would be required to sequester about 50 years of CO₂ emissions in current annual terms. The precise contribution of tropical rainforests has not been assessed. However, Whittaker and Likens have estimated that tropical rainforests hold approximately 42% of all carbon locked up in terrestrial vegetation.

The dominant polluters have been the industrialized economies. However, as growth proceeds in the less developed world, emissions, particularly of CO₂, are expected to overtake those from the developed nations. Flavin (1989) has estimated that the discrepancy in per capita use of fossil fuels among the world's largest countries varies by more than a factor of 10. North America emitted 1,379 million tons of carbon in 1988, or 5.07 tons per capita. Centrally planned Asia (China) emitted 774 million tons of carbon in 1988, at a rate of 0.66 tons per capita. India's per capita rate was below 0.5 tons. Per capita rates in the USSR and Eastern Europe were 3.55 tons of carbon per person; in Western Europe, 2.03; in Japan, about 2.1; in Latin America, 2.09; in Africa, 0.86. According to Flavin, world emissions of carbon totalled 7,319 million tons in 1981, at a worldwide per capita average of 1.42 tons.

Methane, tropospheric ozone, and nitrous oxides collectively contribute about 25% to the current warming. Our understanding of the precise sources of the emissions of these gases and their growth is less certain. Atmospheric concentrations have been steadily rising in recent years; methane and tropospheric ozone at roughly 1% annually and nitrous oxides at 0.25% per year. Methane sources include livestock, rice paddies, termites, fossil fuel combustion including natural gas flaring, and landfill decomposition. Tropospheric ozone is a major component of smog produced from the reaction of hydrocarbon and nitrogen oxide emissions fueled by ultraviolet radiation. Nitrous oxide sources include fertilizers, cement producers, biomass burning, fossil fuel combustion, and various natural sources. These gases are generally unmanaged.

1.1.2 Projections

The long time frames characterizing this problem require projections of economic growth, energy production, and population in order to forecast future greenhouse gas emissions and their climatic consequences. However, projections of socio-economic factors on a 70-100 year time scale are notoriously fraught with problems. The result is the identification of alternative emission scenarios, possible future emissions trajectories under alternative assumptions about the future state of the world.

Current projections are that the developing countries intend to increase their use of fossil fuels significantly in coming decades. Depending upon global economic conditions, energy growth in many less developed countries could occur at twice the 1.5 - 2.1 percent per year forecasted from OECD nations (World Resources Institute, 1990). In view of the fact that many of these countries today are using these fuels significantly below the worldwide per capita average, it should be clear that the industrialized countries will have to reduce emissions of CO₂ in a major way if the build up of CO₂ in the atmosphere is to be slowed. It is also generally assumed that growth in the demand for energy will outstrip efficiency improvements in the LDCs.

These emission trajectories are the inputs to the General Circulation Models (GCMs). GCMs are nonlinear models of climatic processes at varying degrees of resolution and complexity which predict climatic variables such as temperature and precipitation on the basis of initial concentrations of gases in the atmosphere and future discharges. Much has been made of the

uncertainties inherent in climatic modelling. Examples include the formation and mix of clouds and their feedback effects over time and the role and speed of ocean-atmosphere interactions.

1.1.3 Estimates of Damages

The most comprehensive review to date of the damages expected from climate change in the U.S. is the recent congressionally mandated EPA study (Smith and Tirpak, 1989). The EPA study attempted to quantify effects ranging from impacts on human health (increased mortality from stresses related to temperature increases) to the implications for regional water resources.

Recent research has reported the potential for increased tropical storm intensity. Emmanuel estimates a 40 -50% increase in destructive power from the increased surface temperature of the oceans under a doubled CO₂ atmosphere. Farber recently estimated the value of wind damage reduced by coastal wetlands in Louisiana. Present values ranged between \$7 and \$23 per acre depending upon whether an 8% or 3% discount rate were applied. He notes that winds accounted for only 5.4% of total property damage from coastal storms. Damages in his sample ranged from \$3.3 to \$122 million (1985). Increases in storm intensity could thus produce significant damage increases.

As the most weather sensitive sector of our economy, agriculture has been the focus of several impact assessments. In the aggregate, these studies have estimated climatic changes to cause losses in economic welfare from agriculture of between \$0.6-\$11.6 billion in 1982 dollars in average annual terms (Adams, et al; Dudek, 1987). By comparison estimates of the effects of the 1988 drought were approximately \$3 billion for three major crops (Associated Press, 1988). The estimates of damage to agriculture from other environmental problems provide useful comparisons. Tropospheric ozone or smog is estimated to cost the agricultural economy approximately \$2 billion annually (Adams and McCarl, 1985). Stratospheric ozone depletion and the increased ultraviolet radiation that it would generate would cost about \$2.5 billion (Adams and Crocker, 1987). Climate change impacts upon agriculture can be several times larger than the damages caused by these environmental stresses. Depending upon the future state of technologic advance, export market conditions, and the nature of adaptive responses, actual costs to the agricultural sector could be significantly different. Dudek (1989) estimated the mitigation offered to California's economy if irrigation water marketing policies were adopted to be on the order of 10% of damages otherwise expected.

Since the transient path of the economic system to a doubled CO₂ condition is not known, it is not presently possible to estimate the average annual cost to agriculture. The greatest complications arise in estimating regional effects owing to uncertainties in the General Circulation Models (GCMs) and their lack of spatial resolution. The problems of evaluating agricultural impacts illustrates the difficulty of assessing the implications of climatic changes generally. These difficulties will become increasingly important as advocates of international action to control greenhouse gases attempt to convince negotiators of the severity of the consequences of inaction.

D R A F T

Also at risk is extensive coastal infrastructure and investment. It is well-known that the coastal regions of the United States contain very high population concentrations as well as very high property values. It is also well-known that water expands when it is heated and that as the temperature increases from the greenhouse effect, coastal areas will be inundated by the rising sea. Hoffman, et al predict a probable sea level rise between 144 and 217 cm for a global warming of 2.3 to 7.0 degrees Celsius.

Several case studies of the impact of sea level on coastal communities have been completed (Barth and Titus). Case study analyses produced damage estimates ranging from 15 to 1,065 million 1980 dollars in Charleston, South Carolina and from 10 to 360 million dollars for Galveston, Texas. The estimates varied with the scenario for sea rise and the discount rate. For Charleston, the estimated damages would amount to losses of between 1% and 20% of total net economic services in the region. In the Galveston economy, losses were estimated to account for between 0.2% and 3.6% of the net product of the area.

The total net stock of federal, state, and local nonresidential capital stock is estimated to be worth between 2.2 and 2.6 trillion 1985 dollars (Boskin, et al). Total private capital stock is several times larger and while only a small fraction would be at risk from sea level rise, the value of these threatened assets may still be substantial as the case studies demonstrate. On the other hand, investments in coastal defenses against sea level rise are only beginning to be estimated.

Several studies have attempted to estimate the overall magnitude of the economic consequences of climate change. Nordhaus (1982) concluded that the economic effects of a doubled CO₂ atmosphere would range between a cost of 12% and a benefit equal to 5% of global GNP. More recently, Nordhaus (1990) has stated that "the impacts of climate change on developed countries are likely to be small, probably amounting to less than 1% of national income over the next half-century". Cutting an equally broad swath, Laurmann estimated the costs of a changing climate as primarily the costs of spatial adjustment of economic activity. He concludes that these costs would be on the order of 3% of gross world product.

1.2 Existing and Proposed Policies

As with most policy issues, the climate change debate has focused on a range of dichotomous choices. Some argue that humans are infinitely clever and therefore adaptable to diverse and changing environmental circumstances. Therefore, we should not waste resources preventing climate changes, but we should plan for them and increase flexibility. Others believe that the prevention of climatic changes is the appropriate policy response. Other elements of the debate include unilateral versus international actions and the responsibilities of developed versus less developed nations.

1.2.1 Summary of Policies

Many existing policies have implications for the production of greenhouse gases. For example, transportation policies such as the Federal Highway Trust Fund provide funds for states to expand the

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interstate highway system thus increasing vehicle carrying capacity and CO₂ emissions. In some limited circumstances, highway construction may temporarily improve efficiency due to relieved congestion, but vehicle miles travelled (VMTs) normally increase with system expansion. While policies such as the highway trust fund could be altered to account for CO₂ by allowing funds to be used for mass transit investments as well, initiatives that would integrate greenhouse gas management into traditional single purpose policies are only beginning to emerge.

1.2.1.1 CO₂

The policy with the greatest likelihood of affecting CO₂ emissions is the acid rain emissions trading program envisioned in the Clean Air Act amendments being considered in conference. The flexibility offered to sources by the trading system could result in reductions of up to 170 million tons of CO₂ per year over a decade if all cost-effective CO₂ sensitive investment opportunities were exploited (Dudek, et al, 1990). These CO₂ saving control strategies include cogeneration, energy efficiency and conservation, and switching to less carbon intensive fuels.

1.2.1.2 Ozone Depleting Chemicals

The Montreal Protocol controlling substances that deplete stratospheric ozone has just been renegotiated. Fully halogenated chlorofluorocarbons (CFCs) and halons will not be produced after 2000 (Monastersky, 1990). In addition, methyl chloroform will be reduced by 70% by 2000 and eliminated by 2005 and carbon tetrachloride will be cut by 85% by 1995 and phased out by 2000. The hydrochlorofluorocarbons (HCFCs) will be eliminated by 2040 if not sooner. While this revision demonstrated the importance of creating a flexible, renegotiable framework for international atmospheric treaties, it also clearly stressed the importance of transfers from developed to less developed nations to secure agreement. The developed nations set up a fund of at least \$160 million to be spent over the next three years to assist developing nations in the transition away from CFCs.

1.2.2 Effectiveness of Current Policy Tools

Other than CFCs, no current policy is directly focused on the reduction of greenhouse gas emissions. There are many policies which can produce significant ancillary benefits in the form of emission reductions but this is not the main objective of the policy. For example, the global elimination of agricultural subsidies would eliminate excess fertilization (source of N₂O), the additional fossil fuel combusted in the production of subsidized commodities, and the methane from the additional animals supported by national agricultural income programs.

Current tax policy as it affects vehicle fuels could have a substantial effect on reducing CO₂, CO, and NO_x. Eliminating subsidies and tax breaks for energy producers and users would contribute to more efficient energy decisions. Some tax policies may actually improve internalization of externalities and promote efficiency. For example, continuing the tax incentive to recover coalbed methane provides a greenhouse benefit equal to the difference in radiative forcing between the vented CH₄ and the CO₂ resulting from its ultimate combustion. Of course, these same recovery incentives could also be produced by

deregulating natural gas completely. Forest policies of subsidizing harvests results in sub-optimal harvest rates and loss of sequestered carbon while many current timber management practices result in injection of CO₂ from site disturbance and slash burning.

Improved energy efficiency has often been invoked as a panacea by those concerned with the environmental consequences of energy production and use. As a result there are a variety of government programs designed to produce improved energy efficiency. For example, the Corporate Average Fuel Economy (CAFE) program requires that the vehicle manufacturers achieve a sales weighted average fuel efficiency established by Department of Energy rule-making. Appliance energy efficiency standards pursue the same objectives and may include some elements of flexibility for individual manufacturers. Energy conservation in the form of demand side management has been promoted in utility rate making proceedings as an alternative to new electric generating capacity investments.

However, these programs are an unfocused hodgepodge whose full potential in realizing CO₂ reductions is not likely to be felt. For example, the disincentives to electric utilities and their investors to make energy efficiency investments are well known. Adding a CO₂ emissions trading program would add a critical motivating incentive to these regulatory programs in the form of an income stream derived from the production and sale of CO₂ credits.

2 Conceptual Overview of CO₂ Permits

This paper will develop both an argument for the use of greenhouse gas permit trading as well as a strategy for its implementation. The argument for permit trading is based upon the assets of the policy itself and not upon a comparison with other policy instruments. For a comparison of marketable permits with alternative instruments see Dudek (1987). The focus in this paper is on implementation. As such, marketable permits for greenhouse gases can be seen as a natural outcome of the evolution of market-based environmental policy experiences in the U.S. The transition from emissions trading in nonattainment areas to national SO₂ trading through lead rights trading among refiners and transferable production permits for CFCs is very clear. The transition to greenhouse gas trading is from SO₂, to international SO₂ exchanges between the U.S. and Canada, to CO₂ monitoring and reporting, to CO₂ sensitive investments induced by a new source CO₂ offset requirement.

2.1 General Introduction to Emissions Trading

Emissions trading is actually a generic term for a collection of flexible air pollution policies created to overcome the conflicts produced by the failure to meet air quality goals in urban areas in the late 70's. The EPA's final emissions trading policy includes provisions for bubbling, offsetting, and netting. Tietenberg (1985) provides an excellent overview of the development of these policy reforms for the management of air emissions. Over time, these basic concepts have been applied to a wider number of pollutants and circumstances. Emissions trading is ideally suited for the management of transboundary pollutants such as acid rain.

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The concept of emissions trading is based on the premise that pollution reductions can be accelerated if polluters are allowed to optimize pollution control investments. The evidence from the experience with trading clearly shows significant cost savings for emitters (Dudek and Palmisano, 1988). The environmental account has been more hotly disputed however. Both Hahn and Hester (1986) and Liroff (1986) in their reviews of the performance of netting and bubbling respectively observed no significant deterioration in air quality.

The system operates quite simply. Polluters are assigned a baseline for each emissions source which establishes the initial conditions from which reductions can be assessed. Baselines are established by regulation by the appropriate air quality management authority. The polluter must meet the minimum standards in force for each pollutant at each source. However, these regulatory obligations can be met by overcontrolling at another emissions point and transferring the overcontrol. The flexibility provided by the ability to transfer overcontrol is the heart of emissions trading. It encourages firms to search for cost-effective reductions. When coupled with the prospect of trade outside the firm (for offsets or in the case of the acid rain trading proposal), the incentive of revenues for emissions reductions is added. Institutional innovations such as emission reduction banking and recordation functions reduce the transactions costs of extra-firm transactions.

It is important to point out that a tradeable permit system is a supplement to a regulatory program that establishes overall limits on emissions of CO₂ or, as a surrogate, limits on combustion of fossil fuel or deforestation. The trading system is designed to introduce flexibility in economic decisionmaking by allowing regulated sources to increase emissions above regulatory limits through the purchase of emission credits or to acquire income from the sale of such credits when they emit regulated pollutants below prescribed limits while encouraging investment in pollution reductions beyond minimum requirements. This is the essence of "harnessing the power of the market".

Before describing a trading program at either a national or international level, the regulatory framework must be described. Initially, as a simplifying assumption, consider only one greenhouse gas - carbon dioxide. If, through an international convention or even a series of bilateral conventions, nations want to achieve controls on emissions of CO₂ one approach, based on the Montreal Protocol experience, would be for those countries to establish goals and then allocate the total loadings authorized by the goals among the cooperating nations. These goals and allocation system must take into account environmental objectives, economic efficiency needs and international equity concerns.

For an international agreement to achieve limits on global CO₂ emissions, it must establish overall emission and/or fossil fuel use reduction goals, reduction schedules or formulae, allocation formulae, monitoring, reporting and enforcement provisions and mechanisms for financing and technology transfer. Such an agreement must do all of these things whether or not it provides a mechanism for trading of CO₂ emission or energy efficiency credits among sources in different nation states.

2.2 Alternative Designs

There are a wide variety of alternative greenhouse gas trading program designs. In this section, two polar extremes are discussed. In both cases the limiting, but simplifying assumption of CO₂ trading is introduced.

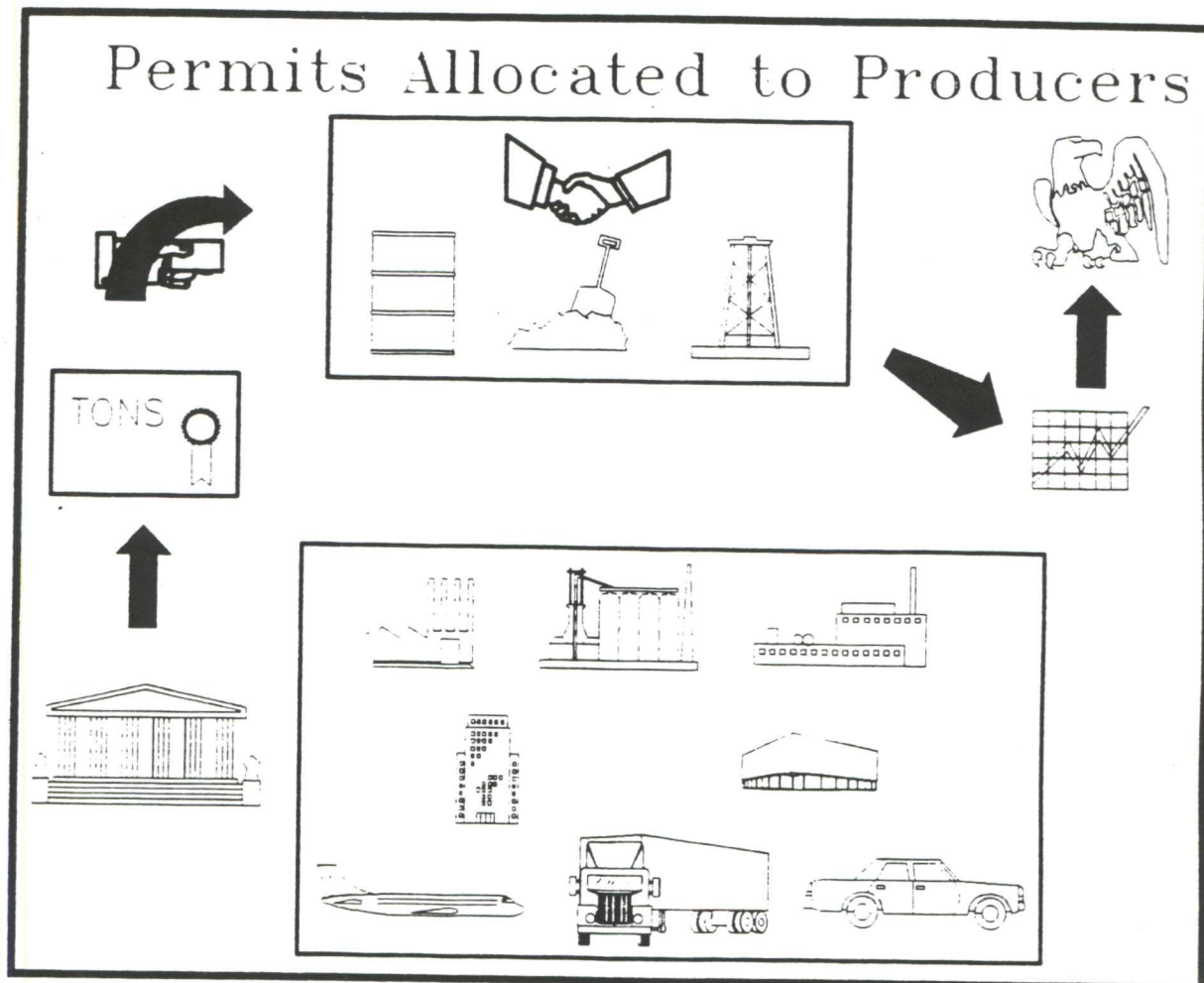
The first case involves allocating permits to fossil fuel producers. The second would assign permits to fossil fuel end users. The designs differ largely in effect, extent of trading, and administrative ease.

2.2.1 Allocation to Fossil Fuel Producers

Allocating permits to fossil fuel producers as indicated in the diagram below, would restrict the bulk of trading activities to energy producers and sink managers. In the case of greenhouse gas trading, the capture and destruction of banked CFCs and halons would also be a valuable source of reductions as would the recovery of coalbed methane. In both designs the control point for compliance is the fossil fuel producer who would be required to turn in a sufficient quantity of permits to cover annual production.

End users would perceive the program in economic terms much as a tax on carbon, i.e. they would face higher energy prices. In fact, users would be offered energy at two prices -- one price with the permit bundled in and another with the permit to be supplied by the fuel purchaser. Buyers would evaluate the costs of generating new permits versus the price differentials charged by the energy producers.

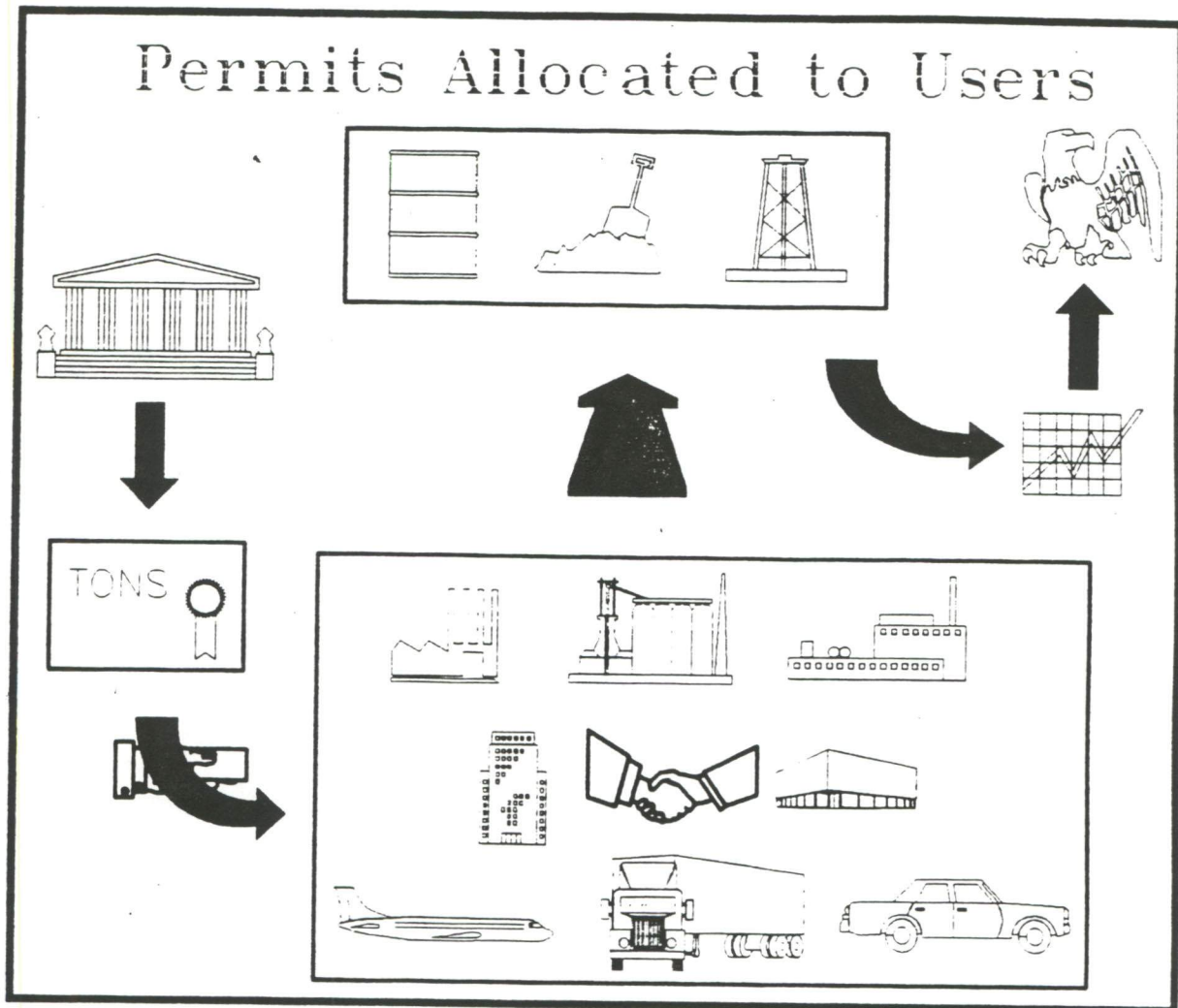
As indicated above, the permit program, although behaving somewhat as a tax policy in effect, would nonetheless differ in at least two critical aspects. First, the "tax" would be determined by the market in permits, i.e. by the decisions of private actors rather than through legislative or bureaucratic means. Second, sinks are encouraged.



2.2.2 Allocation to End Users

An alternative design for a CO₂ trading program would allocate permits to end users of fossil fuels as depicted in the figure below. The big liability of this approach is the creation of baselines for all of the sources involved. Even if a line were drawn at major commercial and industrial consumers, literally thousands of firms' records would have to be evaluated. The big asset is the direct stimulus to energy efficiency. Any energy use reduction below the individual baseline is by definition a credit that can be transferred. This direct revenue mechanism would be a dramatic boost to fossil fuel conservation efforts.

This design would still encourage sinks and reductions in other greenhouse gases for the purposes of trading. Fossil fuel producers could still offer two tiered prices, but the main permit supplies would come from end users who would pass permits covering their purchases to producers. Compliance would still be measured at the point of production of fossil fuels.



2.3 General Policy Balance Sheet

Economic incentive based policies have enjoyed substantial policy interest in the United States particularly during the Bush Administration. A number of environmental initiatives including acid rain and nonattainment contained proposals which featured strongly the general concept of emissions trading. Internationally, there has been greater experience, particularly in Europe, with various tax measures as economic incentives to environmental management. Economists have argued for over 20 years that economic incentives are superior policy tools because they reduce cost. However, actual field experience has been limited. Nonetheless, as pollution problems have more diffuse sources, increasing expense, and compete with other social objectives, economic incentive policies are likely to be adopted. Of the available economic incentives, marketable permits are ideally suited to the greenhouse problem.

2.3.1 Advantages

The primary advantages of using marketable permits were distilled recently in the process of the IPCC discussions concerning response policies. Those identified included:

- flexibility
 - direct control of emission levels
 - efficiency in pollution control
 - mechanism for trading among different greenhouse gases
 - incentives for development of non- or low polluting technologies.
- (Working paper by Bertram et al. For IPCC/WG3-II/Doc 3)

In addition, permits would decentralized pollution control decision-making commensurate with the numbers of sources involved. An international CO₂ (or greenhouse gas) trading program also can accommodate a variety of separate national implementation strategies and policies. No nation would be compelled to achieve its control obligations through trading. Lastly, by linking sources and sinks in one comprehensive strategy, an explicit mechanism of self-interest is established between along the often divisive North and South axis.

2.3.1.1 Sink Stimulus

CO₂ trading is likely to produce the same proliferation in supply options as generated in the deregulation of the financial services industry. The huge variety of precisely tailored investment vehicles available in the current market are likely to be mirrored in the CO₂ (or greenhouse gas) permit markets. After all, a CO₂ trading program would create a new form of environmental currency. One direct effect would be the stimulus to develop sinks as well as source reductions.

Since tropical forests are a major sink for carbon and their burning or destruction at current rates constitutes some 15% of global CO₂ loadings, the question is how an international agreement can promote the retardation of the destruction or the re-establishment of any forests and whether a trading program can facilitate attainment of those goals.

The destruction and burning of tropical forests in countries such as Brazil and Indonesia contribute a significant fraction of their CO₂ budgets. Thus, if such countries allocated their CO₂ emissions targets proportionately to the forest sector and fossil fuel sectors, Indonesia would have to take steps to prevent any increase in the destruction of its forests; Brazil would have to implement a program to decrease the rate of loss of its forests by 2% per year.

If tropical forest acres can be converted into CO₂ and energy efficiency equivalents, countries like Brazil and Indonesia might find it economically attractive, as well as environmentally sound, to retard the destruction of their forests even faster or to implement restoration programs where, in the process, they can earn CO₂ credits which their own industry could use or which they could sell to foreign firms or governments. Those countries in turn could use the revenues from the sale of such credits to finance programs to retard forest loss. A trading program authorized under an international convention/protocol could therefore provide such countries with substantial economic incentives to protect their forests over and above the regulatory mandates of such a convention.

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While a convention should encourage the creation and protection of carbon sinks, such as forests, defining quantitatively the magnitude, size and rates of loss of those sinks is an enormous undertaking. Satellite monitoring is a critical tool. But this effort must be made whether or not international trading of credits involving sinks is authorized so long as CO₂ emissions from destruction or creation of such sinks is incorporated into a convention.

One of the primary advantages of greenhouse gas trading is the fact that it is quantity denominated. Everyone can readily determine what is required and what has been accomplished. The program is denominated in environmental terms. There are no conflicts over revenue and its distribution internationally. It is completely consistent with any underlying national implementation policy. It is voluntary, no one is compelled to trade. Depending upon the initial distribution of CO₂ permits (reduction responsibilities), it also contains an explicit mechanism for North-South flows of funds. Tropical forests in less developed nations would be linked to fossil fuel combustion in developed nations.

2.3.1.2 Technology Transfer²

A major benefit is that such a system provides manufacturers with an economic incentive to develop and use technology that uses fossil fuel energy more efficiently than national regulations (promulgated to be consistent with an international allocation formula) alone would provide or that relies on renewable sources of energy. It could also provide large industrial or commercial users of energy systems with incentives to make efficiency investments. The reason for this is that such a manufacturer may be able to sell (or large users may be able to earn credits) based on this added efficiency. The ability to sell CO₂ emission credits produces economic value for the more efficient technology. Internationally, a potential benefit of a trading program is that, if properly designed, it could promote transfer of energy efficient technologies from highly industrialized to less developed countries.

To simplify this illustration, let us look at how an international agreement could affect the energy efficiency of, initially, one major appliance, namely, refrigerators, and, then, a broader range of fossil fuel energy systems. Furthermore, by way of illustration, let us assume that the industrialized countries of the world are required by such an international agreement to reduce their emissions of CO₂ by prescribed amounts annually or in multi-year phases, that countries with high rates of forest loss would have to reduce their rates of CO₂ growth modestly and that many developing countries, such as India and China, with very low but growing per capita rates of CO₂ emissions would be authorized to increase those rates modestly for some period of time. The CO₂ control/reduction schedule should be pre-announced both in the convention and each national program so that firms and government agencies can plan and make their investments accordingly.

² This section has been liberally abstracted from a set of comments submitted by Tripp and Dudek to the Response Strategies Working Group of the Intergovernmental Panel on Climate Change.

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For the U.S., or any other industrialized country, to meet internationally prescribed CO₂ reduction goals, it would have to consider a range of strategies, including adoption of progressively more stringent energy efficiency standards for vehicles, building heating, ventilation and air conditioning (HVAC) and lighting systems and major appliances (CHVAC), such as refrigerators. Under the National Appliance Energy Conservation Amendments of 1988, the U.S. Department of Energy (DOE) has the authority to promulgate energy efficiency standards for many household appliances, including refrigerators. DOE has in fact recently promulgated new energy efficiency standards for refrigerators and freezers to take effect January 1, 1993, 54 Fed. Reg. 47916 (Friday, Nov. 17, 1989). In announcing these new rules, DOE has claimed that they will improve overall refrigerator/freezer energy efficiencies by 25% compared to products on the market today. Each nation could translate CO₂ emission controls into percentage improvements in energy efficiency for all industrial sectors.

To take advantage of a trading program, the DOE standard-setting program for appliances such as refrigerators could be revised along the lines of the Department of Transportation's Corporate Average Fuel Efficiency (CAFE) standard-setting program for automobiles. A car manufacturer complies with the applicable CAFE standard if the average fuel economy of its entire fleet sold in a given year meets the mandated fuel efficiency level. Energy efficiency standards for refrigerators could be similarly set so that the average refrigerator made and sold by a manufacturer complied with the standard in effect in a given year.

Under a trading program, a manufacturer (or importer of a foreign-made refrigerator) that produced and sold in the U.S. refrigerators the average energy efficiency of which was better than the applicable product standard could obtain energy efficiency (surrogates for CO₂ emission) credits. These can be statistically translated into CO₂ equivalents using average lifetimes of appliances, etc. DOE or some other agency would have to certify the issuance of these credits based on reliable information supplied by the manufacturer. Similarly, a manufacturer whose average refrigerator did not meet the prescribed energy efficiency standard for the applicable year would have to purchase credits. Manufacturers of refrigerators and freezers could therefore buy and sell credits amongst themselves. The end result would be that the average refrigerator/freezer manufactured and/or sold in the U.S. would meet the efficiency standard although the average appliance of any single manufacturer need not.

If well-designed, administered and enforced, this arrangement would give all manufacturers of refrigerators/freezers added flexibility in planning and timing the making of investments to increase the energy efficiency of these appliances. This added flexibility would provide cost savings and therefore afford economic efficiencies to the overall program. In addition, one or more manufacturers might find the economic incentive provided by the potential to earn and sell efficiency credits great enough to invest larger sums in conducting research on and developing even more efficient technologies than the applicable standards prescribe. So long as at least one manufacturer takes advantage of these incentives, the introduction of improved technologies would occur at a faster pace than otherwise.

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Domestically, in the framework of a U.S. program designed to meet CO₂ emission goals, this kind of approach could be expanded so that efficiency standards applied to all products that utilize energy. The manufacturers/importers of those products - be they cars, lighting systems or industrial boilers - could then obtain credits if their average products were more efficient (or emitted no CO₂ because they used solar energy) than a prescribed baseline and could purchase credits if the contrary were the case. Such credits could be fungible and tradeable among manufacturers of all products subject to the overall program. Further, energy suppliers could directly bundle CO₂ credits along with their fuel. In effect, the use of that part of the sector's fuel would be CO₂ neutral. Permits could be generated or held by anyone. Third parties could also participate in this program. For example, a supplier of energy efficient systems for commercial buildings or industrial plants would have an incentive to retrofit such buildings or plants for a share of the CO₂ credits.

For this program to function effectively, manufacturers would have to furnish reliable information about the energy efficiency of their products to the responsible agency that in turn would certify the issuance of credits and report any trades. However, most of this information would have to be gathered and reliably reported, stored and analyzed for a national program designed to meet CO₂ emission goals even in the absence of a trading feature.

Other industrialized countries might adopt similar kinds of regulatory and economic incentive programs to comply with their allocated energy efficiency/CO₂ emission targets. If such programs included, among other things, a procedure for generating and certifying efficiency credits for refrigerators and freezers, the U.S. and such other industrialized countries could enter into bilateral agreements whereby manufacturers of those appliances could buy and sell credits internationally on the same basis as described above.

To give a more concrete example, let us assume that western European countries or the European Community (EC) as a whole would have to reduce CO₂ emissions annually by rates or amounts prescribed in an international convention. Those rates may be different from those applicable to the U.S. The EC could establish efficiency standards for refrigerators and freezers. The efficiency standards in force in those countries or throughout the EC in any particular year might be different from those in the U.S., in part reflecting differences in applicable national goals or, within those countries or groupings, differences in allocating responsibilities for meeting national goals among different sectors of their economies.

With a bilateral agreement in place, a manufacturer of refrigerators/freezers selling in both the North American and western European markets might produce and sell appliances which on average were not as efficient as required in one market but more efficient than required in another market. That manufacturer would be eligible for credits in the latter market (i.e., the market where the appliances were sold). It could then use those credits to compensate for its failure to meet the applicable standard in the former market. Or, pursuant to contract, a more energy efficient manufacturer in the latter market could sell or transfer credits to a manufacturer in the former market.

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This discussion has been limited to manufacturers of refrigerators and freezers to present a concrete example of how a bilateral credit transfer system could operate. As with any national program, such a bilateral arrangement could be designed to cover other appliances or all energy-consuming systems. Under such an arrangement, energy efficiency baselines for such systems would be set by the participating countries. Those baselines could be modified in accordance with a prescribed schedule. Energy efficiency or equivalent CO₂ emission credits could be traded, bought or sold amongst all manufacturers/importers of such systems. The arrangement would set forth the procedures for monitoring, certification of credits, reporting of transfers and enforcement. It could also authorize participation in the market for credits by third parties. If planting of trees as a sink of CO₂ were included in the national program, the energy efficiency credits would have to be denominated in CO₂ equivalents as well.

Such bilateral agreements expand the universe of manufacturers who could benefit from the investment and flexibility provided by such trading arrangements. CO₂ concentrations in the atmosphere are a function of global loadings and are not affected by the geographic distribution of individual sources. The fact, therefore, that one industrial country emits a smaller total load in a given year than an international convention/protocol prescribes while another country emits a concomitantly larger total load as a result of trading among those countries is irrelevant in terms of environmental protection.

Bi-lateral or international agreements that authorize trading of energy efficiency/CO₂ emission credits between an industrialized country, and a developing country, are also possible. A major objective here would be to design the international allocation system so that firms that decided to take advantage of the trading program would indirectly be contributing to the kinds of technology transfer and financing goals described in the Report of the Second Session of IPCC Working Group III/Response Strategies Working Group, Geneva, 2-6 October 1989, in particular, "Implementation Measures on Technology Development and Transfer Measures" and "Implementation Measures on Financial Measures."

To illustrate how this transfer mechanism might work, consider the example of a highly industrialized country that is a large emitter of CO₂ today (HIC) and a less developed country (LDC) that is a low emitter of CO₂. Let us assume that the LDC intends to increase its coal-fired electrical generating capacity substantially over the next 10 years. Some part of this capacity is to be used to generate electrical power for a rapidly increasing number of refrigerators and freezers in that country. Under an international convention/protocol, the LDC might be allowed to increase its total CO₂ emissions at a fixed rate of growth, but lower than otherwise projected.

One way for the LDC to decrease its projected CO₂ emissions growth rate as mandated by an international agreement would be to set efficiency standards for refrigerators and freezers. While those standards may require production and use of more efficient refrigerators and freezers than might be the case absent an international agreement, those standards might not be as stringent as those that the HIC (any hypothetical highly industrialized country) would have to adopt to meet its CO₂ reduction obligations.

Under this example, a firm located in the HIC might find it economically attractive to enter into a joint venture with a firm manufacturing refrigerators/freezers in the LDC. Pursuant to such a joint venture, the HIC firm could provide the know-how and right to use the more energy efficiency technology to the LDC firm. That firm would then be able to manufacture more efficient refrigerators/freezers than the LDC regulations required. In turn, taking advantage of that advanced technology, the LDC firm would obtain credits that it would then transfer to the HIC firm pursuant to the terms of the joint venture. The HIC firm could then use those credits to permit it to manufacture and/or sell in the HIC's market refrigerators/freezers that were less efficient than the HIC's standards otherwise prescribed. Alternatively, depending on the law of the host country, the HIC firm might simply invest in new plant capacity in the LDC to manufacture more efficient refrigerators/freezers than LDC regulations mandate and obtain credits accordingly for its use in the HIC.

The HIC firm (any firm in any industrialized country) might find this arrangement to be economically attractive if it could save significant funds by postponing investments necessary to meet the domestic standards. Because the firm would be obtaining credits under this scheme from a firm in a less developed country, it would be willing to lease or transfer the refrigeration technology at lower cost than it would otherwise. In turn, the LDC firm could make and sell the more efficient refrigerators at less cost than it would otherwise.

Under this example, the potential to obtain credits in a developing country from investments that increased the energy efficiency of appliances made there would create an economic incentive on the part of a firm in an industrialized country to transfer technology and, in effect, to finance the transfer of that technology beyond what otherwise would be the case. The point is that a well-designed protocol that encourages such international trading of energy credits could promote least cost energy efficiency investments (as well as renewable energy investments) on an international basis that would accomplish international equity and technology transfer objectives as well.

As a general proposition, the tougher the CO₂ reduction goals that industrialized countries must meet, the more their manufacturing firms should be inclined to look for such joint venture opportunities in less developed countries as a source of credits. In addition, so long as developing countries face constraints on the rate of growth of their CO₂ emissions, firms there have an incentive to enter into such joint or contractual arrangements as well.

2.3.2 Disadvantages

At least one of the advantages is also a potential disadvantage. Since a trading program establishes clear responsibilities for reductions, would nations be able to agree upon an allocation formula? LDCs will

desire formulas which weight population for example more heavily.³ Given the announced involvement of the General Assembly of the UN in some aspects of the development of any convention, this problem seems inescapable.

Another advantage that poses practical problems and potential disadvantages is the need to establish baselines for all sources such as deforestation. Monitoring of compliance for non-forest biomass resources may also be very challenging. Even large tract forest resources will have to be monitored by satellite imagery. While not an intractable problem, agreement on frequency and the interpretation of imagery would be critical. One only need take note of the widely differing estimates of Brazil's rate of deforestation to appreciate the problem (Goldemberg, 1990). Will the baseline issue overshadow the flexibility and potential gains from trade offered by permit trading? Undoubtedly that will depend upon the skill of the advocates negotiating the international framework agreements. It is not clear whether LDCs would prefer trading or a system of payments from CO₂ derived tax revenues.

3 Design and Implementation Issues

3.1 Detailed Policy Proposal

International trading in greenhouse gas permits can be established in a limited number of coordinated phases. The first phase would build the infrastructure necessary to facilitate such a global market. This phase would be devoted to the creation of international monitoring systems, tracking and recording systems, and market clearinghouse. The second phase could be a limited permit system more narrowly focused as an offset program targeting new sources. The final phase would be the development of full scale trading perhaps only for CO₂ initially with other gases included as the capacity of the trading system is expanded.

One question that has occupied analysts, as it did in the acid rain debates in the U.S. is the question of emission reduction leasing versus sale. In fact, this is a non-issue. Transferable permits allow individual entities to engage in any transactions that they find mutually advantageous. In the mechanics of trading, a ton is a ton, i.e. either the emitter or the producer (in the case of fossil energy firms) must hold a compensating permit for every unit discharged or pay the penalty. A lease in this context is nothing more than a contractual agreement to supply or purchase a time stream of permits. Individual permit holders can produce the same advantage for themselves by simply banking reductions or extra allowances and using them as needed over time.

3 During the UNEP technical workshops that preceded development of the Montreal Protocol, the Canadian delegation floated a proposal which would have allocated CFC entitlements to nations on the basis of GNP and population. The Canadian formula was based upon regression coefficients but could be arbitrarily selected.

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For an international convention that imposes limits on emissions of CO₂ from burning of fossil fuels and destruction of forests to function effectively, the participating nation states must be willing to and be able to obtain and report reliable information about fuel use and forest loss. The convention must also provide for a credible enforcement mechanism and the establishment or strengthening of an international agency to receive and assimilate data and to assure compliance.

If the convention authorizes bilateral or multinational trading of CO₂ emission credits, that international agency or some international body would have an additional role to play. More specifically, at the national level, any country with a domestic trading program would have to have in place an administrative mechanism for certifying that individual firms were entitled to credits or had to acquire credits to comply with standards. If those credits were to be tradeable to a source in another country, some international agency should have the authority to record those credits and to assure that the national credit certification program was viable and accurate. Since a country might have an incentive to inflate its eligibility for credits, this international agency would need additional resources to assure reliable national reporting of information and valid credit issuance programs.

A trading system can also help to assure the integrity of any system of emissions limits. As industrial enterprises -- or even governments -- attempt to comply with CO₂ limits, technical or economic factors will inevitably prevent some from complying at some times. Without a trading system, a variance system (formal or simply by non-enforcement) will inevitably develop. A formal system will in turn require technical or economic criteria for evaluating variance requests and bureaucracies to apply those criteria. In a comprehensive, worldwide system for regulating CO₂ emissions, the variance bureaucracy may become comparably massive. Inevitably also, those bureaucracies will not close needed economic enterprises for the sake of what may appear "temporary" violations of CO₂ limits. The problem could lead to distrust between nations and diminishing willingness to make needed sacrifices.

A trading system should eliminate the need for variances by allowing industries and nations that cannot comply with limits to purchase credits. No criteria would be necessary to evaluate variance requests, and the sole task for bureaucracies would be the registration and verification of the transfer. Enforcement officials would not need to negotiate complex compliance orders, but simply to order the purchase of credits. Enforcement could also be more credible because the purchase of credits should often be less draconian than shutdown of enterprises. In addition, the failure of some enterprises to comply with initially set limits should always be matched by compensating reductions. And because a market mechanism will replace bureaucratic judgment, those enterprises that do not comply with initial limits should do so because of real economic needs not political influence.

3.1.1 The Offset Program

One of the first direct implementation steps for CO₂ trading is an offset requirement for new CO₂ sources. Major new sources would include new fossil fueled electric generating stations, new industrial boilers, and cogeneration facilities selling power into the grid. Such a program would:

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- * begin reduction of accumulation of greenhouse gases in the atmosphere
- * establish administrative mechanisms to facilitate trading (create infrastructure consistent with the current U.S. response policy position)
- * allow utilities to obtain regulatory credit for CO₂ reductions produced as a by-product of the acid rain control program
- * stimulate private market development of CO₂ reducing technologies.

The heart of the program is the ability to create and transfer CO₂ credits. Any CO₂ reduction meeting the certification requirement would constitute a legitimate CO₂ credit available for offset. The program would create explicit procedures for the certification of several identified offset credit sources. In addition, these procedures would allow any source to receive credit for CO₂ reductions for any such reductions that can be demonstrated to have been explicitly created for this program and which constitute CO₂ reductions that would have normally been emissions.

Examples of sources of CO₂ offsets include energy efficiency investments, vehicle fuel efficiency improvements beyond the CAFE baseline, appliance efficiency improvements beyond the mandated standards, fuel switching to less CO₂ intensive fuels, and the planting of trees. Putting the burden of proof of new reductions upon the potential offset supplier allows the program to be open-ended and to encourage the widest diversity of offset sources to be developed, demonstrated, and engaged. These sources should include other greenhouse gases, e.g. methane, and N₂O. The greenhouse trading ratios to represent radiative differences between gases could be established by EPA by regulation in consultation with NOAA.

Certification for some sources will require the development of specialized rules and methods. For example, in the case of automobiles, reductions beyond the CAFE standard would be translated into a quantity of CO₂ through a statutory assumption concerning the actuarial life of a vehicle. In the case of trees, the uptake rates of individual species by location and soil type would be specified by the EPA in consultation with the U.S. Forest Service. Improved uptake rates could be prospectively established through demonstration projects. For example, new more intensive management procedures could improve uptake rates and should not be precluded from being developed.

In order to insure that a sufficient supply of offset credits is available, an offset bank could be created at the Environmental Protection Agency. Sources generating reductions can be certified for credit as soon as the reductions are produced. These reductions can then be maintained as an available supply by EPA. This bank can function like an information exchange identifying the owners of certified reductions. Information maintained would be contact, quantity and minimum bid price.

For some offset supplies such as trees, it will be critical to assure that the CO₂ sequestering value of the offset is maintained. For example, for trees, it is critical that the stored carbon credited as an offset is maintained as stored carbon. For example, if a forest used for an offset is subsequently harvested, only those amounts of wood transferred into a relatively permanent use like housing stock should be credited with maintaining the stored carbon.

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Each year, each source subject to the offset provisions would be required to deposit with the Administrator sufficient CO₂ offsets to fully compensate for its CO₂ emissions in that year. Each year all sources regulated by the program would submit to the EPA a report of CO₂ emissions. Each source would be required to adopt CO₂ emissions monitoring or a monitoring method of equivalent accuracy. Each year, the Administrator would publish a report of such emissions.

Sources failing to comply would be subject to a penalty per ton of CO₂ not covered by an offset. The penalty should be adjusted by the producer price index in order to assure its continued economic force over time. In addition, the emitter would be required to submit a plan to the EPA Administrator to be approved by the Administrator for the production of offsets to compensate for the uncompensated emissions.

3.1.2 CO₂ Trading

CO₂ trading is likely to be the easiest to implement. We have reasonably good data on CO₂ emissions and fossil fuel production. Beginning with a single gas and building the infrastructure to manage trades in that gas initially makes good sense. Limiting the ultimate system to CO₂ only does not solve the greenhouse problem as the estimates of contributions from other trace gases indicate. For example, despite the fact that the renewed Montreal Protocol will require the elimination of the most damaging CFCs by 2000, there are significant banked emissions of CFCs. Depending upon the speed that manufacturers convert to less damaging formulations, these banked emissions may be vented to the atmosphere in the absence of an economic incentive for their recovery. If, on the other hand, trading in all greenhouse gases were allowed there would be an economic incentive to recover and destroy banked CFCs.⁴

3.1.3 Greenhouse Gas Trading

In U.S. policy circles debate has swirled over whether to focus on CO₂ alone for a trading program or whether a comprehensive trading system covering all greenhouse gases should be developed. Victor (1990) argues for trading limited to CO₂. He supports this position by stating that the pace of introduction of other gases into the trading framework may be slow and limited by the pace of scientific knowledge about these gases and the capacity to reduce administrative costs. While these are important factors, the incentive to introduce other gases is most critical. If there is significant profit potential, then firms or nations will cooperate in the development of baselines, budgets, and appropriate certification methods. A recent example of such cooperation is the toxicological testing of alternatives to CFCs funded by several major multinational chemical firms. The expansion of supplies for trading in general and the comprehensive inclusion of all relevant gases are critical if greenhouse gas permit trading is to produce both economic and environmental benefits. Increasing potential supply sources will reduce costs and limit the economic power of any one actor within the system. By

⁴ Effective destruction technology for CFCs exists. It is not the intent of this paper to claim that this technology is cost-effective in exchange for CO₂ allowances, but rather to indicate that in the absence of incentives to recover or to develop and deploy destruction technology, it is not likely to happen.

including all greenhouse gases as soon as practicable, we eliminate the uncertainties associated with the need to revise the basic regulatory structure because only CO₂ is managed.

3.2 Implementation

The greatest challenge facing proponents of market based policies in the climate change debate will be to educate decision makers of the importance of dynamic efficiency. Because the political litmus test for action on the greenhouse problem will likely devolve to a simple comparison of the stringency of reductions, the effectiveness over time of a policy strategy is likely to be ignored.

Beyond selling market mechanisms, the primary implementation issues are:

- allocation of national responsibilities (permits)
- certification of reductions (credits)
- international buffer fund or reserve
- creation of a bank or international clearinghouse
- use of separate country denominations to indicate origin of credits
- and to allow for appropriate discounting for country risk
- and design of any futures market.

3.2.1 Potential Implementation Problems

The most serious implementation problem with any market-based environmental policy is convincing decision makers and the public that such policy tools will perform environmentally. Hahn and Stavins (p. 29, 1990) identified 7 factors that would tend to increase the adoption of incentive-based policies. Of these, public confidence, the last on their list, is critical if marketable permits are to be adopted internationally. Mobilizing a sufficient number of interested parties to support such an approach will be critical. Only the actual U.S. experience with acid rain emissions trading will have a greater impact upon the form taken by international negotiations to control greenhouse gases.

Beyond gaining public acceptance, the regulatory agencies charged with implementation must be committed to producing a successful market. For example in the case of CFCs, Shapiro and Warhit (1983) noted the unanticipated "difficulty of introducing and explaining the marketable permit concept to potentially affected parties" (p. 591). This difficulty and the failure to proselytize interested parties contributed to a regulatory backlash which doomed the first attempt to introduce the program. No doubt this problem will be compounded in the international context. Will effective and credible champions for trading appear in the international arena? It was extremely difficult to find support within EPA for EDF's acid rain emissions trading program during the recent Clean Air Act reauthorization debates.

A corollary to the acceptability and commitment issues are restrictions to trading. As Hahn and Hester (1989) have noted, the major lessons learned from the existing marketable permit programs are that trading restrictions can be subtle or overt, that transactions costs are independent of the level of government, and that some technology can facilitate trading.

A critical issue which emerged in the context of the acid rain emissions trading debate is the certainty of targets and control levels. How frequently would any framework agreement be revised? Would control schedules be consistent with investment lags and payback periods? Would a firm have enough assurance that investments to produce credits would not be expropriated by bureaucratic fiat? Would schedules be published sufficiently far in advance to allow rational firm planning?

3.2.1.1 Unilateral versus Multilateral Programs

The theoretical case for global action on greenhouse gases stems from the common property nature of atmospheric resources. Frequently, this argument is taken to imply that unilateral national actions to control greenhouse gas emissions are neither efficient nor effective. Each of these points is valid when viewed from the standpoint of solving the global problem. However, this paper focuses on implementation issues and of necessity on the path to that global solution. Taken in this light, unilateral actions can be critical determinants of the ultimate control path selected either nationally or internationally.

For example, the acid rain emissions trading program in the U.S. is an important demonstration of the feasibility and effectiveness of marketable permits. Without this program, there would be no significant example of trading on a scale that would permit extrapolation to the global level. This policy precedent will be critical both for domestic as well as international policy decisions.

Other examples of unilateral actions that would help to determine the control path include CFC policy and an offset program. In CFC policy, the U.S. is in the midst of creating regulations for the recycling of CFCs controlled by the Montreal Protocol. While many uses will be amenable to capture and reuse, the speed of introduction of alternative chemicals and the cost of recovery will determine the incentive to recover regulated chemicals. The potential exists for banked CFCs to be rendered valueless through substitution. An incentive to recover could be created by establishing a bank for recovered and destroyed CFCs. The regulatory credit established in the bank could be sold to sources required to produce offsets or could be saved for later use if a full fledged marketable permit program emerged. In either case, the depositor would receive a number of CO₂ credits which reflect the greater greenhouse gas potential of CFCs. Since CFCs are thousands of times more effective infrared absorbers than CO₂, there should be a huge incentive to recover and destroy. In order to guarantee a greenhouse benefit, something less than the estimated 10,000:1 trade-off ratio could be offered and still create a substantial incentive.

An offset program is another unilateral policy that could usefully condition the choice of control path. Establishing an offset requirement would build experience with the infrastructure required to successfully manage and implement a global CO₂ trading program. Its operation would generate useful data about the cost and effectiveness of control options. Depending upon firm response, the offset policy could also help to provide data on the stimulation to innovation claimed for marketable permits.

3.2.1.2 Control Levels

Any greenhouse gas policy, whether national or international presumes some agreed upon goal for management of the atmosphere translated into an allowable level of emissions over time. The goal can be variously stated as limiting the rate of change of average global temperature change or achieving a fixed level of ambient greenhouse gas concentrations.⁵ This level can be established as a reduction from a baseline either historic or projected. Once established globally, however, these allowable emissions must then be distributed to individual nations.

3.2.1.3 Allocation of Responsibilities

The thorniest problem associated with any international greenhouse gas control program is achieving agreement on both the global emissions cap and individual national control obligations. The trading program highlights this problem. Since the program would create a new environmental currency denominated in tons of CO₂ (as the numeraire gas for example), every nation will know immediately its reduction responsibilities.

A variety of alternative allocation mechanisms have been suggested. For example, Grubb (1989) lists allocations based upon GNP, real GNP, total population, adult population, land area, and emissions. There are an infinite number of possibilities. Each of the singular criteria listed above will have adherents, largely those with larger allocations under that criterion. However, the politically feasible criteria set will likely contain more than a single criterion. For example, the Canadians proposed using population and GNP as allocation criteria when CFC reduction obligations were being considered in the development of the Montreal Protocol. It seems more likely that several criteria could be effectively blended to create international consensus on emission allocations.

A number of proposals have been made for allocating CO₂ loadings among the industrialized and developing countries of the world to meet global CO₂ emission goals. These include proposals by a) Florentin Krause, Energy Policy in the Greenhouse, Vol. One, >From Warming Fate to Warming Limit: Benchmarks for a Global Climate Convention, IPSEP (September 1989) (funded by the Dutch Ministry of Housing, Physical Planning and Environment and published in conjunction with the European Environmental Bureau); b) Christopher Flavin, Worldwatch Paper 91; and c) David Wirth and Daniel Lashof, A Global Greenhouse Gas Convention: Recommendations on Structure and Substance, NRDC (October 2, 1989). These three proposals all call for proportionately higher rates of reduction in CO₂ emissions by the industrialized countries and, among the industrialized countries, by the United States, and substantial reductions in the predicted rates of increase in CO₂ emissions by most developing countries. Any convention

5 While the goal can be stated in many forms, it is critical that it be sufficiently flexible to accommodate trading. For example, restricting the ambient concentrations of each greenhouse gas to a fixed level would place ultimate limits on trading among gases. On the other hand, a goal stated in terms of maximum allowable temperature change could be translated into a CO₂ equivalent if CO₂ is the numeraire gas.

will have to deal with the issue of establishing global and national baselines, i.e., overall levels of global emissions and separate national allocations.

Beyond the control levels, a critical issue is responsibility for reductions. Who will be issued permits? Who would be required to hold permits as a condition of engaging in some economic activity? This problem is illustrated nicely by the CFC trading program established in the U.S. The EPA opted for ease in administration when it chose to issue permits to a handful of producers and require permits as a condition of production. Alternative designs included auctioning permits at large or issuing permits to CFC users who would transfer them to producers who would still have the obligation of producing a permit for every unit of CFC weighted output.

This latter example is probably the best design for a national trading program. For example, fossil fuel producers could be required to submit CO₂ permits equivalent to their annual production. By focusing on producers the administrative burden of tracking compliance is minimized. The initial distribution of the permits becomes the major program design issue. For example, permits could be initially allocated to fuel distributors or direct purchasers from fossil fuel producers if an auction was not politically feasible. Anyone would be allowed to generate CO₂ credits for sale in the general market provided that the credits met the minimum test of certifiability and enforceability. Fuel prices would be quoted with and without permits bundled in. Purchasers could opt for the lower price from the fuel producer and agree to supply corresponding permits to cover the resulting CO₂. Alternatively, the fuel producer could acquire CO₂ permits (or greenhouse gas permits more generally) from the market or from permit producing investments whose costs would then be included in the fuel price. In this latter case, the fuel purchaser never need deal with permits at all.

Of course, the program should be broadened to include all major primary producers of CO₂ such as timber companies. Vertically integrated forest product firms would have very direct, business related opportunities for generating additional CO₂ credits. For example, improvements in the productivity of existing forest assets would increase CO₂ sequestration thereby increasing the ultimate forest yield and generate CO₂ credits in the process which could be sold or used to cover the CO₂ generated by harvesting elsewhere. As with fossil fuel producers the most difficult issues are the creation of baselines and the initial distribution of permits. Baselines could be developed on the basis of historic firm activities backed by federal tax records and then geared to any internationally negotiated reduction schedule. Natural sources (or sinks) like forests face additional problems such as wildfires and the liability for inadvertent combustion of forests. Presumably these latter issues could be accommodated within the definition of the baselines. Conceivably, an insurance program could be developed.

3.2.2 Solutions to Problems

The major implementation problems identified for trading in greenhouse gas permits are associated with acceptability rather than any inherent technical hurdle. These problems can be tackled head-on by the development of credible international champions, the education of affected

parties, and the creation of effective coalitions. Non-governmental organizations such as the Environmental Defense Fund, public policy efforts such as Project 88, governmental organizations such as the OECD, and individual decision makers in the private and public sectors all can play a role. Unfortunately, no concerted effort is in evidence as yet and international negotiations for a greenhouse convention will begin in November of 1990.

3.2.3 Unresolved Implementation Problems

A number of technical issues associated with trading have been defined. None are insurmountable obstacles. In fact, none need impede the introduction of a national, bi-lateral, or global trading program. Rather, the trading program contains inherent incentives for sources and sinks to be brought into the program in a reliable and enforceable manner. Developing credible and effective advocates particularly in the environmental bureaucracies will be a more formidable task. For example, in the CFC case, the EPA was not particularly interested in creating a market, although a few trades have occurred, since the agency's long run preferred policy objective was the elimination of the most damaging formulations.

4 Conclusions

In the debate about greenhouse gas policy much energy has been expended in the prices versus quantities issue. In this sense advocates of economic incentives have been arguing over rearranging the deckchairs on the Titanic. In actual implementation, the distinction is likely to blur. For example, if the penalty for failing to hold sufficient CO₂ permits is a fine levied per unit of excess CO₂ discharged as in the acid rain case, then that fine becomes the upper limit of the price for CO₂ permits. On the other hand, if not only a fine is levied but a requirement to produce a compensating CO₂ reduction, then there is no price ceiling and the systems do not necessarily diverge.

In any event, the fines, if collected internationally, could provide a source of technical assistance financing for less developed nations, an issue which bedeviled the Montreal Protocol and is likely to plague greenhouse gas negotiations. As previously noted, however, the trading mechanism provides an explicit incentive for investment in LDCs to generate extra reductions.

International greenhouse gas permit trading has several critical advantages unmatched by alternative policy options. First, marketable permits would provide the greatest spur to innovation in both low polluting technologies, emission control options, and pollutant sinks. This latter aspect is an important and often overlooked feature of any greenhouse policy. Providing the option of producing additional permits over time lessens the impact of greenhouse gas control on economic performance. Permits also provide an explicit mechanism for reallocating scarce resources, namely CO₂ permits, over time and space. Certainly fixed international obligations could be periodically renegotiated, but it difficult to imagine that such a process could even begin to approach the efficiency of a genuine global market. Lastly, a system of marketable

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permits provides all parties with a relatively simple means of determining performance. The sum of permits transferred to control authorities at any one point in time measures total emissions.

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**GREENHOUSE GAS TRADING:
REDUCING THE COST OF ACTION**

Daniel J. Dudek

**Environmental Defense Fund
New York, New York**

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1 Introduction¹

Economists have long believed that the internalization of environmental externalities is a positive and effective policy prescription for managing these problems. Although internalization can be accomplished through a wide array of policy instruments,² economists have preferred the use of economic incentives. Most frequently these prescriptions have taken the form of charges or fees for emissions, in essence a special form of corrective tax.

While convenient in theory, effluent fees have not met with success in the U.S. The fee concept has not been able to overcome the daunting practical problems of political acceptability and implementation. In many cases the problem is typified by the ethical concern that the effluent fee policy would allow companies to "pay to pollute". In addition, the fee imposes an information burden upon regulatory agencies similar to the requirements of the traditional command approach. The fee setting authority must know the shape and location of the aggregate marginal treatment cost curve and either the marginal benefit function or a socially accepted emissions reduction target. Alternatively, it must be able to experiment with different fee levels to trace out polluters' responses. For industries, like electric power, characterized by high fixed costs of pollution control, uncertainty in the fee level compounds the difficulty of the investment problem.

An alternative, based upon transferable permits denominated in physical quantities of pollutants has flourished in the U.S. however. Transferable permits have been applied to everything from land development rights to atmospheric discharges (Tripp and Dudek, 1989). Marketable permit programs require the regulatory authority or the political process to explicitly define the goals of the pollution control policy in terms of allowable emissions. Once total levels are defined, emissions are parcelled out to individual emitters. In contrast to fee or charge systems, the market in these transferable permits performs the valuation function, not the regulator. The regulatory authority records transfers of title and monitors compliance.

The tremendous political appeal of these systems is based upon the policy's focus on environmental objectives. At their root is a solid regulatory program which prescribes emissions reductions to each source. Sources are free to determine their individual control strategy, including purchasing extra reductions from more distant sources, but they are not free to avoid their control obligations.

1 The author gratefully acknowledges the support of the Joyce Foundation.

2 In fact, any policy which requires the emitter to take account of emissions would produce internalization. Command-and-control regulations requiring the use of specific control technologies is one extreme form of internalization.

reductions. When coupled with the prospect of trade outside the firm the incentive of revenues for emissions reductions is added. Institutional innovations such as emission reduction banking and recordation functions reduce the transactions costs of extra-firm transactions.

It is important to point out that a tradeable permit system is a particular policy tool built upon a regulatory program that establishes overall limits on emissions of CO₂ or, as a surrogate, limits on combustion of fossil fuel or deforestation. The trading system is designed to introduce flexibility in economic decisionmaking by allowing regulated sources to increase emissions above regulatory limits through the purchase of emission credits or to acquire income from the sale of such credits when they emit regulated pollutants below prescribed limits while encouraging investment in pollution reductions beyond minimum requirements. This is the essence of "harnessing the power of the market".

3 Acid Rain Emissions Trading

The U.S. Congress stands on the verge of enacting a sweeping reauthorization of the Clean Air Act. The most innovative aspect of this new legislation is the acid rain provisions. These provisions would require a 10 million ton reduction in SO₂ emissions from 1980 levels (see Figure 1.), 8.9 million of which would be required from electric utilities. The reductions would be accomplished in 2 roughly equal 5 year steps.³

While there are differences between the House and Senate versions, both would use emissions trading as the main policy vehicle. Each would create virtually a national market for SO₂ emission allowances. The essential ingredients of the policy are represented in the schematic in Figure 2. The first step is to determine a baseline for each source. In this case, historic fuel use in btu's was used. The baseline is multiplied by an allowable emissions rate per Btu to yield an annual SO₂ tonnage allowance which is assigned to each utility plant by permit. In effect, this can be thought of as the initial deposit into a checking account which the plant draws upon as it discharges pollutants. Discharges are monitored in real time through continuous emissions monitoring systems (CEMS) which are required for all sources within the system.

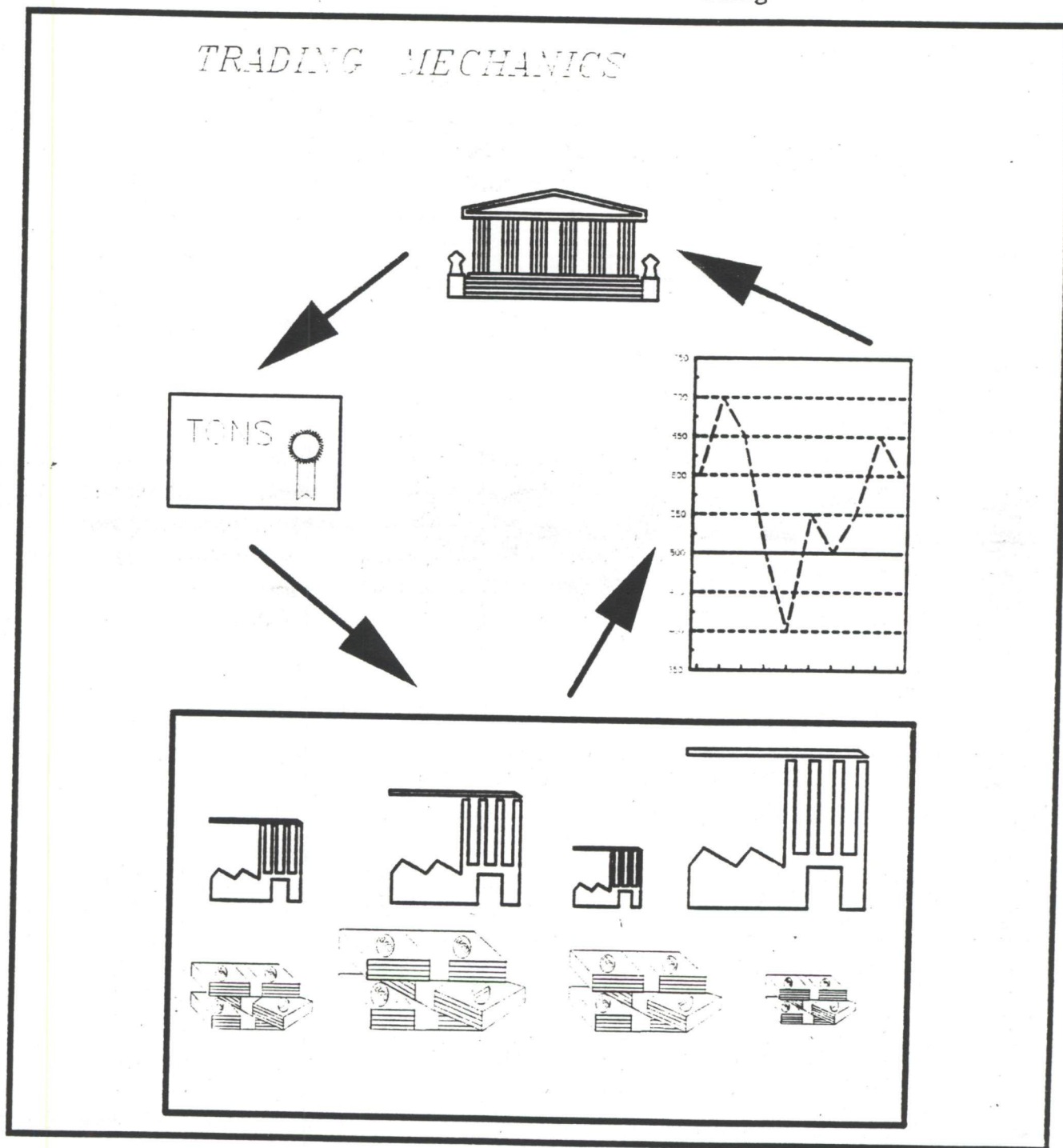
The regulatory agency, in this case the Environmental Protection Agency, assures compliance by comparing each plant's actual emissions as tracked by CEMS with the annually permitted emissions. Plant emissions beyond annual allowances that are not compensated by reductions at other plants are subject to a \$2000/ton fine⁴. In addition, the offending source must produce additional reductions in order to compensate the environmental account. The combined financial implication of these penalties is 2-3 times the highest marginal cost of control. These penalties also depart from previous practice in that they are designed like income

3 Since the precise form of the legislation is not known currently, the reduction paths shown in Figure 1 are only approximate.

4 The level of the fine is automatically adjusted over time according to changes in the consumers' price index in order to maintain its economic force.

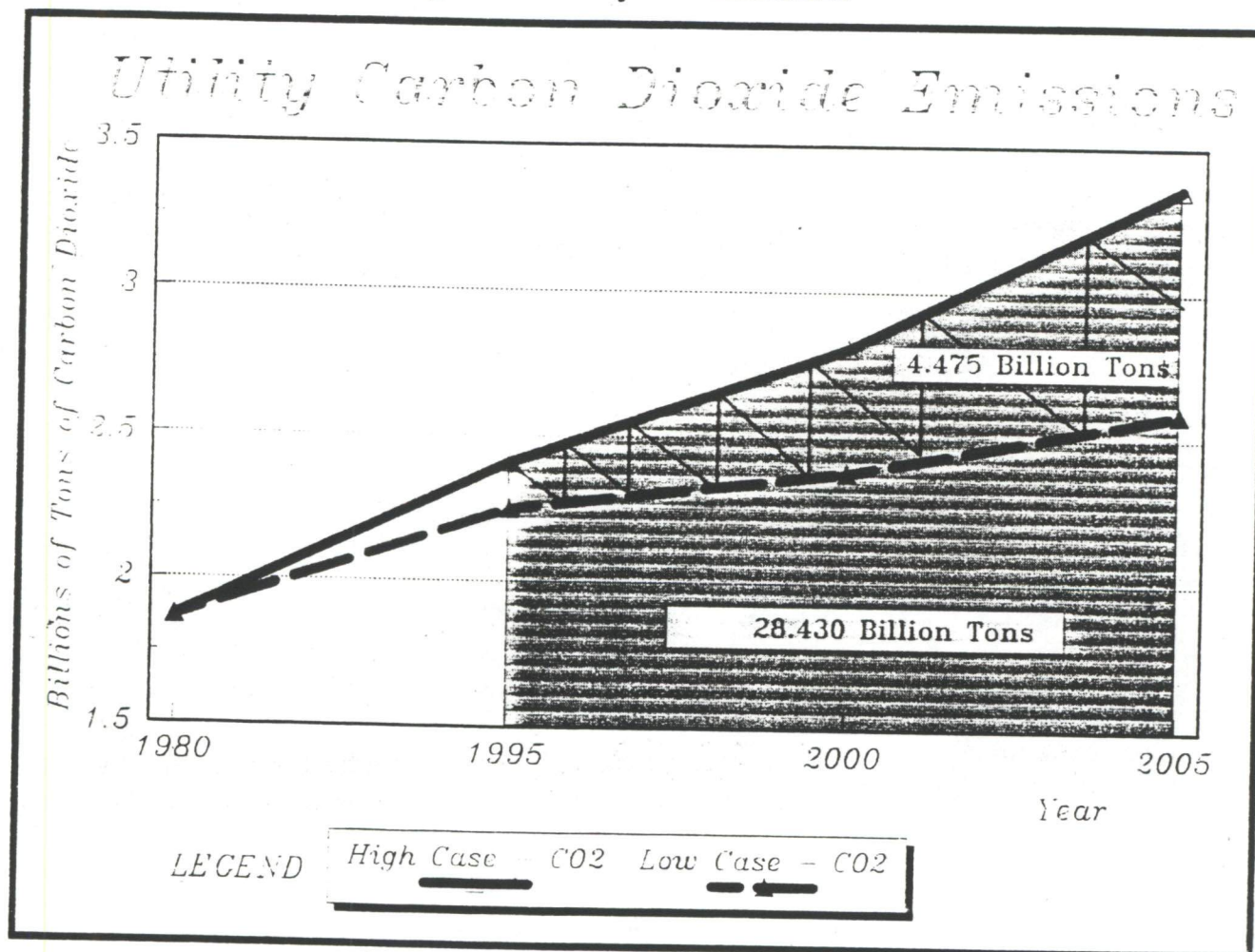
tax bills which are due and payable upon receipt. In the past, polluters were able to defer fines pending adjudication before an administrative law judge. Frequently this was a protracted process with time and inflation eroding the economic force of any penalty. In addition, penalties were based upon a judicial interpretation of any profits made as a result of the violation.

Figure 2. Elements of Emissions Trading



damentals such as the relative price of oil and natural gas and the rate of energy demand growth. In addition, energy efficient technologies such as cogeneration are much more aggressively exploited in the low base case.

Figure 3. Utility CO₂ Emissions



Since the CO₂ profiles of these two scenarios are so radically different, the question naturally arises as to what policies can help society achieve the low base case? One way would be for emitters to be required to take account of all of their emissions and optimize their operations over all costs. Unfortunately, no policy is so systematically rational. Pollution control policies tend to be focused on a pollutant-by-pollutant basis without concern for any synergy or antagonism. Nonetheless, policies do differ in their effects on several pollutants despite the ostensible focus on a single pollutant. For example, in the case of acid rain controls, requiring the use of flue gas desulphurization devices will likely add to CO₂ emissions. However, if utilities were left to determine their own control strategy, cost-effective SO₂ controls that also reduced CO₂ could be undertaken. Table 1 summarizes the expected results for CO₂ if utilities are free to choose control strategies as under emissions trading (Dudek, *et al.*, 1990).

For an international agreement to achieve limits on global CO₂ emissions, it must establish overall emission and/or fossil fuel use reduction goals, reduction schedules or formulae, allocation formulae, monitoring, reporting and enforcement provisions and mechanisms for financing and technology transfer. Such an agreement must do all of these things whether or not it provides a mechanism for trading of CO₂ emission credits among sources in different nation states. Of course, CO₂ trading could be implemented on a separate national basis irrespective of whether any international convention/protocol authorized international trading. One of the most likely and useful examples for allocating national environmental performance responsibilities is given by the Montreal Protocol. By stating national requirements in terms of consumption requirements, all nations would have a role within the framework of the agreement irrespective of whether they produced significant fossil fuels or not. In addition, the market power that the main fossil fuel producers might otherwise wield would be diluted.

There are a large number of alternative designs for a greenhouse gas trading program. Only two specific alternatives are described in this short discussion paper. Two polar extremes are discussed. One option would allocate permits to fossil fuel producers while the other would distribute permits to end users. In both cases the limiting, but simplifying assumption of CO₂ trading is introduced. This discussion pertains both to national as well as international trading systems.

The first case involves allocating permits to fossil fuel producers. The second would assign permits to fossil fuel end users. The designs differ largely in effect, extent of trading, and administrative ease.

4.1 Allocation to Fossil Fuel Producers

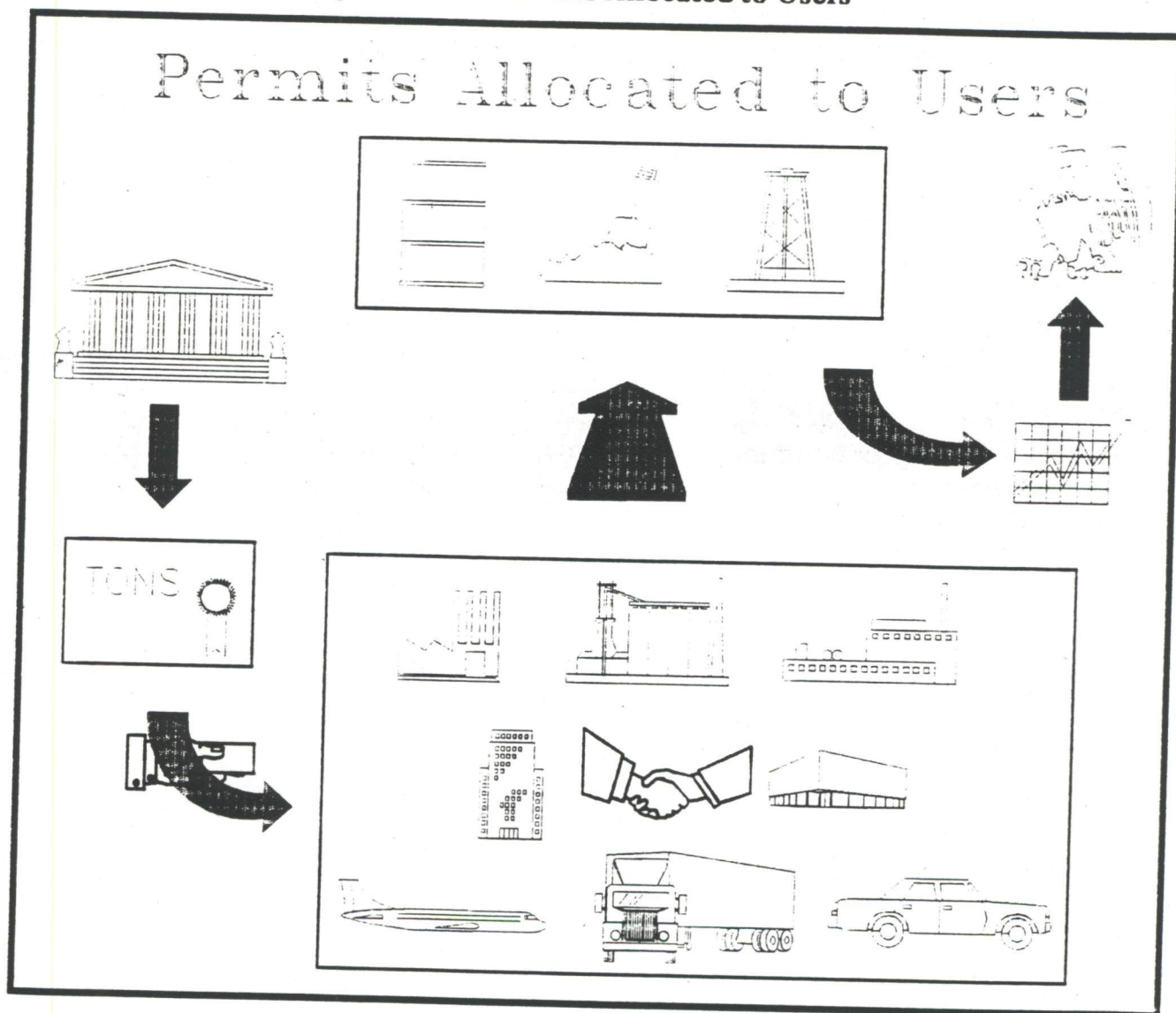
Allocating permits to fossil fuel producers as indicated in the diagram below, would restrict the bulk of trading activities to energy producers and sink managers. In the case of greenhouse gas trading, the capture and destruction of banked CFCs and halons would also be a valuable source of reductions as would the recovery of coal-bed methane. In both designs the control point for compliance is the fossil fuel producer who would be required to turn in a sufficient quantity of permits to cover annual production.

End users would perceive the program in economic terms much as a tax on carbon, i.e. they would face higher energy prices. In fact, users would be offered energy at two prices -- one price with the permit bundled in and another with the permit to be supplied by the fuel purchaser. Buyers would evaluate the costs of generating new permits versus the price differentials charged by the energy producers.

big asset to this approach is the direct stimulus to energy efficiency. Any energy use reduction below the individual baseline is by definition a credit that can be transferred. This direct revenue mechanism would be a dramatic boost to fossil fuel conservation efforts.

This design would still encourage sinks and reductions in other greenhouse gases for the purposes of trading. Fossil fuel producers could still offer two tiered prices, but the main permit supplies would come from end users who would pass permits covering their purchases to producers. Compliance would still be measured at the point of production of fossil fuels.

Figure 5. CO₂ Permits Allocated to Users



If tropical forest acres can be converted into CO₂ and energy efficiency equivalents, countries like Brazil and Indonesia might find it economically attractive, as well as environmentally sound, to retard the destruction of their forests even faster or to implement restoration programs where, in the process, they can earn CO₂ credits which their own industry could use or which they could sell to foreign firms or governments. Those countries in turn could use the revenues from the sale of such credits to finance programs to retard forest loss. A trading program authorized under an international convention/protocol could therefore provide such countries with substantial economic incentives to protect their forests over and above the regulatory mandates of such a convention/protocol.

While a convention/protocol should encourage the creation and protection of carbon sinks, such as forests, defining quantitatively the magnitude, size and rates of loss of those sinks is an enormous undertaking. Satellite monitoring is a critical tool. But this effort must be made whether or not international trading of credits involving sinks is authorized so long as CO₂ emissions from destruction or creation of such sinks is incorporated into a convention/protocol.

One of the primary advantages of greenhouse gas trading is the fact that it is quantity denominated. Everyone can readily determine what is required and what has been accomplished. The program is denominated in environmental terms. There are no conflicts over revenue and its distribution internationally. It is completely consistent with any underlying national implementation policy. It is voluntary, no one is compelled to trade. Depending upon the initial distribution of CO₂ permits (reduction responsibilities), it also contains an explicit mechanism for North-South flows of funds. Tropical forests in less developed nations would be linked to fossil fuel combustion in developed nations through the opportunities provided by greenhouse gas trading.

6 Implementation Issues

International trading in greenhouse gas permits can be established in a limited number of coordinated phases. The first phase would build the infrastructure necessary to facilitate such a global market. This phase would be devoted to the creation of international monitoring systems, tracking and recording systems, and market clearinghouse. The second phase could be a limited permit system more narrowly focused as an offset program targeting new sources. The final phase would be the development of full scale trading perhaps only for CO₂ initially with other gases included as the capacity of the trading system is expanded. The phased sequence above could be easily pursued by individual nations irrespective of any international greenhouse gas control agreement. In the event of an agreement with significant reduction schedules, the second and third phases would be collapsed into one. In any event, the administrative

with initially set limits should always be matched by compensating reductions. And because a market mechanism will replace bureaucratic judgment, those enterprises that do not comply with initial limits should do so because of real economic needs not political influence.

6.1 The Offset Program

One of the first direct implementation steps for CO₂ trading is an offset requirement for new CO₂ sources. This is a program which the major industrialized nations should undertake unilaterally as a first rational step toward the significant reductions required. It is a minimalist step which can be established now without any regulatory lag or lead-in. Major new sources would include new fossil fueled electric generating stations, new industrial boilers, and cogeneration facilities selling power into regional electricity grids. Such a program would:

- * begin reduction of accumulation of greenhouse gases in the atmosphere
- * establish administrative mechanisms to facilitate trading
- * stimulate private market development of CO₂ reducing technologies.

The heart of the program is the ability to create and transfer CO₂ credits. Any CO₂ reduction meeting the certification requirement would constitute a legitimate CO₂ credit available for offset. The program would create explicit procedures for the certification of several identified offset credit sources. In addition, these procedures would allow any source to receive credit for CO₂ reductions for any such reductions that can be demonstrated to have been explicitly created for this program and which constitute CO₂ reductions that would have normally been emissions.

Examples of sources of CO₂ offsets include energy efficiency investments, vehicle fuel efficiency improvements beyond the Corporate Average Fuel Economy (CAFE) baseline, appliance efficiency improvements beyond the mandated standards, fuel switching to less CO₂ intensive fuels, and the planting of trees (see Dudek and LeBlanc (1990) for offset costs). Putting the burden of proof of new reductions upon the potential offset supplier allows the program to be open-ended and to encourage the widest diversity of offset sources to be developed, demonstrated, and engaged. These sources should include other greenhouse gases, e.g. methane, and N₂O. The greenhouse trading ratios to represent radiative differences between gases could be established in consultation with WMO or any other internationally recognized atmospheric scientific authority.

Certification for some sources will require the development of specialized rules and methods. For example, in the case of automobiles, reductions beyond the CAFE standard would be translated into a quantity of CO₂ through a statutory assumption concerning the actuarial life of a vehicle. In the case of trees, the uptake rates of individual species by location and soil type would need to be specified. Improved uptake rates could be prospectively established through demonstration projects. For example, new more intensive management procedures could improve uptake rates and should not be precluded from being developed.

feature of any greenhouse policy. Providing the option of producing additional permits over time through forest management changes lessens the impact of greenhouse gas control on economic performance. Permits also provide an explicit mechanism for reallocating scarce resources, namely CO₂ permits, over time and space. Certainly fixed international obligations could be periodically renegotiated, but it difficult to imagine that such a process could even begin to approach the efficiency of a genuine global market. Lastly, a system of marketable permits provides all parties with a relatively simple means of determining performance. The sum of permits transferred to control authorities at any one point in time measures total emissions.

In the international context, the primary gains from trading include:

- 1) powerful incentives for extra reductions
- 2) stimulus to technical change and innovation
- 3) creation of a mechanism for international transfer of reductions reducing the burden of any individual emissions limit
- 4) consistency with any national control program

International trading in greenhouse gases would build directly upon the successful model of the Montreal Protocol. The administrative apparatus required to implement trading is no different than that required to track CFC production for example. The administrative requirements to track and monitor any greenhouse gas protocol will be very similar. The definition of control obligations within the Montreal Protocol include the tracking of exports and imports as well as conversion factors between different CFCs to account for differences in ozone depletion potential. The Montreal Protocol allows has provisions which allow for the economic rationalization of production which by any other name is trading. International greenhouse gas trading would function in a like manner.

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Emissions Trading: Why is this Thoroughbred Hobbled?

Daniel J. Dudek*
John Palmisano**

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* Senior Economist, Environmental Defense Fund, 257 Park Avenue South, New York, New York 10010.

** President AER*X, 1625 I Street N.W., Suite 719, Washington, D.C. 20006.

I. INTRODUCTION

Since 1976, politicians, economists, attorneys and policy analysts have written at least 100 articles endorsing market-based approaches to achieving regulatory goals. Since then, the U.S. Environmental Protection Agency (EPA) has developed a series of reforms which attempt to reduce the cost, inconvenience and time it takes to meet air quality goals. These administrative means to meet air pollution control ends have been generically called emissions trading.¹ By providing the private sector with flexible approaches to meeting the public sector goals enunciated in the Clean Air Act, air emissions credit trading has become an example of a successful regulatory reform. Our experience with this collection of policy tools demonstrates that market-based incentives which enlist the expertise of on-site managers can achieve more pollution control results for less money, now instead of later.

However, widespread adoption of emissions trading has been handicapped by bureaucratic inertia and infighting, dogmatic opposition by environmentalists, hostility in Congress, as well as indifference by polluters. Yet emissions trading is sufficiently well-developed to justify an endorsement of its performance and its continued role in solving air quality problems. A new administration and a reauthorized Clean Air Act will provide opportunities to break new productive ground in the application of market-based incentives for air pollution control.

This paper presents the conceptual underpinnings of emissions trading, reviews the experience of a market-based approach to pollution control within EPA's air program and presents new opportunities for application of these policies.

The authors conclude that despite differences with some environmental advocates on the magnitude of cost-savings and environmental benefits derived from emissions trading, there is overwhelming evidence that this approach to achieving air quality objectives:

1. reduces the tension between economic growth and air quality goals;

1. Emissions Trading — Regulatory compliance alternatives involving the creation of surplus emission reductions at certain emission sources and use of these reductions to meet requirements applicable to other emission sources. Emissions trading alternatives include netting, offsetting, bubbling, and banking of emission reduction credits. See also *infra* section IV.A. of this paper.

2. produces equivalent (or better) emissions reductions for less money;
3. establishes private sector pollution control expertise as a complement to command-and-control;
4. creates the systems, knowledge, and materials needed to take more effective steps toward reaching regulatory goals, but by means which build on, not thwart, private sector energies;
5. produces essential experience with market-based policies critical for extending these methods to politically more complex transboundary air pollution problems; and
6. demonstrates that market-based systems can be grafted onto command-and-control based regulatory programs.

The bottom line is that the successes of emissions trading cannot be denied.

The shortcomings of command-and-control must finally be recognized. Successful resolution of increasingly complex local and global air quality problems requires greater emphasis on decentralized trading programs and less on omniscient bureaucracy.

Market-based approaches for meeting environmental goals should, therefore, be expanded in EPA's air program and extended into new regulatory settings. The transboundary problems of acid rain, stratospheric ozone depletion and climate change are major contemporary environmental problems to which emissions trading could be effectively extended. Emissions trading, whether in emission reduction credits or marketable permits, should be supported as the reasonable middle-ground between re-regulation and de-regulation.

II. EMISSIONS TRADING: THE CONCEPT

The Clean Air Act requires each state to develop a plan which describes how National Ambient Air Quality Standards (NAAQS)² for so-called criteria pollutants will be attained. These

2. National Ambient Air Quality Standards (NAAQS) — Maximum allowable concentrations in ambient (outside) air for each pollutant for which air quality criteria have been issued. EPA has determined that attainment and maintenance of such standards is required to protect public health and welfare from any known or anticipated adverse effects that may be associated with the presence of such pollutant in ambient air. EPA requires states to develop plans which demonstrate how ambient air quality standards will be attained or maintained. The NAAQS are periodically revised as more health data are reviewed. The standards can increase or decrease over time.

State Implementation Plans³ (SIPs) describe the emission control requirements which individual sources and categories of sources must meet.

By and large SIP control strategies reflect design standards, i.e., specific emissions control technologies for specific production processes. For existing sources in areas that do not attain NAAQS, EPA requires that, at a minimum, Reasonably Available Control Technologies (RACT) be installed. For new sources or major modifications in nonattainment areas, EPA requires a class of technologies that produce the Lowest Achievable Emission Rate (LAER). For new facilities in clean air areas, EPA requires Best Available Control Technology (BACT).⁴ In practice, LAER and BACT are usually the same technology.

At first glance, this technology forcing approach to cleaning-up the nation's air seems to make sense. In practice, command-and-control has taken regulators only part of the way toward their objectives. The failure of command-and-control results from incomplete knowledge about what each firm can best achieve (in terms of emission reductions) and because command-and-control relies on a few big decisions made by omniscient regulators.

While it may be appropriate for a national regulator to establish air quality standards or goals, it does not follow that the regulator should determine how these goals are met. For example, the best way for facility X in Chicago to meet its pollution control obligation may not be the best way for facility Y in Akron. This is true because: (1) each facility's pollution control obligation will be different; (2) local air quality conditions vary; (3) each company, even in the same industry, will have different control options determined by unique plant attributes; and, (4) technical change

3. State Implementation Plan (SIP) — The state's air quality management plan which is reviewed and approved by U.S. EPA before a state receives primacy in managing regulatory programs. Either U.S. EPA or the states have primacy in the management of environmental programs. Changes to the SIP are "SIP revisions." The SIP contains rules, enforcement conditions, and permit requirements. Some SIPs directly define emission control requirements.

4. Best Available Control Technology (BACT) — In attainment areas, an emission limitation based on the maximum degree of emission reduction achievable for a source or modification through application of available methods, systems, and techniques for control. BACT is determined on a case-by-case basis, taking into account the energy, environmental and economic impacts of the limitation. EPA supports a clearinghouse to assist regulators to determine what technologies are BACT or LAER. BACT usually equals LAER requirements.

and competitive pressures guarantee different plant sizes, production techniques, and management options.

National programs based on design standards respond well to the regulator's need for simplicity, but invite litigation and are blatantly inefficient and inequitable. Most importantly, national programs tend to undermine the legitimacy of the air pollution control effort because they cannot and do not take into account individual variations in the regulated entities. What is a plant manager to think when expensive controls are mandated, yet no incentives exist for investing in new pollution control techniques and cost-effective alternatives to mandated controls are either rejected or used against his company's interests?

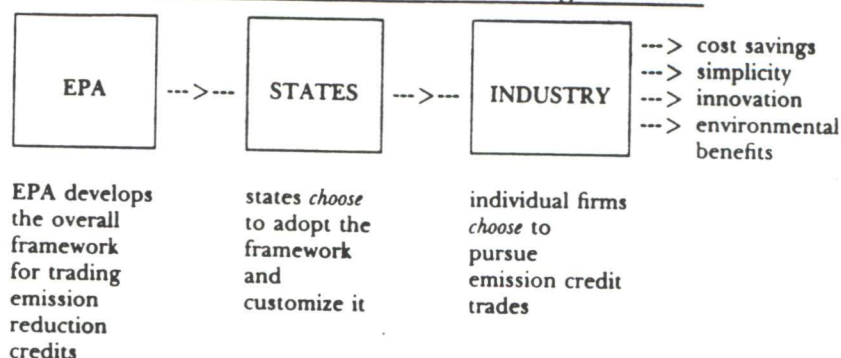
The underlying concept behind emissions trading, therefore, is to provide regulated entities with maximum flexibility to meet their emissions control obligations. The success of particular emissions trading tools requires the definition of facilities' emission control obligations, creating a system of granting "credits" for doing better than the control obligation, establishing administrative means for certifying these credits, and establishing uses for these credits. New and existing sources of emissions can then use these so-called Emission Reduction Credits⁵ (ERCs) to meet current and future pollution control obligations.

The model for evaluating the adoption of emission trading is characterized in Figure 1. Under the Clean Air Act, EPA establishes the broad outlines for most regulatory programs and states subsequently adopt or customize particular programs which incorporate national programs into their state implementation plans. Emissions trading is a voluntary program for states; firms, therefore, can only use trading tools if a state has rules which make these tools available.

In evaluating emissions trading, outcomes must be compared to what really happens under the Clean Air Act as it is implemented and not with some theoretical construct. We must keep the model described in Figure 1 in mind and recognize that it takes years for EPA to act, years for states to act, and then some time for industry to act. We should remember that the results we see today are fruit from seeds planted years ago.

5. Emission Reduction Credit (ERC) — ERCs are the currency of emission trades. Emission reductions determined to be surplus, enforceable, permanent, quantifiable and available for banking use or use in emissions trading.

Figure 1
The Flow of Emissions Trading Activities



III. WHY WE SHOULD USE MARKET MECHANISMS

Traditional regulatory approaches are often characterized as "command-and-control." Market mechanisms become part of regulatory programs either by initial design or because the original program is at the limits of its inherent ability to deal with the current regulatory problems. As the easy targets for regulation become regulated, as inefficiencies and inequities become more glaring, as the aggravation for all participants in the regulatory process begins to choke environmental progress, and as faith in the regulatory system is undermined by stretching the limits of the existing regulatory regime, many people begin looking for meaningful regulatory complements.

Market-based policies overcome these defects and have additional virtues. Chief among these is decentralized mediation between the willingness of suppliers to produce and the financial abilities of demanders to consume. This balancing is accomplished through price signals which reflect the relative scarcity of resources, goods and services. Scarce commodities tend to have higher prices, all else being equal, and the last one of anything is almost infinitely valuable. As a result of this fact, industry responds to such situations by developing better technologies that minimize scarce resources, relocating, or by making other adjustments. Inevitably, therefore, prices act as a rationing device.

As applied to air quality, the resource in question is the limited ability of an airshed to accept pollution discharges; i.e., the disposal services of the atmosphere. If local air quality is poor due to

unique local atmospheric conditions or to excessive discharges, then additional air pollution burdens should be very expensive to reflect the low capacity of the airshed to absorb increased emissions. Those wishing to increase discharges should face high prices to do so. These high prices encourage the search for alternatives—other plant locations, a different production process, a more effective control technology.

This pricing approach forces air polluters to learn that disposal of waste by-products requires financial outlays and the commitment of resources, a lesson that hazardous waste generators have come to appreciate. At the same time, it creates opportunities for firms to evaluate their production processes, reduce emissions at the source, save money, and, if facilitated by markets, earn income through the sale of the "saved" discharges. This is precisely the point to emissions trading.

The result of a market-based approach to meeting regulatory responsibilities is that industry comes to view air pollution control cost as a variable, not, as has been the case, as a fixed cost of doing business. Employees responsible for pollution control activities within a firm have gained more respect and authority, and scarce public sector resources are magnified by the thousands of self-interested micro-decisions which result in better air quality outcomes.

By reducing the cost of improving and maintaining air quality, everyone is better off. The natural resistance of polluters to pay for a previously "free" resource is lessened with concomitant savings in unproductive political and legal outlays. The profitability of firms is enhanced and fewer resources are devoted to waste management. The dreaded trade-off between economic well-being and environmental quality is improved and environmental quality objectives cease to act as competitive barriers to entry. Further, by explicitly valuing pollution control outputs, the substantial creative ingenuity of entrepreneurial talents is harnessed in pursuit of environmental quality improvement.

IV. EMISSIONS TRADING: THE PRACTICE

A. *Background*

The use of market-based approaches to remedy the dual problems of the SIP process and inefficient design standards has been the history of emissions trading. This approach was origi-

nally called "Controlled Trading" and is now called "Emissions Trading." It began in 1976 and has evolved into a comprehensive voluntary supplement for the existing command-and-control based program. Emissions trading has been touted as the most significant environmental reform by both the Carter and Reagan Administrations.

1. Offsets

Initially, the Clean Air Act did not contemplate failure to attain the national air quality standards. In 1975, it became obvious that the deadline for attaining air quality standards would not be met. One concern was how new sources of air pollutants could be permitted in areas which have failed to either attain air quality standards or demonstrate attainment at some future date.⁶ The remedy to this problem came in 1976 and was called the Offset Policy.⁷

The Offset Policy allowed new sources or major source modification to be sited in nonattainment areas so long as overall emission reductions were achieved within the airshed leaving the area better off than before. These new emissions would need to be more than "offset" by emissions reductions. For example, a new source generating 100 tons per year of hydrocarbon emissions would be obliged to obtain more than 100 tons of emission reductions in order to obtain a permit to construct. The emissions reductions would have to come from the relevant airshed and must be of the same pollutant type. This administrative process of review and approval of permit conditions is called new source review. It is through this review process that state and federal regulators impose the offset requirement.

The word "offsets" has become part of the lexicon of air pollution engineers and plant managers. Today, we refer to an offset as an emission reduction credit (ERC) and the transaction as an offset trade, whether or not the trade is an option, lease or sale.

6. These are the so-called nonattainment areas.

7. While nationwide there was little growth in major facilities during the late 1970s, some areas were experiencing rapid growth. In California, for example, most communities failed to meet the ozone standard. Yet, there was considerable pressure to site new industrial facilities. This conflict was resolved by EPA's interpretative ruling of December, 1976. These actions created what was called the Offset Policy which is now the offset requirement.

Firms have usually obtained ERCs for use in trades from reductions at their own plants or other company-owned plants in the same airshed. Increasingly, firms are turning to other companies to buy or lease offsets. Several active markets are developing in California and elsewhere, with ERCs becoming a commodity of sorts. Since 1976, there have been thousands of applications of the offsets approach; well over 100 offset transactions have been arms-length transactions between firms.

Offsetting was incorporated into the Clean Air Act in 1977 and most communities have included an offset requirement in their SIP. By all accounts, offsetting⁸ new source growth is a policy that works. Industry may claim that offsets are unavailable, regulators may dislike the system because it appears to them that some companies "make money from selling pollution," and some environmentalists may be concerned about abuses to the system; but the *vast majority* of offset trades meet the letter *and* the spirit of the law.⁹

There has been no extraordinary enforcement problems encountered by regulators; and the system has been "debugged" to the point that manuals, procedures and human capital pertaining to offset trading exist in virtually all regulatory agencies. The offset system is up and running, and running well.

2. Netting

Netting is the use of ERCs from within a facility to avoid New Source Review (NSR) when an expansion or other modification occurs.¹⁰

8. Offsetting — Emissions trading method allowing industrial growth in nonattainment areas by requiring that proposed emission increases be offset by adequate emission reductions to result in a net air quality benefit.

9. Except in very rare circumstances offsets are available in virtually every community which has offset requirements. Firms that use offsets must be going through an LAER or BACT determination; this determination results in the application of very advanced technological requirements. These requirements translate into costs of control which range from \$500 to \$10,000 a ton of pollution control *per year*. With the exception of two offset trades out of thousands, no trade has ever been for more than \$10,000 in *one time costs*. Offsets, therefore, are less expensive than most of the control technologies being imposed on industry and are certainly cheaper than those being developed today.

10. New source review requirements apply if a modification is major. But what do we mean by major? If emissions will be more than, for example, 100 tons per year after pollution controls are installed, then the modification is major. The particular "cut-off" point is determined by EPA.

At the core of the "netting"¹¹ concept is the question of how to count emissions—should counting be based on a gross or net emission basis? If emissions are measured among *all* emitting points in a plant instead of only at the modified emitting point, emissions reductions from other emitting points can turn what would otherwise be a significant increase into a plant-wide reduction. The result, therefore, is no "net" increase (hence, "netting") and no need for new source review.

The key to netting is the definition of source. Today, the single, plant-wide definition of source (allowing netting) applies to sources in attainment areas¹² and nonattainment areas.¹³ Netting is the most controversial of the emissions trading concepts. Most observers believe that market mechanisms are entirely appropriate for *meeting* emission control obligations. Netting, on the other hand, is perceived to allow *avoidance* of pollution control responsibilities.¹⁴

11. Netting — Emissions trading method involving the use of credits from surplus emission reductions at an existing facility to compensate for the emission increases associated with a proposed modification at the same facility.

12. States, of course, have the option of setting stricter limits than EPA does. Many states have followed this route.

13. For nonattainment areas, a number of states retain a "dual definition" under which new source review applies whenever a modification produces a significant emissions increase at either a single emitting point or plant-wide. In 1981, EPA promulgated regulations which would allow a state to define the term "stationary source" as a plant. After protracted litigation, the U.S. Supreme Court upheld EPA's discretion to allow states to use the single, plant-wide definition in nonattainment areas, and a number of states have adopted this netting approach. *See Chevron, U.S.A. v. Natural Resources Defense Council*, 104 S.Ct. 2778 (1984).

14. Because netting was billed as an extension of the Bubble Policy, the hostility toward netting "spilled-over" to the Bubble Policy. As EPA's press release from June 26, 1984 read:

The Supreme Court today affirmed the authority of EPA and state air pollution control agencies to let facilities use a 'bubble concept' to meet Clean Air Act requirements more quickly and inexpensively when they add industrial processes or modify existing ones. . . . Capping developments that began in 1979, the court went on to note that EPA and the 32 states that had adopted this 'bubble approach' properly balanced the Act's twin goals of economic growth and environmental progress in ways which serve . . . environmental objectives as well.

The press release goes on for two more pages describing the Bubble Policy and hardly mentions netting.

This was a pyrrhic victory for industry and EPA. Since this victory, environmental wrath toward the Bubble Policy and emissions trading increased from slight to, on occasion, bitter and intense. Emissions trading, which was originally billed as the middle ground, was now perceived by some environmental interests, rightly or wrongly, as a sell-out to industrial interests.

3. Bubbles

Offsets and netting provided benefits to new sources. Bubbles provide similar benefits to existing sources. The Bubble Policy was to be the second major market-based approach supported by EPA.¹⁵

The term "bubble" implies an imaginary dome over several emitting points from which pollution reductions can then be treated in the aggregate, rather than point-by-point. This aggregate treatment offers the flexibility to make alternative, less costly reductions and forgo the more expensive ones. Bubbles give plant managers the opportunity to rearrange facility emission controls for a specific pollutant in virtually any configuration so long as the resulting aggregate emissions are equivalent to the plant's aggregate SIP emission control obligation for a specific pollutant.¹⁶

The Bubble Policy went final in December of 1979. The 1986 final emissions trading policy now governs the processing of individual bubble trades.

4. Banking and ERCs

Emissions credit banking encompasses the processes of creating, certifying, and storing Emission Reduction Credits (ERCs).

15. While offsets were required in order to avoid a politically charged conflict between economic growth and environmental constituencies, there was no similar political forcing which propelled the Bubble Policy. Rather, it was the initiative of individual regulators, industrial advocates for increased efficiency in regulation, and progressive environmentalists, which produced the "critical mass" necessary to translate this concept into reality.

16. Bubbles use ERCs to comply with emission limitations set for existing sources in state implementation plans. EPA issued the first bubble policy in 1979 (44 Fed. Reg. 71779 (1979)), and generally expanded bubble opportunities in its 1982 proposed emissions trading policy (47 Fed. Reg. 15076, (1982)). EPA and several states (under "generic" emissions trading rules) have approved about 75 bubbles, with several hundred million dollars of savings to applicants. Bubbles are also allowed between plants as well as within plants, although only two firms have thus far taken advantage of this added flexibility (See 47 Fed. Reg. 1291 (Jan. 12, 1982) and 47 Fed. Reg. 2012 (May 11, 1982) for these two cases).

As noted, the bubble relies on the basic currency of emissions trading—the emission reduction credit. ERCs used in bubbles are required to be surplus, enforceable, and quantifiable, and to endure at least as long as their proposed use. Among these four bubble requirements, the "surplus" requirement has been the most controversial. Because of the way most SIPs were developed and because of continued nonattainment problems for many areas, it is often unclear what is "surplus." Many regulators are concerned, therefore, that granting credits today for needed additional control requirements tomorrow would undercut their ability to meet statutory requirements. Other than netting, the Bubble Policy is the most controversial aspect of emissions trading.

An ERC must meet certain criteria such as being: (1) real, (2) certifiable, and (3) enforceable emission reductions beyond that which is required by the SIP. Banking allows sources to use ERCs in a manner that protects the public and firms' interests; it provides some measure of certainty.¹⁷

ERCs can be used in a bubble, offset, or netting transaction to meet a regulatory requirement.

5. Generic Rules

Generic rules refer to a class of state regulations which describe the circumstances under which states can review and approve individual bubbles without EPA review of each transaction. A generic rule is essentially a state delegated program. The use of generic rules allows trades which fit generic criteria to occur without a SIP revision, thereby avoiding one to two years of regulatory delay in obtaining approval for specific bubbles.

Generic rules also promote greater predictability and signal industry regulators' commitment and support for trading programs.¹⁸

6. Emissions Trading Policy Statement

The Final Emissions Trading Policy Statement describes how to create, certify, store, and use emission reduction credits for use in bubbles, offsets, netting, and banking procedures. It is the umbrella concept for EPA's current market-based approach to air pollution control. The final policy was published December 4, 1986 (51 Fed. Reg. 43814). It codifies how the various emissions trading tools are integrated into a coherent whole.¹⁹

17. Because it takes many months to create ERCs when needed for a bubble or offset, emissions banking was developed so companies could better plan how they would create or use ERCs. Since ERCs are the currency of the emissions trading program, it is common sense that a depository be provided. Lastly, banking strengthens incentives for maximum early reductions instead of encouraging industry to "sit on" potential reductions.

18. Few states have developed generic rules because the guidelines for the generic rules were only just finalized within EPA's Emissions Trading Policy Statement. Each generic rule itself, of course, must be a SIP revision and, therefore, can take a year or two to be processed and approved by EPA. New Jersey had the first generic rule approved on March 26, 1981. As with most generic rules, the rule governs only bubbles for hydrocarbon emissions. Under this program, over 25 bubbles have been approved.

19. As such, it removes the cloud of regulatory uncertainty stemming from the prior interim status of preceding rules. It has not, however, reduced threats of congressional proscription.

Figure 2 expresses when and where the various emissions trading tools are to be used. Note, emissions banking can be used in any situation described below.

Figure 2
Summary of Permissible Transactions in Emissions Reduction
Credits Under the Emissions Trading Policy

	<u>Existing Sources</u>	<u>New Sources</u>
Clean Air Areas	bubble (voluntary)	offsets (voluntary) or netting (voluntary)
Nonattainment Areas	bubble (voluntary)	offsets (mandatory) or netting (voluntary)

B. *The Environmental Scorecard*

Assessing the effects of emissions trading presumes that there is a standard against which data can be compared and supposes that data is collected to support analyses. EPA does not, as a matter of routine, collect data on the environmental outcomes of offset, netting, and banking transactions. EPA also does not collect data on bubbles processed through generic rules. EPA does collect data on bubbles that are processed through the SIP process and has conducted occasional reviews of select bubbles.

In evaluating emissions trading, the program's objective should be compared to its results. Emissions trading reforms were intended to:

1. reduce the conflict between economic growth and air quality goals;
2. simplify developing alternative emissions control programs for individual sources;
3. yield more information regarding what is right and wrong with existing systems for tracking and controlling emissions;
4. build credibility in the way we regulate air emissions; and

5. result in no air quality deterioration as a result of emissions trades.

Question #1: *Has emissions trading reduced the conflict between the dual goals of better air quality and more economic growth?*

Offsets have effectively reduced the conflict between new source growth and both attaining and maintaining air quality objectives. Out of the thousands of cases where offsets were sought, there are no more than five cases where offsets were truly unavailable. Even in areas like Santa Barbara, California, where offsets are only granted for retrofit-based credits (equipment shut downs cannot yield credits), offsets have been obtained. Although there are a few areas where offsets are scarce and industry claims they are expensive, if available at all, offset systems have worked in almost every community in which they have been tried. There is *no* evidence that contradicts this claim.

As to whether or not offsets result in an air quality benefit, data does not exist to test the veracity of such propositions. However, local regulators, not industry, govern the effectiveness of the offset system. Procedures have been developed for effective review, qualification, and evaluation of offset transactions, thus providing strong environmental safeguards. Furthermore, though offset tradeoff ratios vary, they are *at least* 1.1:1, and assuming compliance with the offset policy, new sources *must* achieve greater reductions than their new emissions.

Question #2: *Has emissions trading simplified the acquisition of alternative emission limitations?*

Before the Bubble Policy, firms which wanted to develop an alternative compliance program to that specified in the SIP had to use the SIP revisions process. This process is time-consuming, labor intensive, and uncertain. In order for firms to develop cost-effective regulatory alternatives on a routine basis, regulators had to develop streamlined review and approval procedures. The notion of generic rules was developed as an outcome of the Bubble Policy. The Bubble Policy also resulted in one of the first systematic reviews of the SIP process which was begun in 1980 and re-

sulted in parallel processing of select SIP revisions and other improvements in the SIP review process.²⁰

Question #3: *Has emissions trading produced useful information on what is and is not working in air regulatory programs?*

As noted elsewhere,²¹ emissions trades became the air program's bearer of ill tidings. Problems that were able to be "swept under the rug," hidden by complexities in the SIP process, were spot-lighted by individual bubble, banking, or offset transactions. Questions of baselines²² and the integrity of the SIP, issues such as how the shutdown of facilities was treated in the SIP, and hours of operation, which *must* be addressed under a marketable permit based system, are avoidable under command-and-control.

The old bromide: "Ask me no questions and I'll tell you no lies" was true for many elements of air pollution regulation. When firms proactively fight for entitlements, then baseline, modelling, shutdowns, and other issues become prominent.

Marketable permit systems require uniformity and a clear and consistently upheld standard of review by regulators. Because emissions trading violates the first rule of regulators—never regulate yourself—it forced regulators to address weaknesses in the current SIP system.

Question #4: *Has emissions trading enhanced the credibility of air pollution control programs?*

As to whether or not emissions trading has built credibility within the regulated community, the results are mixed. Many firms were encouraged by regulators to develop trades; these firms subsequently found themselves up the proverbial creek without a paddle. There have been incidents of regulators declaring that any firm that can do better than required should be required to employ the new controls. The new controls, therefore, cannot be used to create emission reduction credits since they are now required, not voluntary. Also, there have been attempts to confiscate banked emission credits. All the problems normally as-

20. See, Memorandum from Steve Seidel, Proposed Rule Requiring EPA to Propose Action on a SIP Amendment for a Bubble Within 90 Days After Receipt (April 6, 1981) (member, EPA Regulatory Reform Staff).

21. J. Palmisano, Emission Trading Reforms: Success and Failures (1985) (paper delivered at Annual Meeting of the Air Pollution Control Association, Detroit).

22. Emissions Baseline — Ambient pollutant concentration level that exists in the baseline area at the time of the applicable baseline date. As only those emission reductions not currently required by law are creditable, regulatory agencies establish an emissions baseline, against which surplus reductions can be calculated.

sociated with the start-up and de-bugging of a new way of doing business have occurred. As a result, signals to industry have not been consistent.

There have also been mixed signals from state and federal regulators, which have confused individuals in firms who might have either advocated and/or advanced emissions trading options but who regressed from normal risk-aversion to ultra-risk-aversion. Firms often react to regulators in the spirit of "letting sleeping dogs lie" and, thus, are leery of advancing bubbles if regulators persist in sending discouraging signals. There is no way of measuring whether or not faith in the regulatory system has been enhanced or eroded as a result of implementing emissions trading.

Question #5: *What have been the results of emissions trades on air quality?*

As noted elsewhere, offsets *must* result in a net reduction in emissions of air pollutants. Rules developed and implemented by states and localities can make offsetting as rigorous as needed. In areas where there is substantial experience, high growth communities in California, offsetting has resulted in emission reductions.

By definition, netting does not result in net air quality degradation. Hahn and Hester assert that netting is the most common of the emissions trades. They also conclude that "it seems reasonable to conclude that netting has not had significant adverse impact on environmental quality."²³ Furthermore, it is the regulatory community which establishes the review criteria for netting, as it does with offsets, and that criteria can be strengthened if needed.

Offsetting and netting have been over 95% of all emission trades. It is important to note, therefore, that in the aggregate, there have been no adverse effects on the environment as a result of these trades.

Emissions banking is, in general, air quality neutral. That is, unless a banking system requires a reduction in the credits as in the Los Angeles emissions bank (a 10% reduction for credits going into the bank), emissions banking *per se* does not improve or injure the environment.

The question regarding bubbling is more difficult to answer. Of those bubbles going through the SIP revision process *before*

23. R. HAHN & G. HESTER, WHERE DID ALL THE MARKETS GO? AN ANALYSIS OF EPA'S EMISSIONS TRADING PROGRAM 48-49, 52 (1986).

the final emission trading policy went into effect, some "have reduced pollution more than compliance with conventional regulatory requirements . . . and some have sped pollution abatement, producing reductions in emissions faster than would have occurred in response to conventional control requirements."²⁴

As to the environmental effects of bubbles under generic rules, there is no evidence that these have resulted in any degradation in air quality. Given the nature of the requirements for an EPA-approved generic rule, environmental improvements are very likely to result from trades under these state run programs.

The future of emissions trading is the future of the bubble. There are many more existing firms than there are new sources. The cost savings available to existing sources are very substantial—perhaps halving the cost of compliance with air pollution control requirements. It is, therefore, important that safeguards exist for maintaining environmental protections for individual bubbles. That is why EPA has instituted procedures that will protect the integrity of each bubble trade.

The environmental effects of emissions trading have not, therefore, in the aggregate, been hostile to air quality objectives. Future trades reinforce this conclusion since current rules go even further than earlier rules in supporting the attainment of emission controls and air quality goals.

C. *Impact on the Bottom Line*

There is no dispute in any quarter regarding the certainty of cost savings due to emissions trading. There may be some dispute over the exact size of the cost savings. Yet by any measure, the cost savings to date are impressive. Costs savings due to offsetting must be in excess of \$25,000,000 (assuming savings of \$10,000 per offset and 2,500 offsets since 1976, both very conservative numbers). Hahn and Hester provide a conservative estimate for bubble savings at \$650,000,000 and netting savings of \$500,000,000 — \$12,000,000,000.²⁵ Even assuming up-side bias in estimating, the aggregate saving from emissions trading is surely in excess of \$500,000,000, even in emissions trading's in-

24. R. LIROFF, *REFORMING AIR POLLUTION REGULATION: THE TOIL AND TROUBLE OF EPA'S BUBBLE* xvi-xvii (1986).

25. R. HAHN & G. HESTER, *supra* note 23, at 43, 51.

fancy. Clearly, given an investment of less than \$10,000,000 has brought about a considerable return on investment.

D. *Stimulus to Innovation*

One way of describing invention is "getting more with less." If firms are able to achieve the same amount of emission reduction with less money, then there has been some form of technological progress. If we assume that there are only three factors of production—capital, labor, and management—then increased outputs (more pollution control) must be due to increased marginal productivity from one or more inputs. This result derives from either invention or the diffusion of inventions, which is called innovation.²⁶

One of the advantages touted for emissions trading is that it provides incentives to develop new techniques for pollution control. Critics charge that not much of this has happened. In exploring the innovation outcomes resulting from emissions trading, we rely on two models.

First, consider the model presented earlier in Figure 1. This model demonstrates the many links between the development of an emissions trading system and the outcomes from that system. Individual trades, whether bubbles, offsets or the banking of emission credits, could be developed only in states which were pre-disposed to advocating emissions trading concepts.

Second, due to considerable inefficiencies in the system of prescriptive air regulations, firms do not always need to obtain some "space age" technology to generate cost-effective control strategies. There is a considerable gap between the performance capabilities of off-the-shelf control technologies used in unconventional ways and existing control technology used in conventional SIP mandated ways. Firms can develop more cost-effective control strategies than regulators because plant managers *know more* about production processes than regulators.

The menu of cost-effective control strategies before many firms is sufficiently broad that there is little incentive to push the frontiers of technology outward. Under the current system of pollution control, moreover, firms are loath to identify new and superior control technologies. They fear that regulators will sub-

26. See Palmisano, *supra* note 1 for a description of the model used to assess the diffusion of trading concepts and innovation outcomes.

sequently mandate that technology not only for one facility, but eventually on all facilities and production processes of a given type. Their fears are well founded, given the appetite of regulators for new control technologies.

It is neither profitable nor cost-effective for industry to develop exotic new technologies when the application of existing technologies or changes in production processes can meet current regulatory requirements. Just as gold miners pick up the nuggets in the river bed first, pan for gold second, and bring in heavy equipment last, emission credit "miners" will seek cheap reduction first. Technology will be pushed or pulled depending on the benefits expected from invention and innovation and the efficacy of existing technologies. Emissions trading gives plant managers the opportunity and incentive to use existing technologies, production, process, operations, and maintenance changes in new ways which invariably result in more emission control for less money! That is the kind of innovation that makes sense to everyone. Thus, we would expect that "cheap" reductions would be taken first and that consequently, mostly economic, as opposed to environmental, benefits would develop in the early phases of adoption of the program.

Figure 3 illustrates a relative ranking of emissions credit creating opportunities. As emissions credits generating opportunities become more scarce, firms begin considering more expensive control methods. The escalation from Group I controls to Group III has occurred in areas where emissions trading roles are con-

Figure 3

The Relative Cost of Control for Creating Offsets

Expensive Controls

Group III	area sources controls
	transportation based controls
	improved operations and maintenance
Group II	innovative technologies
	off-the-shelf hardware
Group I	company specific "tweaks" to existing equipment
	selected curtailments
	selected shutdowns
	shutdown of unneeded equipment

Cheap Controls

roles are constricted or credits are scarce—such as Santa Barbara or San Luis Obispo Counties in California.

The combination of these effects—lagged industrial responses to EPA and state emissions trading programs and the general availability of relatively cheap emission control opportunities—has resulted in an absence of broad scale “hardware” invention/innovation resulting from emissions trading. Recent data on trading in California, where “cheap offsets” are scarce, confirms that invention and innovation will result from emissions trading programs.

New “hardware” might occasionally result from industry’s self-serving search for a better way to meet air pollution control requirements. No one, however, should be disappointed if firms meet their pollution control responsibilities and no new technologies are developed.

Clearly, as the cost of emission credits increases, “hardware” and “software” technological change in pollution control will occur. In high ERC cost areas, it is occurring. The fact, however, that new “hardware” embodies technologies that have not been required to create ERCs, confirms an underlying assumption of market-based systems—plant managers *do* know more about pollution control in their plants than do regulators.

E. Implementation Problems

Policy design and implementation are often confused. Conceptually, market mechanisms have so many attractive features that one would assume they would be the dominant regulatory tool. If emissions trading is so great, how come it is not more widely adopted and why are there still adversaries? This section addresses this query.

1. Why Are Some Environmentalists Skeptical?

The implementation of a regulatory program is a dynamic process. It involves organizational learning within the community of those affected by the program. The cost and extent of learning vary with the voluntary or involuntary nature of the policy. The emissions trading program today is very different from its original design. The modifications are a result of feedback from both advocates and adversaries.

Unfortunately, emissions trading has become the harbinger of bad news. Individual emission trades have focused regulatory at-

tion on short-comings of the existing system, sloppiness in the SIPs, and problems which could be ignored under a command and-control regime but are spot-lighted under a market-based approach. The resulting tension forced emissions trading to change to accommodate the short-comings of the existing system.

The required changes in emissions trading policies resulted in a 46 page Final Emissions Trading notice in Federal Register²⁷ hardly the "lean and mean" system which original advocates envisioned. However, the result has been a hand crafted policy which fits with the idiosyncracies of the SIP process and the implementation of the Clean Air Act. Though these "bells and whistles" impede the ease of trading and appear to industry to be a formidable hurdle, the policy is a careful compromise which honors the required environmental integrity of each emission trade.

Yet despite environmentally strengthening mid-course corrections, some environmentalists and some regulators still are ill at ease with market mechanisms in general and emissions trading in particular. These feelings derive, in part, from a notion that industry makes money from emissions trades. Others feel that regulators need to squeeze every emission reduction out of industry at every opportunity. Still others believe that much of industry is not to be trusted and view attempts by industry to secure maximum reductions for particular emission trades as a systemic pattern of behavior which gives credence to a position of mistrust. As a basis for debunking emissions trading, none of these claims has merit.

As to the claim that industry profits from emissions trading, this claim invokes a moral or ethical paradigm to which economics does not necessarily speak. Market-based regulatory systems address both economic and political questions of resource allocation and regulation. Ethical arguments neither counter nor affirm arguments of efficiency or equity. That industry should reduce compliance costs, with the same or better compliance outcomes, is, however, an intended result of emissions trading not an attribute to be defended.

As to the claim that emissions trading results in missed opportunities for more controls, while that may be true in the short run, it is false in the long run. If regulators adopt an attitude that every emission reduction should go toward improved air quality, the in-

27. 51 Fed. Reg. 43,814 (1986).

centives to industry to produce extra emission reductions, *in the real world*, are antagonistic to long run regulatory objectives—more controls, sooner, with less intrusions and fewer public sector resources. The claim that extra reductions are lost hides the concern of some regulators that they, the regulators, would lose control in a decentralized system like emissions trading. The rules necessary to run an emissions trading system not only regulate industry but would regulate regulators' freedom to be arbitrary.²⁸

The issue can be distilled to an ends versus means argument. Through the design and implementation of emissions trading or any market-based system, environmental and regulatory safeguards can easily be designed-in or added-on. If, on the other hand, regulators or environmentalists want to make industry suffer, cry "uncle," and beg for mercy, the result will be less faith in the regulatory system, more deception, foot-dragging, and litigation.

With respect to the concern about the trustworthiness of industry, it strains credulity to imagine that industry has more than its fair share of scoundrels. All things being equal, people try to follow the rules, if the rules are known. While it is entirely true that there have been some emissions trades which have failed close scrutiny, that is not a shortcoming of the system but a tribute to its ability to be fine-tuned and continue to work. Industry is always going to be concerned with advancing some self-interest. Yet if safeguards are built into the system to filter out trades which are inconsistent with the goals of the program, the result is either an improvement or no degradation in environmental quality.

In sum, the concerns of some regulators and environmentalists have more to do with myth and visceral feelings regarding industry "paying for past sins" than a concern for either equity or economic efficiency. Many in the environmental and regulatory community now have a vested interest in maintaining the *status*

28. The criteria for creating an emission reduction credit is simply that an ERC must be: (1) a surplus emission reduction—reductions below the control obligation of the facility, (2) enforceable, (3) permanent and (4) quantifiable. The result of a banking and trading system is certainty for industry and certainty for regulators. In order to have certainty, both parties must recognize that a certain amount of flexibility or capriciousness will be lost. Any emissions trade meeting the criteria above should be approvable by appropriate regulators; regulators, therefore, must lose some freedom to be arbitrary.

quo. Thus, claims of cheating under a market-based system or the notion that selling "permits to pollute" is morally wrong are *ad homin* arguments which either obfuscate the real issues—reaching goals cost effectively—or confuse ends and means.

The political realities are such that the existing system is a savage competitor against any new idea, even when the regulatory innovation is introduced to "save" the existing system. That emissions trading has resulted in the successful "de-bugging" of a market-based approach to regulation cannot be ignored. The concerns of detractors have been substantively addressed by the final emissions trading policy.

2. Haven't There Been Paper Trades?

When EPA required states to develop implementation plans, few resources were available for the design and the review of SIPs. This is still true today. States themselves have not devoted sufficient resources to SIP development. SIP development has also been hampered by poor air quality modeling and unreliable inventories of emitting facilities.

Paper trading refers to the trading of emission credits which never really existed or that would have happened anyway. For example, a firm may try to take credit for emission reductions achieved in the past. The reductions may have been for allowable emissions and then subsequently traded as actual emission reductions. Richard Liroff,²⁹ in his review of bubble experiences, provides some examples of potential paper trades. In some cases the credits might be from a facility that has not operated in years, hence the claim that there is no air quality improvement. In other cases, there are real questions as to what, in fact, is a facility's emission control obligation and whether or not a credit came from over-control.

Paper trades were possible with any emission trade because the basis for many SIPs was faulty, record keeping has sometimes been unreliable, and because of the discrepancy between actual and allowable emissions. To the extent that paper trades took place, they have become fewer and fewer over time. That paper trades have occurred, however, cannot be denied. It also cannot be denied that concrete steps have been taken to remedy this problem.

29. R. LIROFF, *supra* note 24, at 98-99.

In communities with substantial trading, such as the Los Angeles area and New Jersey, regulators have developed procedures for the systematic review of emissions trades; these systems have reduced the likelihood of paper trading. In spite of having the worst air quality problem in the country and the toughest regulation, industry in Los Angeles is still able to create emission credits which are not "paper credits" and *do* result in real emission reductions. New Jersey's generic bubble rule, for example, does not permit credits for shutdowns, thus eliminating one source of contention. By adopting standards and procedures for the review of trades, the integrity of the system is maintained.

What has happened cannot be undone and shortcomings in the original emissions trading rules have been remedied. EPA's final emissions trading policy comes down squarely on the side of tighter safeguards.³⁰ Consider the following actions which should eliminate the use of "paper credits" or any environmental degradation resulting from bubbles:

- Bubbles may not result in any increase in applicable baseline emissions *except* under conditions which assure ambient equivalence.
- Baselines for bubbles must take into account emission rates, capacity utilization, and hours of operation.
- All emission reduction credits *must* be state-enforceable in order to be deposited in EPA-approvable banks.
- In all areas bubble must meet stringent tests for *ambient* equivalence.

These are only some of the revised review and approval criteria for emissions trades under the final policy. As a result, each trade will test the quality of the underlying SIP. As a result of these fixes, the integrity of any emissions trades will meet or exceed the integrity of any other part of a state's air program.

In short, what was a legitimate concern has been remedied.

F. Industry's Response

Emissions trading policies can be divided into two classes—voluntary and required. Firms voluntarily choose to advance a "bubble" or an emissions banking application. For most firms, offsets are not voluntary; they are a requirement of a community's new source review process. Industry's response to emissions trading

30. 51 Fed. Reg. 43,815-16.

opportunities, therefore, is specific to the policy instrument—offsets, netting, bubbles, or banking. The response, however, has generally been mixed and because of considerable regulatory uncertainties, industry has been quite cautious, too.

Industry's tentative approach to emissions trading is exactly what we should expect. First, emissions trading is just like any other technology. There are initial adopters, secondary adopters, and laggards. Rates of adoption are determined by many factors internal and external to the firm. Most importantly, rates of adoption are related to the chance of success and strength of the guarantee that emissions trading works as billed.

For the emissions trades which are not voluntary (offsets and netting), there have been many transactions since 1976. Hahn and Hester³¹ believe there have been between 5,000 and 10,000 netting transactions. There have been over 2,500 offsets, of which over 100 have been external.³² Five years ago in Los Angeles, offsets were traded only occasionally, perhaps one trade took place every month or two. Two years ago, trading in Los Angeles increased. The number of offset trades in Los Angeles went from around three in 1983 to about five in 1984 to 42 in 1985.

The increase in offset trading in Los Angeles took place because regulators closed loop-holes and firms began to accept the requirement to acquire offsets as part of the cost of doing business. During the last year, trading for offsets in Los Angeles has become commonplace, with two or three middlemen emerging as trade facilitators. Today, in Los Angeles, there is probably one trade every two weeks.

Firms wanting to locate in nonattainment areas have no choice—they either obtain emission credits, site in their second best alternative location, or forego expansion. Every offset trade, on its face, therefore, yields benefits to industry because second or third best investment alternatives are avoided. The number of offset trades, however, has more to do with the economics of expansion, local air pollution conditions, local regulatory require-

31. Hahn and Hester think that it is fair to think that about 8,000 netting transactions have occurred compared to about 2,500 offsets. See R. HAHN & G. HESTER, *supra* note 23, at 33.

32. EPA has estimated that there were at least 2,000 offsets by 1980. Since there is no central registry for offset transactions, it is impossible to estimate with any precision the number of offsets to date. Hahn and Hester have used AER*X estimates of at least 2,000. See R. HAHN & G. HESTER, *supra* note 23, at 33. AER*X trading data suggests that there have been at least 100 external trades in the last 4 years alone!

ments and the abilities of the relevant regulatory staff, than with other factors.

When the Bubble Policy emerged in late 1979, the response by industry was positive and pronounced. No one, however, forces a company to develop a bubble; no one forces a company to save money. Bubbling requires motivation and championship within a firm. Advocacy of a bubble within a firm will be predicated on some level of confidence that the firm *and* the individual will benefit from successful advocacy.

The use of bubbling has diffused more slowly than some might have expected. A company's pollution control strategy is much like a durable good; as such, the economic aspects of the diffusion of durable goods provide insight into what should have been expected from the market place of bubble adopters. Liebermann and Paroush offer some interesting insights into how new durable goods are adopted over time.³³ Their analysis suggests that large firms are likely to be initial adopters of such goods and that potential adopters will delay obtaining the product until they have a desired level of accurate information regarding its attributes. Since most small and medium sized firms have little practical access to information regarding regulatory program, it is expected that mostly large firms would be adopters of bubbles. In fact most bubblers are very large, Fortune 500 companies.³⁴

Compounding the above-mentioned factors was the perception that bubbling and banking were draft or interim policies for many years. Even though the Bubble Policy was finally promulgated in December of 1979, by the fall of 1980, EPA was already telegraphing potential changes to industry. Early in 1981, EPA was wrestling with several changes to the Bubble Policy, revisiting the offset policy, and attempting to tie together all of the potential changes to trading policies under one rubric then called Controlled Trading, now Emissions Trading. The uncertainty caused by these policy changes and by the debates between EPA's Office of Air and Radiation and the Office of Policy, Planning and Evaluation confused industry, confused and alienated state regulators,

33. Liebermann & Paroush, *Economic Aspects of Diffusion Models*, 34 J. ECON. & BUS. 95-100 (1982).

34. J. Palmisano, *An Evaluation of Emissions Trading* 13 (June 1983) (unpublished paper given at the 76th Annual Meeting of the Air Pollution Control Association, Atlanta GA).

and left EPA emissions trading advocates at war with other EPA staff.

In spite of many inhibiting factors, there have been over 50 approved or proposed bubbles with savings exceeding 300 million dollars, over 35 bubbles have been approved under state generic rules, and over 170 more bubbles have been advanced by industry.³⁵ Total cost savings are conservatively estimated to exceed \$500,000,000.

Emissions banking is, like bubbling, a voluntary action. As with bubbling, most companies which initially banked credits are fairly large. As of January 1986, EPA had approved five state wide or local emission banks and eight were being reviewed for approval.³⁶ Seven more banking rules were being developed. The evidence from the Los Angeles, San Francisco, and Louisville banks confirms that firms will use the bank, trades are facilitated by the bank, and that the system is more simple than early nay-sayers projected.

Industry has saved over \$500,000,000 from emissions trading reforms.³⁷ Industrial support for maintaining emissions trading, therefore, should come as no surprise. Industry does support offsetting as compared to the alternatives but continues to promote the myth that offsets are "expensive." Industry rhetorically supports continued use of the bubble concept; greater use of the bubble, however, awaits state regulators embracing bubbling and moving into a more facilitating role.

On the other hand, while industry supports bubbling, it is very difficult for individual plant managers to "get out front" pushing bubble opportunities in light of threatened litigation by some en-

35. U.S. EPA REGULATORY REFORM STAFF, EMISSIONS TRADING STATUS REPORT (January 10, 1985). Bubble savings approached \$800 million according to this estimate. Hahn and Hester estimated bubble savings at around \$650 million. See R. HAHN & G. HESTER, *supra* note 23, at 43.

36. U.S. EPA REGULATORY REFORM STAFF, EMISSIONS TRADING STATUS REPORT (1986). The five banks approved were: the state of Oregon, the state of Missouri, the state of Rhode Island, Cane County, Oregon and Puget Sound, Washington. The eight banks under consideration were: Pima County, Arizona; Jefferson County, Kentucky; Middlesex County, New Jersey; Allegheny County, Pennsylvania and four air pollution districts in California.

37. Bubble savings are estimated to be at least \$500 million and netting savings are estimated to be \$500 million on the low end. See R. HAHN & G. HESTER, *supra* note 23, at 51. It is obvious that even without offset savings added into the aggregate, the summed savings is over \$1 billion. Five hundred million dollars in savings is, therefore, a very conservative number.

vironmental groups, uncertainty as to the potential construction ban, and perceived down-side risks due to broad and in-depth reviews of plant operations by regulatory agencies reviewing bubble applications.

Before industry can widely use emissions trading concepts, Congress, EPA, and states must make the rules more certain, provide assurance that the trading based systems will be in place for the foreseeable future, and that opportunities will exist for firms to meet new emission limitations through single and multi plant bubbling. Otherwise the uncertainties and mixed signals from regulators will impede wide-scale adoption of bubbling, the most powerful of the emissions trading concepts.

V. IMPROVEMENTS AND EXTENSIONS

A. *Dealing With Current Nonattainment Problems*

The Clean Air Act is now a subject of much debate. The use of market mechanisms and emissions trading is one element of that debate. Authors of an amended Clean Air Act should be concerned with both the ends and the means by which regulatory objectives are attained. In particular they should be asking themselves:

1. will the proposed tools help us achieve our regulatory goals,
2. what is the evidence that this is true,
3. how long and how many resources will it take to develop and implement new programs,
4. how much energy is left in existing programs to merit continued reliance, and
5. is the overall strategy flexible enough to meet changing environmental goals and resource restrictions?

The scorecard for emissions trading reveals high marks on every one of the above evaluation criteria, yet the current Congressional proposals³⁸ fall short of what is required if emissions trading is to realize its potential benefits.

As things now stand, if Congress does nothing, EPA will continue to build new programs and expand existing programs in ways that jeopardize emission trading gains. As things now stand, if Congress or some coalition of stakeholders, or some "cham-

38. Senate Bill S. 1894, 100th Cong., 1st Sess. (1987) would eliminate bubbling and netting.

pion" does not step forward, the *status quo* will have again beaten back all competitors.

One extension of emissions trading Congress should be considering is to allow firms who are subject to new emission control obligations to meet their obligation by either employing technologies or by applying ERCs. This concept is, in part, imbedded in both the current Senate and House Bills³⁹ by virtue of new goal-setting and upcoming emission reduction assessments in the more than sixty areas which do not meet the ozone standard.

Over sixty metropolitan areas are expected to fail to meet the ozone air quality standards by December 31, 1987. As a result of this failure, extra regulatory actions will be required to obtain additional hydrocarbon emission reductions. These actions might include introducing new and very expensive controls on existing stationary sources, new controls for mobile sources, new BACT/LAER requirements, new enforcement techniques, greater offset ratios, and lower *de minimis* emission levels. All of these strategies are continuations of the traditional regulatory programs which have already failed to achieve many of their original goals.

One remedy breaks out of the traditional command-and-control mold and builds on the administrative and institutional foundation established by emissions trading reforms. This remedy is called TERA for Transferable Emission Reduction Assessments. TERA is just another name for a specific application of emissions trading.

A TERA program requires an air quality region's regulatory authority to make assessments as to what the emission reduction shortfall is for the affected airshed. The aggregate emission reduction assessment is then divided into an obligation for mobile sources, area sources, and stationary sources. Individual stationary sources would then be assessed an emission control obligation beyond their current control responsibilities. These assessments would take into account, of course, myriad factors like the current degree of control for the facility or source.

Facilities or sources which are assessed new emission reductions would be required to achieve the reductions by:

—a shutdown of activities,

39. Regulatory concepts advanced by Congressman Waxman (Cal.) would mirror some of the proposed changes in S. 1894 which void bubbling.

- a production change,
- a control technology change, or
- application of emission reduction credits (ERCs).

Firms assessed reductions could, therefore, have all the certainty of the current system and all the freedom inherent in an emissions trading system.

In order for a state to implement a TERA program, there must exist a program describing the rules for creating, certifying, storing, and using ERCs. Any community that has either an offset, banking, or bubble rule will be very close to developing a TERA rule.

In order to implement TERA, regulators must be willing to provide assurances that innovative control strategies which go beyond RACT requirements will not suddenly become RACT. Regulators *must* have faith in the TERA system, in essence, in order to regulate their own actions. The system must be designed with rules and procedures which are well understood and not ever-changing. The following table summarizes these implications:

Figure 4

PRO	CON
Less reliance on design standards	Some sources may be assigned new control obligations which may not have been targets under a straight RACT
Greater flexibility	
Cost savings	
Voluntary	
PRO	CON
Less reliance on developing RACT	May be more difficult to enforce
May be able to achieve air quality improvements faster	Regulators must build TERA on an emissions trading program
TERA may limit legal challenges to alternative control programs	Deviates from current regulatory philosophy
Promotes technological progress	

TERA poses no technological problems for industry or regulators. The main concerns are institutional and philosophical. It has been shown, unfortunately, that institutional and attitudinal changes are more difficult to achieve than are technological

changes. What is required for TERA to become a viable policy option is leadership from EPA, leadership from industry, leadership from environmental stakeholders and leadership from Congress. Clearly, the Clean Air Act amendments provide an opportunity to clarify the legal standing of emissions trading and TERA-like programs.

B. *Stratospheric Ozone Depletion*

Among the range of air pollution problems for which market-based management mechanisms are appropriate, global problems involving fund pollutants present current unique opportunities. Since the early 70's, when a theory for the destruction of stratospheric ozone by a series of chemical reactions involving chlorofluorocarbons (CFCs) was first proposed, a variety of approaches to limit such damage have been implemented by a number of nations individually. The United States was the first to act in 1978 with a ban on CFCs in non-essential aerosol products. Canada, Norway and Sweden were the only nations to follow the U.S. lead however. The European Economic Community (EEC) in 1980 agreed to cap CFC production capacity at the sum of the capabilities of existing production facilities.

Neither of these approaches has proven to be sufficiently global in scope to protect the stratospheric ozone layer. After a hiatus in the market for CFCs in the late 70s, variously attributed to the effects of regulation or to the poor performance of the global economy, CFC production and use has rebounded with a vengeance. Annual growth rates in sales of CFCs have averaged 4.5% per year since 1982.⁴⁰ In individual nations (e.g., the U.S.S.R.) and for individual chemicals (e.g., Halon 1301), annual rates of growth have been substantially higher.⁴¹ Since the atmospheric lifetimes of these chemicals are measured in decades,

40. GRANT THORNTON AND COMPANY, 1985 PRODUCTION AND SALES OF CHLOROFLUOROCARBONS CFC-11 AND CFC-12 (July 1986) (Chemical Manufacturers Association Fluorocarbon Program Panel).

41. During the negotiations underlying the development of the Montreal Protocol for the Protection of Stratospheric Ozone, the U.S.S.R. announced plans to expand production by 8% per year through 1990. 1 U.S. EPA, REGULATORY IMPACT ANALYSIS: PROTECTION OF STRATOSPHERIC OZONE 4-17 (1987). Halon 1301 is one ozone depleting chemical that has exhibited high rates of growth averaging 15% per annum. J.K. HAMMITT, KATHLEEN A. WOLF, FRANK CAMM, WILLIAM E. MOOZ, TIMOTHY H. QUINN, AND ANIL BAMEZAI, PRODUCT USES AND MARKET TRENDS FOR POTENTIAL OZONE-DEPLETING SUBSTANCES, 1985-2000 at 70 (1986) (RAND R-3386-EPA).

the cumulative effects over time of these high chemical emission growth rates are of substantial concern.

1. Previous Attempts to Manage the Problem

The aerosol ban in the United States did not anticipate the growth in demand for nonaerosol uses of CFCs. Production in the U.S. has grown significantly despite the ban.⁴² While the aerosol ban probably needed time to allow both atmospheric and political science to catch up, it has also contributed to tensions with other nations. The EEC believes that it acted responsibly in placing an ultimate limit on the production of CFCs, thus effectively preventing the unimpeded growth of emissions possible under current U.S. regulatory strategy. In fact, it is a continued long term growth in emissions which produces large scale depletion according to current models. The EEC agreement, while capping production ultimately, has had no effect on current emissions since capacity greatly exceeds utilization levels.⁴³

Under Section 157 of the Clean Air Act, the Administrator of EPA is empowered to take whatever actions are necessary to protect the stratospheric ozone layer. Under the terms of a consent decree produced by a suit filed under this section, EPA is currently studying several regulatory options for the further control of CFCs. Among the choices under review are marketable use permits, production quotas, emission fees and command-and-control, i.e., process and engineering controls and product bans.⁴⁴ At the time of this writing, production quotas seem to hold the inside track within the agency.

2. Marketable Permits

Marketable use permits would seem to be ideally suited to the problem of efficiently restricting the production of CFCs. Only

42. U.S. production of CFCs 11 and 12 reached a post-ban low of 205.5 million kilograms in 1980. Preliminary estimates put 1986 production of these chemicals at 237.5 million kilograms. U.S. TRADE COMM., SYNTHETIC ORGANIC CHEMICALS INTERNATIONAL (1986).

43. Production capacity constraints affect emissions, all other things being equal, only when output is limited and imports prohibited. Clearly, such limitation can only occur when producers can no longer expand output.

44. The U.S. Environmental Protection Agency has sponsored public meetings to solicit views concerning the relative performance and economic impact of alternative control strategies. One such meeting, "EPA Workshop on Alternative Control Strategies for Protecting the Ozone Layer" was held July 23-24, 1986 in Washington, D.C.

production quotas offer the same guarantee of hitting the regulated CFC limit, a feature which is critical to assure compliance with any international control agreement. Permits go a step beyond, however, in also providing market incentives to both producers and users. Production quotas would simply restrict the aggregate level of output (or equivalently, each firm's or plant's output) and allow the market to determine the allocation of available supplies. We would expect prices to rise over time in response to the supply constraint generating significant additional profits for producers. Producers would not necessarily be motivated to begin investment in safe, non-depleting, but more expensive substitutes. Of course, production quotas could also be implemented via a system of marketable permits either auctioned or distributed to producers.

The effect of a marketable permit scheme would depend upon the method of distribution. Permits auctioned to the industry at large (producers, distributors and users) would have the lowest transaction costs,⁴⁵ but relatively high transfer payments.⁴⁶ Permits distributed to users would require significant innovation by EPA to reduce administrative costs since the industry has tens of thousands of industrial users. However, a distribution scheme which would effectively grandfather existing firms into the market would have the lowest transfer payments. Nonetheless, an acceptable allocation formula has thus far eluded EPA despite proposals to consider only first rank users, i.e., firms purchasing directly from producers.

3. Barriers to Implementation

While the auction of marketable permits has the greatest appeal, this policy suffers from legal difficulties. In the opinion of EPA's general counsel,⁴⁷ this approach would likely be challenged in court as a form of unauthorized taxation since any auction would yield significant revenues which would accrue to the treasury. Needless to say, this opinion has dulled the agency's appetite

45. Transaction costs is a catchall term used to describe both public and private costs incurred in the actual implementation of a policy. Such costs would include information, contracting and policing costs.

46. Transfer payments measure shifts of wealth from one segment of society to another. In this case, wealth would be transferred from CFC producers purchasing permits at auction to the public at large through the U.S. Treasury.

47. 52 Fed. Reg. 47,507 (1987).

for this option. There is a direct remedy to the problem as well as ample precedent. Other federal programs involving auctions, e.g., offshore oil leasing, are enabled by specific legislative authorities. In the case of the Clean Air Act, the Mitchell bill explicitly authorizes such revenues from its emission fee provisions for nonattainment areas. A similar amendment to section 157 would seem to be a genuinely useful public service.

Even if auctioning were permitted, there would still be substantial industry opposition. Of particular concern is the domination of auctions by large firms with "deep pockets." Consequently, a permit distribution scheme to users would seem to offer the best compromise. As in the case with emissions trading, bureaucratic inertia is the most significant obstacle to adoption.

4. International Agreement

In March of 1985, the Vienna Convention for the Protection of Stratospheric Ozone was signed. The Convention established the desirability, but not the method by which stratospheric ozone would be protected. Since that date, negotiators have been struggling to develop a protocol containing the operative elements for ozone production. On the 16th of September 1987 in Montreal, an agreement was adopted specifying a freeze in the production of CFCs 11, 12, 113, 114 and 115 at 1986 levels, followed in 5 years by a 20% reduction, and a further 30% reduction 5 years later.

One of the interesting features of the agreement is the definition of each nation's control target. Control levels are equal to the sum of production plus imports for 1986 weighted by the ozone depletion potential (ODP) of each CFC. Since the environmental concern focuses on the amount of chlorine which reaches the stratosphere, it is immaterial which chemical form it takes as long as differences in atmospheric lifetimes are accommodated. Consequently, market forces or executive fiat may determine the exact mix of CFCs to be produced or consumed within each nation. For example, the Japanese have expressed concerns⁴⁸ about the restrictions on CFC 113 and the impact of reduced supplies for their electronics industry. Under the terms of the protocol, market forces in Japan will determine the most profitable allocation.

48. Discussion and briefings during UNEP negotiations on an Ozone Layer Protocol, December 1-5, 1986, Geneva, Switzerland.

tion of the nation's now limited CFC budget. This is one key ingredient to the creation of a more complete international trading system for CFCs.

Another element of a CFC trading system is addressed by the provision which would allow for the movement of production between nations. The rationale for such spatial adjustments derives principally from the cost structure of the industry. CFC production is subject to strong economies of scale, i.e., the average cost of production declines as output increases over a range given by the particular scale of plant. Under the scheme of proportional reductions in production embodied in the protocol, at some point in the reduction schedule it may be cheaper to close one facility and operate another at a greater rate of output. Such multi-plant adjustments, which would occur normally under conditions of a declining market, would reduce the costs of attaining the control levels specified by the protocol.

International transfers of production could also potentially facilitate the adjustment of low consuming countries (also, in general, less developed countries) to the world of substantially more expensive CFCs. Substitute CFCs 134a and 123 are estimated to cost 2-4 times more than current formulations when they are commercially available. DuPont has stated that if incentives from the market or from regulatory action are sufficient, then commercial production could occur within five years.⁴⁹ It is expected that the more developed OECD nations, which account for the vast bulk of world output, will invest in facilities for the production of substitutes. As demand switches to the new non-depleting formulations, we would expect OECD demand for depleting CFCs to fall sharply. Exports to low consuming nations would not fall so rapidly, however, since these countries are allowed a 10 year hiatus from the reduction provisions of the protocol⁵⁰ up to a limit of 0.3 kilograms per capita. For most countries in the low consumption category, this limit would allow substantial growth in consumption. This growth potential could make these nations desirable markets for a regional production facility set up through off-setting closures in other regions. However, the lack of effective demand is likely to limit this potential.

49. Crawford, *United States Floats Proposal to Help Prevent Global Ozone Depletion*, 234 SCIENCE 928 (Nov. 21, 1986).

50. Article 5 entitled "Special Situation of Developing Countries" of the Montreal Protocol on Substances that Deplete the Ozone Layer, Final Act, UNEP, 1987.

The recently inked protocol contains provisions⁵¹ which could allow development of more formal market-based approaches to managing CFCs. For example, the EEC is treated as a single control unit as long as each member state ratifies the agreement. This "CFC bubble" permits the rationalization of production facilities over time. A similar exclusion is allowed for shared production facilities between the U.S. and Canada. Expansion of these trading provisions without regional limits would facilitate increased global cooperation and build confidence in trading as an effective element of international environmental policy.

C. *International Emissions Trading in Greenhouse Gases*

Another global atmospheric problem occupying increasing international attention is that of climate change. Trace gases like CO₂, methane, N₂O, and CFCs are radiatively active, i.e., they absorb infrared radiation preventing its escape into space. The result is an increase in temperature similar to that which occurs in a greenhouse and a climate change unprecedented for the speed of its occurrence. Weather and precipitation patterns are predicted to be altered with severe consequences for agricultural and natural ecosystems in particular.⁵²

The global nature of the greenhouse problem clearly requires cooperative international efforts. Preventive actions would concentrate on limiting the emissions and buildup of radiatively active trace gases. CO₂ is the most common of these gases with its dominant anthropogenic source arising from fossil fuel combustion. Given this intimate link to energy use, marketable (or transferable) permit schemes are desirable for CO₂ management because:

- a. they handle distributional problems explicitly while allowing the possibility for efficient allocations to emerge; and
- b. they would induce active management of carbon sinks which would generate valuable credits.

51. Article 1, point 8 defines "industrial rationalization" as "the transfer of all or a portion of the calculated level of production of one Party to another, for the purpose of achieving economic efficiencies or responding to anticipated shortfalls in supply as a result of plant closures." Article 2 (Control Measures), items 1, 2, 3, 4, 5, 7 and 8 implement the conditions surrounding industrial rationalization.

52. Dudek & Oppenheimer, *The Implications of Health and Environmental Effects for Policy*, in 1 *EFFECTS OF CHANGES IN STRATOSPHERIC OZONE AND GLOBAL CLIMATE* 357 (J.G. Titus ed. 1986) (overview, entitled Proceedings of a conference convened by United Nations Environment Program and U.S. Environmental Protection Agency, August 1986).

The former advantage stems from the incentive that some permit designs would offer less developed countries (LDCs) to cooperate in a global agreement. The latter advantage for marketable permits creates the possibility that another global commons problem, i.e., tropical deforestation, could be linked to the problem of climate change with positive net benefits.

Tropical deforestation raises at least two significant environmental issues—biological diversity and the role of forests in the biosphere. Considerable research and attention has been devoted to species diversity and the critical role of rain forests as a habitat. Substantially less attention has been paid to the role of such forests in the maintenance of our life support system, the biosphere. An extreme view of the forest conceives it as a standing stock of biomass chiefly composed of carbon. Deforestation, particularly by burning, releases this carbon into the atmosphere in the form of carbon dioxide.

The mid to high latitude regions contain many of the world's developed economies which also act as bankers to the world economy. Of particular interest is the role that these developed economies play in financing the economic development of the LDCs, the main repositories of the world's tropical forest resources. Much has been written about the third world debt crisis. In essence, interest rate increases and poor economic performance in the world economy coupled with questionable loan practices created circumstances under which debtor nations found they could no longer service their debt obligations. This had threatened the solvency of major banking institutions in the developed world, created additional pressures for quick payoff resource exploitation, and prevented more orderly investment in economic development.

There is a mutuality of interest between developed and less developed nations that could focus on tropical forests as the nexus between the climate change and debt problems. The role of tropical forests in the carbon budget of the biosphere must be assessed as a first step. Some research has been developed in this area. The contribution of tropical forest maintenance to delaying the climate warming could be determined and translated into an economic value measuring the magnitude of damages avoided. These estimates could be compared with the debt service obligations of those nations with significant forest resources. Payment schedules and amounts could be recomputed on the basis of the

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values of forest to the developed nations. It is not expected that the amounts involved would be substantial enough to offset all outstanding debt obligations. However, it is expected that they would be sufficiently great to stimulate interest in a debt for forests swap.

This kind of intermediate exchange experience could help to lay the foundation for wider trading between nations for the purpose of managing global atmospheric environmental problems. Alternatively, if we were in an active market for permits for CO₂, then nations with large healthy tropical forest ecosystems could then be transferred to a debt holder or sold to an international broker.

The problems in initiating this type of debt swap, if economically feasible, are primarily institutional. Who would hold the rights to tropical forest development? Would a separate debt holding entity similar to that set up by the Japanese have to be created? Could new debt instruments backed by tropical forest assets be issued and successfully marketed? Can the banks, developed nations and debtor countries find enough advantage in this proposal to abandon the unproductive negotiating positions they have currently staked out?

VI. CONCLUSIONS

Reforming environmental policy to incorporate market-based methods is not a trivial task. Often, the battle to force resolution of an environmental problem is so exhausting that advocates rarely care about the specific policy tool to attain the hard-fought environmental objective. The critical point this paper advances is that it does matter what tool is selected to implement a policy. Environmental advocates must go the extra distance and champion market methods if environmental objectives are to be attained. The competition for resources is intense, and resources should never be squandered. That is a fundamental environmental tenet rarely applied to environmental policy.

A. *National Air Policy*

Further improvements in air quality are likely to be increasingly expensive. This additional pressure upon budget constraints can be eased by improving the efficiency of programs. One example is emissions trading.

There is no doubt on the part of regulators, industry and environmentalists that the next round of technology-based control requirements for achieving air quality goals will be much more expensive on a dollar per pound controlled basis. The next 10,000 tons of hydrocarbons will cost more than twice the previous 20,000 tons controlled for cities like Los Angeles and Houston. The next 10,000 tons will cost even more.

There is also no doubt that the public at large is becoming increasingly frustrated with our inability to achieve environmental quality goals and regulators are burdened by increased responsibilities and static or decreasing budgets.

To some there is no way out of this regulatory box. The solution, however, to this dilemma is not more of what has failed, i.e., increased command-and-control. What is needed is "smarter" regulation, built on tried and true principles which work in harmony with existing institutions and ways of thinking. Tomorrow's regulatory tools must be more decentralized and more powerful, pressuring the regulated to work for the regulators. This class of tools will use carrots and sticks to pull the regulatory wagon.

One tool which meets these conditions and has passed the test of time is emissions trading. Because of a unique set of circumstances, the choice before politicians and opinion leaders is especially clear and must soon be made. The major driving forces affecting the control of air emissions in nonattainment areas is the subject of considerable current debate. Either existing progress toward developing market-based air regulatory strategies will successfully "go over the hill" in 1988 or will be buried prematurely under it. Inaction, by default, dooms progress.

The alternatives are simple: increased complexity in the Clean Air Act, increased adversarial relationships, more process and less product or faith in a system of private sector efforts that complement existing regulatory programs. If emissions trading is allowed to succeed, it will be the harbinger for more creativity by regulators at all levels—not for re-regulation, not for regulatory relief and not for more regulation for regulation's sake. If it is allowed to succeed, the necessary conditions will be met for successfully extending this class of reforms into new settings. If, however, it is allowed to fail, only a few thousand people will know of the cost to society of this institutional neglect, but all of us will be paying for years and years to come.

What is needed now is Congressional support for keeping a broad definition of "source" so trading can be promoted, explicitly allowing firms to meet future control requirements by applying their own or others' ERCs, and encouragement for EPA and states to promote more participation in buying and selling emissions trading. If action from Congress or the White House is not forthcoming, the future of emissions trading and sensible regulation may be quite uncertain indeed.

B. Global Pollution Problems

Beyond our national concerns, there are global air pollution problems like stratospheric ozone depletion and the climate change due to greenhouse gases which will require unconventional policies for an effective solution. These policies must accommodate a diversity of governments, cultures, values and economic systems if international cooperation is to be achieved. The stakes are high and only concerted international action will have an impact. Policies must be designed to entice participation, rather than repel it. Market-based systems like transferable permits provide these advantages.

In the recently agreed upon protocol for the protection of the stratospheric ozone layer, we have the essential ingredients to begin the necessary learning process. As with emissions trading, these concepts must be tested in implementation before they are credible policy tools. The United States can begin this effort by adopting a national marketable permit system for CFCs as an example of how such a policy can practically operate in a diverse political and economic setting. The environmental challenges confronting us demand that we achieve a greater degree of coordination in our policy making. Only economic incentives also allow the freedom of individual national choice in implementation.

FACT SHEET

The recent National Academy of Sciences (NAS) report on climate change is not inconsistent with the Administration's approach to this important issue and is a contribution to our growing understanding of global climate change. The study, "Policy Implications of Greenhouse Warming," summarizes the science and the limitations of our knowledge. The report cites a number of actions that could be taken to meet the challenge of climate change. It highlights the uncertainties in modeling and the current inconsistencies between trends in temperature and accumulation of greenhouse gases. In setting a least cost hierarchy, it rejects options requiring great expense.

- o Bush Administration policies, including measures enacted in the Clean Air Act and proposed in the National Energy Strategy, are projected to stabilize U.S. greenhouse gas emissions through the year 2030, even accounting for growth in economic activity. The NAS study calls for a 10 to 40 percent reduction in greenhouse gas emissions at a constant 1990 activity level. Using the NAS no-growth framework, Administration policies will produce greenhouse emissions reductions comfortably within the range advocated by the NAS study.
- o Targets and timetables for the future reduction or limitation of greenhouse gases as an aggregate, or of carbon dioxide alone, are not advocated by the NAS study.
- o A strong research program is endorsed the NAS panel as an important element of our response to the possibility of greenhouse warming. The U.S. is currently investing almost \$1.2 billion in our global climate change research program, which includes studies of the scientific, social and economic questions surrounding climate change, and possible policy responses.
- o Elements of the comprehensive approach, endorsed by the Administration, are highlighted. The study considers climate change in terms of all greenhouse gasses (using CO₂ equivalent, not CO₂ alone) and the contribution of CFCs, an important greenhouse gas.
- o Continued development of nuclear power is strongly advocated by the NAS study. The President's National Energy Strategy supports the development of a new generation of safe nuclear reactors.

- o The study recommends R&D into the possibilities for adaptation and the need to study geoengineering options. Because natural sources account for 96 percent of the annual CO₂ flux, it makes sense to investigate these options -- although it would be premature to pursue them at this time.
- o Efforts to limit deforestation, and modest domestic and international reforestation efforts, are recommended in the NAS report. The Administration has proposed a multi-year reforestation proposal to plant one billion trees per year on 1.5 million acres, and to improve forest management practices. The United States also supports debt-for-nature swaps, and is active in pushing for a global forestry agreement.
- o Research and development priorities cited by the NAS study in areas such as solar energy and other alternative energy sources, and energy efficiency are receiving additional resources in the President's FY 1992 budget. The budget includes strong efforts in biomass resources, and expansion of solar and other alternative energy research efforts through cost-shared collaborative ventures.

President Bush has established a comprehensive strategy for action on climate change which is outlined in the brochure America's Climate Change Strategy, and implemented through the National Energy Strategy (NES) and the Clean Air Act. The strategy is part of the Administration's commitment to responsible stewardship of our planet, which includes the promotion of economic growth and sound environmental policies.



Department of Energy
Washington, DC 20585

October 19, 1990

MEMORANDUM FOR NANCY WOLICKI, SPECIAL ASSISTANT TO THE SECRETARY
(COUNSELOR)

FROM: David B. Rivkin, Jr.
Associate General Counsel for Legal Policy and Analysis

Subject: Preliminary Recommendations for DOE strategy on Global
Climate Change.

A. Introduction.

Among the many environmental issues currently facing the Nation, "global warming" -- more properly, "global climate change" -- is fast moving to the top of the list. The principle cause of "global warming" is believed to be the "greenhouse effect." This innocuous term describes the results stemming from the presence of certain elements in the Earth's atmosphere, which trap the Sun's heat, much like the glass walls of a greenhouse.¹ Many scientists now believe that "excessive"² amounts of carbon dioxide in the atmosphere will exacerbate this phenomena, leading to a precipitous warming of the Earth's surface temperatures, changing vegetation growth patterns, altering growing seasons, re-routing ocean currents, and perhaps, even melting of the polar ice caps.

To be sure, these dire predictions are still fairly speculative. It is certain though that the single greatest contributor to "man-made" carbon dioxide in the atmosphere is the burning of fossil fuels for energy generation, particularly the burning of petroleum and coal. Assuming that a decision is made, at some point in the future, to cap carbon dioxide emissions, or at least to curb their growth, any strategy designed to attain this result will inevitably have a drastic impact upon the Nation's

¹ The most important of these elements are water vapor and, to a lesser degree, "greenhouse gases," such as methane, nitrous oxide, and CFCs.

² There is no agreement on what constitutes "excessive" amounts of carbon dioxide or of other "greenhouse gases."

energy policy.³ While the resolution of most environmental issues has an impact on the Department of Energy (DOE), global climate change policies, once they are adopted, will have a particularly major influence on the DOE's programs. Accordingly, DOE should play a major role in the development and implementation of such policies. Moreover, given the fact that global climate change policies are being debated in both the international and domestic arenas, within the Executive Branch, on Capitol Hill, in the media, and among the general public, DOE should be a player in all of these diverse fora.

B. Domestic Developments.

With the completion of the Clean Air Act process, global climate change is likely to become the focus of environmental attention in the coming year, with major roles played by interest groups, industry, the media, and the general public. Tremendous pressure will be put on Congress to pass legislation quickly addressing the perceived problems of global warming.⁴ This is not surprising, it is always easier to paint a grim picture of coastal cities inundated by rising oceans, or of deserts where wheatfields once stood, than it is to explain rationally that, while we cannot ignore the possibility of global climate change, our response must be measured and effective.

Despite these anticipated developments, the Administration must be prepared to keep things in perspective. We should emphasize that very little is certain about global climate change, except that it has happened in the past. The questions that remain open include: (1) is the Earth's climate really changing? (2) if so, by how much and how fast? (3) what will be the cumulative impact of these changes on the environment and human civilization? (4) what are the causes of the climate change? (5) what solutions are needed to redress, or at least minimize, any adverse impacts stemming from global climate change trends. Indeed, the existence of many outstanding uncertainties with respect to global climate change was recognized in the recent Final Report of the United Nations' Intergovernmental Panel on Climate Change (IPCC). Given these facts, it would be highly irresponsible for us to commit scarce resources to strategies that may prove to be ineffective, or would only address a problem that may prove ephemeral, or at

³ The severity of the impact will, of course, depend on the strategy involved. There is no denying, however, the generic nexus between global climate change policies and energy strategies, of whatever stripe.

⁴ Among the already pending bills that would address global climate change issues are S. 324, H.R. 5521, and H.R. 2984.

least not as severe as has been alleged.

The recognition of these uncertainties is the foundation of the Administration's current global climate change policies. Up to now, the Administration has adopted a strategy of "multiple objective steps" or "no-regrets." Briefly, the "no-regrets" policy stipulates that whatever actions are taken in this area should make sense from an overall environmental/energy/economic perspective, so that if global climate change turns out to be less of a problem than has been initially thought, we need have "no-regrets."⁵

Because of the acute impact of any global climate change policy decisions on the DOE's programmatic responsibilities, the Department must take a leading role in the continuing elaboration, and presentation, of the Administration's response to global climate change. Concomitantly, it is essential that global climate change considerations do not come to drive the formulation of energy policy, particularly on the Hill. We must emphasize the continuing uncertainties in this area, and promote a rational response that takes into consideration not merely environmental imperatives, but also the realistic energy/economic needs of the United States. The possibility of global climate change cannot be ignored, but we must always keep in mind that the resources available to address environmental issues are limited.

Proposals for DOE studies that identify, analyze, and ultimately reduce the various uncertainties in this area should be fully supported.⁶ This will aid the Administration as a whole to get its message out, and will, hopefully, help to cope with the pressures that will be brought to bear on Congress to legislate a "quick-fix" solution.⁷ Moreover, there is a keen need to have more

⁵ Currently, this policy is enshrined in a number of efforts, including: The Montreal Protocol and London Agreements to reduce CFC emissions, current Energy Efficiency Standards, the America The Beautiful Initiative -- tree planting to create CO₂ sinks, the proposed controls on non-methane organic emissions from landfills, and the emission controls in the proposed Clean Air Act.

⁶ An option to intensify our research efforts is a part of the NES options package recently forwarded to the EPC.

⁷ In particular, we must avoid the erosion of the "no-regrets" policy, actively resisting efforts, for example, to adopt a "least cost" energy strategy defined as a program that would achieve maximum CO₂ stabilization and reduction. This is not an idle concern. Sentiments to this effect were expressed in the recent hearings on H.R.

of DOE's own studies, instead of merely reacting to analytical products generated by other entities.

Regardless of the substance of our global climate change policies, to promote effectively its interests, DOE would be well advised to intensify its cooperation with the industry and its allies on the Hill, e.g., the Senate Committee on Energy and Natural Resources. Experience of various intramural battles over the key Clean Air Act provisions demonstrates both that such cooperation can be invaluable, and that it cannot be fashioned at the last minute. A long educational campaign, involving DOE senior managers and public affairs officers, is in order.⁸

DOE, of course, is not the only concerned agency. Policies for handling greenhouse gas emissions will have a wide economic impact, and will seriously implicate the international competitive position of the United States. In particular, in addition to EPA, such policies will implicate the interests and responsibilities of the Departments of Agriculture, Commerce, State, Transportation, and of the Office of the U.S. Trade Representative, to name just a few. We must make it clear to these agencies that the approach we advocate -- addressing global climate change within the context of the overall energy and economic needs of the country -- is consistent with their own programmatic responsibilities and objectives.

Throughout this process, there are a number of basic policy points that both the Administration in general, and DOE in particular, must keep firmly in focus. First, in addition to preparing our own studies, we must continue to support outside scientific research into the existence, causes, and effects of global climate change in an all-out-effort to eliminate the uncertainties surrounding the issue. Until a problem is firmly identified and isolated, framing responses is a risky business at best.

Second, we must hold firm to our "no-regrets" policy. As noted above, until the uncertainties with respect to global climate change are adequately dispelled, our response should be driven by the achievement of tangible environmental goals, such as the reduction of fluorocarbon emissions into the atmosphere or the

5521, the "National Energy Policy Act of 1990," before the House Energy and Commerce Committee's Subcommittee on Energy and Power.

⁸ It is our impression that the industry, while being concerned about global climate change issues, is presently totally unequipped to deal with them. This situation mirrors the industry's attitudes toward the Clean Air Act issues.

creation of new forests to provide additional carbon sinks --all steps that also have an effect on global climate change patterns.

Third, and perhaps most importantly, we must continue to support an overall, truly global solution to the problem of climate change. Here it is essential to avoid a piece-meal approach. The issues involved are so intricately intertwined, that to attempt to address them one-by-one will (1) ultimately be unsuccessful, and (2) quite possibly leave the United States at a distinct disadvantage with respect to its global competitors. Any approach adopted must cover both "greenhouse" gases⁹ and emission sinks, and include as many other countries as possible.

C. International Developments.

Because of the very nature of global climate change issues, the international activities will be particularly important, and the most difficult to handle.¹⁰ Unilateral action by the United States, or by the United States and its allies, cannot solve the problem of global climate change. It will matter little if the industrial democracies, and even the emerging democracies of Eastern Europe, drastically slash their emissions, if the developing nations of the Third World continue to pump these gases into the atmosphere unrestrained. The problem can only be effectively addressed through widespread international cooperation in a comprehensive approach.

DOE should take a leading role in preparing the United States position in negotiations on global climate change, to ensure that American energy needs and economic growth strategies are adequately taken into account in any ultimate international agreements. The Department also must be prepared to promote United States views on the appropriate response to global climate change, particularly the importance of a comprehensive approach, the need for more research

⁹ These gases, in addition to CO₂, include methane, nitrous oxide, various naturally occurring "trace" gases, as well as the manmade CFCs that have been depleting the stratospheric ozone.

¹⁰ Both the domestic and international tracks of global climate change policies must be handled in a coordinated fashion. Moreover, we should be cognizant of the fact that a blunder in one arena might well complicate our position in another. For example, given our experience with congressional CFC legislation, it is likely that, should an international consensus to cap greenhouse gas emissions be formed, Congress would likely try to outdo this "accomplishment." We certainly cannot expect any relief on the domestic track in this area.

in this area before making an all out commitment of resources, and the need for an effective integration of energy and environmental concerns, in international fora. In particular, we must highlight the accomplishments of the "no-regrets" policy.¹¹

The Department also should continue to promote high-level contacts with the energy ministers and officials of other nations with like interests and concerns in this area, i.e., the USSR, China, Australia, the United Kingdom, and Japan. Negotiations for bi-lateral and multilateral agreements on energy matters provide an opportunity to advance the Administration's "no-regrets" policy, to solicit actively support for it, and to identify potential allies and opponents. Above all, the Department should work closely with the Department of State and EPA to draft an appropriate version of a Framework Convention on Global Climate Change, in addition to the research and analysis protocols.¹² Additionally, the Department must ensure that its interests are represented at the upcoming Second World Climate Conference (October 29-November 7).¹³

Unfortunately, crafting an international consensus in this area will be difficult. While all of the Earth's nations have an interest in avoiding sharp, long-term climate shifts, their short-term interests are often very different, and even diametrically opposed. This is particularly true in the area of "global warming." The basic problem is that, philosophical and scientific differences aside, any limitations on the emission of "man-made"

¹¹ For example, we should emphasize the benefits of not only "no-regrets" inspired reductions in the emission of greenhouse gases, but also the benefits of the additional greenhouse gas sinks that we are generating.

¹² The first negotiation session on the Framework Convention is currently scheduled for February, 1991. Here, it is particularly important to avoid a draft that will "lock us in" with respect to our subsequent policy options. In particular, we must avoid being put in the position of having to object to a document that has gained widespread international support. Therefore, an early and effective effort on our part is essential. In addition to the Framework Convention there are a number of other planned international activities with respect to global climate change, including the Second World Climate Conference.

¹³ While this conference is not an IPCC event, it ought to be handled carefully. An injudicious final document, if any, produced at such a conference will have an extremely negative impact on both our domestic and international efforts.

carbon dioxide into the atmosphere will not affect all members of the world community equally. Some nations, such as France -- which has already reduced its dependence on fossil fuels by heavy investment in nuclear power -- would enjoy a competitive advantage under a draconian regime of carbon dioxide emission reductions. Others, such as China and much of the developing world, would be put at a disadvantage, because they are still very dependent upon coal and petroleum as energy sources. Given our own dependence on fossil fuels, the United States, of course, also would be at a considerable disadvantage under a regime that drastically reduces the amount of carbon dioxide we can emit into the air.

Above all else, assuming that a major effort to reduce greenhouse gas emissions is launched, our solutions must be imaginative and innovative. A traditional command-and-control regime is simply not feasible on the international level. The world's nations have very different political and social traditions, as well as very different internal means of addressing environmental problems. Moreover, there is no effective, overall international means to force nations to comply with environmental standards -- save such cumbersome tools as UN economic sanctions.¹⁴

Any effective solution must take these matters into account.

Finally, national sensibilities must also be considered. This is particularly true with respect to the developing world, without which there can be no true solution to global climate change. Many of these countries have only recently achieved their own independence. These former colonies are not likely to welcome suggestions that their interests should again be subordinated to "metropolitan" concerns, without some very tangible environmental and economic benefits hanging in the balance.

Any solutions that are adopted also must take into account the very different economic positions of the various participants. It is, for instance, much easier for the United States to conserve fossil fuels, and to use alternative energy sources, than it would be for a developing country like China, which is heavily dependent for its energy on coal. Indeed, the developing world may well ask why they must now be good environmental citizens, when the developed world industrialized over the last two centuries with little or no regard for the environmental costs to the planet.

Therefore, solutions must be developed that will take into account the lack of an effective enforcement mechanism, national sensibilities and economic realities, while at the same time achieving a tangible environmental benefit. Incentive programs

¹⁴ Indeed, in this context, such sanction would likely make the problem worse, since even greater economic pressure would be placed upon the governments concerned to develop their resources as a matter of survival.

will be critical. Here, it is particularly important to establish an international market in greenhouse gas emissions. Under such a regime, once agreement is reached on appropriate limits on overall greenhouse gas emissions, countries could meet their goals by either reducing their own emissions, or by purchasing the right to exceed the agreed level from another country. The ultimate level of reduction in emissions will remain the same, but the burdens can be shifted and allocated through the interplay of the market's forces. Moreover, this approach would provide an incentive for countries to create an "exportable surplus" in emission rights, leading perhaps to an even larger overall decrease in emissions.

Such a system would provide particular benefits to the developing world. As EPA points out in its draft Economic Incentives report, there are many developing countries who would find it cost-effective to create exportable emission rights, particularly if credit is provided for the creation of carbon sinks -- by reforestation for instance -- as well as limits on emissions.¹⁵ At the same time, such a flexible market approach will allow developing nations, who are unable to meet emission control goals, to purchase emission rights in the market, avoiding the severe economic dislocation that might result if they had to alter drastically their sources of energy. Given its current leadership in innovative, market approaches to environmental protection, the United States is well positioned to be a global champion of these policies.

cc: Stephen A. Wakefield
Mark Schroeder

¹⁵

Allowing credit for such efforts would also, of course, benefit the United States, and other industrialized nations, who have already undertaken reforestation programs.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
Washington, D.C. 20503

MAR 08 1991

LEGISLATIVE REFERRAL MEMORANDUM

LRM #D-209

TO: Legislative Liaison Officer:

AGRIC-CR - Cindy Ayers (all testimony) - 447-9201 - 230
CEA - Francine Obermiller - 395-5036 - 242
CEQ - Larry Flick - 395-5750 - 256
COMMERCE - Michael A. Levitt - 377-3151 - 324
DEFENSE - Samuel T. Brick, Jr. - 697-1305 - 325
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NSC - William Sittmann - 456-6534 - 249
NSF - Charles H. Herz - 357-9435 - 248
OSTP - Damar Hawkins/Ken Yale - 456-6272 - 288
TRANSPORTATION - Tom Herlihy - 366-4687 - 226
USTR - David Weiss - 395-3475 - 223
SPACE COUNCIL - Liz Prestridge - 395-6175 - 309
HUD - Edward Murphy - 708-1793 - 215
EPA - Thomas C. Roberts - 382-5414 - 326

SUBJECT:

FYI - Attached is a copy of State testimony on
GLOBAL CLIMATE CHANGE CHANGE that will be given on
March 20th, 1991. This statement was previously
given on February 21st.

The Office of Management and Budget requests the views of your
agency on the above subject before advising on its relationship to
the program of the President, in accordance with OMB Circular A-19.
Please advise us if this item will affect direct spending or
receipts for purposes of the "Pay-As-You-Go" provisions of Title
XIII of the Omnibus Budget Reconciliation Act of 1990.

Questions should be referred to Holly FITTER (395-6194),
the legislative analyst for this bill, or to Robert
FAIRWEATHER (395-6827).

CC:

N. Hartness
R. Fairweather
H. Williamson
C. B. Gray
T. Follows

Ronald K. Peterson
RONALD K. PETERSON (for)
Assistant Director for

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To Holly
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(same as
2/21 testimony)

**Testimony of
ROBERT A. REINSTEIN
Deputy Assistant Secretary of State for
Environment, Health and Natural Resources
United States Department of State**

before the

**Subcommittee on Environmental Protection,
Committee on Environment and Public Works**

**United States Senate
March 20, 1991**

- 1 -

Thank you, Mr. Chairman. I am Robert A. Reinstein, the Deputy Assistant Secretary of State for Environment, Health and Natural Resources. I am also the United States negotiator for the proposed Framework Convention on Climate Change.

It is a pleasure to appear before this subcommittee to discuss the negotiations on a framework convention on climate change. I would like to discuss briefly with you the results of the negotiating session that just ended, the timetable for future sessions and the overall U.S. position in these negotiations.

Results of the First Session

At President Bush's invitation, the United States hosted the first session of these negotiations on February 4-14 just outside of Washington, DC. One hundred and one countries from every region of the world and representatives from over 20 international organizations, representing both developing and industrialized nations, participated in this session. Consistent with the open process that we sought, 68 non-governmental organizations (NGOs) also participated and will be able to provide input throughout the negotiations.

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Not content with merely hosting the first session, we entered these negotiations eager to move the discussion forward substantively. We had hoped to develop a draft negotiating text during this session, although we expected that such a draft text would have numerous brackets reflecting the differences in positions to be expected at the start of any negotiations. Compiling a bracketed text would have clarified the initial negotiating positions of the various parties, thus facilitating the negotiations in subsequent sessions. Towards this end, we distributed a number of documents explaining the U.S. perspective on the contents of a framework convention. Unfortunately, however, resolution of procedural matters left no time for consideration of substantive proposals at the first session. The difficulty in resolving even procedural issues indicates the complexity of this subject and the importance many countries, including the United States, attach to it.

We are confident, nonetheless, that the organization and procedures on which we agreed in this session will pave the way for steady, substantive progress in the sessions to follow:

- We agreed to organize two working groups, one which will consider all sources and sinks of all greenhouse gases, and one which will consider mechanisms of implementation of the convention. This structure will provide for a comprehensive discussion of the issues and will provide

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for full consideration of the concerns common to the negotiating parties.

- We adopted on Rules of Procedure which emphasize decision making by consensus and which will, as I have mentioned, allow NGOs to play a viable role in the negotiations. The United States was a forceful advocate of NGO participation.
- We also discussed ways to increase the participation of developing countries. These negotiations, and any long-term response to climate change, will be effective only if the broadest spectrum of nations participates. The United States was the first country to contribute to a voluntary trust fund established to support the participation of developing countries. The number of developing countries participating should increase in later sessions and they should now be able to send experts from their capitals.
- Working with other nations, the United States helped to produce an informal paper outlining the scientific, technical and economic research needs which the convention should address. This exchange of views should make it easier to conclude these sections of the convention at a later stage in the negotiations.
- We also reached agreement on the important role the Intergovernmental Panel on Climate Change (IPCC) will play in responding to the technical needs of the negotiations. With this mandate, the IPCC will be in a position to

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provide information and resolve questions of a technical nature during the negotiations.

Perhaps most importantly, we have laid the foundation for a cooperative relationship with other national delegations which will help to move the process along and will facilitate positive consideration of our position.

Next Sessions

This session was the first of four or five sessions of the negotiations established under the auspices of the United Nations General Assembly by Resolution 45/212 on the "Protection of Global Climate for Present and Future Generations." The next session is tentatively scheduled for the first two weeks of June in Nairobi. Following that session, we will meet in September, again in December, and in 1992, as necessary. The goal, as articulated in 45/212, is to complete the negotiations so that the framework convention will be opened for signature during the UN Conference on Environment and Development in June 1992 in Brazil.

The U.S. View on the Negotiations

The United States is approaching these negotiations with several principles in mind -- principles which are key to an effective convention and global response to climate change:

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- First, we believe we must take a comprehensive approach to climate change, one which considers all aspects of this complex issue and which addresses all greenhouse gases and their sources and sinks;
- Second, we must not wait for all uncertainties to be resolved, but must pursue economically efficient and cost-effective actions - already justified on other grounds - which will limit net greenhouse gas emissions;
- Third, we must continue to pursue aggressively scientific and economic research; systematic observation; collection, archiving and distribution of information; and technology development in order to resolve uncertainties and build a solid foundation for innovative responses;
- Fourth, we must recognize the special needs of the developing countries and design mechanisms for assisting them in securing the scientific and technical tools necessary for their fullest participation in a truly global effort.
- Fifth, any response must be global. Emissions from developing countries are growing rapidly. Action by industrialized nations alone would be ineffective at restraining emissions. We must also be sensitive to the ways in which different commitments could affect the competitive position of both developing and industrialized nations. An effective response will require that all nations participate and meet obligations that are appropriate to their circumstances.

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The United States will seek to translate these principles into an innovative and effective framework convention that will engage all nations in a concerted international response to climate change.

A Comprehensive Approach to Climate Change

The United States strongly supports a comprehensive approach, one which considers all sources and sinks of all greenhouse gases, for a number of reasons. This approach provides the flexibility needed for each nation to address climate change in the context of its unique circumstances. A comprehensive approach also ensures that research and technology development address all facets of the problem. Further, a comprehensive approach will ensure that we take advantage of the most cost-effective opportunities to address climate change across the range of sources and sinks of all greenhouse gases. The comprehensive approach accounts for all activities that emit or absorb greenhouse gases and avoids creating incentives that shift emissions from one type of gas or sector to another, as we know from experience can happen with narrowly focussed approaches. A comprehensive approach would allow each nation the flexibility to choose its best mix of response measures. Accordingly, the framework convention, and any subsequent legal instruments, must be comprehensive

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and deal with the full array of greenhouse gases and their sources and sinks. In addition, the IPCC First Assessment Report notes that both limitation and adaptation must be considered as part of an integrated response.

During the first session, the United States distributed a booklet and led an informal discussion on the comprehensive approach. We will continue this effort to engage in open dialogue with the international community about the rationale and implications of this approach.

Actions that are Justified in Their Own Right

The United States is already taking concrete measures that are justified in their own right, but that also have climate change benefits. As outlined in the brochure "America's Climate Change Strategy: An Action Agenda" which we distributed at the first session, this strategy will result in net U.S. greenhouse gas emissions in the year 2000 being equal to or below the 1987 level. These actions include:

- Phasing out chlorofluorocarbons (CFCs) and other ozone depleting compounds that are also greenhouse gases faster than required by the Montreal Protocol;
- Encouraging energy efficiency and reducing greenhouse gas emissions by capping sulfur dioxide emissions at substantially reduced levels while allowing utilities the

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flexibility to meet this cap in the most economically efficient manner possible;

- Reducing air pollutants which are greenhouse gases or greenhouse gas precursors, such as volatile organic compounds and methane;
- Initiating a program to plant a billion trees a year;
- Speeding the adoption of energy efficient technologies and practices in homes and businesses; and
- Promoting the use of, and research into, non-fossil fuel energy sources.

Role of the National Energy Strategy

The National Energy Strategy, echoing the recommendations of the IPCC, includes a number of actions that, although taken principally for other energy related reasons, will have significant environmental benefits, including curbing the buildup of future U.S. emissions of greenhouse gases. The strategy includes actions that provide cost-effective alternatives to burning fossil fuels for generating electricity and more efficient and alternative-fuel vehicles that will reduce greenhouse gases produced from transportation emissions.

Many of these NES actions are in addition to those described initially in the brochure "America's Climate Change

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Strategy: An Action Agenda." We believe that the United States climate change strategy must be flexible and capable of being modified as scientific and economic knowledge about climate change and potential responses is improved.

When all greenhouse gases are considered in terms of global warming potential, the National Energy Strategy, coupled with the existing Administration programs described in "America's Climate Change Strategy," will substantially curb the growth in these gases beyond the year 2000. The NES will allow us to hold emission levels within a range that is close to current levels well into the foreseeable future.

Consistent with our Climate Change Strategy and the NES, the framework convention could commit all nations to develop similar national strategies, emphasizing attention to actions that are warranted for other reasons and that also limit net greenhouse gas emissions. In light of the remaining uncertainties on global climate change and its effects, a global response of this nature will provide a realistic, prudent and cost-effective framework under which all countries can begin to implement measures with climate change benefits. At the same time, it recognizes that the appropriate measures available to different countries will vary depending on their social, environmental, and economic circumstances.

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Research and Systematic Observation

Research and systematic observation are essential to improving our understanding of climate change and helping us to tailor responses that are appropriate, efficient, effective, and sustainable over the long term. Research can also provide the needed energy-efficient technologies that are both economic and environmentally beneficial. For our part, we are pursuing a \$2 billion program of global change research and energy technology development that will provide the tools for devising innovative, long-term responses. Consistent with our own actions, the United States put forward an informal paper at the outset of the first session outlining a strong program of scientific and economic research and systematic observation that the framework convention could provide.

Implementation Issues

There are many other specific issues that must be addressed prominently in the framework convention. With regard to the developing countries, we recognize their desires and aspirations for economic growth. It is essential for developing countries to participate in any response to climate change in a manner that recognizes both their development needs and the greenhouse gas implications of such development. Thus, the framework convention should include a

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general commitment to promote financial assistance to developing countries to study and address climate change. Existing bilateral and multilateral financial-assistance mechanisms and, in particular, the newly established Global Environmental Facility in the World Bank are the appropriate mechanisms for providing such assistance.

Technology transfer is essential to any effective global response and there are many existing low-cost, effective technologies that can be transferred now. We stated in the first session our willingness to explore such ideas as energy efficiency centers and agricultural and forestry demonstration projects, as well as facilitating industry joint ventures with other countries to promote available technologies. Implementation of these concepts will need to be considered, of course, in the context of specific commitments to action. Special efforts will need to be made to match appropriate technologies to needs.

Over the long term, new technologies will play an increasingly important role in the response to climate change. Many of these technologies are still only ideas, or must undergo further development to become technologically and economically feasible. Therefore, the framework convention must provide the right incentives for continual research, development, and dissemination of relevant technologies.

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Since the private sector researches, develops and disseminates new technology most effectively, the framework convention should seek to remove barriers to effective commercial development and transfer of technology and should ensure that intellectual property rights are fully protected so as to provide the incentives necessary for continual development of new technology.

We should also discuss ways to transfer the knowledge necessary to understand, plan for and address climate change. The United States has traditionally provided a great deal of technical assistance in dealing with specific environmental problems, developing environmental institutions, and conducting country studies. During the first session, therefore, we stated that we are prepared to undertake, in cooperation with other nations, specific country studies to define appropriate technologies to reduce greenhouse gases. The NGO community, including the business community, also has an important role to play in this regard.

Conclusion

Mr. Chairman, procedural matters prevented us from developing a draft negotiating text during this first session, as we had hoped. Nonetheless, we agreed on a negotiating process which will promote an expeditious, open and unbiased

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discussion of the issues surrounding climate change. In the sessions that follow, the United States will continue to seek a framework agreement that is comprehensive, that recognizes the value of actions which help to address climate change and are justified on other grounds, that provides for a strong scientific and economic research program, and that recognizes the special needs of the developing countries. Rest assured that the United States will make every effort to conclude such an agreement before the June 1992 target date that we have endorsed. Such a convention is the crucial first step in what the United States realizes must be a sustained and long-term effort to address climate change.

Mr. Chairman, let me thank you again for the opportunity to appear before this subcommittee. I would be happy to answer any questions that you might have.

DRAFT TALKING POINTS ON GLOBAL CLIMATE

I. FRAMEWORK CONVENTION ON CLIMATE CHANGE THE FIRST NEGOTIATING SESSION

[Source: Reinstein testimony 3-5-91]

- o The United States hosted the first session of the negotiations for a framework convention on February 4-11, with one hundred and one countries from every region of the world and representatives from over 20 international organizations participating. 68 NGOs also participated.**
- o This session was the first of four or five sessions of the negotiations established under the auspices of the United Nations General Assembly by Resolution 45/212.**
- o We agreed to organize two working groups, one which will consider all sources and sinks of all greenhouse gases, and one which will consider mechanisms of implementation of the convention.**
- o We adopted on Rules of Procedure which emphasize decision making by consensus and which will allow for NGO participation.**
- o We also discussed ways to increase the participation of developing countries. The U.S. was the first country to contribute to a voluntary trust fund established to support the participation of developing countries.**
- o The U.S. helped to produce an informal paper outlining the scientific, technical and economic research needs which the convention should address.**
- o We also reached agreement on the important role the IPCC will play in responding to the technical needs of the negotiations.**

II. FRAMEWORK CONVENTION ON CLIMATE CHANGE FUTURE SESSIONS

[Source: Reinstein testimony, 3-5-91]

- o The next session is tentatively scheduled for the first two weeks of June in Nairobi.**
- o The following sessions will meet in September, December, and in 1992, as necessary.**
- o The goal, as articulated in 45/212 is to complete the negotiations so that the framework convention will be opened for signature during the UN Conference on Environment and Development in June 1992 in Brazil.**

III. FRAMEWORK CONVENTION ON CLIMATE CHANGE NEGOTIATION PRINCIPLES

[Source: Reinstein testimony, 3-5-91]

- o First, we believe we must take a comprehensive approach to climate change, one which considers all greenhouse gases and their sources and sinks.**
- o Second, we must not wait for all uncertainties to be resolved, but must pursue economically efficient and cost effective actions - already justified on other grounds - which will limit net greenhouse gas emissions.**
- o Third, we must continue to pursue aggressively scientific and economic research; systematic observation; collection, archiving and distribution of information; and technology development in order to resolve uncertainties and build a solid foundation for innovative responses.**
- o Fourth, we must recognize the special needs of the developing countries and design mechanisms for assisting them in securing the scientific and technical tools necessary for their fullest participation in a truly global effort.**
- o Fifth, any response must be global. An effective response will require that all nations participate and meet obligations that are appropriate to their circumstances.**

IV. ELEMENTS OF A FRAMEWORK CONVENTION

[Source: Reinstein testimony, 3-5-91]

- o A framework convention could commit all nations to develop national strategies, similar to our Climate Change Strategy and National Energy Strategy, recognizing that the appropriate measures available to different countries will vary depending on their social, environmental, and economic circumstances.**
- o A framework convention should include a general commitment to promote financial assistance to developing countries to study and address climate change. Existing bilateral and multilateral financial-assistance mechanisms and, in particular, the newly established Global Environmental Facility in the world Bank are the appropriate mechanisms for providing such assistance.**
- o A framework convention could include technology transfer, which is essential to any effective global response. Implementation of technology transfer will need to be considered, in the context of specific commitments to action. Special efforts will need to be made to match appropriate technologies to needs.**
- o A framework convention should seek to remove barriers to effective commercial development and transfer of technology and should ensure that intellectual property rights are fully protected so as to provide the incentives necessary for continual development of new technology.**

V. COMPREHENSIVE APPROACH

o Why is a CO2 target alone inappropriate?

[Source: Reinstein Qs & As, House 3-5-91, Senate 2-21-91]

(1) We believe a comprehensive approach, addressing the sources and sinks of all greenhouse actions. concentrating on just one greenhouse gas ignores the possibility of other, more cost-effective responses aimed at other greenhouse gases. The focus of environmental concern should be the net effect on radiative forcing, not emissions of any one gas. In fact, CO2 is the weakest greenhouse gas per kilogram.

(2) Focussing narrowly on CO2 could unintentionally increase emissions of other greenhouse gases. For example, an early response to a CO2 target would be fuel-switching from coal to natural gas. This would reduce CO2 emissions but increase methane emissions from distribution leaks of natural gas. Methane is a much more potent greenhouse gas than CO2 and even small methane leaks can offset large CO2 reductions. This problem could be important in many nations.

(3) Any response to climate change must be global if it is to be effective. Most proposal regarding a CO2 target would impose that target on industrialized countries immediately but delay its application to developing countries. Yet emissions are growing much faster in the developing world. Imposing restrictions only on industrialized nations is likely to be undercut by the relocation of emissions intensive activities to other countries.

(4) Imposition of restrictions on a few nations could cause significant distortions in the international competitiveness of those nations.

(5) The economic consequences of such targets are extremely uncertain. Projections of emissions are heavily dependent on expected growth rates. Should economic growth prove to be faster than expect, emissions will probably also grow faster than expected and meeting a target could prove to be prohibitively expensive, with potentially serious consequences for the world economy, including the development aspirations of developing countries.

(6) Climate change will occur over the long term. Any response must be sustainable over the long term and encourage all nations to develop plans of action that will carry us beyond the turn of the century. Most targets and timetable, however, focus only on the next ten to fifteen years.

(7) The environmental benefits of such targets are unknown because of scientific uncertainties about the strength, rate, and timing of climate change from a given change in GHG emissions. Given such uncertainties, we believe a flexible approach which focuses initially actions justified for other reasons is prudent.

(8) Rigidly imposing identical obligations does not adequately recognize the diversity of national circumstances. We must instead seek ways to build on the unique strengths of individual nations in devising the international response to climate change.

o Why the comprehensive approach?

Policy formulations need to match the underlying ecological systems they address. The optimal design for the climate change convention, and for any policy responses, would be a "comprehensive" approach that addresses all relevant trace gases, their sources and sinks. This approach has been discussed by United States officials in several papers. [Source: A Comprehensive Approach to Addressing Potential Climate

Change, A Report of the Interagency Task Force on Comprehensive and Incentives Approaches to Climate Change, January 1991, p. 12]

o In keeping with its commitment to a comprehensive approach, the United States has undertaken a set of policy measures that together constitute a comprehensive approach, addressing several radiatively active trace gases (RATGs), sources and sinks, and will keep U.S. contributions to radiative forcing at 1987 levels through the year 2000. [Source: A Comprehensive Approach to Addressing Potential Climate Change, A Report of the Interagency Task Force on Comprehensive and Incentives Approaches to Climate Change, January 1991, p. 12-13]

o The international reality: integration of physical and social science is making clear that a comprehensive approach to the complex global system is essential, addressing all the relevant trace gases, their sources and sinks. [Source: A Comprehensive Approach to Addressing Potential Climate Change, A Report of the Interagency Task Force on Comprehensive and Incentives Approaches to Climate Change, January 1991, p. 12]

o In August the Intergovernmental Panel on Climate Change (IPCC) stated in its Overview: "A comprehensive strategy addressing all aspects of the problem and reflecting environmental, economic and social costs and benefits is necessary." [Source: IPCC Overview, August 1990, p. 14 and A Comprehensive Approach to Addressing Potential Climate Change, A Report of the Interagency Task Force on Comprehensive and Incentives Approaches to Climate Change, January 1991, p. 12]

o In November, the government ministers at the Second World Climate Conference (SWCC) declared: "We recommend that in the elaboration of response strategies, over time, all greenhouse gases, sources and sinks be considered in the most comprehensive manner possible." [Source: Ministerial Declaration of the SWCC, paragraph 14, and A Comprehensive Approach to Addressing Potential Climate Change, A Report of the Interagency Task Force on Comprehensive and Incentives Approaches to Climate Change, January 1991, p. 12]

o What is the comprehensive approach?

[Source: A Comprehensive Approach to Addressing Potential Climate Change, A Report of the Interagency Task Force on Comprehensive and Incentives Approaches to Climate Change, January 1991, p. 2]

o It is an approach to structure consideration of climate change issues --- scientific, economic, and policy -- on a comprehensive basis, addressing all the human interactions with the climate system.

o It stands in contrast to the "piecemeal" approach currently dominating discussion, which focuses narrowly on emissions of one gas, carbon dioxide (CO₂), primarily from the energy sector, and omits other critical factors.

o It considers all of the significant human-influenced "radiatively active trace gases" (RATGs) that affect climate:

Carbon dioxide (CO₂)

Methane (CH₄)

Nitrous Oxide (N₂O)

Chlorofluorocarbons (CFCs), Hydrochlorofluorocarbons (HCFCs), and related substances

Tropospheric Ozone (O₃) and its precursors:

Nitrogen oxides (NO_x)

Carbon monoxide (CO)

Volatile organic compounds (VOCs or NMHCs)

o It focuses on "net emissions" (sources less sinks), the important variable for determining atmospheric concentrations.

VI. ACTIONS THAT ARE JUSTIFIED IN THEIR OWN RIGHT

[Source: Reinstein testimony, 3-5-91]

- o Phasing out chlorofluorocarbons (CFCs) and other ozone depleting compounds that are also greenhouse gases faster than required by the Montreal Protocol.**
- o Encouraging energy efficiency and reducing greenhouse gas emissions by capping sulfur dioxide emissions at substantially reduced levels while allowing utilities the flexibility to meet this cap in the most economically efficient manner possible.**
- o Reducing air pollutants which are greenhouse gases or greenhouse gas precursors, such as volatile organic compounds and methane.**
- o Initiating a program to plant a billion trees a year.**
- o Speeding the adoption of energy efficient technologies and practices in homes and businesses.**
- o Promoting the use of, and research into, non-fossil fuel energy sources.**

VII. ROLE OF THE NATIONAL ENERGY STRATEGY IN THE GLOBAL CLIMATE

o The National Energy Strategy (NES) includes a number of actions that, although taken principally for other energy related reasons, will have significant environmental benefits, including curbing the buildup of future U.S. emissions of greenhouse gases. [Source: Reinstein testimony, 3-5-91]

o Greenhouse gas emission reductions would be produced by the National Energy Strategy. These reductions are achieved by: (1) greater use of renewable energy and nuclear power and improved energy efficiency in both the electricity and the transportation sectors; and (2) other actions already taken by the United States (for example, the Clean Air Act Amendments of 1990). With all of these initiatives, the United States' contribution to potential global warming would, in the National Energy Strategy scenario, remain at or below present levels for the foreseeable future. While the accuracy of any future projections diminishes as the time horizon under consideration lengthens, the National Energy Strategy will significantly reduce greenhouse gas emissions relative to any current policy baseline. [Source: Executive Summary, National Energy Strategy, p. 19]

o If no actions were taken, emissions in the U.S. from one important greenhouse gas, CO₂, are projected to grow by 80% by the year 2030, according to one part of the NES scenario. Likewise, emissions of other greenhouse gases, such as methane, nitrous oxides and carbon monoxide, are projected to grow as well. [Source: Department of Energy Qs & As to Waxman 2-26-91 and Reinstein testimony, 3-5-91]

o Without the NES, greenhouse gas emissions, as measured in terms of global warming potential, are likely to increase by over 2.82 billion tons of CO₂ equivalents. This would be a 38.4 percent increase over the 1990 levels by 2030. [Source: Department of Energy Qs & As to Waxman, Reinstein testimony, 3-5-91]

o Carbon monoxide and Carbon dioxide. After 2015, increased use of alternative fuels, energy efficiency, renewable and nuclear energy will result in these emissions leveling off and remaining stable through 2030. [Source: Department of Energy Qs & As to Waxman, Reinstein testimony, 3-5-91]

o Methane. NES actions as well as EPA's regulations controlling methane from landfills, will reduce methane emissions below current levels through 2015. Further after 2015 annual methane emission from energy sources will continue to decline. [Source: Department of Energy Qs & As to Waxman, Reinstein testimony, 3-5-91]

o Nitrogen oxide and volatile organic compounds, precursors to tropospheric ozone that could lead to potential warming are held to levels that are about the same or below the 1990 levels and decline from 2015 to 2030. [Source: Department of Energy Qs & As to Waxman, Reinstein testimony, 3-5-91]

VIII. COMMITMENTS AND POLICES THAT OTHER NATIONS HAVE ADOPTED OR ARE PLANNING TO ADOPT TO REDUCE EMISSIONS OF GHGS

- o Many other industrialized nations have announced their intention to stabilize CO2 emissions by the turn of the century. A few of these, like Austria, Australia, Denmark, Germany and new Zealand, have stated further that they hope to reduce CO2 emissions by the Year 205. The baseline year used varies somewhat between countries. Baseline year used varies somewhat between countries. some of these nations, such as France and Japan, have adopted per capita targets that allow for continued growth in their overall emission. All major CFC producers have also committed under the Montreal Protocol to phase-out their production of ozone depleting substances, which also contribute to climate change. [Source: Reinstein Qs & As 2-21-91 House of Representatives, 3-5-91 Senate]
- o Canada proposes actions on several RATGs in several sectors, and terms the strategy a "comprehensive response" [Source: Canada's Green Plan (1990), p.97-108]. Other nations have announced proposals that address not only CO2 but also other RATGs. "Climate Change Policy in the Netherlands and Supporting Measures," Netherlands Ministry of Housing, Physical Planning and the Environment, D.G. for Environment, November 1990 (addressing CO2 sources and sinks, CFCs , and CH4); Cabinet Study Commission, Bonn, German, November 7, 1990 (addressing CO2 and CH4); "Action Program to Arrest Global Warming," Decision made by the Council of Ministers for Global Environmental Conservation, Government of Japan, October 23, 1990 (addressing CO2 sources and sinks, CH4, N2O). [Source: "A Comprehensive Approach to Addressing Potential Climate Change," A Report of the Interagency Task Force on Comprehensive and Incentive Approaches to Climate Change, footnote 6, p. 13.]
- o None of these countries has set quantified emission targets for any of the other greenhouse gases, such as methane, or for total global warming potential, except Australia, Iceland, and Canada. Meeting their CO2 targets could still allow an increase in emissions of methane e and other greenhouse gases more potent than CO2. Moreover, no developing or Eastern European nation, other than Poland, has set any emission targets. This is particularly significant in that these countries will probably account for over half of the greenhouse gas emissions by early in the next century. [Source: Reinstein Qs & As 2-21-91 House of Representatives, 3-5-91 Senate]
- o A review by EPA found that over twenty government have issued statements of intent to stabilize or reduce CO2 emissions by various target dates, most often the year 2000. Six countries intend to reduce CO2 emissions by 20 percent or more by 2005 or later years. The most aggressive targets have been set by Germany, which plans to achieve a 25 percent reduction by 2005 and an 80 percent by 2050 for both CO2 and methane. A few countries have made their intentions contingent on international agreement or on economic conditions. [Source: EPA Qs & As 2-19-91]

IX. INVENTORY OF CO2 AND OTHER GREENHOUSE GASES, BOTH WORLDWIDE AND FOR THE US

o The Intergovernmental Negotiating Committee recognized a global emissions inventory as high priority need for the IPCC to pursue during the next year. The IPCC Bureau met on February 15, 1990 to discuss the issue and requested that the U.K. develop a plan for review by the full IPCC in March. EPA has provide over \$150 thousand to support the development of a manual and workshop through the OECD. The Department of Energy h as also provided support. We expect that the report of February 18-21 workshop will enable the IPCC to move forward quickly during the coming months.

[Source: EPA Qs & As 2-19-91]

o The most important anthropogenic greenhouse gases worldwide, weighted according to their climate forcing potential are CO2 (approximately 55%), followed by methane (15%), chlorofluorocarbons (CFCs) (24%), and nitrous oxide (6%). Warming is also caused by the direct and indirect effects of other greenhouse gases such as carbon monoxide, and the interactive effects of other trace gases such as tropospheric ozone (produced by the chemical interactions of emissions of nitrogen oxides and volatile organic compounds) although the worldwide inventory is not yet accurate enough to compare their forcing potential to the gases above. [Source: IPCC, Climate Change: The IPCC Scientific Assessment, p.xx]

X. US GLOBAL CLIMATE RESEARCH PROGRAM (USGCRP) FY 1992

o The highest priority scientific and policy-related issue for the USGCRP in FY 1992 is whether, and to what extent, human activities are changing or will change the global climate system.

[Source: Our Changing Planet: The FY 1992 U.S. Global Change Research Program, A Supplement to the US President's Fiscal Year 1992 Budget, p.9]

o The President's FY 1992 Budget requests \$1186 million for the USGCRP. This represents an increase of \$232 million, or 24.2 percent, over the FY 1991 level. [Source: Our Changing Planet: The FY 1992 U.S. Global Change Research Program, A Supplement to the US President's Fiscal Year 1992 Budget, p.3]

o The Committee on Earth and Environmental Sciences (CEES) relied on the results of the Scientific and Impacts Assessments of the Intergovernmental Panel on Climate Change (IPCC) in developing the FY 1992 Program. [Source: Our Changing Planet: The FY 1992 U.S. Global Change Research Program, A Supplement to the US President's Fiscal Year 1992 Budget, p.9]

o The USGCRP identified four high priority Integrating Themes for FY 1992:

- (1) Climate Modeling and Prediction
- (2) Global Water and Energy Cycles
- (3) Global Carbon Cycle
- (4) Ecological Systems and Population Dynamics

[Source: Our Changing Planet: The FY 1992 U.S. Global Change Research Program, A Supplement to the US President's Fiscal Year 1992 Budget, p.2]

o Using the integrating themes, the collective efforts of government and academic scientists focus on:

(1) Developing an improved predictive capability of the Earth as a coupled system with enhanced regional resolution.

(2) Improve the understanding of the water and energy cycles by focusing on the role of clouds, oceans, terrestrial ecosystems, and changes in sea level.

(3) Improve the understanding of the carbon cycle by quantifying sources and sinks, the processes that control them, and how the processes may influence and be influenced by global change.

(4) Improve the capacity to assess the effects of global change at regional scales on intensively managed and natural terrestrial and oceanic ecosystems.

[Source: Our Changing Planet: The FY 1992 U.S. Global Change Research Program, A Supplement to the US President's Fiscal Year 1992 Budget, p.2]



U.S. Department of Justice

Environment and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

3/8/91

FAX NUMBER

(202) 514-0557

(FTS) 368-0557

CONFIRMATION NUMBER

(202) 514-2701

(FTS) 368-2701

FROM:

J. Wiener

NO. OF PAGES:
(INCLUDING
COVER PAGE)

9

TO:

Jeff Holmstead

TELEPHONE NO:

456-7953

FAX NO:

456-7929

MESSAGE:

Our comments on State's
draft US submission
re Climate Convention.PLEASE NOTIFY SENDER IMMEDIATELY IF YOU HAVE ANY PROBLEMS
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U.S. Department of Justice

Environment and Natural Resources Division

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Office of the Assistant Attorney General

Washington, D.C. 20530

March 7, 1991

MEMORANDUM

TO: D. Allan Bromley
Assistant to the President
for Science & Technology
Chair, DPC Global Change Working Group

FROM: Dick Stewart *DS*
Assistant Attorney General
Chair, Task Force on Comprehensive and Incentive
Approaches to Climate

SUBJECT: Draft "Submission of the United States" to the
Framework Convention on Climate Change

Thank you for the opportunity to review the State Department's thoughtful draft submission. It is a useful document that embodies much of the U.S. approach to addressing potential climate change. We suggest the following modifications.

In the Preamble:**In point (a):**

We are somewhat concerned about the legal meaning of "common concern of the international community" and its relation to the term "common concern of mankind," which latter term, we understand, may be developing particular significance in customary international law. We would prefer not to tie the climate convention to others' understandings of these terms. The key ideas can be expressed more precisely as follows:

(a) recognize that climate change is a global phenomenon: that greenhouse gas sources and sinks exist in virtually all areas of the globe, that greenhouse gases tend to mix globally in the atmosphere no matter where they are emitted and that it is their joint and cumulative effect that are of interest, that impacts of climate change would be felt globally, and that any action to prevent climate change would require global cooperation and participation.

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In point (c):

We suggest paraphrasing, spelling out or quoting from Principle 21 of the Stockholm Conference, referring to nations' sovereign autonomy over their internal management and simultaneous responsibility not to damage the global environment.

We suggest adding a new tick after point (c):

(c.2) recognize the interdependence of environmental protection and economic growth -- investment in environmental quality depends on economic growth, and long-term economic growth depends on sustaining natural resources -- and the need to pursue strategies of global stewardship that advance both these goals.

This point is important in many respects, including the general need to avoid impairing economic growth and the more specific need to encourage better resource use practices (e.g. land use) in many, chiefly developing, countries.

In point (d):

This point could be made stronger by rephrasing as follows:

(d) recognize, welcome and encourage measures that are already being taken or have already been taken at the national, regional and international levels that help address issues of climate change, including relevant national actions and actions taken pursuant to the Vienna Convention... and the Montreal Protocol..., the Global Forestry Agreement, and other international agreements.

This phrasing would better ensure that actions under other agreements and national policies count toward any efforts (whether voluntary or obligatory) under the climate agreement, in order not to discourage such other related actions.

Add a new point after point (d):

(d.2) recognize that different nations have different social, economic and other circumstances, including different sets of net greenhouse gas emissions, and will accordingly need flexibility in the choice of any response options;

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In point (g):

Add the words indicated below:

strategies to understand and address climate change will be most environmentally effective and most economical if they address all sources and sinks of greenhouse gases and their precursors comprehensively,

The word "reservoirs" is deleted here because it is a stock variable not a flow variable; because we suggest including it in the definition of "sinks" (see below); and because it adds some confusion to the now well-accepted definition of the comprehensive approach: "all GHGs, sources & sinks."

Add a new point after point (g):

(g.2) recognize that each gas has a different impact on climate change (different radiative forcing), as well as other important environmental effects, all of which need to be taken into account in selecting sound response strategies

In point (i):

This tick offers the chance not just to defend against an extreme version of the "precautionary principle," but to affirmatively and intelligently define our view of decisionmaking under uncertainty. We suggest rewriting as follows:

(i) reaffirm that decisionmaking under uncertainty requires assessment of the likelihood and severity of harms and of the likely costs and effectiveness of various response options; that where there are threats of serious and irreversible damage, lack of full scientific certainty does not warrant inaction, but rather counsels intelligent selection of prudent response options and aggressive pursuit of better understanding; that where environmental problems are poorly understood, hasty choice of actions may miss or even worsen the true problems, and that obtaining better information is a critical and environmentally essential strategy in the face of great uncertainty.

Certainly the current text should be edited by deleting from "to mitigate" to the end, and adding "and the costs of such measures." The current text omits reference to the costs of response options.

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In the Definitions:

In "Climate," line 2, replace "of" with "such as."

In "Climate change," line 2, replace "attributed" with "attributable."

In "Greenhouse gases," line 3, should "emission" be replaced with "transmission"? The use of "emission" in other contexts in this convention could make its use here confusing.

In "Sinks," add at end ", including reservoirs that store greenhouse gases and their precursors." This is important because the phrase "net emissions" is defined as "sources minus sinks." Also, reservoirs are stocks not flows; gases escaping from a reservoir -- such as CFCs being slowly released from abandoned refrigerators, or methane released from thawing tundra -- would fit the definition of "sources." At the same time, action to understand reservoirs and to prevent such escape -- such as by recapturing the CFC reservoir -- should be encouraged. Hence we endorse including reservoirs in the convention but suggest referring simply to "sources and sinks" in the "net emissions" definition.

A new item should be added before the GWP definition:

"Greenhouse gas index" is a measure of the relative environmental impact of each unit of a trace gas added to the atmosphere.

This definition is important (i) because the key word "index" is not defined in the GWP definition; (ii) because a general definition of a comparative measure is important to explain why an index is useful to decisionmakers (the GWP definition is technically accurate but does not explain its importance) -- namely as a guide for optimal decisionmaking and the critical tool needed to allow nations flexibility in their choice of response actions; and (iii) because experts may now or in the future develop useful variations on the GWP formulation, to which the convention should remain hospitable.

In "Cooperative arrangement," line 2, delete "s" on the end of "cooperates". In line 3, replace "or any protocol thereto" with "or any subsidiary instrument."

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In General Obligations:

Paragraph 1, bottom of p. 3:

In line 1, after "provide," insert "mechanisms for developing".

In line 2, replace "developing" with "formulating".

In lines 7-8, delete "and any protocol thereto".

Top of p. 4:

In line 2, delete "the sources, sinks and reservoirs" and replace with "net emissions". Enumeration of "sources, sinks and reservoirs" could suggest treating each separately; the term "net emissions" is defined above and ensures the desired flexibility.

In lines 3-5, after "comprehensively," delete "taking into account" and replace with "employing".

In line 4, replace "warming" with "gas" (to track the more general definition suggested above).

In line 5, following "index" on line 4, delete "('GWP')", and insert ", the most recent example of which is attached as Annex A to the Convention, and also taking into account other environmental impacts of the gases."

In line 5, after "index ... Annex A to the Convention" [as just indicated], end the sentence. Then delete "and should provide for" and begin next sentence with: "The Convention should enable and encourage Parties to fashion".

At end of paragraph on top of p. 4, add:

The Convention should recognize and encourage actions taken by nations that help address climate change, including national actions and actions under other international agreements.

Items

In item (a):

In line 3, after "changes in the global climate" add ", their impacts,".

In item (b):

Change "in their own right" to "in the face of current uncertainty". That is a better explanation of decisionmaking under uncertainty, and still preserves

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autonomy for each nation to exercise its considered judgment.

In item (c):

After "develop" add "and publish" or "and share".

In item (d):

After "climate change" add: ", and publish an accounting of the elements of the strategy and the effect of such strategy on net emissions of greenhouse gases (employing the most recent IPCC greenhouse gas index).

In item (e):

After "assessments" add ", by the IPCC and other competent bodies,". Delete "and" at end of line 2.

Add a new item after (f):

(f.2) cooperate in programs to improve measurement of net greenhouse gas emissions, including field studies, remote sensing, data sharing, and development of factors or surrogates for difficult-to-measure emissions and sink removals;

In item (h):

At end, add ", including on research to promote understanding of scientific and economic aspects of climate change, its causes, impacts, and response options".

Add an item (i):

(i) enter into cooperative arrangements to achieve any of the obligations of this Convention, or its subsidiary instruments, as the cooperating Parties find mutually satisfactory.

In the paragraph on the bottom of p. 4:

In line 8 (2nd line from bottom), replace "protocol" with "subsidiary instrument".

At end on last line, add:

The Convention and subsidiary instruments should also recognize and count the effect on net greenhouse gas emissions of relevant actions taken under national policy and other international agreements.

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In Research, Systematic Observations, and Information Exchange:

We should be sure to suggest that the "information exchange" include information on: net emissions inventories, their component elements, and information on emissions and removal rates for various sources and sinks; means of measuring emissions and sink removal; and national strategies, including actions taken, costs and effectiveness.

The second paragraph could be strengthened to defuse objections we can expect to hear: to explain the great importance of the research & information annex; to note its similarity to the Vienna Convention science annex; and to distinguish its role from that of the IPCC.

In Assessment and Consideration of Response Measures:

In the opening paragraph: We should explain or reference our rationale here. Hence delete "Rather than", capitalize "Specific,", and add at end of line 1 after "reductions":
should not be required because of the need for flexibility in nations' choice of their own measures rather than international edict: nations vary considerably in their economic, social and other circumstances and different steps will be more environmentally effective and more economical in different nations. Further, there is a real need for further analysis of the costs and benefits of international responses, at the same time that prudent steps may be taken by nations even in the face of great uncertainty.

In item (a):

At end add: "and on other aspects of the environment;".

In paragraph on the top of p. 6:

In line 2, after "to update" add "and publish".

Items (a)-(c) seem redundant given the "General Obligations" to take these actions. Moreover, placing them here implies that Parties will be obliged in advance to take actions that will be identified in the future by the Assessment of Response Strategies function of the Convention. A better approach might be to leave these items (a)-(c) out here and to address the question of updates at a future date. Or, a more general item could be used here obliging the parties to "update their net emissions inventories, national strategies and cooperative arrangements

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regularly in light of the ongoing Assessment of Response Strategies and other research."

In the last paragraph under this section, lines 3-4, replace "take into account the most recent IPCC GWP" with "employ the most recent IPCC greenhouse gas index."

SUBMISSION OF THE UNITED STATES

The United States welcomes this opportunity to provide its views on the elements to be included in a framework convention on climate change. We believe that the Legal Measures paper of Working Group III of the Intergovernmental Panel on Climate Change (IPCC) provides a good starting point for discussions within the Intergovernmental Negotiating Committee (INC). The work of the INC has also been facilitated by United Kingdom's submission of a draft framework convention that reflects the consensus elements of the IPCC Legal Measures paper in the form of a legal text. We offer the following views on elements that should be included in a framework convention on climate change:

Preamble

The IPCC Legal Measures paper and the UK draft convention contain many appropriate preambular clauses. In particular, the preamble should:

(a) acknowledge that climate change is a common concern of the international community;

(b) recall the relevant resolutions of the United Nations General Assembly, particularly resolution 45/212;

(c) recall relevant declarations, such as the Ministerial Declaration of the Second World Climate Conference, the Bergen and Noordwijk Ministerial Declarations, the Declaration of the 1990 Houston Economic Summit and principle 21 of the Declaration of the United Nations Conference on the Human Environment (Stockholm 1972);

(d) recognize the interdependence of environmental protection and economic growth, and the need to pursue strategies of global stewardship that advance both these goals;

(e) recognize, welcome and encourage measures that are being taken or have already been taken at the national, regional and international levels that help address issues of climate change, including relevant national actions and actions taken pursuant to the Vienna Convention for the Protection of the Ozone Layer, the Montreal Protocol on Substances that Deplete the Ozone Layer and other international agreements;

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(f) recognize that different nations have different social, economic and other circumstances, including different sets of net emissions, and will accordingly need flexibility in the choice of any response options;

(g) acknowledge the important scientific work that has already taken place, particularly that of the IPCC and other international bodies (e.g., the World Meteorological Organization (WMO), the United Nations Environment Program (UNEP), the International Council of Scientific Unions (ICSU), the International Geosphere-Biosphere Program (IGBP) and the Intergovernmental Oceanographic Commission (IOC));

(h) endorse further scientific research and systematic observation and further study of possible social and economic impacts of climate change, and of measures that might be used to address them;

(i) recognize that strategies to understand and address climate change will be most environmentally effective and most economical if they address all sources, sinks and reservoirs of greenhouse gases and their precursors comprehensively, are based on, and continually reevaluated in light of, relevant scientific, technical, and economic considerations, and are as equitable and economically efficient as possible.

(j) recognize that each greenhouse gas has a different impact on climate change, as well as other important impacts on the environment, all of which need to be taken into account in selecting sound response strategies;

(k) stress the need for all nations to participate in any international responses to climate change, in accordance with the means at their disposal and their capabilities;

(l) reaffirm that where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures, commensurate with the extent and likelihood of the adverse impacts and reflecting the costs and benefits of such measures, to understand, limit, reduce, facilitate adaptation to, and, as appropriate, prevent the adverse impacts of climate change;

Definitions

Following are definitions of terms used in this submission, which could be included in the convention:

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"Climate" means the average weather (including its appropriate components, such as temperature, precipitation and wind) over a period of years, together with the natural variations of those components.

"Climate change" means the variation in the climate beyond what is attributable to natural variability.

"Impacts" means effects on human health, economic activity, social systems, water resources, agriculture, sea levels, and natural and managed ecosystems.

"Greenhouse gases" means gases which alter the radiative transmissive properties of the atmosphere, principally through impeding the emission of long-wave terrestrial radiation.

"Greenhouse gas precursors" means substances that interact in the atmosphere to produce greenhouse gases indirectly or that prolong the atmospheric lifetimes of greenhouse gases.

"Greenhouse gases and their precursors" means greenhouse gases and greenhouse gas precursors.

"Sinks" means all anthropogenic and biogenic activities and processes that remove greenhouse gases and their precursors from the atmosphere.

"Sources" means all anthropogenic and biogenic activities and processes that lead to greenhouse gases and their precursors being emitted into the atmosphere.

"Reservoirs" means storage media for greenhouse gases and their precursors.

"Net emissions" means emissions from sources minus removals by sinks.

"Greenhouse warming potential index ('GWP')" is an index that defines the time-integrated warming effect due to the release of a unit mass (1 kg) of a given greenhouse gas relative to that of carbon dioxide.

"Cooperative arrangement" means any arrangement whereby any group of two or more countries cooperates together to achieve the objectives of the convention or any subsidiary instrument.

General Obligations

The framework convention should provide mechanisms for developing the scientific, technical, economic and

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environmental bases for formulating and implementing, as appropriate, measures to address the potential modification of climate caused by greenhouse gases and the possible adverse impacts therefrom. It should require the Parties to develop and pursue, in accordance with the provisions of the convention and to the extent deemed desirable in light of the scientific, technical, economic, and environmental bases outlined above, appropriate measures that prevent, limit, reduce, or facilitate adaptation to climate change. The Parties, in developing and taking such measures, should address the net emissions of all greenhouse gases and their precursors comprehensively, taking into account the best available greenhouse warming potential index ("GWP") and other environmental impacts of the gases. The framework convention should enable the Parties to fashion economically efficient and effective implementation, including through the use of cooperative arrangements. It should also recognize and encourage actions taken by nations that help address climate change, including national actions and actions under other international agreements.

To these ends, the Parties should:

- (a) cooperate in systematic observations, research and information exchange to better monitor, understand, and predict changes in the global climate, their impacts, potential responses thereto and the costs and benefits of such responses;
- (b) adopt ~~measures~~ ^{which} which are justified ^{for a variety of reasons and} ~~in their own right~~ that ^{which} ~~could~~ have the effect of limiting or adapting to ^{any} ~~the~~ adverse impacts of climate change; ^{also}
- (c) develop and make public national inventories of net emissions, using an agreed methodology that is developed in light of the work of the IPCC;
- (d) establish national strategies to address and facilitate adaptation to climate change and make public an accounting of the elements of the strategy and the effect of such strategy on net emissions; ^{mitigation and}
- (e) base any additional responses on thorough assessments, by the IPCC and other competent international bodies, of climate change and potential responses to that change;
- (f) cooperate in promoting public awareness of climate change;
- (g) encourage the development and transfer of relevant technologies, as well as the provision of technical and financial assistance, to facilitate the fulfillment by the developing countries of their obligations;

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(h) cooperate with competent international bodies.

The article on general obligations should include a provision in which the Parties agree that, in developing and implementing measures pursuant to the convention or any subsidiary instrument, they should take into account other types of environmental impacts that such measures could have. In addition, the convention should provide the opportunity for Parties to meet their obligations under the convention and any subsidiary instrument through bilateral, multilateral or regional cooperative arrangements. The Convention and subsidiary instruments should also recognize and count the effect on net greenhouse gas emissions of relevant actions taken under national policy and other international agreements.

Institutions

The articles of the UK draft convention establishing a conference of the parties and a secretariat (UK draft articles 6 and 7) are generally acceptable. However, whereas the UK draft provides that the interim secretariat would be provided by UNEP, we believe that both UNEP and WMO should provide interim secretariat assistance.

Research, Systematic Observation, and Information Exchange

A strong program of research, systematic observation and information exchange must be a cornerstone of the framework convention. An aggressive effort to obtain better information is an environmentally essential strategy that will help the international community to tailor response strategies that are appropriate, effective and sustainable over the long term.

The research and systematic observation article (Article 3) and information exchange article (Article 4(1)) of the UK draft convention provide a good starting point for convention text on research, systematic observation and information exchange. The Parties' obligations should extend to scientific, economic and social research, and the Parties should consider both the social and economic costs and benefits of changes to the global climate and of potential responses to those changes. The information exchange provisions of the framework convention should include information on net emissions inventories, emissions and removal rates for various sources and sinks, means of measuring emissions and sink removal, and national strategies, including actions taken, costs, and effectiveness.

During the first meeting of the INC, scientists from several delegations held informal meetings, under the

chairmanship of Dr. A. Baede of the Netherlands delegation, to develop an inventory of priorities for research, systematic observations, assessments and information exchange. This informal work could provide a useful starting point for the preparation of annex to the framework convention concerning research and systematic observation and information exchange.

Assessment and Consideration of Response Measures

Specific commitments for emissions reductions should not be included in the framework convention, because of the need for flexibility in nations' choices of their own measures. Further, there is a real need for further analysis of the costs and benefits of international responses, at the same time that prudent steps may be taken by nations even in the face of great uncertainty. Accordingly, the framework convention should include an article on assessment and response measures that is modelled on Article 6 of the Montreal Protocol on Substances that Deplete the Ozone Layer and that requires the Parties to periodically assess the available scientific, technical, and economic information with respect to:

- (a) the effects of emissions of greenhouse gases and their precursors on the climate;
- (b) the possible impacts of such effects; and
- (c) possible response measures that could be taken at the national, regional, and/or international levels.

As part of this work, the Parties should be required, as necessary, to update and to make public, using a standardized methodology developed in light of the work of the IPCC and other competent international bodies, national inventories of all sources and sinks of greenhouse gases and their precursors.

In light of this work, the Parties would be obligated:

- (a) to update national, regional, and international strategies and policies to limit, reduce, facilitate adaption to, and as far as appropriate, to prevent the adverse impacts of climate change, in accordance with the provisions of the convention and any subsidiary instrument;
- (b) to update programs for research, systematic observation, information exchange, and the development and transfer of technology and knowledge;

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(c) to consider and undertake any additional action that may be appropriate in light of the purposes of the convention.

In the assessment and consideration of response measures, and in particular, in the development of national, regional and international response strategies, the Parties should take into account the best available GWP. In addition, the Parties should consider, in consultation with the IPCC and other relevant international bodies, whether the GWP should be revised at some future date.

Development and Transfer of Technology

Article 4(2) of the UK draft convention addresses the development and transfer of technology and is generally acceptable. It provides that the Parties, consistent with their national laws, regulations and practices, shall cooperate in promoting, directly or through competent international bodies, the development and transfer of technology and knowledge relevant to scientific and technical research. The UK draft provides for such cooperation through the supply of necessary equipment and facilities for research and monitoring and through appropriate training of scientific and technical personnel.

Settlement of Disputes and Compliance

We note the suggestion in the IPCC Legal Measures paper that dispute settlement provisions similar to those in the Vienna Convention for the Protection of the Ozone Layer might be employed in the framework climate convention. This suggestion is reflected in Article 11 of the UK draft convention and in Annex III thereto. We believe that it is important that all parties comply fully with the obligations that they undertake in the framework convention and any subsidiary instrument thereto. Dispute settlement provisions are one means of achieving such objective, as are other mechanisms, such as the compliance procedures developed by the parties to the Montreal Protocol. To be most effective, however, such procedures and mechanisms should be tailored to specific obligations contained in a given agreement. Accordingly, these questions should be considered after the INC has reached agreement on the substantive obligations to be included in the framework convention.

Final Clauses

The final clauses contained in the UK draft convention (Articles 8-10 and 12-21) are generally acceptable. However,

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we believe that the procedures for entry into force of protocols, amendment of protocols, and withdrawal from protocols, as well as the provisions relating to the proposal, adoption, and entry into force of annexes to protocols, should be left to any such protocol. This would permit the Parties to tailor those provisions to any particular protocol.

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