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POLICY APPROACHES FOR CONTROLLING GREENHOUSE GASES

Prepared for
Energy Research Group

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POLICY APPROACHES FOR CONTROLLING GREENHOUSE GASES¹

by

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I. INTRODUCTION

Concern for global warming and the "greenhouse effect" has been thrust onto the public agenda. President Bush highlighted global warming as one of the key environmental issues of his administration, and numerous commentators have joined the chorus. A bill to control greenhouse gases--including a proposal to use a CO₂ tax as one of the control levers--was introduced in the last Congress and reintroduced this year. Given the large revenues that such a tax might raise, global warming might also figure into congressional deliberations on deficit reduction.

Although the public, through its elected officials, seems intent on "doing something" about global warming, there are surprisingly few analyses of policy options. Many scientific studies have assessed whether a warming trend is taking place and, if so, what are the causes. (See Abrahamson 1989 for a summary of recent evidence.) Despite disagreements among scientists on these issues, these studies have been the catalysts for public concern. Other studies have described the impacts that a warming trend would have on different parts of the world (see Abrahamson 1989).

Economists and policy analysts have provided economic frameworks for evaluating policy alternatives in light of the scientific evidence. (See Nordhaus 1982, Schelling 1983, and Lave 1988.) In addition, several authors have provided specific recommendations for actions to reduce greenhouse gases, including reduced dependence on the fossil fuels that generate CO₂ and other gases linked to global

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fuels altogether. (See e.g., Lovins 1981, Mintzer 1988, Mintzer 1987, Moomaw 1988, and Schneider 1987.) None of these studies, however, has evaluated alternative policy approaches to reduce greenhouse gases, including the CO₂ tax initiative already proposed in Congress.

A. Objectives

This paper is not designed to address the scientific issues regarding global warming and the decision whether or not to take action. Nor does it consider alternative policies to accommodate the economic changes that might occur as a result of global warming (e.g., changes in electricity requirements). (See, e.g., Starr 1988.) Rather, this paper begins with an assumption that greenhouse gases are to be reduced in the U.S. and asks the question--how should this reduction be accomplished? Should the U.S. rely upon the traditional "command-and-control" approach in which the government sets specific control requirements? Or, should the U.S. adopt an economic incentive approach, such as the CO₂ tax introduced in Congress or a marketable permits scheme that has been suggested for chlorofluorocarbons?

Answering these questions in detail requires an empirical study. However, we can learn much from our background in pollution control--theory, empirical studies, and past successes and failures--about the efficiency and distributional properties of various approaches. Moreover, this background provides a structure for identifying the information we need for an empirical study.

Although this paper focuses on greenhouse gases, these lessons are applicable to other environmental problems. Indeed, there is increasing interest in the economic incentive approach. For example, two U.S. Senators from opposite poles of the traditional regulatory spectrum have sponsored a report calling for widespread use of economic incentives to deal with problems as diverse as acid rain

and municipal trash (Stavins *et al.* 1988). The New York Times has reported that their support confers a new political legitimacy on the economic incentive approach and that environmental groups are increasingly interested in the approach (Passell 1988). As further evidence, the U.S. Environmental Protection Agency (EPA) recently released a report documenting the enormous potential cost savings from allowing utilities flexibility in reducing their SO₂ emissions as part of an acid rain control program (ICF Resources Inc. 1989). This greater political acceptability suggests that economic incentives will move out of the academic realm and into the world of serious policy debate. There is, therefore, even greater need to identify their advantages and disadvantages both in theory and in practice.

B. Organization of the Paper

This paper is therefore organized as follows. In Section II, we summarize the major policy alternatives. Section III describes the principal evaluative criteria and assesses the strengths and weaknesses of the alternatives. Section IV discusses the key information needed to implement and evaluate the alternatives in practice. The final section summarizes the conclusions.

II. POLICY ALTERNATIVES

Environmental policy consists of two principal elements. The first is the setting of ambient goals. For example, the Clean Air Act establishes criteria for ambient air quality that are then translated through administrative rulemaking by the Environmental Protection Agency (EPA) into specific ambient air quality standards.

The second element is the translation of ambient goals into specific emission limitations for individual sources. For air pollutants, the EPA sets specific emission limits on new sources (e.g., new power plants) and the states set limits on existing sources that, in theory, lead to compliance with the ambient standards.

Our principal concern is with the second element, the setting of individual emission standards. The major choice is between mandatory controls--in which the government sets specific emission limits for each source--and the economic incentive approach that allows individual firms to set their own emissions in response to prices. (See Lave 1981 for a general discussion of regulatory alternatives.) Two versions of the economic incentive approach are usually identified--an emission tax in which price is set directly, and a quota or permits scheme in which price is set indirectly through competition for a limited number of emission permits. In addition to these three alternatives, it is useful to add a fourth "regulatory reform" option consisting of recent EPA reforms of the mandatory controls approach.

A. Mandatory Controls

The dominant policy approach in the U.S. is to set technology-based emission standards for major emission sources. These emission standards specify the maximum amount of pollution permitted, usually expressed as a per unit of output or input. For example, the nitrogen oxides (NOx) standard proposed for existing power plant boilers in the South Coast Air Basin (Los Angeles) is 0.03 tons of NOx per million Btus (South Cost Air Quality Management District 1988).

The set of emission standards that has evolved is complex but has a relatively simple technology-based logic. Standards for both new and existing sources are based primarily on the "availability" of control technology. For example, the proposed NOx standard for existing Los Angeles power plants was based upon the use of selective catalytic reduction at each plant. Standards for new plants are typically more stringent because of the possibility of incorporating the latest technology.

The logic for allocating standard-setting responsibility between governments is primarily political. New sources are controlled directly by the federal government--on the theory that states or regions should not compete for industry by allowing higher limits--while existing sources are controlled by the states as part of their state implementation plans (SIP) for each airshed within their jurisdiction.

Economics plays a role in the standard-setting process, but distributional impacts rather than economic efficiency are usually the motivating concern. Most pollution control laws require that emission standards be economically achievable. In practice, this means that discharge standards for industries cannot be set at such a stringent level that a nontrivial number of plants would close or lay off substantial numbers of workers. Even when a comparison of benefits and costs might justify additional controls, such controls would not be required if the industry could not afford them.

The process of setting emission standards for major industries has often been characterized by brinkmanship and litigation. Congress typically sets specific timetables for promulgating standards which encourages tough bargaining and brinkmanship as the deadline approaches. For example, in the 1970 Clean Air Act, Congress required EPA to set standards to reduce auto emissions by 90 percent by the 1975-76 model years. As the deadline for meeting the standard approached--and the EPA faced the possibility of shutting down the U.S. automobile industry if standards were not met--there was a great deal of posturing that may well have retarded technological progress toward reducing automobile emissions. (See Mills and White 1978.)

Disagreements over the legality of emission standards often wind up in the courts. Although the technology-based approach has the appearance of

objectivity, in fact there are often wide disagreements about what technology is "available" and how effective it is in reducing emissions. Moreover, the setting of standards can affect groups other than the regulated industries (or at least other groups believe they will be affected). These groups can often affect regulatory requirements.

The well-known case of setting sulfur dioxide (SO₂) standards for new power plants illustrates the controversies that often surround standard setting. (See Ackerman and Hasler 1981.) Although the standards were to be based upon the "best available technology," there was little agreement on which technologies were "available" and on which was "best." For example, in its initial evaluation, the EPA pointed to several plants built in England and Japan with control equipment, but the utility industry contended that the equipment was unreliable and expensive to operate.

The EPA and the utilities were not the only interested parties. A provision of the Clean Air Act requires that all new or substantially modified coal-fired power plants remove some percentage of the sulfur contained in their boiler fuel, regardless of its initial sulfur content. As Ackerman and Hassler point out, the requirement was designed to discourage electric utilities from using low-sulfur coal to meet emission standards, since this may have caused some unemployment among midwestern miners of high-sulfur coal. Given the large stakes involved--all parties agreed that the costs of controls would be billions of dollars--and the ambiguity of the criteria, it is not surprising that the standards took many years to promulgate and eventually wound up in court.

It is also not surprising that the set of standards that emerges from the inherently political process does not minimize the overall cost of meeting ambient

standards. Standards set piecemeal on the basis of "technological feasibility" are likely to result in widely divergent costs for given emission reductions.

B. Regulatory Reforms

In recent years, the EPA has modified its regulatory approach in several ways that are designed to reduce the overall costs of pollution control without compromising environmental quality. (See Hahn and Hester 1989 and U.S. Environmental Protection Agency 1986.) Referring to these changes as "controlled trading," EPA emphasizes both that the changes are in fact trades rather than reductions in overall control and that they are controlled by agency procedures and personnel.

The controlled trading reforms include the following three major elements:

(1) Bubbles: A single plant with several emission sources may be permitted to increase emissions beyond the current standard at one location within the plant if it makes a greater reduction in emissions somewhere else at the same facility. (2) Offsets: A firm may add new emissions if it pays for a greater reduction in emissions at another plant in the same area. (3) Banks: A firm that reduces emissions below the standard may deposit as a credit some fraction of the excess emission reductions in an emission bank. These banked emission credits can then be sold to other firms seeking emission credits.

The trading allowed under these reforms--and thus the potential for cost savings--is limited in several important ways by EPA. (See Hahn and Hester 1989). Only a few air pollutants can be traded under current EPA regulations. Another major limitation is that a firm can only include emissions from its own facilities within a "bubble" and thus cannot trade with another firm. Moreover, a firm cannot trade between new and existing sources, since the bubble policy only applies

to standards on existing plants. However, a firm can use the offset policy to locate a new plant in an area that does not meet the ambient standards--and thus in theory could prohibit new pollution sources--by paying another source to reduce its emissions by more than the emissions from the new plant.

Trading also might not be worthwhile from a firm's standpoint. The administrative obstacles and costs provide one reason. In addition, the advantages from trading might be eliminated if EPA or the states tightened emission standards. Engaging in trades may send a signal that standards can be tightened--because tighter control technology is "available"--and thus any temporary cost savings would be overwhelmed by the increased costs of stricter controls.

C. Marketable Permits

A system of marketable permits can be viewed as an extension of the controlled trading reforms that the EPA has already adopted. Rather than limiting trades in various ways (only trades within a single facility, etc.), the EPA would set an overall limit on emissions in an airshed and allow anyone to buy and sell emission permits. Marketable permits would in effect be "uncontrolled trading."

There would be no need to set emission limits for individual sources under the marketable permits scheme. Indeed, a major virtue of this approach is that it decentralizes decision-making and allows firms to determine their pollution output just as they determine their production levels. Firms can purchase pollution permits just as they purchase other materials. Like other materials, a market price would be established that reflects demand and supply conditions.

The simplest means of establishing the market for pollution permits would be for the government to auction the permits and then make them freely transferable. Although the EPA would still have to monitor individual sources, it

would not have to promulgate individual standards or determine "available technology."

D. Emission Taxes

Emission taxes change the focus from regulating the quantity of emissions to regulating the price; however, there are more similarities than differences between a marketable permits scheme and an emission tax scheme. The similarities are as follows: both decentralize the decisions on individual emission standards; both result in a price for emissions that firms can use to determine their optimum emission levels; both require that individual emissions be monitored, either to collect tax revenues or to verify permit amounts; and both can result in payments to the government treasury, either as tax payments or permit payments.

The emission tax scheme does, however, break the distinction between the two elements discussed above--the setting of ambient targets and the setting of individual emission standards. Unlike marketable permits, which begin with an overall limit on emissions, ambient conditions would be determined by individual firms' reactions to the tax.

III. THEORETICAL STRENGTHS AND WEAKNESSES

The theoretical advantages and disadvantages of economic incentive schemes have been pointed out by many authors. (See, e.g., Anderson *et al.* 1977, Barrett 1986, Baumol and Oates 1975, Crandall 1983, Freeman *et al.* 1973, Harrison and Portney 1983, Kneese and Schultze 1975, Nichols 1983 and Rose-Ackerman 1973.) Economists usually applaud economic incentive schemes primarily because they promise to produce lower compliance costs. Although this efficiency advantage is important, a complete analysis includes other criteria, such as distributional impacts and administrative burdens. This section considers seven criteria related to the efficiency and distributional properties of the various approaches.

In addition to using theory, this section uses information from empirical case studies of economic incentive approaches. Although economic incentives have not been adopted in the United States, these studies provide indications of how they would perform in practice. Exhibit 1 lists seven empirical studies of which three concentrate on marketable permits, two focus on emission taxes, and two devote equal attention to both. (See Harrison and Portney 1982 for additional discussion of five of these studies.) The air pollution examples include two conventional pollutants that have been regulated for some time (NO_x and SO_x), one hazardous pollutant that has recently been regulated (benzene), and one that is linked to both global warming and ozone depletion (chlorofluorocarbons, or CFCs).

A. Compliance Costs

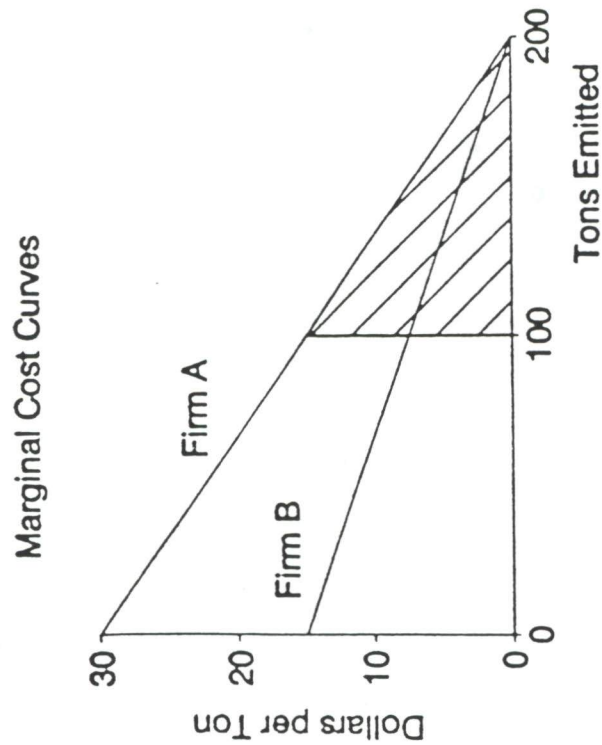
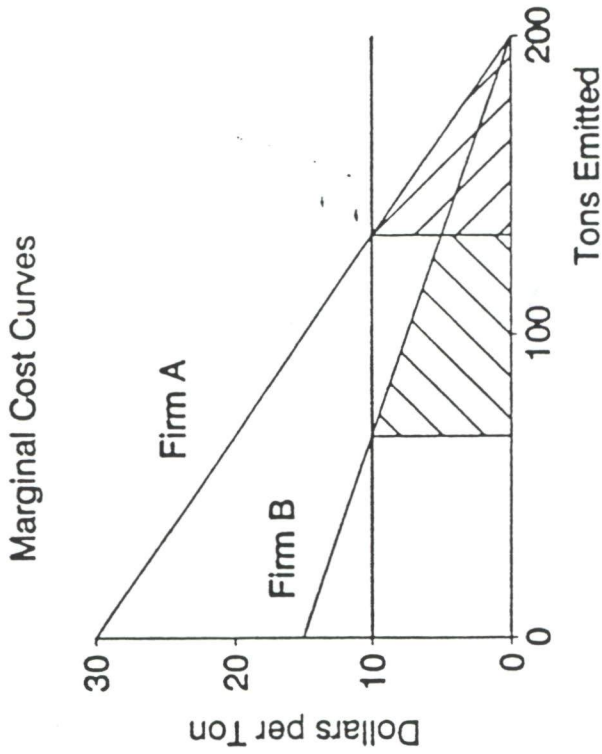
Economic incentive schemes reduce compliance costs compared to mandatory controls--for a given level of emission reduction--because they set a common level for the marginal cost of control. This efficiency advantage is analogous to the efficiency advantage of a common price in any market. The common price puts a cap on the cost per ton--since a firm could pay the tax or permit price rather than pay for controls that cost more per ton--and thus an economic incentive approach avoids overly expensive control measures.

Exhibit 2 illustrates the potential for cost savings by considering two hypothetical firms. Each firm emits 200 tons per day without controls and faces an emission standard of 100 tons per day. The schedules show the marginal cost each firm would incur if it reduced its emissions. The shape of the curve shows the familiar pattern for pollution control costs--reducing the first tons is relatively cheap, but the cost increases rapidly at high levels of control. For example, in the case of SO_x, relatively inexpensive coal washing can be used to remove the first tons, but expensive scrubbers have to be installed to achieve high control levels.

EMPIRICAL STUDIES OF ECONOMIC
INCENTIVE SCHEMES

<u>Reference</u>	<u>Pollutant</u> (1)	<u>Scheme(s)</u> (2)	<u>Geographic Area</u> (3)	<u>Issues Considered</u> (4)
Anderson et al. (1979)	Air/NOx	Marketable Permits Emission Taxes	Chicago	Cost savings Geographic variation Income transfer
David et al. (1977)	Water/ Phosphate	Marketable Permits	Wisconsin	Cost savings Income transfer
Hahn and Noll (1981)	Air/SOx	Marketable Permits	Los Angeles	Geographic variation Income transfer Market power
Harrison (1983)	Aircraft Noise	Emission Taxes Marketable Permits	United States and Boston's Logan Airport	Cost savings Geographic variation Income transfer
Nichols (1983)	Air/ Benzene	Emission Charges	United States	Cost savings Geographic variation
Palmer et al. (1980)	Air/CFC	Marketable Permits	United States	Cost savings Income transfer
Perl and Dunbar (1982)	Air/SO ₂	Emission taxes	United States	Cost savings

AN EMISSIONS TAX REDUCES OVERALL COMPLIANCE COSTS



 Firm A Costs
 Firm B Costs

(A) Mandatory Controls
(100 tons)

(B) Emissions Tax
(\$10 per ton)

Firm A is a "high cost" firm. To meet the emission standard of 100 tons, the firm would have to pay \$15 per ton to reduce the last ton (from 101 to 100 tons). The overall costs to Firm A of meeting the standard are shown by the shaded area.

Firm B faces the same general pattern of increasing control costs, but its costs are lower. Its marginal cost to achieve a standard of 100 tons would be one-half of Firm A's cost, or \$7.50 per ton. Its overall costs are the much smaller shaded area shown for Firm B. Given the wide divergence in costs at the margin, it is clear that overall costs would be reduced if control requirements were reallocated.

Exhibit 2(b) shows that an economic incentive scheme would, in theory, lead to lower compliance costs. If each firm faced an emission tax of \$10--or if the market price of a permit were \$10--then each firm would control emissions up to the point that its marginal costs equaled the tax. Firm A would increase its control level and emit 133 tons, while Firm B would decrease its control level and emit only 67 tons. The total number of tons would be the same--200 tons--but the overall costs would be considerably less.

This same example can be used to illustrate the limitations of the regulatory reform approach. If A and B represent two sources at the same facility (e.g., two boilers at the same power plant), the bubble policy would allow the firm to reallocate controls and minimize costs. However, these cost savings would not be possible if the two sources were owned by different firms, or were owned by the same firm but at different facilities.

All of the empirical case studies show cost savings from switching to an economic incentive strategy. For example, Perl and Dunbar (1982) calculate the cost savings to electric utilities from maintaining the same total SO₂ emission

reductions but eliminating the arbitrary features that require utilities to use high cost controls. Annual costs fall from \$7.1 billion per year (1980 dollars) to \$4.47 billion per year--a decline of 37 percent--when emissions in each region are held constant but utilities are able to select the least-cost means of reducing emissions. The cost savings come from increased use of low-sulfur coal and reduced use of scrubbers. Costs would fall still further--to \$3.7 billion per year--if national emissions were held constant.

B. Level of Control

In theory, an emission tax set equal to the marginal benefits of control will result in the "optimum" level of control--the level of control at which marginal benefits equal marginal costs. (See Nichols 1983 for a discussion of complications that arise in targeting requirements to achieve optimum controls.) Indeed, this feature is often mentioned as a theoretical advantage of using a tax rather than a marketable permits scheme.

This advantage is less marked in the case studies than it is in theory. Setting such an ideal charge requires more information than is usually available. To determine a price that equates marginal benefits and marginal costs, the regulator must estimate the schedules relating marginal costs and benefits to the level of control. The difficulty of making such estimates, together with reluctance to set environmental goals solely on the basis of efficiency, probably explains why tax proposals usually do not seek to achieve the most efficient level of control, but only to enforce a somewhat arbitrary level of control at lower cost. For example, one tax proposal for aircraft noise was based upon the cost of noise-control retrofit for older planes. The tax is designed to induce the retrofit of most of these older planes rather than to achieve the "optimum" level of noise control.

The one situation where an ideal charge can be set without estimating the complete costs and benefits schedules is if the benefits are reasonably certain and there are no thresholds. Harrison (1983) points out that aircraft noise is one such case. However, global warming does not fit these conditions. The benefits of controlling greenhouse gases are exceedingly difficult to assess. Moreover, much of the concern for global warming is based upon the possibility of a threshold that would lead to massive climatic changes. Thus, it seems unlikely that an emission tax would be based upon a dollar calculation of the marginal benefits of controls.

Setting a greenhouse gas tax would, however, be easier than for most other pollution problems in one important respect--greenhouse gases have the same effect on global warming regardless of where they are emitted. As the case studies of aircraft noise (Harrison 1983) and airborne benzene (Nichols 1983) emphasize, the marginal damages from emissions depend upon where and when they occur. The reason is simple--emissions in dense urban areas cause more exposure and thus more damage than the same emissions in sparsely settled areas (Harrison and Nichols 1983 and Nichols 1983). Both the aircraft noise and benzene case studies illustrate the advantages of tax rates that vary geographically (and the similar advantages of geographically-varying standards).

The world-wide nature of global warming does, however, raise the additional problem of obtaining international cooperation to reduce emissions, since even large reductions in the U.S. may not have much effect on global warming if they are not combined with similar efforts in the rest of the world. The conflict between the U.S. and Canada over acid rain indicates that achieving international cooperation is often difficult. The recent Montreal agreement among industrialized nations to control CFCs indicates, however, that such cooperation is possible.

Indeed, the pressure to control greenhouse gas emissions in the United States may well come from a similar international initiative.

C. Differential Impacts Among Firms

The major drawback to an economic incentive scheme--at least from the standpoint of regulated firms--is the potential for large income transfers. Although all the empirical studies demonstrate efficiency gains, these studies also show that some groups lose.

Firms or industries that stand to lose by a switch to economic incentives have the following characteristics:

1. low compliance costs;
2. high volumes of wastes; and
3. little ability to pass control costs on to consumers.

The example in Exhibit 2 illustrates how a firm with low compliance costs could lose under a tax. Because Firm B's marginal cost of control under mandatory controls (\$7.50 per ton) is lower than the tax (\$10 per ton), the tax will lead the firm to increase its control level. In contrast, Firm A will cut back on controls because its marginal cost (\$15) is less than the tax.

Firms with little ability to pass on costs lose because of the way that EPA currently sets emission standards. Because regulatory standards are generally based on the "affordability" of compliance costs, firms and industries that cannot pass costs on--either because they are marginal firms or because they face substantial foreign competition--typically operate under less stringent environmental regulations. These firms would therefore face higher costs (or greater likelihood of going out of business) if EPA used a tax or permit approach. In contrast, firms or industries that can afford control costs--either because they have "deep pockets" or

are permitted by regulatory authorities to pass on costs--would tend to gain from a switch to economic incentives.

The empirical studies also indicate the size of these cost effects. Exhibit 3 shows results for CFCs. While overall compliance costs fall by \$77.5 million (58 percent) under a hypothetical permit scheme, compliance costs increase by \$21.6 million for makers of solvents, a 25 percent increase from costs under mandatory controls. However, the decreases in costs for the other two major emitters are even more dramatic: compliance costs decrease for flexible foam and rigid foam by \$64.1 million (70 percent) and \$35.0 million (90 percent), respectively. Solvent manufacturers are nonetheless likely to have little enthusiasm for the permit scheme. Differential impacts are even more dramatic for aircraft noise. With a hypothetical noise charge for Boston's Logan Airport, overall landing fees would triple; but for some carriers, the increase would be more than ten-fold.

Economic incentive schemes may also increase costs to firms or municipalities whose emissions were previously ignored by the regulatory system. In the Lake Michigan case, for example, Wisconsin regulations exempted small towns from discharge limitations, even though they emitted about one-fourth of the phosphorus in the lake. (See David *et al.* 1980.) Under a marketable permits scheme, these exempted communities would share the cost of abatement.

D. Distributional Impacts on Business as a Whole

A fundamental difference between economic incentive schemes and mandatory controls is the property rights they presume. Even stringent controls usually allow some emissions, thereby implying that each source "owns" some right to emit. In contrast, under the emission tax or permit approach, polluters must pay for all their emissions.

**COMPLIANCE COSTS FOR INDUSTRIES
UNDER A CFC MARKETABLE PERMIT SCHEME**

Product Area	Cumulative Effects of Economic Incentives		Deviation from Mandatory Controls	
	Emissions Reduction -(Million Permit Pounds)- (1)	Compliance Cost -(Million Dollars)- (2)	Emissions Reduction -(Million Permit Pounds)- (3)	Compliance Cost -(Million Dollars)- (4)
Flexible Foam	380.7	29.2	-120.5	-64.1
Solvents	390.3	67.3	+204.6	+21.6
Rigid Foam	26.7	3.8	-79.4	-35.0
Retail Food	18.3	7.3	-	-
Chillers	1.0	0.1	-	-
TOTAL	816.9	107.8	+4.6	-77.5

Source: Palmer, *et al.* (1980).

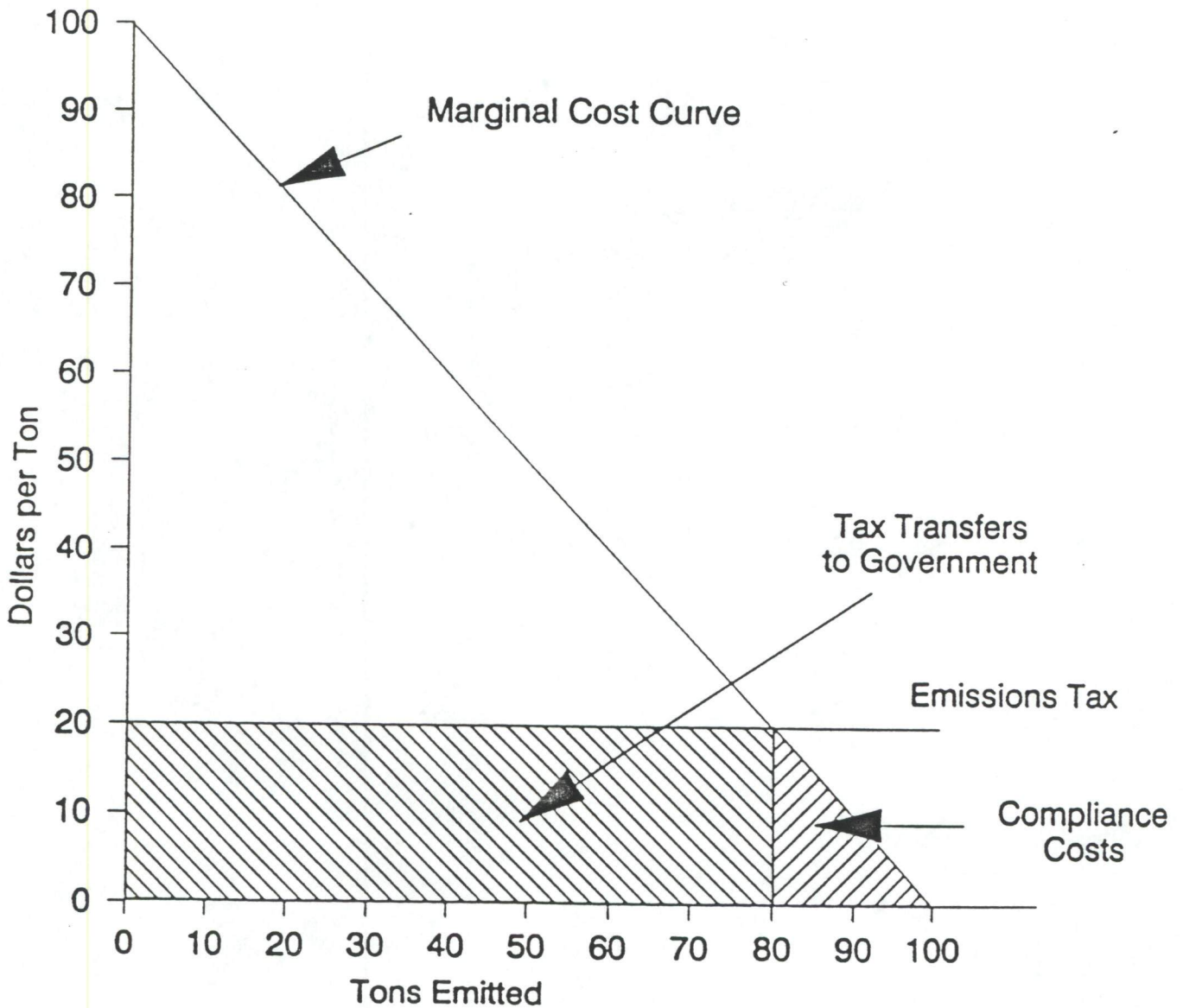
Exhibit 4 shows that economic incentive schemes can generate very large income transfers to the government. As discussed above, a tax allows firms to use the cheapest means of reducing emissions, rather than the more expensive measures that are often required under mandatory controls. But, unlike mandatory controls, firms must pay for the emissions that they do not control. The size of the income transfer depends upon the level of the tax, the costs of control, and the number of tons emitted. Under the conditions illustrated in Exhibit 4, tax transfers would almost certainly swamp any savings in compliance costs due to the tax.

These transfers are initially paid by businesses. But businesses will pass some or all of the costs on to customers or labor in the form of higher product prices or lower wages. The fraction passed on depends upon industry cost and market conditions. Like the excise taxes they resemble, such costs tend to be regressive, i.e., borne more than proportionately by the poor. (See Harrison 1975.)

In contrast to compliance costs--which represent expenditures of real resources--tax or permit payments are transfers. When the government receives tax or permit revenues, it can use the money to reduce other taxes or increase spending. Nonetheless, transfer costs are likely to be considered real by the businesses that initially pay them. The prospect of large payments undoubtedly explains why business has not generally supported economic incentive schemes.

The empirical studies indicate that the sums involved are far from trivial. The transfer payments for a CFC permit scheme would amount to about \$150 million per year (1976 dollars)--and that the present value of a ten-year program would be between \$1.15 billion and \$1.7 billion--considerably greater than overall savings in compliance cost of \$78 million per year (Palmer and Quinn 1981). Harrison (1983) estimates that a national aircraft noise tax with a baseline (no tax level) of 98 decibels would generate about \$150 million per year in revenue (1980 dollars).

AN EMISSIONS TAX CAN REDUCE COMPLIANCE COSTS BUT LEAD TO LARGE INCOME TRANSFERS



The empirical studies also indicate the factors that affect the relative importance of compliance costs and transfer payments. The water pollution and CFC studies illustrate the two extreme cases. The marginal cost of removing phosphorus from Lake Michigan is graphed in Exhibit 5. Transfer payments are relatively small because cities are required to remove 85 percent of the phosphorus under either a mandatory control or a permit scheme, and thus only 15 percent was previously "owned" by cities that must now buy permits. Compliance costs dominate. In contrast, under the benchmark CFC control strategy that Rand evaluated--in which CFC emissions are only reduced by about 15 percent--expenses for transfers are about 14 times the costs of actually reducing emissions. The CFC case is thus close to that shown in Exhibit 4. Indeed, only a few CFC-using firms have compliance costs that exceed permit payments (assuming that all permits are originally government owned).

E. Compensation to Avoid Transfers

The potential for large government revenues may not be viewed as a defect of economic incentive schemes, given concerns about the federal deficit. Indeed, some argue that the strategies are justified either as "user fees" or as the most efficient means of raising necessary revenue (Terkla 1984). Nevertheless, large transfers will certainly be viewed by some as undesirable side effects of the schemes--at least from a political perspective--and the following questions arise: How can the transfers be reduced? What effects would any modifications have on the schemes' effectiveness and efficiency?

The empirical case studies indicate that large transfer payments can be reduced, but only by increasing administrative costs and complexity.

1. Tax Revenues

Tax revenues can be reduced by setting a cutoff before the tax is levied. For example, Harrison (1983) shows that using 98 decibels as the starting point for the noise tax reduces the airline transfer payments dramatically without compromising the efficiency advantages of the scheme. Exhibit 6 shows a simplified version of this approach in which taxes are only charged on emissions above a cutoff of 70 tons and revenues are decreased enormously.

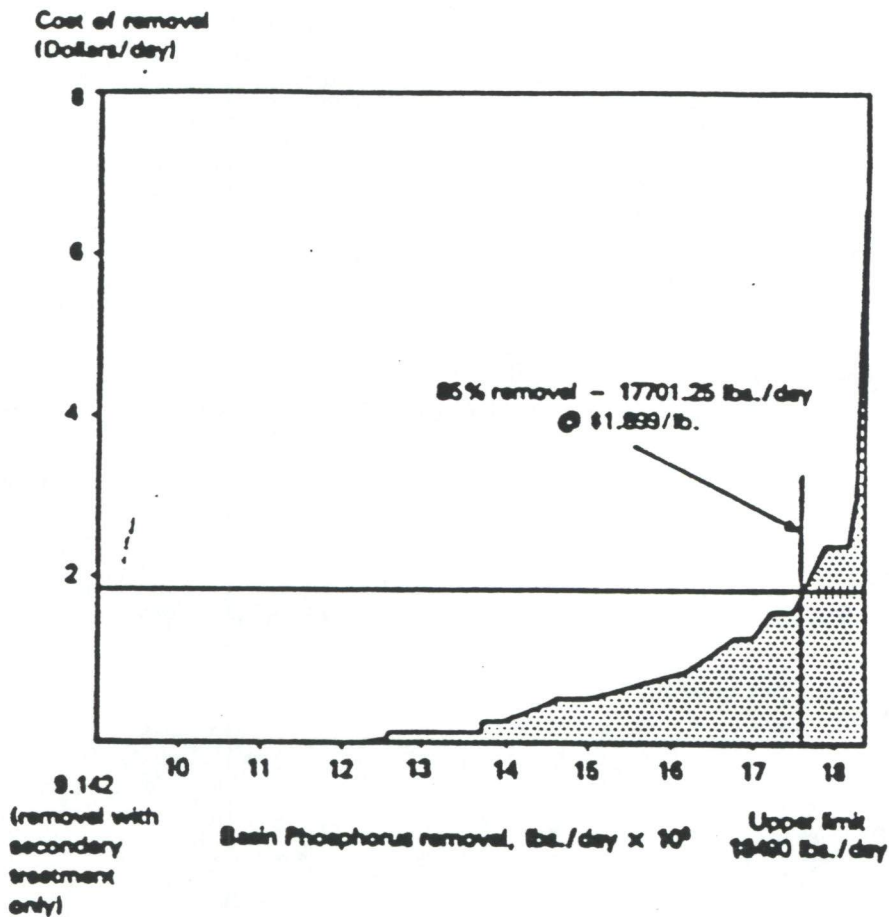
Reducing tax revenues by setting a threshold is, however, a complicated task. Thresholds would have to be established for individual sources rather than total emissions, leading to the same complexities as setting mandatory standards. If the cutoffs were set on the same basis as mandatory controls--i.e., emissions per unit of output or input--the tax approach would lose some of its efficiency advantages. This is because firms would not have the most efficient incentives to reduce output or inputs. (See Nichols 1983.) Moreover, as a practical matter, it would be extremely difficult to set thresholds that eliminated all tax payments, and thus, at least some distributional effects would occur.

2. Permit Payments

The government could eliminate all permit payments simply by distributing permits to polluters. Property rights would be split among polluters and the public in much the same way as they are with mandatory controls; firms would "own" the right to pollute up to the number of permits. The market for permits would determine which firms actually control their emissions and by how much. Thus, reducing transfers from polluters as a whole is not difficult, in theory.

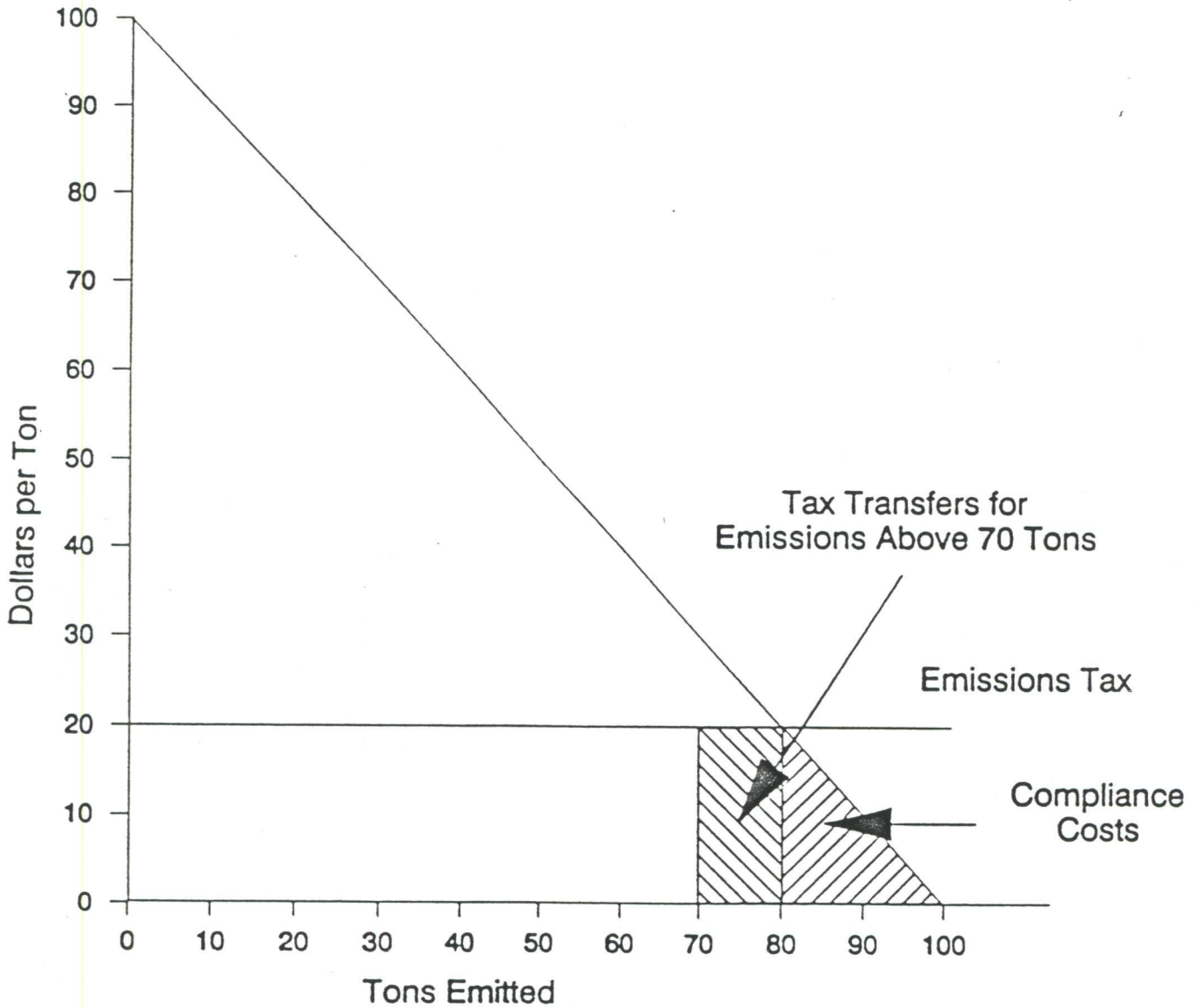
The empirical studies, however, suggest that practical difficulties would arise. For one thing, the distribution can create enormous wealth. Although polluters as a group make no payments to the government, they would make

REMOVAL OF PHOSPHOROUS VERSUS COST FOR LAKE MICHIGAN BASIN



Source: David *et al.* (1980).

AN EMISSIONS TAX CAN BE MODIFIED TO REDUCE THE INCOME TRANSFERS



payments to one another. Firms whose initial allocations are greater than their needs would reap large transfer benefits. For example, if CFC permits were initially allocated solely to the five CFC producers, using historical production as a criterion, DuPont would receive permit rights worth over \$1 billion during a ten-year period. (See Exhibit 7.) (Restricting CFC's may also add to producers wealth by permitting price increases, in the same way that monopolistic output restrictions would add to profits.)

Firms that do not receive the initial permits would no doubt argue that the allocation is unfair. However, allocating permits to a larger number of users increases administrative costs. For example, if CFC permits were issued to firms that purchase (as opposed to produce) CFCs--in an effort to reduce the large wealth effects--administrative costs could increase substantially, since the number of CFC users is very large; over 140,000 firms install and service CFC-using mobile air conditioning units alone. If as many as 250,000 firms were eligible for permits and the cost of obtaining data and computing entitlements were \$100 per firm, the administrative costs would be \$25 million.

F. Administrative Costs

A control strategy is worthless if it cannot be administered and enforced effectively. A large number of activities are involved in promulgating and enforcing regulations: collecting data, holding public hearings, drafting proposals, responding to public comments, setting the regulations, dealing with legal challenges, etc. Many regulatory schemes have failed because they have become mired in administrative delay and litigation (Melnick 1983). New approaches such as economic incentive schemes may be particularly vulnerable to such difficulties.

On theoretical grounds, the schemes have both administrative advantages and disadvantages. Since EPA is familiar with mandatory controls, the

**ESTIMATED TRANSFERS TO CFC PRODUCERS
RESULTING FROM DISTRIBUTION OF PERMITS**

<u>Producer</u>	Millions of <u>Permits</u> (1)	Discounted Cumulative Receipts, 1981-1989 <u>(1978 \$ x 10⁶)</u> (2)
Allied	79.5	472.7
DuPont	197.4	1,173.8
Kaiser	25.0	148.7
Pennwalt	25.0	163.3
Racon	8.5	50.5
TOTAL	338.2	2,011.1

Source: Palmer and Quinn (1981).

implementation costs are likely to be greater for an economic incentive approach. (See Drayton 1978.) However, once in place, the enforcement costs may well be smaller. Because they avoid the "all-or-nothing" element of mandatory controls, tax or permit strategies may be less susceptible to the brinkmanship and delay of stringent mandatory controls. (See Mills and White 1978.)

Permit strategies are, however, likely to be considerably more difficult to implement than taxes. For one thing, experimental studies of markets indicate that the assumption that competitive permit prices will be established quickly and easily may not be justified (Plott and Smith 1978). In addition, the empirical case studies indicate that the permit market may not operate in a competitive fashion.

In the case of Los Angeles sulfates, Hahn and Noll (1982) concluded that one source (a utility) would account for all net purchases of permits--all other firms would be sellers. Thus, the utility would have strong incentives to engage in monopsonistic purchasing practices. If the utility operated as a monopsonist, some of the efficiency advantages of the economic incentive scheme would be lost; it would buy fewer permits at a lower price than under a competitive market and thus abate too much pollution. (Additional abatement is worthwhile to the monopsonist because it would depress the price paid for permits it acquires from other companies.)

Hahn and Noll suggest several ingenious ways to avoid the potential problem of an uncompetitive market for permits. However, all of these other allocation mechanisms add to the administrative burdens of the scheme. These complicated distribution formulas may also reduce the political appeal of permits, as the merits of the proposal might be buried in the controversies over the initial allocation of permits.

G. Uncertainties in Control Costs

Because technology is often uncertain when controls are established, actual costs may turn out to be much different than expected. Cost uncertainties lead to different uncertainties for the various policy approaches. Under mandatory controls, if the emission standards are not changed when new cost information becomes available, the uncertainties are reflected primarily in costs rather than environmental quality.

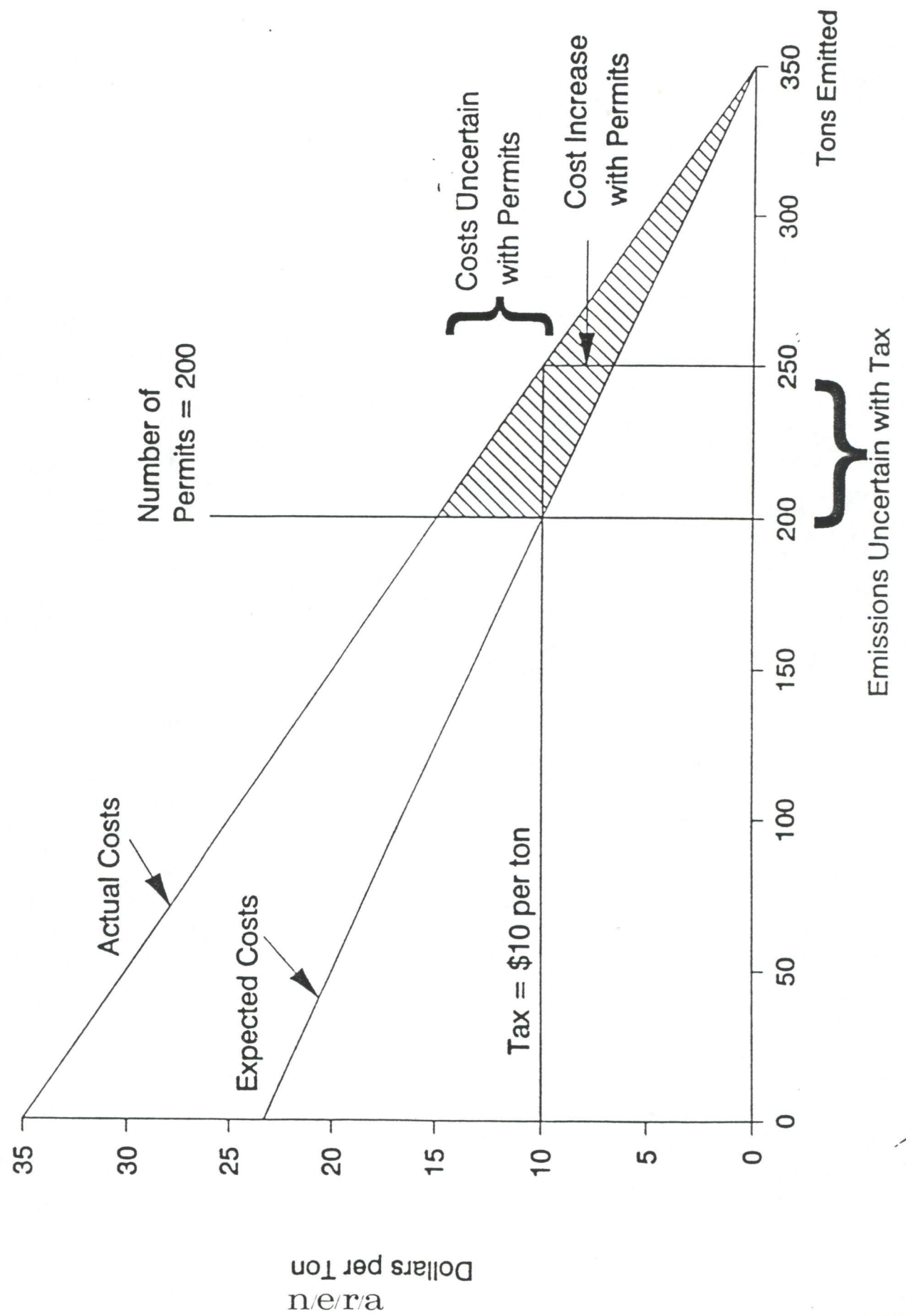
The two economic incentive schemes differ in the effects of control cost uncertainty. Under a tax, if compliance costs increase, firms will decide to control less and emit more. Thus, uncertainties will be reflected in changes in environmental quality. This uncertainty no doubt explains some environmentalists' objections to tax strategies.

In contrast, a marketable permit scheme guarantees a given level of environmental quality regardless of changes in costs. (This guarantee is not as secure when the effect of emissions differs by location or time; see Harrison and Nichols 1983.) Indeed, setting a total number of tons of pollutants provides more control over environmental quality than establishing a set of mandatory emission controls. (See Harrison 1983.)

Exhibit 8 illustrates these differing effects of the tax and permit schemes. Under the tax approach, higher costs will lead to more emissions than expected, 250 tons rather than 200 tons. Although total control costs increase, the tax puts a cap on the marginal cost. (No firm would pay more than \$10 to reduce a ton because they could always pay the tax instead.) In contrast, under the permits strategy the number of tons remains the same, but the cost increase is greater.

EMISSION TAXES AND MARKETABLE PERMITS HAVE DIFFERENT EFFECTS WHEN CONTROL COSTS ARE UNCERTAIN

EXHIBIT 8



Transfer payments would increase under both strategies. For the tax, the increase is equal to the tax rate times the increased emissions (\$10 times 50 tons, or \$500 in the example in Exhibit 8). For the permits strategy, the increase is equal to the number of permits times the increased price of permits (200 times about \$5, or \$1000 in the example).

In sum, the two economic incentive schemes lead to different responses to uncertain control costs. Tax strategies provide greater certainty in overall compliance costs, but less certainty over emissions. Permit schemes provide certainty over emissions, but less certainty over compliance costs. Cost uncertainty leads to changes in transfer payments under both strategies.

H. Incentives for Technological Progress

A common criticism of mandatory controls is that they provide no incentive to develop technology to reduce emissions below the mandated level. In theory, standards do encourage development of less costly technology for meeting a given standard. In practice, however, many emission standards have generated perverse incentives for technological development because compliance timetables have encouraged firms to develop relatively costly, though more immediate, technology. Automotive emissions are often cited as a case in point. Many commentators believe that the 1975-76 deadline established in the 1970 Clean Air Act for a 90 percent reduction in emissions forced the automobile companies to choose high-cost, unreliable, "bolt-on" technology rather than lower-cost technology that would not necessarily have been ready for production by the deadline (Mills and White, 1978). According to this argument, an emission tax would have allowed the auto manufacturers to develop less expensive and more reliable controls because they would not have faced the prohibitive sanctions for noncompliance (a fine of

\$10,000 per car). In addition, the automobile companies might have developed means of achieving more than a 90 percent reduction in some pollutants.

The use of economic incentives thus promises to speed the introduction of lower-cost technology in two ways. First, a tax or permit scheme would provide incentives to develop control technology that reduces emissions below the levels set by standards. Second, economic incentive schemes would provide flexibility for firms to develop less costly control technology even if they could not be implemented as quickly as a legislative timetable would require.

I. Summary of Theoretical Strengths and Weaknesses

The theoretical strengths and weaknesses of the four strategies are summarized in Exhibit 9. Economic incentives promise to lower compliance costs, provide greater incentives for technological development, and avoid some of the brinkmanship of mandatory controls. However, because they are untried, economic incentives are likely to be harder to implement. In addition, economic incentive schemes can create large income transfers. Avoiding these income transfers may be difficult and, in any event, would add to the administrative burden of implementing incentive programs.

IV. KEY INFORMATION

Comparisons among policy approaches ultimately raise empirical questions. For example, although we know on theoretical grounds that economic incentives can lower compliance costs, the critical question is--by how much? Moreover, even if we know the potential size of the savings, these savings might in theory be overwhelmed by extra administrative costs. Thus, economic incentive schemes may not be superior to mandatory controls, even when judged solely on efficiency grounds. If we add the potential for large income transfers--which would certainly

**COMPARISON OF MANDATORY CONTROLS
AND ECONOMIC INCENTIVES**

<u>Criteria</u>	<u>Mandatory Controls</u> (1)	<u>Economic Incentives</u> (2)
1. Compliance costs		Lower costs
2. Distributive effects	Lesser effects than uncompensated incentives	Lesser effects than controls when compensated
3. Implementation	More familiar to EPA	Greater problems with permits and with compensation procedures
4. Enforcement		Avoids brinksmanship
5. Certainty of achieving environmental goals		Greater certainty with permits; less certainty with taxes
6. Vulnerability to cost overruns		Less with taxes
7. Incentives for new technology		Greater incentives

be viewed negatively by those harmed--it becomes clear that any preference for economic incentive schemes must ultimately rest on empirical information.

This section lays out the critical information needed to assess the strengths and weaknesses of alternative approaches.

A. Inventory of Greenhouse Gases

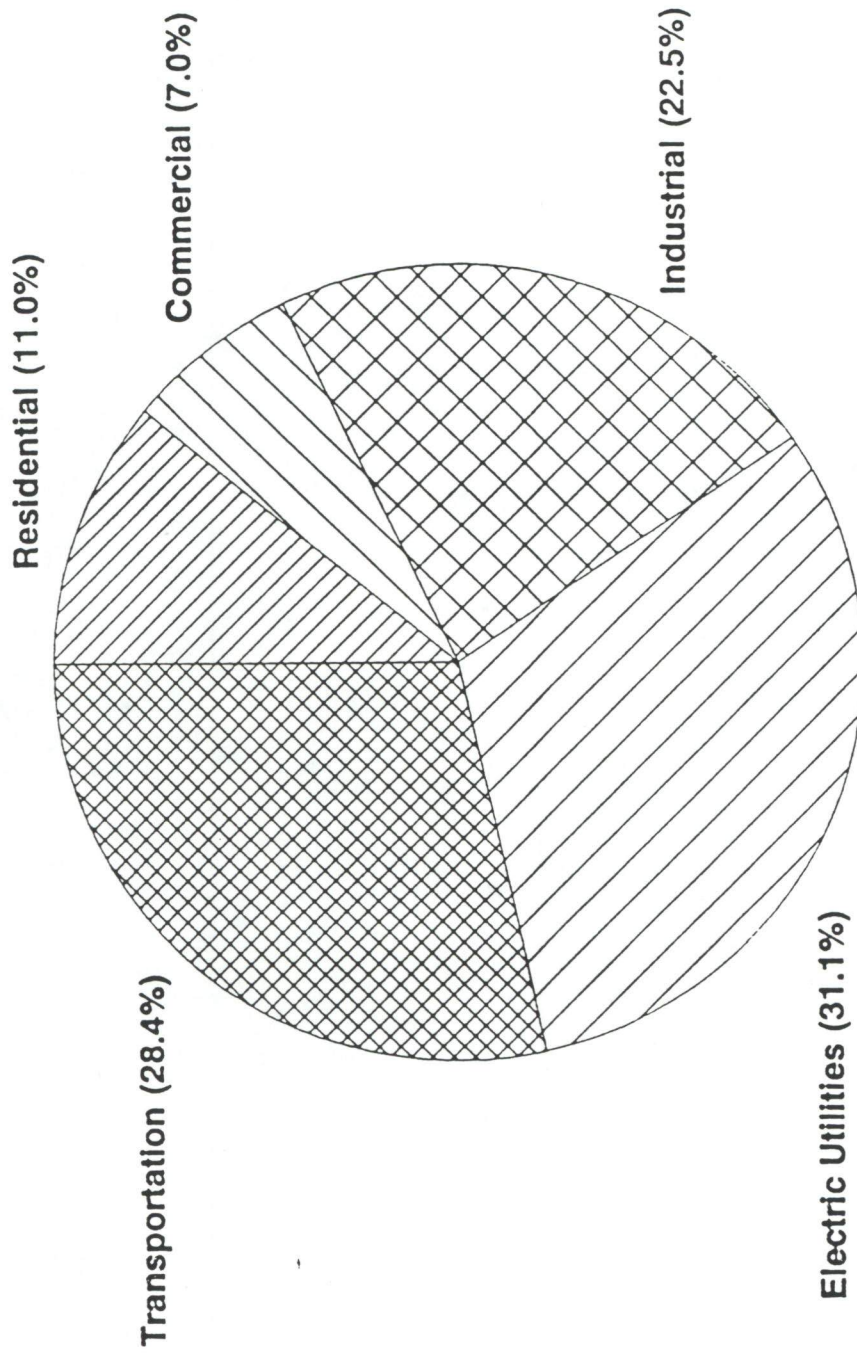
A detailed inventory of greenhouse gases is an essential first element of any empirical study. Exhibit 10 provides a breakdown of CO₂ emissions by major sectors in the U.S. economy. These figures are incomplete for two reasons. First, U.S. emissions account for approximately one-fourth of worldwide CO₂ emissions. Second, CO₂ emissions account for about one-half of total emissions linked to the greenhouse effect. Other greenhouse gases include CFCs, methane, and nitrous oxides.

It is important to identify all substantial sources of greenhouse gases--and not just major sources such as utility CO₂ emissions. Other sources may in fact be easier and cheaper to control. In addition, the inventory should take into account any major interactions with other control requirements. For example, there is evidence that the scrubbers required to meet stringent SO_x limitations would increase CO₂ emissions by between 6 and 10 percent. (See Exhibit 11.)

B. Technology and Costs to Reduce Emissions

Information on control technology and costs is the bedrock for any study of regulatory options. As discussed above, technological options provide the starting point for the setting of mandatory controls. Control costs--and their variability among emission sources--are also critical to the cost savings from economic incentive schemes. If the cost per ton is similar for most technologies, there will be few savings in compliance costs. In contrast, if costs differ greatly--

Distribution of CO2 Emissions From Various Sectors of U.S. Economy



Source: Steinberg, et al., 1984.

COMPARISON OF TOTAL EMISSIONS
FROM ALTERNATIVE COAL-FIRED POWER PLANTS

	Pollutant		
	SO ₂	NO _x	CO ₂
	------(tons/year)-----		
	(1)	(2)	(3)
Conventional Coal Plant	104,000	16,000	3,270,000
Coal Plant With Scrubber	15,500	16,000	3,531,600
Combined Cycle Conversion	0	1,500	1,188,042

Note: The figures are for 500 Mw base load units.

Source: American Gas Association 1989.

and if mandatory controls tend not to require the most cost-effective controls--adopting an economic incentive scheme can produce large overall savings.

Variations in control costs are also critical to other efficiency and distributional effects. Variations in the cost per ton of control alternatives within a single source (e.g., a given power plant) determine whether a company would gain from use of the bubble policy. Variations in cost per ton among firms within a single source category (e.g., all coal-fired power plants) determine not just the overall gains from economic incentives but also who wins and who loses. Variations in cost per ton over time--due to changes in control technology or costs--determine the quantitative importance of the dynamic efficiency advantages of economic incentives.

C. Illustration: Controlling CO₂ Emissions from Electric Power Plants

Quantifying potential cost savings and other effects of economic incentives requires that one assemble information on all potential control options, even if they would not necessarily be considered in setting mandatory controls. To illustrate the range of information, consider the alternatives for reducing CO₂ emissions from fossil-fueled power plants.

1. Removal of CO₂ Stack Emissions

This option would include conventional, "bolt-on" controls to reduce the CO₂ emitted from stack gases. For example, scrubber technology is available to reduce CO₂ emissions, although the costs are currently estimated to be high. A second technology is bubbling stack gases into algal ponds; a prototype of this technology is currently being tested in Hawaii (Phillips *et al.* 1986).

2. Increased Fossil Fuel Burning Efficiency

A number of fossil-fired technologies are being developed which burn fuel

more efficiently and thereby generate fewer CO₂ emissions per unit of output. Exhibit 12 provides a summary of some of these technologies.

3. Increased End-Use Efficiency

Pollution from power plants can be decreased by reducing the demand for power. Concern for greenhouse gases might therefore prompt regulators to require that utilities "invest" in conservation programs to reduce CO₂ emissions, as they have done in order to reduce the need for new power plants. However, as Joskow (1988) points out, "negawatt" programs to encourage conservation--such as those proposed by Amory Lovins (1981) and others in which utilities would pay firms or individuals to conserve energy--are likely to be inefficient means of reducing energy use. Although the cost of controlling CO₂ emissions should be taken into account in a utility's conservation policy, these costs should only be one factor influencing a utility's conservation policy.

Note that costly regulations will themselves lead to some reduction in energy use. Since utilities will pass most of their costs on to electricity customers in higher rates, controls will lead to less electricity use.

4. Alternative Energy Sources

Like the oil shocks of the 1970's, concern for greenhouse gases has generated interest in alternative fuels. Among the alternatives mentioned are nuclear, solar, fuel cells, and geothermal. None of these energy sources contributes to greenhouse gases. However, as with conservation, emissions of greenhouse gases is simply one factor to be considered in evaluating the cost-effectiveness of alternative energy technologies.

5. Shift in Fuel Use from Coal to Natural Gas

Natural gas-fired plants have greater efficiency than coal--measured in terms of Btus per kilowatt-hour (kWh)--and thus they produce fewer CO₂ emissions

per unit of output than coal-fired plants. (See Exhibit 12.) Thus, one option for a utility to lower CO₂ emissions is to shift fuel use from coal to natural gas.

6. Reforestation and Other Mitigation Strategies

Utilities may also reduce CO₂ emissions elsewhere if they could obtain credits that offset their own emissions. One option is to contribute to efforts to prevent deforestation, another significant source of greenhouse gas buildup. When forests are leveled and the trees burned or left to rot, the carbon in the biomass is released as CO₂ (Electric Power Research Institute 1986). Conversely, growing plants absorb CO₂ from the air and through photosynthesis, fix the carbon in their tissues. Thus, any efforts to prevent deforestation and encourage reforestation would reduce the greenhouse effect. (Such offsets might also apply to other greenhouse gases, such as nitrous oxide or methane; there is evidence that changes in fertilizer formulations or agricultural practices might reduce the emissions of these gases. (See Electric Power Research Institute 1988.)

The potential for an offset of this sort was illustrated recently by the agreement of Applied Energy Systems to contribute \$2 million to the cost of planting 52 million trees in South America. This commitment was designed to offset partially the approximately 15 million tons of CO₂ that will be emitted by the utility's Connecticut plan over its lifetime. (The offer implies a willingness to pay about \$0.50 per ton of CO₂. Based upon a reported tree-planting cost of \$16.40, the total cost would be approximately \$4 per ton of CO₂ reduced.)

D. Characteristics of Policy Alternatives

Policy approaches will have to be specified in some detail in order to develop empirical estimates of their advantages and disadvantages. Consider the elements of an emissions tax that would have to be specified:

ALTERNATIVE TECHNOLOGIES FOR ELECTRIC POWER PLANTS

	<u>Power Plant Heat Rates¹</u> (bTU/kWh) (1)	<u>CO₂ Emissions²</u> (kG of c/kWh) (2)	<u>Development Status³</u> (3)
Conventional Gas Combined Cycle (liquid/gas fuel)	8,394	232	mature
Coal-Conventional FGD wet supercritical, bituminous	9,660	250	mature
FGD wet supercritical, subbituminous	9,730	261	mature
Coal-Advanced Advanced Pulverized Coal With FGD	8,570	234	demo
Atmospheric Fluidized Bed Combustion	10,000	252	pilot
Pressurized Fluidized Bed Combustion	8,980	227	lab
Integrated Gasification Combined Cycle	9,280	234	demo
Coal Refining	NA	low	lab
Gas-Advanced Advanced Gas Combined Cycle (liquid/gas fuel)	8,140	158	pilot
Inter-Cooled Steam Injected Gas Turbine	7,262	102	pilot
Nuclear	10,530	none	mature
Fuel Cell	8,300	90	demo

Sources and Notes:

¹Net heat rates are average annual values taken from Electric Power Research Institute, December 1986.

²CO₂ emissions are preliminary estimates based on descriptions presented in U.S. Congress 1985, discussions with industry experts, and K. Yeager and Stephen B. Baruch (1987), pp. 471-502. Note that a recent American Gas Association report indicates a substantial reduction in absolute tons of CO₂ by converting from conventional coal to combined cycle generation. See Exhibit 11.

³Development status refers to how close the technology is to commercial availability. Lab indicates that the technology has not been built at any scale. Pilot indicates a small scale plant has been constructed. Demonstration indicates that a full scale plant has been constructed. Mature indicates that five or more plants are operating commercially.

- Level of the tax;
- Cutoff before the tax is imposed;
- Calculation of credits; and
- Allowance for changes over time.

1. Level and Structure of Tax

In theory, an emissions tax could be set on the basis of marginal damages. Indeed, this criterion was suggested by Senator Max Baucus of Montana in the Senate debate on the Climate Control Protection Act, when he suggested that policy options should include "a carbon dioxide emission tax to reflect damage to our climate in the price of energy." However, calculating marginal damages from greenhouse gases would be extraordinarily difficult. Thus, it seems likely that the tax would be set to encourage particular technology or a specific cutback in emissions.

The structure of the tax will also affect the efficiency and distributional effects. Will the tax be based upon the absolute level of emissions from each plant, or upon the emissions per unit of output or input? The latter alternative accounts for the wide range in plant sizes--and thus reduces distributional effects--but compromises the efficiency of the tax because it does not provide the correct incentives to reduce emissions by reducing outputs or inputs.

2. Cutoff for Tax

Setting a cutoff level of allowable emissions is critical to reducing potential income transfers. This element is likely to be highly controversial. Certainly some will argue that the tax should be designed to collect revenue that could be used to reduce the federal deficit, and thus, there will be debate over the level of the cutoff.

But the structure of the cutoff will also be controversial. Should the cutoff be set as a percent of current emissions, as an absolute number of tons per plant, or as tons per Btu? Different utilities will gain and lose depending upon which cutoff criteria is adopted, and thus there will be disagreement on the "fairness" of the alternatives.

3. Credits

The effects of the tax also depend upon the offsets that might be credited in calculating the tax. Will alternatives such as the reforestation credits proposed by Applied Energy Services be permitted under the emission tax approach?

In theory, allowing utilities credits for any reductions should lead to the least cost means of achieving emissions reductions. In practice, it may be difficult to verify and administer a program that is so flexible.

4. Changes Over Time

Given the enormous uncertainty and the international nature of the global warming problem, it seems likely that any regulatory program will change over time. Firms often have to hit a moving regulatory target and make adjustments accordingly. Similar adjustments will be made for uncertain tax or permit programs. For example, if the tax is likely to change, it may not be sensible to invest in longer-term alternatives even if they promise to be the least expensive responses to the current tax.

D. Political Considerations

Although most empirical case studies emphasize economics, it is important to take into account political realities as well. At the very least, the political reaction to economic incentive schemes will influence their administrative costs. The tax approach must overcome its characterization as a "license to pollute." Some studies have suggested that the public considers the tax approach

inappropriate for environmental protection, regardless of its economic efficiency advantages (Kelman, 1981).

The political winds appear to be changing. As discussed above, there have been a number of indications that economic incentive strategies will be more easily accepted, including political support from widely different perspectives, increased interest of environmental groups, and increasing empirical evidence of the potential cost savings. Perhaps the most persuasive indication of political acceptability is the introduction of a CO₂ tax in Senate deliberations on global warming. The EPA also appears to be supportive; a recent EPA draft report to Congress recommends pricing as "the most effective short-term means of reducing emissions gases that contribute to the greenhouse effect or global warming." (reported in Electric Utility Weekly March 20, 1989.)

V. CONCLUSIONS

Several conclusions emerge from this analysis of policy approaches for controlling greenhouse gases. These include the following:

(1) Theory and the available empirical case studies suggest that economic incentive schemes can lower the overall costs of meeting environmental objectives, provide greater incentives for technological advances, and reduce the brinkmanship and litigation that often characterize the regulatory process. On the other hand, because they are novel, the economic incentives might be more costly to implement.

(2) Not all firms would gain. Firms and industries likely to save on compliance costs are those with high control costs and high ability to pass costs on to customers, since they are hard hit by mandatory controls.

(3) With regard to the choice between taxes and marketable permits, theory and the case studies suggest that taxes have lower administrative costs but provide less assurance that emission targets will be met.

(4) Theory and case studies show that economic incentive schemes might generate enormous transfers to the government--in the form of tax payments or payments for emission permits--which can overwhelm the overall compliance cost savings.

(5) These large transfers can be reduced, but only at the expense of increased complexity and administrative costs.

(6) An empirical study is needed to evaluate fully the advantages and disadvantages of using economic incentives. Such a study would also be necessary to assess the net effect on a firm's or an industry's costs, taking into account both compliance costs and transfer payments.

(7) An empirical study of policy approaches would require the following key information: (a) inventory of greenhouse gas emissions; (b) technological options and costs of controlling greenhouse gases for each source; (c) variations in costs among individual emitters (e.g., utility plants); (d) prospects for technological advances; and (e) specific characteristics of each alternative strategy.

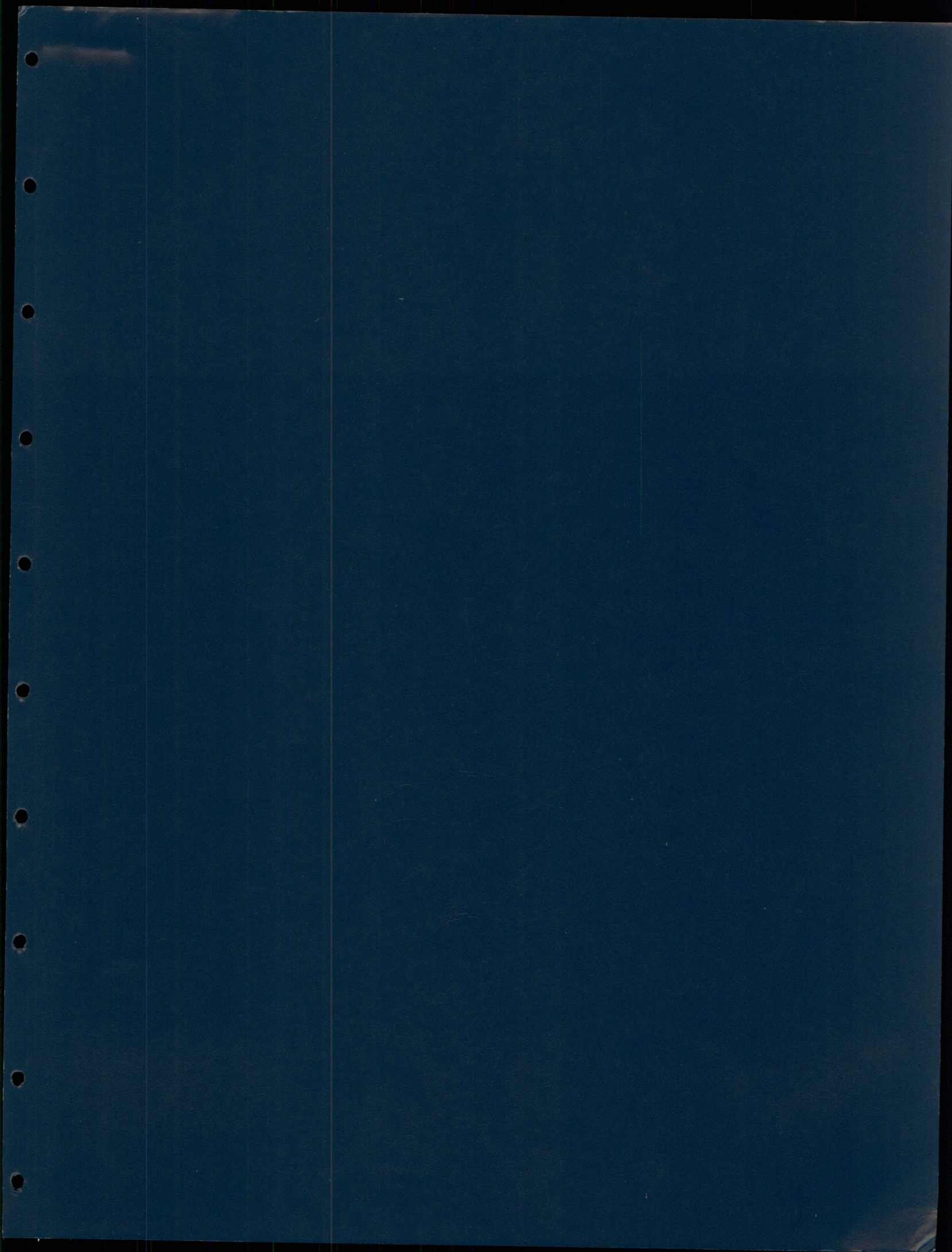
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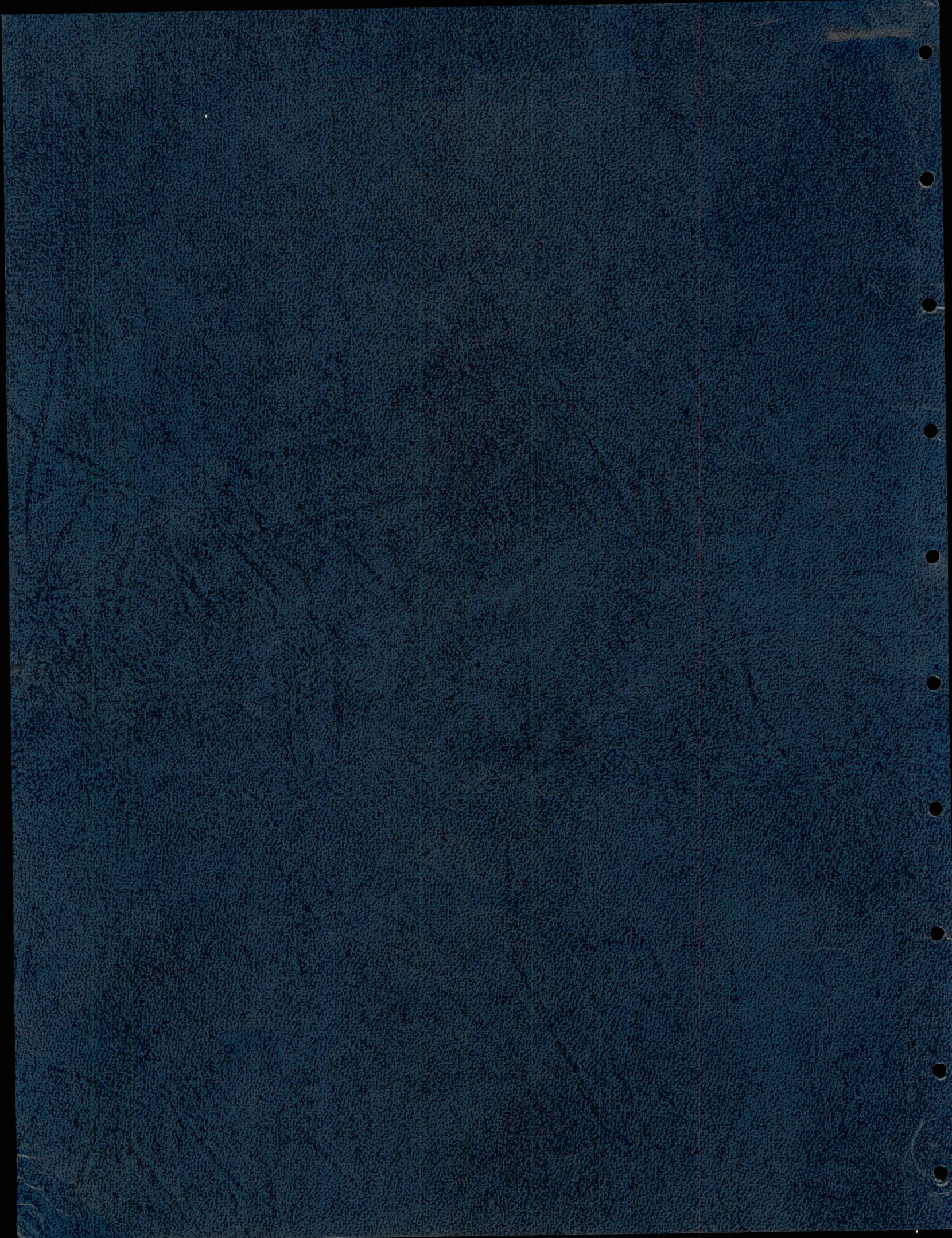
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Hansen vs. the World on the Greenhouse Threat

Scientists like the attention the greenhouse effect is getting on Capitol Hill, but they shun the reputedly unscientific way their colleague James Hansen went about getting that attention

Amherst, Massachusetts

SCIENTISTS GATHERING at the Workshop on Greenhouse-Gas-Induced Climatic Change here in early May were waiting in vain for their unofficial guest of honor to appear. James Hansen, climate modeler and leading scientific spokesman for the greenhouse effect, was in Washington testifying to Congress, again.

Last summer, Hansen made the headlines of virtually every major newspaper, carried his message onto the network news shows ... and irked practically everyone in the field when, in the midst of a drought, he told Congress that the greenhouse warming is here. It was this sort of unconditional claim from Hansen and his group that had prompted this meeting. The greenhouse community was determined to set the record straight with hard facts, but now, even as they got their meeting under way, Hansen was at it once more on Capitol Hill.

This time Hansen was in Washington to stress that climate models had become reliable enough to conclude that rapid strengthening of the greenhouse effect would lead to "drought intensification at most middle- and low-latitude land areas." But the Office of Management and Budget (OMB), in its role as monitor of federal policy statements, was not buying Hansen's views outright. Over his objections, it attached a caveat to Hansen's written testimony—"... these changes should be viewed as estimates from evolving computer models and not as reliable predictions."

When Hansen complained, he touched off a furor in Washington among the politicians but not among the greenhouse scientists in Amherst. "I can't say I agree with censorship," observed Rick Katz, who studies climate change impacts at the National Center for Atmospheric Research in Boulder, "but it seems OMB has better people than I thought. I'd have to agree with their angle."

So Hansen, who is director of NASA's Goddard Institute of Space Studies in New York City, was once again at loggerheads with his colleagues in the climate community over how to speak to outsiders. That

Hansen's colleagues are taking pleasure in the federal bureaucracy's meddling in scientific testimony illustrates the resentment these climatologists feel toward their now famous colleague.

But there's an irony: had it not been for Hansen and his fame, few in public office,



"It's just a logical conclusion that the greenhouse is here."

—James Hansen

and certainly not the public itself, would have paid much attention to a problem that everyone at Amherst agrees threatens social and economic disruption around the globe. After all, experts had been hemming and hawing for a decade on the likely magnitude of the problem, and hardly anyone had listened. Then came Hansen. Now greenhouse scientists have the attention they have wanted but for reasons they think unsound.

By day two of the workshop, Hansen had appeared and, in an interview with *Science*, recalled his testimony on that sweltering day in Washington in the midst of last summer's drought. "I said three things. The first was that I believed the earth was getting warmer and I could say that with 99% confidence. The second was that with a high degree of confidence we could associate the warming

and the greenhouse effect. The third was that in our climate model, by the late 1980s and early 1990s, there's already a noticeable increase in the frequency of drought. Despite all the criticism, I wouldn't change any of these." *CMS*

His colleagues certainly wish he would. What really bothers them is not that they believe Hansen is demonstrably wrong, but that he fails to hedge his conclusions with the appropriate qualifiers that reflect the imprecise science of climate modeling. *MJB*

Hansen's critics start with his statement that he has 99% confidence in the reality of the global warming trend. At the workshop, as he already had in the *New York Times*, statistician Andrew Solow of Woods Hole Oceanographic Institution picked on the few quantitative facts involved. Hansen had said in last year's testimony that 1987 had been so hot, so much warmer than the average of the previous 30 years, that its warmth had only a 1% chance of being a random quirk of the climate system. *F. J. J. J.*

"That's not a test for the greenhouse in any way," Solow told the workshop. The year "1987 should be assessed against previous data. The key thing is logic, and I think there's a logical problem here." When statistician Solow calculated how unusual 1987 had been, he found that it did not stand much above an underlying upward trend, giving a confidence of just 70% that it was an exceptional year. To statisticians, that is practically no confidence at all.

Climatologist Tom Wigley of the University of East Anglia, though critical, was more sympathetic. "I think his 99% confidence is not justified theoretically. But he's just saying that, relative to 1958, there's been a warming." In his enthusiasm for proper statistical analysis, Wigley was arguing, Solow had removed the trend that Hansen was trying to point out.

Wigley's sympathetic point of view might have some merit, responded Solow, but "this kind of giving a result and not telling the whole story, that's what I'm criticizing."

If many of Hansen's colleagues find his first point about the warming trend regrettable, they view his second—that the warming could, with "high confidence," be linked to the greenhouse effect—as unforgivable. None of the select greenhouse researchers at the meeting could agree with him. "Taken together, his statements have given people the feeling the greenhouse effect has been detected with certitude," says Michael Schlesinger, himself a modeler at Oregon State University. "Our current understanding does not support that. Confidence in detection [of the greenhouse] is now down near zero."

Hansen's third point—that "the green-

Greenhouse Models vs. Reality

Climatologists may have a gut feeling that the greenhouse effect is heating up the earth, but they have not been close to proving it. Enter a new generation of greenhouse computer models that are giving scientists some hope that the grossest features of the future greenhouse world are being simulated correctly. But the view ahead promises to be a myopic one for years to come.

The new models, which were described at the Amherst workshop, behave more like the real world than earlier models in two ways. They transfer heat from the atmosphere into the deep sea and carry it in surface waters toward the poles, all in currents that can vary in response to climate change. At best, earlier models had only analogs to surface currents that could not change as climate changed. And while earlier models yielded only a single snapshot of the climate expected toward the middle of the next century when greenhouse gases will have doubled, the new models simulate the effects of gradual, rather than instantaneous, increases of greenhouse gases. This will allow researchers to test the new models against what has actually happened in past decades, as well as to project continuous future climate changes.

The greenhouse worlds of the new models have some aspects in common with those of the old ones, though. In both types of models, the world indeed gets warmer, and the continents also tend to warm faster than oceans. In addition, the new models produce similarities to the real world not seen before. For example, in the model that is run by Warren Washington and Gerald Meehl of the National Center for Atmospheric Research (NCAR), the lower atmosphere warms over North America and Europe as it cools over the North Atlantic and the North Pacific. David Karoly of Princeton University recently reported that this has actually happened in recent decades. And both this NCAR model and the new model developed by Syukuro Manabe and his colleagues at the Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton generate rudimentary El Niños—something previous models could never do.

Analysis of these model results is only just beginning, but the reassuring similarities between them are attended by some disturbing inconsistencies. A relatively greater warming at high latitudes is not so evident in the new models. But the real shocker was the weird behavior of the GFDL model run by Manabe. Its Northern Hemisphere behaved much as in earlier models, but after a few decades of modest warming, its Southern Hemisphere began to cool. "This is a big surprise," said Manabe. A strong cooling of the ocean around Antarctica seems to be the immediate cause. "We really don't understand how the ocean behaves," he added.

While modelers are thinking about the new results, other researchers are using both old and new model results to look for the greenhouse effect in recent climate data. The approach favored at the meeting, called fingerprinting, involves comparing the few reliable aspects of greenhouse climates with recent climate trends. The closer the match between model prediction and recent observations, the more likely that the greenhouse warming is here. Assuming the model predictions are correct, studies presented at the workshop show that any intensification of the greenhouse is not yet detectable above the background of natural climatic noise. Indeed, there was every indication that detection of the greenhouse signal using statistically based fingerprint approaches is perhaps 10 years or more away.

Rigorous, objective detection of the greenhouse may be a ways off, but hints of a greenhouse-like climate change nevertheless continue to accumulate (*Science*, 5 February 1988, p. 559). As reported at the meeting, a new study has confirmed the previously noted contrast between warming near the surface and cooling of the stratosphere. The observed pattern of enhanced precipitation reminiscent of the greenhouse was extended to the Soviet Union. And the amount of water vapor over the tropics was shown to have increased in recent decades, as would be expected. In addition, as reported in the 19 May issue of *Science* by W. R. Peltier and A. M. Tushingham of the University of Toronto, global sea level seems to have risen 2.4 ± 0.90 millimeters per year this century, even after allowing for vertical movements of the land.

How many such hints it would take, combined with the certainty of an eventual greenhouse warming of some magnitude, to convince most climatologists that the greenhouse has arrived cannot be rigorously determined. ■ R.A.K.

house effect will [cause] certain changes in climate variability such as the intensity of droughts and storms"—elicits a less vituperative response. Climate modeler Stephen Schneider of the National Center for Atmospheric Research in Boulder reflects the views of others at the meeting, who would only speak privately, when he observes that "where Jim has had some problems with his friends, and I count myself as one, is when he says that the location of specific areas of drought in his model are robust. I can't make the case as strongly as Jim does," Schneider contends, because model particulars such as how the oceans are simulated could make a difference.

"He's not running a realistic ocean," says Schneider. "You don't really know what it's going to do. But he's probably right anyway. The odds are better than 50:50 that the drought areas are robust."

Despite their sharpness, these criticisms do not reflect on Hansen's research abilities, rather they tend to revolve around the interpretation of climate models. "Jim is not the villain that people make him out to be," says Schneider. "He's a state-of-the-art climate modeler. Jim got bad press that was partly deserved and partly envy of other scientists who resent the way he went to Congress. The problem I have is that he has more confidence in his tools than I do."

The primary tool in the greenhouse game is the general circulation model (GCM) of the climate system. Like its cousin that forecasts the daily weather, the climate GCM cranks through equations that calculate the behavior of climate as greenhouse gases increase. Unlike weather forecasting models, a climate GCM must include a simulated ocean whose behavior—such as the way it carries heat around the globe—bears a reasonable resemblance to that of the real ocean. Last year Hansen was the first to publish the results of a GCM that has any kind of a realistic ocean and that also is driven by realistically increasing greenhouse gases. That work provided the best guess up until then of how climate might be responding now and how it will respond in the next few decades.

Despite the relative sophistication of Hansen's model, other modelers remain unconvinced because they feel Hansen gives short shrift to the remaining shortcomings of even newer, more realistic models. "They [Hansen's group] have been coupling their atmospheric model to a pretty hokey ocean," says Schneider, "we all have. But you have to have less confidence because of that."

Other uncertainties lessen confidence as well. Researchers must have some idea of the degree to which climate is being

changed by forces other than greenhouse gases. For example, volcanic dust in the stratosphere probably cools Earth, changes in solar activity may change the climate, and climate surely meanders a bit from one state to another with no prompting whatever.

All the climatic variability generated by these natural forces generates noise in the climatic record that, Hansen's critics would argue, has drowned out the poorly known greenhouse warming signal. "The variability of climate from decade to decade is monstrous," said Tim P. Barnett, an oceanographer at Scripps Institution of Oceanography. "To say that we've seen the greenhouse signal is ridiculous. It's going to be a difficult problem."

The detection problem is one that may take decades to solve. Barnett and Schlesinger have their own approach, an objective, statistical test. Through the latest results, it has found no signal.

Hansen was in no position to argue. He arrived at the 5-day meeting a day late and left 3 days early. "That is his habit," noted workshop organizer Schlesinger. "He comes, gives his talk, and he leaves." Even while present, his quiet, retiring manner puts him in the background. These habits

What gives Hansen high confidence when others hesitate to make any claim is a variety of supporting evidence. The globe has warmed slightly during the past 100 years. His model roughly tracks the warming of the past 30 years. And analyses of polar ice cores suggest that a reduction of the greenhouse effect due to a reduction in atmospheric carbon dioxide contributed to the chill of the last ice age 18,000 years ago.

"The one thing that has the greatest impact on my thinking," says Hansen, "is the increase in atmospheric carbon dioxide from 280 parts per million in the 19th century to its present 350 parts per million. It's just inconceivable that that is not affecting our climate. There's no model that would not say it's affecting it right now."

"It's just a logical, well-reasoned conclusion that the greenhouse is here now," he says. "I think there are a lot of people who agree the warming is probably due to the greenhouse effect, but they are waiting to see."

There's no arguing with Hansen on that point. Stanley Groch, who has been monitoring the performance of the greenhouse models from Lawrence Livermore National Laboratory, guessed that "if there were a

secret ballot at this meeting on the question, most people would say the greenhouse warming is probably there."

Schneider, who was not in Amherst for the meeting but usually testifies to Congress alongside Hansen, is one of those scarce greenhouse researchers who do not need a secret ballot to express their gut feelings. "We need 10 or 20 years to get an absolutely clear signal. I'll be surprised if it doesn't happen, but how do you assign a probability to some-

thing when you have no objective means of doing so? You base it on physical intuition and then state your assumptions. By my intuitive reasoning, the greenhouse signal has been detected at an 80% probability. My faith is based on the principle of heat trapping by greenhouse gases and the billions of observations that support it. All that objective stuff rests on assumptions. The future is not based on statistics, it's based on physics. Objectivity is overplayed."

Obviously, certitude sells on Capitol Hill, intuition less so. As a group, those at the

Amherst workshop offered neither, only a large dose of uncertainty. On the last day, the 40 participants who stayed to the end gathered en masse to put the finishing touches to a press release. They argued over just about everything except this passage: "It is tempting to attribute [the 0.5°C warming of the past 100 years] to the increase in greenhouse gases. Because of the natural variation of temperature, however, such an attribution cannot now be made with any degree of confidence."

Like it or not, the greenhouse community has a spokesman who is not following the consensus script coming out of Amherst. "What bothers a lot of us," said modeler Alan Robock of the University of Maryland, "is that we have a scientist telling Congress things we are reluctant to say ourselves."

"Jim Hansen has crawled out on a limb," said Danny Harvey of the University of Toronto. "A continuing warming over the next 10 years might not occur." The century-long warming has not been continuous. "If the warming didn't happen, policy decisions could be derailed."

Curiously enough, while researchers worry about the possible down side of the greenhouse's newfound popularity, they are still awaiting the benefits from Hansen's confident testimony. Currently about a dozen people run the four U.S. and one British greenhouse GCMs considered state of the art. Time on supercomputers to run greenhouse simulations is scarce, and most modelers often have to scrounge time wherever they can find it. Hansen ran his transient model nights and weekends on his institute's 1975-vintage Amdahl computer—a relic of the dark ages of supercomputing.

"It's getting done at a rate that will take 25 years to get it right," says Schneider. "I'm hoping we can get the modeling of regional greenhouse changes right before they actually happen. What's depressing is that we aren't seeing more resources."

Will a rapidly changing climate leave researchers forever fiddling with their models, still waiting for a consensus detection of the greenhouse? Hansen thinks so. "I'm confident that we're going to see new global records, but it may not be this year. It may be in a few years. I think these issues will go away in the next few years as the earth gets warmer. There will be no sudden change, there will be those who don't agree, but as soon as the man in the street notices, it won't matter. If the model is correct, the increased frequency of drought will be evident in the 1990s, the early 1990s if there is no large volcanic eruption" to cool the climate. If Hansen is right, an exceptional trust in physical intuition may have won the day.

■ RICHARD A. KERR



One of James Hansen's many critics. Michael Schlesinger runs computer greenhouse models too, but he does not share Hansen's "high confidence" that the greenhouse is here.

have not encouraged mutual understanding. Neither did the audience's polite reticence during Hansen's talk, which contrasted with pot shots from many quarters during his absence. Nor that Hansen is unaware of his colleagues' complaints. Last fall, in his lone confrontation with his critics, Hansen endured what one observer described as "a get-Jim-Hansen session" at a climate workshop in Washington. Hansen, as is his style, was unperturbed. "When we're at this level of signal to noise, anyone can disagree with me. I don't argue with that."

EXECUTIVE OFFICE OF THE PRESIDENT

COUNCIL OF ECONOMIC ADVISERS

WASHINGTON, D.C. 20500

April 12, 1989

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Dear Linda:

I have enclosed CEA's comments on EPA's recent draft of "Policy Options for Stabilizing Global Climate Change". This report represents a substantial work effort. You are to be congratulated on its successful completion. We found many of the data and tables informative and useful.

The primary weakness of the document is that it fails to consider the costs of the policy options that are addressed. It leaves the reader with the incorrect impression that there is a "free lunch" out there. This is a serious oversight. I understand that Bob Hahn has discussed this issue with you and Dick Morgenstern. Unfortunately, such a glaring omission cannot be remedied adequately in the short term. I strongly urge you to appropriately caveat this document and to provide a more balanced treatment of policy options in subsequent documents on this very sensitive issue.

Our detailed comments have two main thrusts. First, the analysis of market-based options needs to be improved. Second, the treatment of risk and cost as they relate to investment in energy conservation and energy-efficiency research is not adequate. Addressing these two issues would substantially improve the document.

If you would care to discuss our comments or related issues, please feel free to contact Dr. Robert Hahn. We are anxious to assist you in this important endeavor.

Sincerely,



Thomas G. Moore
Member

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cc: Terry Davies

Council of Economic Advisers' Comments on
"Policy Options for Stabilizing Global Climate"

We offer the following observations:

1. We are encouraged by your discussion of the primary role that markets can play when prices of fossil fuels, CFCs and forest and agriculture products reflect true social cost. Nonetheless, the analysis could benefit from a more complete analysis the entire range of market-based options. Mechanisms such as the auction or sale of emission permits can be useful in significantly reducing activities that have negative externalities, while still maintaining the efficient use of the remaining resources. These mechanisms can be used to address "problems" with inelastic demand (VIII-18), particularly if the amount of permits are reduced very gradually over time. Hence, your conclusions that there are practical limitations to the use of markets (VIII-18) is overstated.
2. Your concern for the equitable outcome of the policies is well taken (ES-66). However, your arguments that a market approach will not allow an equitable outcome again shows a narrow interpretation of the scope of these mechanisms. When policies that encourage greater efficiency have the side effect of redistributing wealth, they can be coupled with other programs that redistribute in the opposite direction. Moreover, it is generally possible to design programs in such a way as to preserve neutrality if that is an objective.
3. Another criticism of the market approach is that consumers tend to under-invest in energy efficient technologies (VIII-19). Your response to the list of responsible factors such as limited information and access to capital is to regulate through efficiency standards. This is but one of many approaches that can be used, and is often not terribly efficient.

Further, your analysis suggests that consumers have chosen the wrong discount rate for calculating investments in energy efficient appliances. It may simply be they view the risks or uncertainties of such investments as significantly higher, and hence use a higher implicit discount rate.

4. On a larger scale, we encounter the same difficulty with your heavy reliance on research into more energy efficient technologies. Implicit in your discussion is the assumption that the government must take the lead in the engineering research. However, you give no indication of the inherent risks of such research or the means of evaluating when such research is justified. It should be the case for those new technologies that are licensable that, once market prices of energy reflect true social costs, the market incentives will

be enough to encourage the optimal level of research. It is only when the benefits of the research are non-appropriable that the government has a role.

5. You have many excellent figures and tables. We would suggest that Figure 10 of the ES be graphed on an absolute scale (CO₂ equivalents of each country) rather than on a relative scale (percent contribution of each country). It would also be helpful if you could combine that data with Figure 3 of the ES and Figure 4-1 to develop a series of tables that would provide the projected emissions by type crossed with the countries or regions of origin over time. This would help us to identify regional impacts of various policy options. A similar table showing country or regional breakdown of Figure 15 in the ES would be helpful.
6. The discussion of population trends in chapter IV is very good. However, we see little follow-through to the policy discussion. Although this is a sensitive subject, we feel that since it is a fundamental driving force behind increases in greenhouse gases, a thorough policy document should deal with the subject.
7. On page 23 of the ES, the discussion of increases in methane does not indicate by what date the concentrations increase by factors of 2 and 2.6 for the SCW and the RCW, respectively.
8. You may have placed too much emphasis on technical solutions, and particularly on renewable energy. For example, your discussion of biomass substitutes (VII-137), and particularly of biogas and gasification gives no indication of the extreme sensitivity of these systems and their inherent unreliability. Similarly, your rather hopeful evaluation of solar photovoltaics (VII-150) gives no indication of the toxic waste by-products that arise from the manufacture of PVCs. This is extremely important in light of conclusions such as that at ES-59, regarding technical options and the use of renewable resources for gaining 25% of the reduction in global warming.
9. In general, you tend to project a sense that the best policy response is to increase efficiency in the use of energy. However, you give very little indication that gains in efficiency are generally had at some cost -- when we decrease energy as a factor of production, we generally increase some other factor(s). These factors carry a cost, whether it is in terms of increased labor, increased research expenditures, or losses of convenience and services. On page 88 of the ES, you state that one of the most effective options to reduce commitments to greenhouse warming is applying already attractive energy-efficient technologies, but you have done little to examine why those technologies have not already been

used. It may not be simply an information problem. There may be unrecognized costs inherent in these technologies.

10. Your use of displays such as Figure 5-21 are disturbing because they seem to imply a preferred level of each policy option. For example, Figure 9 in the ES would seem to imply that increasing the availability of biomass can do much more to decrease greenhouse gas emissions than improvements in the efficiency of cars or buildings. In fact, the relative contributions of each option should be determined by examining the marginal cost per unit of emissions reduction for each mechanism. You have done little or nothing to examine the relative cost effectiveness of the various options and have failed to highlight the importance of that omission.
11. Although you correctly point out the importance of participation of the LDCs in any limitation effort (ES-40), you have not addressed the question of their incentives to become involved in international efforts. Their bargaining position is a strong one, and they may be able to make the situation very difficult for the developed countries.
12. On page 86 of the ES you state that "Although delaying action would allow time to increase knowledge of risks and refine the choice of policies, it could reduce the effectiveness of policy responses." An alternative statement could be "Although taking action now may be politically attractive and may increase the effectiveness of those policies chosen, by delaying commitment to certain types of policies we can refine our choices, reduce uncertainty and assure that our actions are warranted."
13. On VIII-5 we suggest the last sentence read "...can therefore be implemented in a manner that is consistent with..."
14. On VIII-9, your analysis of energy demand responses to price is somewhat confusing. You state that had the pre-1973 energy demand/GNP rate continued, U.S. energy demand would have doubled between 1973 and 1985, implying that GNP doubled during that time. But then you state that the economy increased by only 40%. The figures don't square. Further your statement that energy efficiency improvements save the U.S. economy \$160 billion annually is misleading. It saves that in energy costs, but those savings are had at some other cost.

RESPONSE STRATEGIES WORKING GROUP
of the
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

FIRST MEETING

WASHINGTON, D.C.

January 30 - February 1, 1989

*Work
on
Climate*

INF/3
1/26/89

PROVISIONAL LIST OF PARTICIPANTS

This List is based on information received as of noon,
Thursday, January 26, 1989. PLEASE REPORT ANY CHANGES OR
CORRECTIONS TO THE CONFERENCE INFORMATION CENTER NO LATER
THAN Noon Tuesday, January 31, 1989

considered by

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Frau Dr. Edda Mueller MR'in
Ministry of the Environment

Prof. Dr. Klaus Heinloth
University of Bonn

Anne Ruth Herkes
Embassy of the Federal Republic of Germany

FINLAND

Mr. Kari Kourilehto
Director General
Ministry of Environment

Mrs. Maija Pietarinen
Chief Inspector
Ministry of Environment

Mr. Veikko Marttila
General Secretary
Ministry of Agriculture and Forestry

JAMAICA

Mr. Calvin Gray
Head, Climate Branch
Meteorological Service

NEPAL

Dr. Adhikary
Permanent Representative of NEPAL

NEW ZEALAND

John Gilbert, Deputy Secretary
Ministry for the Environment

PERU

Representative from
Embassy of Peru
Washington, D.C.

POLAND

Prof. Stefan Reichhart
Scientific Secretary
Institute of Meteorology and
Water Management
Warsaw

PORTUGAL

Luis Lorvao
Embassy of Portugal

SENEGAL (tentative)

Assistant to Bakary Kante, Director
Office of Environment
Ministry for Protection of Nature

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Embassy of South Africa

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Ministry of Public Works and Urbanism
Madrid

Alberto Lines Escardo
Sobdirector General De Climatologia y Aplicaciones
National Meteorological Institute

SUDAN

Dr. Fadlalla El Kider El Sayem
Meteorological Department

SWITZERLAND

Dr. Pascale Morand Francis
Federal Office of Environmental Protection

YUGOSLAVIA

Liliana Milojevic
First Secretary (Science, Technology and Economic)
Embassy of Yugoslavia

B. SPECIAL (Intergovernmental Organizations)

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Division Head, Monitoring of Air Pollution
Directorate General for Environment, Consumer Protection
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Heinz Hilbrecht
First Secretary (Energy, Environment and Transport)
Delegation of the Commission of the European Community

INTERNATIONAL ATOMIC ENERGY AGENCY

Mr. F. Niehaus, Head
Reliability and Risk Assessment
Division of Nuclear Safety

EUROPEAN SPACE AGENCY

Mr. Ian Pryke
Head, Washington Office

INTERNATIONAL ENERGY AGENCY

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OECD

* Mr. Paul Stolpman
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Environment Directorate, OECD

UNITED NATIONS DEVELOPMENT PROGRAM

Charles L. Perry
United Nations Development Program

UNITED NATIONS ENVIRONMENT PROGRAM

* Mr. Peter Usher
Global Environment Monitoring System
Atmosphere Program Officer

Prof. G. T. Goodman, Advisor to UNEP
Beijer Institute
Royal Swedish Academy of Sciences

UNESCO

Dr. Bernd von Droste
Secretary, UNESCO/MAB
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Forestry Department

Mr. Roger Sorenson
Head, Washington Office

WORLD BANK

Prof. Dr. Erik Arrhenius
Principal Advisor, Science & Technology

Dr. Kenneth Piddington
Director, Environment Department

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Rep from Pan American Health Organization

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Dr. Victor G. Boldirev
Director, World Climate Program

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Director, Washington Office

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Joe Goffman

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Richard Mott
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IIT Research Institute

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Liz Cook
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Ms. Peg Stevenson
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Greenpeace United States

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National Association of Conservation Districts

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Commissioner of the Ohio Public Utilities Commission

Ms. Linda Bisson
Commissioner, New Hampshire
Public Utilities Commission

Mr. Charles D. Gray
Assistant General Counsel, NARUC

NATIONAL ASSOCIATION OF STATE DEPARTMENTS OF AGRICULTURE

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Mr. Thomas Altmeyer
Senior Vice President of
Government Affairs

Diane Moody
Senior Economist

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David Wirth
Richard Ayers
David Doniger
Natural Resources Defense Council

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Leslie Black
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Committee on Energy and Natural Resources
United States Senate

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Committee on Environment and Public Works
United States Senate

Curtis Stanford
Technical Consultant
Subcommittee on Natural Resources, Agriculture
Research and Environment
Committee on Science, Space, and Technology
House of Representatives



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

OFFICE OF
POLICY, PLANNING AND EVALUATION

MEMORANDUM

SUBJECT: Organization of the IPCC Response Strategy Workgroup
(RSWG)

FROM: Richard D. Morgenstern, Director *RD*
Office of Policy Analysis

TO: IPCC Interagency Workgroup

The RSWG will soon be adopting a workplan that will require the completion of a number of resource intensive analytic tasks over the next few years. A question has arisen concerning the best organizational structure for completing this work and a solution was proposed in a January 20 memorandum from John Clarke to the IPCC Working Group (attached). There are two major problems with the organizational structure suggested in that memo:

1. It calls for the creation of a U.S. staffed Secretariat to perform the work of the RSWG. This defeats the main purpose of the IPCC which is to develop an international consensus on the scope of the global climate change problem and potential responses to it. By excluding or effectively limiting the role of other countries from the process of generating work products, the proposed structure will lead foreign governments to feel less of a "sense of ownership" of the RSWG's work.
2. It calls for the staffing of a new organization within the U.S. to conduct RSWG work, and coordinate the participation of U.S. agencies. The problem is that no new organization can hope to even come close to replicating the expertise now present in existing government agencies. This means that such a staff will have to rely extensively on executive agency support to generate work products and will serve largely a coordinating function. If this is to be its primary role, other structures (as suggested below) could fulfill this function more effectively and without the creation of a new bureaucracy.

PROPOSED SOLUTIONS

To ensure that foreign governments feel a sense of ownership of RSWG products, it is crucial that the Expert Groups actively invite the participation of and/or assign responsibility to other governments for the preparation of work products. In many cases, this will highlight differences in opinion on various topics and allow a consensus to emerge, or alternatively, allow key differences in points of view to be discovered. For example, all countries may be invited to submit assessments of future CO₂ emissions from electricity generation. While not all countries may choose to do so, the assessments from those that do may differ in many respects and those differences would be discussed at future meetings. Alternatively, the Expert Groups may choose to divide responsibility for different tasks to different countries. Assessments for one technology might be undertaken by one country while another might be undertaken by a different country. In any case, this process is more likely to lead to an international consensus than one dominated by the U.S.

The administrative functions of each expert group should be carried out by the expert group chairman. If they are unable to carry out such function, the U.S. should be prepared to step in.

As to how to organize U.S. participation in the RSWG, no new bureaucracy is needed. We have already organized a DPC working group to coordinate domestic policy development. The reservoir of expertise on this subject is now and will remain in individual agencies. To coordinate the participation of agencies in the RSWG, however, it would be useful to create a standing RSWG Coordinating Council, chaired by the Department of State, and consisting of EPA, DOE, USDA, DOC, and DOI. Membership would be at the office director level. The Council would initially oversee the development of a U.S. workplan. This would involve identifying specific tasks and making assignments. The Council would also oversee and approve the official submission of U.S. products to the RSWG. Obviously, if disagreements cannot be resolved at the Coordinating Council, they will be resolved at higher levels in the Executive. Administrative functions for the coordination of RSWG activities should be carried out by State.

Attachment

DATE: 1/20/89

MEMO TO: IPCC INTERAGENCY WORKING GROUP

SUBJECT: ORGANIZATION OF THE IPCC RESPONSE STRATEGY WORKING GROUP

FROM: J. CLARKE, EXECUTIVE DIRECTOR/ DOE CLIMATE ACTIVITIES

BACKGROUND: In its inaugural meeting the IPCC decided to organize three working groups to accomplish its tasks in the most efficient and expeditious manner. A core group of countries was identified for each working group in order to provide for a manageable and effective group composition. However, each working group was to obtain the best possible expertise, on a world wide basis, in order to achieve a comprehensive and globally balanced product.

The Terms of Reference state that "Working Group III should consider, inter alia, forecasting and assessment of future emissions of greenhouse gases, impacts of changing technology, sources and sinks, adaptation to climate change, strategies to control or reduce emissions and other human activities that may have an impact on climate (e.g. deforestation, changing land use) and their social and economic implications, and legal matters." All Working Groups "should build on past international and national assessments and draw fully on the expertise of existing international scientific bodies." Finally, "they should coordinate their work as far as practicable."

On 1/17/89 the U.S. IPCC interagency working group discussed options for the organization of RSWG to accomplish this mission. Members of the group described the sophisticated modeling and technical analysis that must be performed to arrive at global agreement on emission scenarios. The organizational challenge of obtaining the contributions of a broad cross section of nations, international organizations and NGOs was pointed out. The work involved in reconciling and incorporating this global input was also recognized. Finally, the effort required to obtain agreement on both the scenarios and their inherent uncertainties was noted. Considering the complexities involved and the need for immediate RSWG actions to supply emissions scenarios to the other working groups, there was substantial agreement on the need for a Secretariat to support the Chair in organizing the work of RSWG. There was also considerable support for the idea that the U.S., as Chair of the RSWG, should supply that Secretariat. It was agreed to further develop the Secretariat concept for presentation at the Jan. 30 - Feb. 1 meeting.

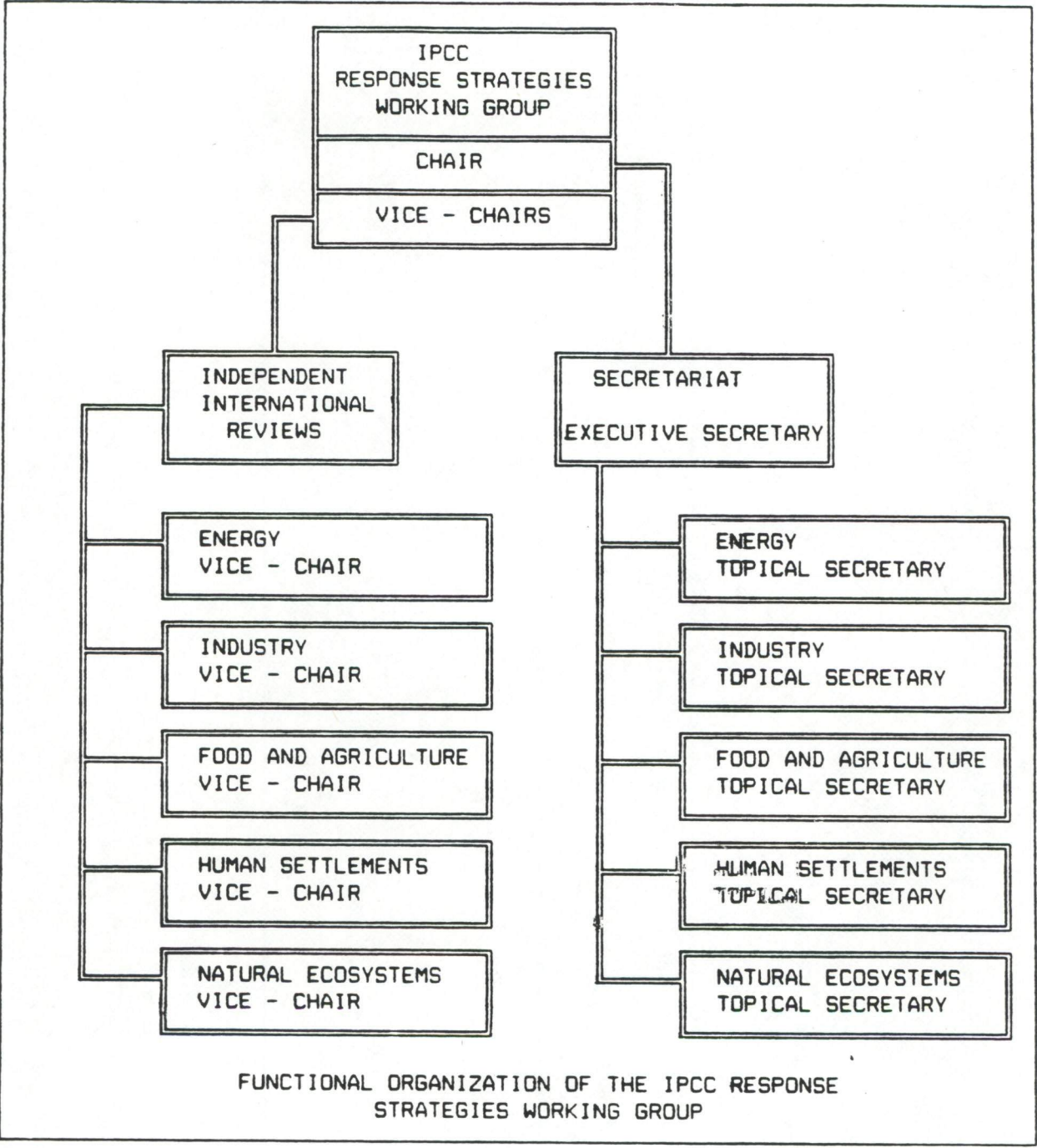
DISCUSSION: The concept of a Secretariat to coordinate the work of international bodies is well established. In the present circumstances, where a great deal of work must be done and coordinated with many nations, international organizations and the other IPCC working groups, it is essential. Considering the limited time chosen by the IPCC for its work and the need for the RSWG to supply the initial emissions scenarios to the other working groups, it would be inefficient and very difficult to organize an international secretariat in the time available. It would be appropriate for the U.S., as Chair of the RSWG, to volunteer to provide a Secretariat. If the other members of RSWG accept the division of the group's work into the four topical areas as proposed by the Chair, the U.S. would need to provide five essentially full time people for the Secretariat: an Executive Secretary and one Topical Secretary in each area.

This Secretariat would work under the supervision of the Chair to carry out the work plan as adopted by the RSWG, soliciting contributions from all appropriate national bodies and international organizations. The Executive Secretary would be responsible for assuring the development of uniform methodologies by the Topical Secretaries and for coordinating RSWG activities with the other IPCC groups. The Topical Secretaries would establish methodologies, integrate contributions, identify, and seek to eliminate, gaps and uncertainties in each topical area. The Secretariat as a whole would work to present the RSWG with a comprehensive and globally balanced product for review and adoption.

The function of RSWG, supported by a strong Secretariat, would be focused on setting directions, reviewing the product of the Secretariat and considering overall response strategies. The five Vice Chairmen could be involved in a direct way by assigning responsibility for organizing independent international reviews of the product of the Secretariat in the topical areas. The correspondence between the number of Vice - Chairs and the number of topical areas for review would be exact if the Industry/Energy topical area were split into separate topical areas. The division makes technical sense if the Industry topic is understood as referring to response strategies of non-energy industries. This division would require a fifth Topical Secretary. The other core members would be involved by their participation in RSWG decisions as well as by identifying relevant national capabilities and arranging the participation of their national organizations in the RSWG work. The attached diagram illustrates the functional arrangement.

The U.S. would have to agree to provide the individuals to staff the Secretariat. These individuals would also require additional staff support from their agencies. Since the U.S. possesses a great deal of the world's capability to carry out the work of the RSWG, the individuals assigned to the Secretariat would spend much of their time arranging for and coordinating input from the U.S. If the individual U.S. agencies divide the responsibility of providing U.S. support for RSWG in the topical areas and supply a Topical Secretary in these same areas, the individuals assigned to the Secretariat could also provide interagency coordination for this U.S. support.

RECOMMENDATION: The U.S. should propose to provide a Secretariat for the RSWG. The Secretariat should be provided by the U.S. agencies responsible for providing U.S. technical input to RSWG. The group of agency representatives assigned to the Secretariat should also constitute the interagency mechanism to provide the domestic coordination of this U.S. input.



FUNCTIONAL ORGANIZATION OF THE IPCC RESPONSE STRATEGIES WORKING GROUP

EXAMPLE

DOC

DOI

USDA

DOE

EPA

EXPERT GROUP A

TASK I

Subtask 1

Subtask 2

TASK II

EXPERT GROUP B

TASK I

EXAMPLE

US

CANADA

NETHERLANDS

SWEDEN

JAPAN

EXPERT GROUP A

TASK I

Subtask 1

Subtask 2

TASK II

EXPERT GROUP B

TASK I

*F
Working
in
Climate*

**EXPERT GROUP MEETING
ON
METHODOLOGIES AND ANALYTICAL TOOLS**
(Under the Auspices of the Intergovernmental Panel on Climate Change)

CENTRE DES CONFERENCES INTERNATIONALES
19 avenue Kléber, Paris 16ème

10th-11th April, 1989

SPONSORING ORGANISATIONS

This expert group meeting is organised under the auspices of the Sub-Group on Energy and Industry of the Response Strategy Working Group (RSWG), Intergovernmental Panel on Climate Change (IPCC) which was set up by the World Meteorological Organisation and the United Nations Environment Programme.

PURPOSE

The purpose of the expert group is to foster an international consensus on the appropriate methodologies and analytical tools for assessing policy options for reducing greenhouse gas emissions and their rate of accumulation in the atmosphere. The expert group is also to examine which analytical methods are most appropriate for assessing the social and economic implications of these policy options in a national, regional and international context. Part of the expert group's work includes the identification of limitations and gaps in analytical tools.

The expert group will advise the Sub-Group on Energy and Industry on the selection and/or development of analysis tools for use by the Sub-Group when it subsequently identifies, analyses and considers policy options for national, regional and international responses. The objective of this expert meeting is to examine, discuss and formulate which methodologies, approaches and analytical tools would be most appropriate for use in a decision analysis framework but it is not to present and debate specific technology and policy options or strategies for reducing greenhouse gas emissions.

PARTICIPATION

In addition to invited speakers, the meeting will be attended by representatives of "core" or designated countries of the Response Strategy Working Group, countries and international organisations which are members of the Sub-Group on Energy and Industry and other "observing" countries under the auspices of the Intergovernmental Panel on Climate Change. Time will be set aside during the meeting not only for questions and answers but also for all participants to actively participate in the proceedings.

PRELIMINARY AGENDA

Invited speakers, and other participants, will be asked to discuss and examine the following topics:

1. Introduction

- ° Progress report by the United States and Netherlands on the development and specification of long term greenhouse gas emission scenarios, including a discussion of:
 - methodology and assumptions;
 - data requirements;
 - preliminary results.
- ° Scope and general conceptual approach and analytical framework for assessing (i) the reduction in greenhouse gas emissions, and (ii) the social and economic effects on national, regional and international levels of policy response measures.

2. Analytical Tools for Assessing Impact on Greenhouse Gas Emission Levels

- ° Techniques for assessing reductions in greenhouse gas emissions associated with policy response measures.
 - (a) Modelling Approaches
 - models that are available for use in assessing policy options to deal with the possibility of climatic change;
 - data requirements, availability, level of disaggregation, regional differences and reliability;
 - assumptions and uncertainties;
 - limits and gaps in modelling techniques;
 - criteria for selecting modelling techniques, and assessment of usefulness in policy formulation.

(b) Other Techniques

- concepts, approaches and tools - differentiated on the basis of policy options (including timing of implementation) - to deal with the possibility of climate change;
- range and type of policies and which tools would be most appropriate to assess them;
- data requirements, availability, regional differences, and reliability;
- assumptions and their importance;
- assumptions of and gaps in analytical tools;
- criteria and parameters for comparison, evaluation and/or selection of analytical tools;
- their usefulness and reliability for policy formulation.

3. Analytical Methods for Assessing Social and Economic Effects of Response Measures

- o Techniques for assessing and estimating the social and economic effects (other than the impact on emissions levels discussed under item 2) associated with implementation of policy options for the reduction of greenhouse gas emissions.

(a) Modelling Approaches

See Item 2(a).

(b) Other Techniques

See Item 2(b).

4. Other Business

- o Usefulness and limitations in single analytical tool approaches;
- o Research institutes and other organisations which perform analysis;
- o Available data and basic input parameters.

TENTATIVE LIST OF INVITED SPEAKERS

C. O. Wene
Chalmers University of Technology,
Göteborg, Sweden

A Methodology for Evaluating
Policies to Control Greenhouse
Gas Emissions from the Technical
Energy System

Y. Smeers
Center for Operations Research
University of Louvain, Belgium

Potential of Global Energy Models
for Assessing Greenhouse Gas
Reduction Policies: the Case of
the EFOM Model

H. L. Schmid
Federal Energy Office
Berne, Switzerland

Swiss Energy Scenarios:
Methodology, Models and CO₂
Emissions

R. Kappel
Center for Economic Research,
Swiss Federal Institute of Technology
Zurich, Switzerland

Economic Development, Energy
Consumption and CO₂ Emissions:
Simulation Model for China

A. Voss
University of Stuttgart,
Federal Republic of Germany

Cost-Effectiveness Analysis: The
key for the identification of
efficient response strategies to
the climate issue - Conceptual
approach and modelling tools

P. Okken
Energy Study Centre
Netherlands Energy Research Foundation,
Patten, Netherlands

The Greenhouse Effect: Uncertainty
Dilemma of Science and Policy

R. J. Swart
National Institute of Public Health
and Environment Protection
Bilthoven, Netherlands

Co-presenter with Dr. Okken (as
above) and also Progress Report
on Development of Emission
Scenarios for RSWG

I. Mintzer
World Resources Institute
Washington D.C.

An Analytical Tool: Model
of Warming Commitment

N. Kouvaritakis
International Energy Agency,
Paris

Exploring the Robustness of Policy
Measures: An Approach

R. W. Shaw International Institute for Applied Systems Analysis, Laxenburg Austria	Under discussion
W. Sassin KFA, Jülich, Germany	Decision Under Uncertainty: A Frame for Evaluating various Contri- butions to Climatic Change and Related Response Strategies
M. Miyata The Energy Data and Modelling Center Institute of Energy Economics, Tokyo, Japan	Under discussion
J. Darmstadter Resources for the Future Washington D.C.	Measuring Economic and Social Costs
G. Horton UK Department of Energy London, United Kingdom	Quantifying the Costs of Emissions Reductions: A Modelling Approach
M. P. Valette Directorate of Science, Research and Development EEC, Brussels, Belgium	Economic Implications for Growth and Trade: An Approach
R. Hoffman Faculty of Environmental Studies, University of Waterloo, Canada	Design Approach to Socio-Economic Modelling

Other speakers from the United States, Japan and other countries will also give presentations (e.g., on Progress in Developing Emission Scenarios and Edmonds-Reilly model).

ORGANISATIONAL DETAILS

Meeting will be co-chaired by Japan and China.

Morning sessions will start at 9:00 a.m. and end at approximately 1:00 p.m. Afternoon sessions will start at 2:30 p.m. and end at approximately 6:00 p.m.

English will be the official language. There will be no simultaneous translation.

Could participants, who have not as yet done so, notify the Delegation of Japan to the OECD - Mr. H. Ogawa, Tel: (1) 47 66 02 22 - or the contact mentioned below of their planned attendance.

All travel and hotel arrangements must be made directly by participants. All visitors to France, other than nationals of the European Communities and of Switzerland, are advised of the necessity to obtain visas for entry into France.

Correspondence should be addressed to:

Dr. George Kowalski,
Head, Energy Economic Analysis Division
International Energy Agency
2 rue André Pascal
75775 PARIS CEDEX 16

Tel: (33 1) 45 24 94 80
Tlx: 630 190 ENERG A
Fax: (33 1) 45 24 99 88



U.S. Department
of Transportation

**Research and
Special Programs
Administration**

Memorandum

Give Bob Hahn a copy done 3/1/89

*F. W. ...
Global Climate*

Date:

Reply to Attn. of:

Subject:

INFORMATION: DOT Comments on EPA Draft
(Feb. 21, 1989) Report to Congress On "Policy
Options for Stabilizing Global Climate"

From:

S. Fred Singer
Chief Scientist

S. Fred Singer

To:

To The Files

This Draft Report was briefed by EPA and distributed at the Domestic Policy Council Meeting held on March 7, 1989.

We have reviewed the Report and offer the attached comments. We commend EPA for presenting a variety of policy options for slowing down the buildup of "greenhouse" gases in the atmosphere; but the Report could be strengthened by certain additions and by spelling out more clearly the assumptions underlying the scenarios used.

Of major interest to DOT is the policy option #3 (on p. 34 of the Executive Summary) relating to improved efficiency of automobiles. Cost-effective technological approaches may exist to this extremely important issue.

Attachment

#

Scientific Basis For Global Warming Is Uncertain

The Report follows the mainstream of current scientific opinion regarding the enhanced greenhouse effect, predicting a $\sim 3^{\circ}\text{C}$ global warming corresponding to a doubling of CO_2 and other greenhouse gases. But an informed minority view holds otherwise: Since there is not yet a sure greenhouse signal in the global temperature record, a negative atmospheric "feedback" may be operating, which cancels much of the expected warming; a likely candidate is increased cloudiness that reduces the amount of solar radiation reaching the earth's surface.

The Report should discuss this matter fully and inform Congress of the basic scientific uncertainty before recommending or even delineating policy options. In other words, there may not be a problem.

In this connection, it is significant that the Report anticipates a warming of $\sim 1^{\circ}\text{C}$ by the year 2000. This is a huge increase that cannot be missed and would make itself evident within a few years--in other words, before any major policy initiative can be launched.

Scientific Assumptions Entering The Scenarios Are Questionable

1. Much, if not most, of the CH_4 and N_2O gases have natural sources and cannot be influenced by human intervention. This point bears full discussion.
2. About half of the CO_2 emitted in fossil fuel burning appears to be immediately absorbed by the ocean. The biosphere represents another sink that could increase as CO_2 concentration grows.
3. The Report implicitly assumes that CFC substitutes have no greenhouse effects. That is highly unlikely to be the case.

Discussion of Policy Strategies Is Incomplete

1. We note with interest that option #3 (Improved Transportation Efficiency) is about as or more effective than either CFC Phase Out, Energy Emissions Fee, Emission Controls, or the Promotion of either Natural Gas, Nuclear Power or Solar Technologies. (See attached p.34.)
2. We should note, however, that the size of the impact of individual policy strategies depends crucially on the assumptions involved. For example, the reason that Promotion of Nuclear has about the same impact as Solar

is that nuclear is assumed to go from 15 percent of electric power generation up to 17 percent, whereas solar (photovoltaic?) is assumed to go from 0 percent to 17 percent.

Recommendations For Making The Report More Effective

To make the Report more realistic and useful, it should be expanded in three respects:

1. The scientific base and assumptions should be more fully presented, as discussed above.
2. The cost (both direct and the wider macro impact) should be stated for each policy option. We eventually require an incremental (i.e. marginal) cost-benefit analysis comparing various degrees of the policy options by their impact and cost.
3. The political and international dimensions cannot be neglected and may ultimately be determinative. On the one hand, the options cited will impact on various domestic constituencies in the fields of transportation, energy supply, agriculture, and so on. On the other hand, the options, to be effective, require international agreements, some of which may be difficult to achieve.

Conclusion: A Cost-Effective Technological Approach

It seems to us that some of the policy options may be premature in view of the uncertain scientific base, while others may be prudent to carry out even if the scientific base did not exist.

For example: If, by technology advance, we could substantially increase the energy efficiency of the internal combustion engine (ICE), at the same time decreasing polluting emissions, we would achieve simultaneously a number of worthwhile objectives. Based on recent laboratory results, such technology advance may indeed be achievable and should become commercially attractive if carried out as a long-term development program by an industry consortium, under appropriate governmental auspices.

The DOT would be willing to develop such an initiative, in cooperation with other government departments and appropriate private-sector organizations.

Attachment

STABILIZING POLICY STRATEGIES: DECREASE IN EQUILIBRIUM WARMING COMMITMENT

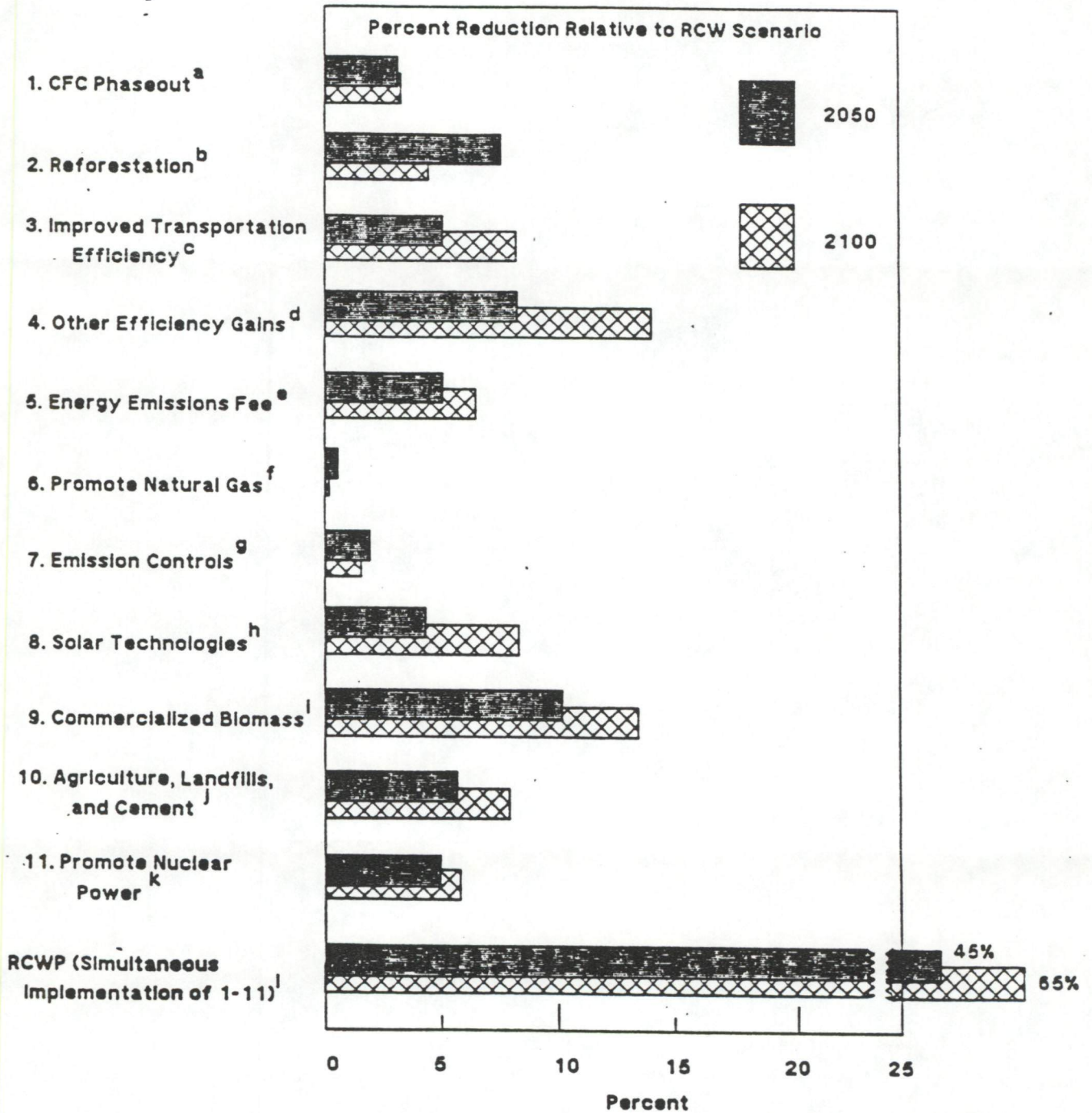


Figure 8. The impact of individual measures on the equilibrium warming commitment in the RCW scenario. The simultaneous implementation of all the measures represents the RCWP scenario.

EXPERT GROUP MEETING

ON

METHODOLOGIES AND ANALYTICAL TOOLS

(Under the Auspices of the Intergovernmental Panel on Climate Change)

CENTRE DES CONFERENCES INTERNATIONALES

19 Avenue Kléber, Paris 16ème

10th-11th April, 1989

*Copy to
Ken
Richard
F.
Wash
Global
Climate*

SPONSORING ORGANISATIONS

This expert group meeting is being organised under the auspices of the Sub-Group on Energy and Industry of the Response Strategy Working Group (RSWG), Intergovernmental Panel on Climate Change (IPCC) which was set up by the World Meteorological Organisation and the United Nations Environment Programme.

PURPOSE

The purpose of the expert group is to foster an international consensus on the appropriate methodologies and analytical tools for assessing policy options for reducing greenhouse gas emissions and their rate of accumulation in the atmosphere. The expert group will also examine which analytical methods are most appropriate for assessing the social and economic implications of these policy options in a national, regional and international context. Part of the expert group's work will be to identify limitations and gaps in analytical tools.

The expert group will advise the Sub-Group on Energy and Industry on the selection and/or development of analysis tools for use by the Sub-Group when it subsequently identifies, analyses and considers policy options for national, regional and international responses. The objective of this expert meeting is to examine, discuss and formulate which methodologies, approaches and analytical tools would be most appropriate for use in a decision analysis framework but it is not to present and debate specific technology and policy options or strategies for reducing greenhouse gas emissions.

PRELIMINARY AGENDA

Invited speakers, and other participants, will be asked to discuss and examine the following topics:

1. Introduction

- ° Overview of the link between scientific models on climate change and the development and specification of long term greenhouse gas emission scenarios on the one hand, and the work of the expert group on the other hand, including a discussion of:
 - methodology and assumptions;
 - data requirements;
 - preliminary results.
- ° Scope and general conceptual approach and analytical framework for assessing (i) the reduction in greenhouse gas emissions, and (ii) the social and economic effects on national, regional and international levels of policy response measures.

2. Analytical Tools for Assessing Impact on Greenhouse Gas Emission Levels

- ° Techniques for assessing reductions in greenhouse gas emissions associated with policy response measures.
 - (a) Modelling Approaches
 - models that are available for use in assessing policy options to deal with the possibility of climatic change;
 - data requirements, availability, level of disaggregation, regional differences and reliability;
 - assumptions and uncertainties;
 - limits and gaps in modelling techniques;
 - criteria for selecting modelling techniques, and assessment of usefulness in policy formulation.
 - (b) Other Techniques
 - concepts, approaches and tools - differentiated on the basis of policy options (including timing of implementation) - to deal with the possibility of climate change;
 - range and type of policies and which tools would be most appropriate to assess them;
 - data requirements, availability, regional differences, and reliability;
 - assumptions and their importance;

- assumptions of and gaps in analytical tools;
- criteria and parameters for comparison, evaluation and/or selection of analytical tools;
- their usefulness and reliability for policy formulation.

3. Analytical Methods for Assessing Social and Economic Effects of Response Measures

- ° Techniques for assessing and estimating the social and economic effects (other than the impact on emissions levels discussed under item 2) associated with implementation of policy options for the reduction of greenhouse gas emissions.

(a) Modelling Approaches

See Item 2(a).

(b) Other Techniques

See Item 2(b).

4. Other Business

- ° Usefulness and limitations in single analytical tool approaches;
- ° Research institutes and other organisations which perform analysis;
- ° Available data and basic input parameters.

ORGANISATION

Meeting will be co-chaired by:

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United States Department of State

*Bureau of Oceans and International
Environmental and Scientific Affairs*

Washington, D.C. 20520

February 23, 1989

*Work on
Global
Climate*

Note to RSWG participants:

Attached for your information is a list of principal RSWG contacts for the 17 core member governments and a list of those who will coordinate U.S. Government participation in RSWG and its subgroups. In both cases, we have listed a single contact point to facilitate communication, but we fully understand that many agencies in each of our governments will contribute to the work of RSWG. Please let me know if there are any changes or corrections to be made.

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RESPONSE STRATEGIES WORKING GROUP
of the
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

FIRST MEETING

WASHINGTON, D.C.

January 30 - February 1, 1989

2/10/89

RESPONSE STRATEGIES WORKING GROUP
(WORKING GROUP III)

of the

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

REPORT OF THE FIRST MEETING

WASHINGTON, D.C.

January 30 - February 1, 1989

1. ORGANIZATION OF THE SESSION

Opening of the Session

The first session of Working Group III (hereinafter referred to as Response Strategies Working Group or RSWG) of the Intergovernmental Panel on Climate Change (IPCC) was held at the Department of State, Washington, D.C. from January 31 to February 1, 1989. It was opened at 9:30 a.m. on January 30 by its Chairman, Dr. Frederick M. Bernthal, U.S. Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs.

The list of participants is at Annex I.

Dr. Bernthal introduced Secretary of State James A. Baker, III, citing his important role in placing environmental concerns on the agenda of economic institutions as Treasury Secretary and noting that he had made clear that global climate change and other environmental issues will receive high priority in the U.S. foreign policy agenda.

Secretary Baker applauded the recognition of environmental problems as a transnational issue. He declared that the time has come for political action, stating that the problem is not merely a scientific one, but rather a diplomatic one involving when and where to take action. He then made four points: first, that we cannot wait to resolve all uncertainties before acting; second, that we should focus immediately on steps which are justified for other reasons, including reduction of CFC emissions, greater energy efficiency, and reforestation; third, that global solutions should be as specific and cost-effective as possible; and fourth, that solutions must reconcile the requirements for both economic development and a safe environment. He concluded by stating that progress generally results when common interests are joined to a common understanding, and declared that the present meeting will play a crucial role in generating that common understanding.

Dr. Bernthal then introduced Professor Bert Bolin, Chairman of the Intergovernmental Panel on Climate Change, declaring him to be one of the world's most renowned atmospheric scientists.

Professor Bolin, in his introductory statement, pointed out that we do not know how rapidly climate change may occur, or what form it may take. Policy, he said, will concern both adaptation to and limitation of climatic change. He then reviewed the causative factors underlying the increase of greenhouse gases, stating that, because of the destructive influence of chlorofluorocarbons (CFC's) on the ozone layer, urgent action is needed to develop more stringent measures to reduce CFC emissions.

He also discussed the need to stop deforestation and to undertake more research into the role of methane. The reduction of carbon dioxide emissions, he said, would mean a major modification of the world's energy supply system, given the preponderant position of fossil fuels among energy sources. He stated that nuclear power could be used during a transition period, but that a long-term solution would involve a significant role for renewable energy sources. In conclusion, he urged that an analysis of overall policy problems not be delayed pending more detailed analysis of the scientific problems involved.

Adoption of the Agenda

The Chairman outlined the provisional agenda and, following an initial discussion of the organization of RSWG activities, the agenda was adopted.

2. ORGANIZATION OF THE WORKING GROUP

The United States outlined a proposal for organization of the RSWG's work, including sectoral subgroups and phases of activity. A general discussion of the U.S. proposal and the organization and work program followed, focusing on the need to organize work in the most efficient manner, to establish clear priorities, carefully delineate subgroups' duties, and recognize environmental and resource differences among nations. Statements concerning national views, policies and activities relating to the climate change issue were made by representatives of several countries.

The Chairman proposed formation of a small group to prepare a draft outline for organization of the RSWG's work for consideration by plenary on January 31. The group, consisting of Professor Bolin (chair) and representatives of Australia, China, the Netherlands, U.S.S.R., United Kingdom, United States and Zimbabwe, proposed a structure and guidelines reflecting comments by many delegations in the plenary discussion. Following further discussion on January 31, the proposal was revised and approved (Annex II, pp. 1-3).

3. REPORT FROM WORKING GROUP I

Mr. Neil Sanders of the United Kingdom presented a summary of the Report of Working Group I (Science). He stated that fifty scientists from twenty countries had met and identified lead authors for each subject area. Working Group I requests that Working Group III provide projections for three scenarios of emissions of CO₂ (fossil fuels and deforestation), methane (population, rice, cattle, landfill, fossil fuel extraction), N₂O (fertilizer, energy), CFCs, CO and NO_x.

4. VIEWS AND ACTIVITIES OF INTERGOVERNMENTAL AND NONGOVERNMENTAL ORGANIZATIONS

A panel of representatives of five nongovernmental and intergovernmental organizations (International Chamber of Commerce, World Resources Institute, Food and Agriculture Organization, International Energy Agency, and U.N. Environment Program) discussed ongoing and planned climate change activities. Representatives of the United Nations Educational, Scientific and Cultural Organization and the World Meteorological Organization commented on their organizations' activities and capabilities. (Annex III)

5. WORKPLAN ORGANIZATION AND LEADERSHIP

The RSWG established a Steering Committee and four subgroups.

The Bureau and, by invitation, heads of delegation of core member countries and of subgroup cochair, and representatives of the IPCC secretariat, UNEP and WMO will comprise the Steering Committee. The Steering Committee will provide overall coordination and direction of the work of the RSWG. It was agreed that the Steering Committee would undertake two initial tasks: (A) The development of emissions scenarios and (B) the development of a strategy for considering implementation mechanisms. Both tasks are described more fully in Annex II (pp. 21-24).

The plenary agreed to the Bureau's proposal for the following subgroup cochair:

- a. Energy and Industry - Japan and Canada or China
- b. Agriculture, Forestry and Other - Federal Republic of Germany and Zimbabwe
- c. Coastal Zone Management - New Zealand and the Netherlands
- d. Resource Use and Management - France and India, and China or Canada

The first two subgroups will focus on limitation strategies and the second two will focus on adaptation strategies.

International and nongovernmental organizations are welcome to participate in and contribute to subgroup activities.

The initial RSWG workplan (Annex II) was developed in meetings of the subgroups and the Bureau and approved, as amended, by the plenary.

6. OTHER BUSINESS

The RSWG decided to await the results of the IPCC Bureau meeting (February 6-7, 1989 in Geneva) before designating the date and place of its next session.

7. CLOSURE OF THE SESSION

The first meeting of the IPCC RSWG was adjourned at 2:30 p.m. on Wednesday, February 1, 1989.

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Structure for conducting the work of
the IPCC Working Group on Response Strategies (RSWG)

IPCC WG III on response strategies should rely on:

IPCC WG I to provide the scientific basis for the analysis, and

IPCC WG II to describe the likely impacts of climate change.

Present knowledge about possible ongoing and future climate changes on global, and certainly on regional and local, scale are uncertain and precise strategy options on a national level can only be developed gradually. In order to progress optimally WG III should distinguish between

a) a short term (18 months) workplan which will be general and preliminary in several regards, but which should be specific in a few priority areas and delineate future options in broad terms, and

b) an intermediate and long term workplan, which will provide for collection and analysis of sufficient data to evaluate possible response options and provide a useful information base as climatic changes occur.

Goals for the WG

- Define policy options for national, regional and international actions, including proposals for short term actions.
- Provide estimates of consequences, costs and benefits.
- Set priorities.
- Define implementation mechanisms and in so doing analyze carefully the implications for nations in different states of development.

RSWG Structure

STEERING COMMITTEE*

Limitation

Adaptation

<hr/>	<hr/>	<hr/>	<hr/>
Energy and Industry**	Agriculture, Forestry and Other	Coastal Zone Management	Resource Use and Management***
<hr/>	<hr/>	<hr/>	<hr/>

* Initial tasks:

- a. Develop emissions scenarios, taking into account population and economic growth in different regions
- b. Develop strategy for considering implementation mechanisms

** Including transportation

*** Including unmanaged ecosystems

Guidelines to Subgroups

- o Recognize the different economic and geographic circumstances of nations (e.g., developed, developing).
- o Seek cost-effective options, including quantitative and qualitative evaluation of social, environmental and economic considerations.
- o Define priority short- to medium-term options (including non-climate actions that can help) and long-term options.
- o Use available information and work done elsewhere.
- o Address institutional and attitudinal impediments to implementation.
- o Structure activities at national, regional and international levels, e.g.:

National: List of actions individual nations can address, information exchange.

Regional: Regional conferences (e.g., Pacific island states).

International: Energy R&D
Energy efficiency
Assistance to developing countries.

Resources

It is important to acquire the necessary resources to get work going during the periods between RSWG meetings.

- Nations, regional economic integration organizations, and intergovernmental organizations will be asked to second experts and other resources to make it possible to organize working parties which will provide the input to further RSWG meetings.
- Nongovernmental organizations will be invited, when appropriate, to contribute to the work on specific tasks as defined by the RSWG.

2/2 0915 0016A

Subgroup Membership*

ENERGY AND INDUSTRY

Japan (cochair)
 China (cochair?)
 Canada (cochair?)
 Australia
 Netherlands
 Federal Rep. of Germany
 Spain
 Saudi Arabia
 USSR
 GDR
 France
 U.K.
 U.S.A.
 Switzerland
 Sweden
 Norway
 Denmark
 Korea
 Finland
 Brazil

E.C.	Beijer
IEA/OECD	WRI
IAEA	IIASA

AGRICULTURE, FORESTRY AND OTHER

Fed. Rep. of Germany (cochair)
 Zimbabwe (cochair)
 Canada
 USA
 UK
 Norway
 China
 Japan
 Brazil
 Finland

E.C.
 UNESCO
 FAO

WRI

COASTAL ZONE
MANAGEMENT

Netherlands (cochair)
 New Zealand (cochair)
 Spain
 Australia
 UK
 Canada
 US
 India
 China
 Japan

EC
 UNESCO
 FAO

RESOURCE USE AND
MANAGEMENT

India (cochair)
 France (cochair)
 Canada (cochair?)
 China (cochair?)
 UK
 Nepal
 Switzerland
 US
 Japan
 Brazil
 USSR
 Saudi Arabia

EC
 UNESCO
 FAO
 RFF

* Subgroups are open to additional membership. Governments and organizations which wish to contribute to the work of a group should advise the secretariat and subgroup cochairs.

2/1/89 1605 0032A

SUBGROUP ON ENERGY AND INDUSTRY

Scope:

The Energy and Industry subgroup will define policy options for national, regional and international responses to the possibility of climate changes from greenhouse gas emissions produced by energy production, conversion and use. The subgroup will consider energy uses in the industrial, transportation and residential sectors that produce CO₂, CH₄, N₂O and other gases which contribute to the greenhouse effect. It will define technology and policy options to attempt to reduce emissions of these gases to a level consistent with or below the emission scenarios defined by the Steering Committee. The subgroup will seek to identify options which can be adequately analyzed and proposed for consideration by the RSWG within 18 months, as well as options that can be developed on a longer timeframe. These options will be analyzed to determine their economic, social and emission reduction effects on national, regional and international levels. In order to facilitate its work, the subgroup will attempt to develop an international consensus on the appropriate analytical tools to be used. Emphasis will be on selecting simple, pragmatic approaches.

Methodology:

The subgroup will begin by utilizing the products of past analysis, as well as the ongoing efforts of national and international bodies.

Task 1: Review past and current work related to technology and energy policies for both developed and developing countries which could reduce the emission of greenhouse gases. Identify options for further study. Place special emphasis on:

- o Identifying options with regional and international as well as national applicability.
- o Identifying information gaps which impede the development or analysis of new options.

Task 2: Select appropriate analytical tools to determine the social, economic and emission reduction effects of technological and policy options.

Task 3: Categorize the options by the timing of their potential application.

- o Options that could be adequately analyzed and proposed for consideration by the RSWG within 18 months.
- o Options that require longer term development.

Task 4: Analyze nearer term options for their social, economic and emission reduction consequences.

- o Prepare report on the nearer term options for the RSWG.

Task 5: Prepare plan to create, or further develop and analyze, longer term options based on the information developed in Task 1.

Schedule:

Experts meeting on selection and/or development of analysis tools:

April, 1989

- o Select useful tools for Working Group efforts.
- o Identify limitations or gaps in capability (regional or other).

Complete survey of past and current work. Issue reports: May 1, 1989

Organize Subgroup Meeting:

Mid May, 1989

- o Review and synthesize reports.
- o Review Steering Committee emission scenarios.
- o Identify short and long term options.
- o Identify gaps in information base.
- o Review UNEP Study.
- o Adopt common analytical tools for next phase.
- o Prepare next phase work plan.

Work Assignments:

Organize experts meeting on selection and/or development of analytical tools.

IEA (tentative)

Prepare reports on past and ongoing work relevant to workgroup tasks.

Australia, FRG, Japan, USA, IEA, UNEP

Prepare report on UNEP study

UNEP

RSWG SUBGROUP ON ENERGY AND INDUSTRY

1989												1990					
F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J

Review Current
Work
Select Options
to be studied

* IEA meeting

Select
analytical
tools

Categorize Options - - - -

** Subgroup Meeting

Analyze nearer term options,
prepare report - - - -

Prepare plan on longer
term options - - - -

2/1/89 1&15 0026A

SUBGROUP ON AGRICULTURE, FORESTRY, AND OTHER

Initial Work Plan (May 1989)

The mandate of the subgroup is to deal with issues related to limitation of greenhouse gas emissions created by human activities other than production or use of energy or industrial activities, such as deforestation and agricultural activities.

The subgroup agreed on the matrix below. This matrix lists the various sources of emissions, as well as the substances relevant to climate change. The Chair of the subgroup will send this matrix to members of the subgroup, who will be invited to comment. In addition, each member country will prepare a report on its national activities related to management of food production, development of crop varieties, forestry management techniques and programs to limit deforestation or promote reforestation.

Members are invited to submit their contributions to the chair of the subgroup by 1st April 1989 as a basis for a subgroup meeting which will take place in May 1989.

At this session in May 1989, the subgroup will discuss national comments and reports as a basis for one or more reports to the RSWG. For the various topics addressed, members may be nominated to undertake drafting assignments.

The subgroup will forward a report on short term actions to the RSWG in time for preparation of an IPCC report to the Second World Climate Conference.

From these first results, a long term plan will evolve.

MATRIX

<u>GASES</u> <u>SOURCE</u>	<u>CO₂</u>	<u>CH₄</u>	<u>N₂O</u>	<u>CFC</u>	<u>QUANTITY</u>	<u>% G.E.</u>
DEFOREST	X				1.4+0.7Gt/ycu	15
REFOREST	(X)				Possible remedial action	--
LIVESTOCK		X			75+35 Miot/year	1
RICE PADDIES		X			70+30 Miot/year	1
FERTILIZER			X		0.8+0.2 Miot/year	1
SOLID WASTE		X			40+20 Miot/year	1
BIOMASS		X			70+40 Miot/year	1
MICROGRG/ FOOD CHAIN OTHER		X				

RSWG SUBGROUP ON AGRICULTURE, FORESTRY AND OTHER

1989
F M A M J

Questionnaire

Draft Reports
to Subgroup

* Subgroup Meeting: 9-10 May

Draft Report for IPCC-2

2/1/89 1725 0024A

SUBGROUP ON COASTAL ZONE MANAGEMENT

Approach

The approach to the work will be:

- (1) Work will be limited to consideration of coastal zones;
- (2) Areas of concern will relate to prediction of likely changes that will occur in the coastal zone which are identified by IPCC Working Groups I and II; and
- (3) Initially, adaptation to sea level change impacts together with other likely changes such as changes in storm tracks and major currents will be the major focus in the program.

Program Outline

By March 1989

Draft workplan of activities to complete a report to Workgroup III by June 1990. [New Zealand, Netherlands]

By May 1989

Inventory of information available from governments, institutions and nongovernmental organizations on technologies and practices and other relevant activities. [United States]

Paper on strategic overview of coastal areas and activities at risk and available adaptive options. [United States] (These areas include: coastal ecosystems, urban development, fisheries, salt water intrusion, ports and infrastructure, human health and safety, and recreation.)

Final workplan of activities. [New Zealand, Netherlands]

Meeting of Coastal Zone Management Subgroup in Geneva at WGIII meeting.

By November 1989

Conduct workshops on technologies and practices in both Southern and Northern Hemispheres.

By May 1990

Draft report on costs and consequences of adaptive options.

By June 1990

Report to RSWG. (Report will identify work to be undertaken by 1992 and beyond.)

RSWG SUBGROUP ON COASTAL ZONE
MANAGEMENT

1989 1990
F M A M J J A S O N D J F M A M J J

- o Co-chairs Complete Draft Work Plan and Circulate to Subgroup Members.

- o 8-9 May 1989: Subgroup Meeting in Geneva: (Inventory of Existing Work (USA), Strategic Overview Paper (USA))
 - o Technical Workshop

 - o Draft Report

 - o Report to RSWG

2/1/89 1725 0025A

SUBGROUP ON RESOURCE USE AND MANAGEMENT

Broad areas of work to be covered by this subgroup in the long term are:

- (1) Land resources
- (2) Water resources
- (3) Air and atmosphere

Specific areas of work are:

- (1) Agriculture
- (2) Fisheries
- (3) Animal husbandry
- (4) Forests
- (5) Wildlife
- (6) Biological diversity including preservation of species, national parks, and biosphere reserves
- (7) Other ecosystems (e.g., marine ecosystems, Alpine and Arctic ecosystems, estuaries)
- (8) Water resources (including droughts, floods)

Short Term Workplan:

(1) By March 31, 1989, the following designated countries will produce a 2-10 page summary identifying adaptive technologies and practices that could be used in the event of climate change to either reduce the potential negative impacts or to take advantage of possible positive impacts:

- (1) Water resources: US and Nepal
- (2) Forestry: Brazil, India and UK
- (3) Agriculture: China, Brazil, US, India and France
- (4) Fisheries: China, Japan and Canada
- (5) Animal husbandry: Australia
- (6) Salinization and desertification: France and Saudi Arabia

As guidance for preparation of these summaries it should be noted that they would eventually (i.e., after May, 1989) be expanded into short papers for the Interim Report which would:

- Describe the strategies;
- Address their effectiveness, and social, economic and environmental consequences;
- Address legal, institutional, financial and other hurdles to adoption of strategies;
- Address methods of overcoming these hurdles; and
- Discuss their applicability to various nations/regions in terms of a number of factors including level of economic development.

(2) By March 31, 1989, each participating country will produce a list of completed and ongoing studies relevant to response strategies. These lists should include a description of the study, schedule for completion (if it is ongoing), and a discussion of methods and results (if completed).

Schedule:

The following process and schedule was agreed upon:

(1) The papers identified above are to be prepared by the respective countries by 31st March, 1989. These papers will be posted by the respective countries addressed to all the other member countries of the sub-group within this period.

(2) The receiving members will provide comments on the papers by April 22, 1989.

(3) The subgroup will meet in May 1989 to discuss these papers and work out the future work plan.

RSWG SUBGROUP ON RESOURCE USE AND
MANAGEMENT

F	M	A	M
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Papers Prepared,
Mailed by 31 Mar

Comments In
by 22 Apr

Subgroup
Meeting

2/10/89 1430 0028A

STEERING COMMITTEE TASK A:

DEVELOPMENT OF EMISSIONS SCENARIOS

The RSWG Steering Committee has tasked the U.S. and the Netherlands with developing preliminary net emissions profiles for three scenarios. These three initial scenarios are not forecasts of possible development outcomes or of likely policy options. Additional scenarios will be considered as possible policy responses are developed. The chosen initial scenarios are: (1) CO₂ concentration equivalent doubling of pre-industrial levels of greenhouse gases by approximately 2030; (2) doubling by approximately 2060; and (3) doubling by approximately 2090 and stable thereafter. These profiles will be broken down gas by gas and source category by source category in accordance with the attached table prepared by IPCC Working Group I. The two countries will jointly develop these preliminary emissions profiles as soon as possible, culminating their discussion at a meeting in early April 1989 in the Netherlands attended by a member of the scientific secretariat of Working Group I. This meeting will produce a set of agreed emissions profiles for the three scenarios described above and will immediately furnish them to Working Groups I and II and the Working Group III subgroups for use in their respective work plans. The profiles will then be presented for discussion at the Spring meeting of Working Group III. It is intended that these emissions profiles will be continually refined through an iterative process involving all three working groups.

INTERACTION WITH IPCC WORKING GROUP 3

Working Group 1 requests the following information from WG3.

Projections of:

1. CO₂ man-made emissions: 3 scenarios only
 - a. fossil fuel;
 - b. deforestation (gigatonnes/year)
2. For methane:
 - a. Population
 - b. Rice production (by region)
 - c. Cattle population
 - d. Landfill and fossil fuel extraction
3. N₂O emissions:
 - a. Fertilizer usage
 - b. Energy production by type of combustion system
4. Emissions of CFCs and replacements
5. CO and NO_x emissions

These requirements will be conveyed to the Washington meeting of WG3 (30/31 January 1989) by the UK delegate and will also be discussed at the IPCC Bureau meeting on 6 February.

2/1/89 1725 0029A

STEERING COMMITTEE TASK B:

DEVELOP STRATEGY FOR CONSIDERING IMPLEMENTATION MECHANISMS

A strategy for identifying implementation mechanisms, their costs and effectiveness, would include consideration of:

Public Education and Information

Develop national, regional and international strategies for creating and improving educational programs and public awareness campaigns on the global climate change issue. Such programs would aim at overcoming cultural and other impediments to identifying and implementing appropriate response strategies for limiting climate change and adapting to potential impacts.

Legal and Institutional Measures

Examine existing legal processes and institutional mechanisms to determine how they may be used to implement options to limit or adapt to climate change.

Consider new legal processes and institutional mechanisms that could be used to implement options to limit or adapt to climate change.

Consider a policy of providing incentives for nations to undertake unilateral or bilateral actions to limit climate change.

Technical Assistance

National, regional and international technical assistance and cooperation programs to provide assistance to developing nations on adaptation and limitation measures (e.g., development of benign and/or less harmful energy sources), including the training necessary for their implementation. Private and public sector institutions in all countries are encouraged to focus their R&D on developing technologies to support limitation and adaptation measures.

Financial & Economic Measures

Incentives (including the removal of disincentives) to encourage developed and developing countries to implement limitation and adaptation strategies. These incentives might include:

At the regional and international level:

- review of bilateral and multilateral development programs to minimize their adverse impact on climate change;
- restructuring of international debt of developing countries;
- new aid initiatives; and
- examination of appropriate incentive and disincentive measures, including market incentives, with particular attention to trade implications.

At the national level:

- reviewing national foreign aid programs to minimize their adverse impact on climate change; and
- examination of appropriate incentive and disincentive measures, including market incentives.

2/1/89 1725 0031A

Summary of Short Term (18 Month) Work Plan
for the Working Group As a Whole

1. Develop and distribute preliminary emissions scenarios.
2. Refine strategy for considering implementation mechanisms.
3. Carry out short term work plans of four subgroups, including preparation of more detailed work plans and reports on national activities and short term measures.
4. Prepare initial reports of subgroups and integrate those reports into a report of the working group as a whole.
5. As part of 4. above, develop longer term workplans for subgroups and the working group as a whole.

VIEWS AND ACTIVITIES
OF NONGOVERNMENTAL AND INTERGOVERNMENTAL ORGANIZATIONS

The representative of the International Chamber of Commerce expressed support for the multilateral approach taken by IPCC. He pointed out that his organization is focusing on the CFC problem, and urged that IPCC give first priority to determining whether increases in greenhouse gases lead to global warming.

The representative of the World Resources Institute stated that it is unnecessary and foolish to delay action pending complete scientific information. He urged establishment of priorities for the near-term reduction of emissions, including the phaseout of CFC's, the establishment of carbon dioxide reduction targets, and a campaign to halt deforestation combined with debt relief for affected developing countries.

The representative of the U.N. Food and Agriculture Organization described FAO agricultural and rural development activities related to climate change issues. He stated that his organization was coordinating implementation of the Tropical Forestry Action Plan, a joint effort of tropical countries and the donor community aiming at reducing deforestation, and is undertaking a new global assessment of tropical forest resources which should be useful in global climate change modeling.

The representative of the International Energy Agency (IEA) noted the organization's strong interest in climate change because of its implications for energy policy. She stated that IEA is cooperating with the OECD Environment Committee on projects concerning the energy dimension of climate change and the environmental implications of long-term energy demand. The IEA is also generating a study of the impact of environmental concerns on energy security.

The representative of the U.N. Environment Program (UNEP) stated that his organization has responsibility for coordinating an effective global response to climate change through monitoring, development of policy options, facilitation of dialogue between scientists and policy-makers, dissemination of public information, and coordination of international studies. UNEP, he stated, has also undertaken a study of the full range of policy responses. He stated that response measures should be decided upon by 1995.

At the end of these presentations the representative of Unesco gave an overview of intergovernmental research related to climate change carried out by the Intergovernmental Oceanographic Commission (IOC), the Intergovernmental Hydrological Programme (IHP) and by the Man and the Biosphere Programme (MAB).

The representative of the World Meteorological Organization (WMO) stated that for many years WMO has been dealing with the evaluation of climate and is the lead agency in implementation of the World Climate Programme (WCP). He noted that WMO cooperates with other international agencies, particularly with UNEP and the International Council of Scientific Unions and is determined to enhance its activities with respect to climate change issues through the WCP and other WMO scientific and technical programmes and by supporting all areas of activities of the WMO/UNEP IPCC.

JAN 30-7:45

RESPONSE STRATEGIES WORKING GROUP
of the
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

FIRST MEETING

WASHINGTON, D.C.

January 30 - February 1, 1989

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Climate
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Doc/1
1/26/89

Provisional Agenda

Bill Nitze
647-2232

Secretaries -
Angie & Dorothy
647-9266

Monday, January 30

Room
1105 - Delegation meeting

7:45

8:30 Registration

9:30 Welcome

Opening Remarks by IPCC Chairman

Adoption of Agenda

10:15 Introduction to Topics to be considered by RSWG

- Overview
- Food and Fiber
(agriculture, silviculture, aquaculture)
- Natural Resources
(water resources, terrestrial, aquatic)
- Human Settlements
(infrastructure, health)
- Industry
(energy, transportation, mining/manufacturing, other)
- Integration/cross-cutting issues
(e.g., water resources, energy, land use, population, sea level)

12:00 Lunch

1:30 Remarks by Member Countries (5-10 minutes each)

4:00 Coffee

4:15 Report on Working Group I (Science)

4:30 U.S. Strategy for Global Change Research

4:40 Panel discussion (International Chamber of Commerce,
World Resources Institute, FAO, IEA, UNEP)

6:00 Reception for delegates hosted by Department of State

Tuesday, January 31

- 9:00 Overview/summary of day 1 discussions, guidelines for drafting groups
- 9:30 Group discussions to develop workplans
- 12:30 Delegates lunch at NAS hosted by Department of Energy
Speaker: Charles DiBona, President,
American Petroleum Institute
- 2:00 Continue drafting group discussions

Wednesday, February 1

- 9:00 Plenary Session: Integration and Adoption of Workplan, discussion of schedule, relationship to other activities
- 12:30 (or as decided by the group) - Adjourn

OUTLINE OF WORKPLAN FOR DEVELOPING
U.S. GLOBAL CLIMATE CHANGE POLICY, FY-1989-1990

Purpose: To provide a plan, including a series of studies, to develop and refine an Administration global climate change policy over the next two and one half years. This policy will be developed in the context of current scientific understandings and uncertainties, consider international developments, and be consistent with the Global Climate Protection Act (GCPA) and other statutory/policy mandates.

The U.S. is working with other nations on the Intergovernmental Panel on Climate Change (IPCC) to review the international scientific understanding on climate change and to consider the need for policy options to adapt to climate change or to limit emissions affecting climate change. If needed, the control of emissions affecting global climate change can only be fully successful if implemented on a global basis.

Timing: By November 1988, the DPC will review and approve the work plan and the position paper for the U.S. delegation to use at the meeting of the IPCC sponsored by UNEP and WMO. Subsequent timing of reports is to be responsive to the DPC or its successor organization providing options and supporting analyses that allow the Administration to meet the Congressional mandate in the GCPA and to develop policy options for the United States by the end of CY-1990. These efforts will also provide available information as needed by the DPC prior to that report and meet requirements of the U.S. delegation activities within the IPCC. At the minimum, annual summary reports will be provided to the DPC by the end of 1989 and 1990.

Elements:

- o Review Data
- o Design Policy Questions
- o Conduct Policy Analysis
- o Analyze Implementing Mechanisms
- o Develop Options Paper

The work plan and subsequent reporting efforts will also include a regular review of the gaps and uncertainties in the knowledge needed for the

development and evaluation of global climate change policy. This review will be available to the DPC so that the character and uncertainties of the knowledge base which exists to support decisions will be fully understood by those decision-makers. This review will also be available to the FCCSET so that its work in coordinating scientific research on global climate change will be fully informed about the information needs of policy developers and policy makers. The work plan will serve as the basis for communications to the public and to the Congress to explain the need for the actions being taken by the Executive Branch and the reasons why further actions are premature.

Review
Data:

Science Assessment - A plan for assessment of the science issues associated with climate change is being developed by NOAA, NASA, NSF, EPA and DOE and will be carried out to meet requirements of the IPCC and the GCPA. A report on the status of the assessment will be provided by December 1989. The assessment for the IPCC is scheduled for completion in December 1990.

Effects Studies - A series of studies to determine potential impacts of climate change on U.S. and selected foreign countries, including impacts on agriculture (e.g., drought), wetlands, forests, water resources, sea level rise, human health, biodiversity, infrastructure and trade. The EPA report to Congress (December 1988) will be the initial reference document, supplemented by additional products from other agencies. EPA and DOE will lead effort with participation by at least DOI, USDA and NOAA.

Emissions Inventory - A series of studies, to be conducted by EPA, DOE, and other agencies, to inventory worldwide sources and project future trends of principal greenhouse gases, including, at a minimum, CO₂, CFC's, N₂O and CH₄. These estimates should consider energy sources, agricultural sources, deforestation and natural sources. The EPA Report to Congress (December 1988) will be the primary initial reference document. A subsequent report will be prepared by DOE and EPA.

Technology Assessment - A series of studies, to be conducted by DOE (with the assistance of NAS), EPA, and other agencies, to assess the current

state of research and development activities in alternative energy sources, including energy conservation and energy efficiency, nuclear, solar, and renewable energy sources, and improved methods of employing fossil fuels. DOE will lead the interagency effort. Technology assessments will also be conducted by appropriate agencies in areas of CFC substitutes and agricultural practices.

Information Transfer Assessment - The current status of data and information available to support public understanding and decision making will be developed periodically. In each of the elements described above, the studies and papers produced will fully describe, in terms useful to the public, policy analyst and policy maker, the assumptions, knowledge gaps, and uncertainties which limit our ability to make the projections and evaluations needed for making policy decisions.

Design
Policy
Questions:

Policies for adaptation, emission limiting, and other strategies will be considered. Three time periods for policy/technology development will be addressed:

- o Near term (until 2000)
- o Midterm (2000 -2025)
- o Long term (beyond 2025)

Policies for the U.S., other developed and developing countries will be identified in general terms. For the U.S., more quantitative results will be provided. An array of policies including those needed to meet a Congressional requirement (a near term 20 percent reduction in U.S. CO₂ emissions and a midterm 50 percent reduction) will be addressed. A much broader set of stabilization/ reduction goals with families of proposed responses will be set out in the study report. An explicit set of policy issues relevant to adaptive strategies will also be identified. Examples of stabilization/adaptive strategies will include deforestation and reforestation practices, resource pricing policies, agricultural policies, CFC emission reduction steps, trade and credit policies, and other policies as appropriate. Quantitative analyses of options will be conducted as

possible. Studies for improving the climate change information bases and for improved forecasting capabilities will be undertaken. EPA and DOE will jointly lead these activities with a draft set of policy issues.

Conduct
Policy
Analysis:

For each policy option for adaptation and emission limiting strategies, total costs (for the set of responses) will be estimated, as well as the distribution of those costs within the U.S. society. Various measures of physical benefits will be estimated, e.g., temperature and physical effects. To the extent practicable, costs and benefits measures will be monetized. Analyses will be conducted by participating agencies. Where relevant, information developed by other countries/international organizations will be considered. The analysis will be done as an interagency effort led by DOE and EPA with at least State, DOI, DOC, Treasury, CEA and USTR participating.

Analyze
Implementing
Mechanisms:

Analysis of a variety of implementing mechanisms may be useful as part of U.S. climate change policy. Domestically, mechanisms to facilitate adaptation will include information dissemination/technical assistance to public and private managers involved in the management of potentially vulnerable resources (e.g., forests, agriculture, water resources). Financial incentives/disincentives and the use of targeted R&D in these areas will also be explored. To limit emissions, a variety of incentives/disincentives, (e.g., stimulation of R&D and of technology modernization, energy and natural resources pricing, tax mechanisms, energy efficiency requirements, international aid and technology transfer) plus targeted R&D will be considered. Internationally, the requirements for, the cost, and the feasibility of coordinated emission reductions will be analyzed. The limitations of unilaterally undertaking implementation mechanisms will be included. The interagency group noted above will be used for developing this and the subsequent task.

Developing
Options
Paper:

An options paper of a full set of potential of potential policy elements--research, technology development, mitigation steps and emissions stabilization responses--with proposed implementation elements will be drafted for discussion by the Domestic Policy Council.

Inasmuch as a significant fraction of the data/analyses referenced above will still be in progress, it is anticipated that the process of developing U.S. policy on global climate issues will be iterative for several years; hence, this first effort establishes an initial information base and sets out follow-on requirements for the next iterations. Initial policy directions are likely to be influenced and modified by any emerging consensus in the science area, Congressional reaction, the direction of IPCC activities, technological, economical and other considerations.

Products

In November 1988, the work plan and the position paper for the delegation to the IPCC will be developed. These papers should outline uncertainties, limitations and gaps in our present knowledge and research activities plus outline some initial activities that could be studied as potential early responses to global climate change.

A first summary report reflecting all interim results will be completed by December 1989. This report will summarize activities, including any conclusions reached at that time, and relevant uncertainties.

By the end of 1990, a more detailed report summarizing all results will be provided to the DPC. This will include detailed findings on the understanding of the science, proposals for adaptation and emissions limiting responses, and proposed study efforts post 1990.

The attached table provides timing and scope of the major reports. Updating of these elements will be done as needed to meet DPC and Administration requirements.

	1988	Interim Products 1989	Final Products 1990
Review Workplan	November		
Review IPCC Position Papers	November		
Review data		x	x
Design Policy Questions		x	x
Conduct Policy Analysis		x	x
Analyze Implementing Mechanism		x	x
Prepare Annual Report		December	December
Develop Options Papers			December

A STATE-OF-THE-SCIENCE REVIEW OF CLIMATE CHANGE:
A PROPOSED PLAN

Bob Watson (NASA)
Dan Albritton (NOAA)

12 September 1988

Contents:

- o **AN OUTLINE OF THE DOCUMENT**
(A "prediction/uncertainty"-oriented review.)
 - I. **SCOPE**
(Goals of the review, rationale for the organization, major research topics, examples, and key questions.)
 - II. **TABLE OF CONTENTS**
(Details within each of the major research topics.)
- o **THE PROCESS OF THE REVIEW PREPARATION**
(Document preparation team, interactions, and timetable.)
- o **U. S. AGENCY INTERFACE COMMITTEE**
(Agency and organizational scientific representatives who are the contact points.)
- o **AD HOC U. S. SCIENTIFIC "SCOPING" GROUP**
(Small group of U. S. scientists who provided initial comments on the scope and approach proposed above.)
- o **INTERNATIONAL SCIENTIFIC STEERING COMMITTEE**
(Group of worldwide scientists who - when approached with a sound plan, momentum, and a challenging undertaking - will be willing and interested in providing scientific guidance from an international perspective.)

STATE-OF-THE-SCIENCE REVIEW ON CLIMATE CHANGE:
AN OUTLINE

Perhaps the best structure for the Review is something resembling (i) the way the atmosphere works and (ii) the way that the research proceeds; namely:

- o from cause to effect [i. e., (1) -> (2) -> (4) -> (6) below],
- o with tests of the understanding of both the individual parts [i. e., (3)] and the whole [i. e., (5)] to define the uncertainty range in the predictions.

I. SCOPE AND MAJOR RESEARCH TOPICS

The Review will consist of an introduction and six major parts:

INTRODUCTION; an explanation of the goal of the review. It is the following:

To produce a *set of predicted physical/effects responses* (with, of course, quantified uncertainty bands) that follow from a *set of specified climate-forcing inputs* (natural processes and human-caused perturbations, the latter being simple and generic), calculated based on the current understanding of *climate/effects processes*.

(1) THE FORCING FUNCTIONS; i. e., the changing natural and human-caused *inputs* (e. g., solar irradiance changes and trace-gas increases) to the climate system. {What initiates climate changes?}

(2) THE PLANETARY RESPONSE PROCESSES; i. e., the climatic-response processes (e. g., water-vapor greenhouse feedback and ocean-atmosphere interactions) that are the "machinery" wherewith the climate system responds to the changed input. {What is our picture of the working mechanisms?}

(3) THE TESTS OF THE UNDERSTANDING OF THE SYSTEM; i. e., *diagnostics*, namely, the process-oriented experiments, calculations, and their comparisons that evaluate the level of understanding of the structure of the climate system (e. g., lower-stratospheric warming observed in the tropics after El Chichon vis-a-vis the predictions of local heating rates based on the calculated amounts of IR absorbed by sulfuric acid droplets). {What are the indications that the parts of our picture are realistic?}

(4) THE PREDICTED CLIMATIC CHANGES; i. e., *prognostics*, namely, the new climate state(s) (i. e., greenhouse warming from IR forcing and surface cooling from dust forcing) that are predicted to follow from the input forcings in (1) above. {Based on our picture of the climate mechanisms: What inputs are contributing to the current climate scene? For selected future climate-input scenarios, what is the range of climates that may lie ahead?}

(5) THE PAST CLIMATE RECORD; i. e., the long-term record of past responses (i. e., *paleoclimate*) to climate forcings, which can be used, within limitations, to test, retrospectively, the ability to rationalize cause and effect on time scales of decades to centuries (since we can't wait for the next century of data before starting such testing of our overall understanding of how the climate machine works!). {How well do our climate models "predict" the past, since we will likely do no better in predicting the future?}

(6) THE CONSEQUENCES OF CLIMATE CHANGE; i. e.; "effects", namely, the predicted environmental consequences (e. g., perturbations of sea level and alteration of agricultural processes) of natural or human-induced climate changes. {How well do we understand those aspects of climate change that cause Homo sapiens the most concern?}

II. TABLE OF CONTENTS

The table below gives examples of some of the details that would be in each major category. There may well have to be more than one chapter for each category.

(1) THE FORCING FUNCTIONS

- (a) Anthropogenic
 - Carbon dioxide
 - Other radiatively important species
 - Land use
- (b) Natural
 - Solar irradiance
 - Volcanoes
- (c) Historical trends
- (d) Future projections and sample scenarios

(2) THE PLANETARY RESPONSE PROCESSES

- (a) Water vapor greenhouse feedback
- (b) Ice-albedo feedback
- (c) Cloud feedback
- (d) Ocean - atmosphere interactions
 - Global SST - circulation/precipitation
 - Heat capacity - ocean circulation
- (e) Land (soil/vegetation) - atmosphere interactions
- (f) Stratospheric chemistry and radiation balance
- (g) Tropospheric chemistry and radiation balance
- (h) Aerosol (natural-anthropogenic) - cloud interactions
- (i) Trace-gases and the biosphere: source, sink, and response

(3) THE DIAGNOSTIC TESTS OF THE UNDERSTANDING OF THE PROCESSES

- Theory vis-`a-vis observations
- (a) Seasonal cycles
 - (b) Biennial oscillations
 - (c) Response to episodic events

(4) THE PREDICTED CLIMATIC CHANGES

- (a) The environmentally important response variables
- (b) The nature and variance of natural changes
- (c) Characteristic signatures of human-caused effects
- (d) The present
- (e) The next ten years
- (f) The next century

(5) THE PAST CLIMATE RECORD

- (a) The direct-measurement epoch
 - Patterns and trends
- (b) The proxy-data epoch
 - Methods
 - Patterns and trends
- (c) Hindcasting: Can we explain the past?

(6) THE CONSEQUENCES OF CLIMATE CHANGE

- (a) Agriculture
 - Forest
 - Crops
- (b) Natural ecosystems
 - Forests
 - Grasslands
 - Tundra
 - Wetlands
- (c) Sea level
- (d) Frequency/magnitude of severe weather
- (e) Ground water
- (f) Human health
- (g) Multiple stresses
 - Climate/ultraviolet radiation/oxidants/acidity/...

THE PROCESS OF THE REVIEW PREPARATION

- o THE DOCUMENT PREPARATION GROUP:
 - Two to four review coordinators.
 - Chapter chairs and co-chairs (dozens).
 - Co-authors (a few hundred).
 - Peer reviewers.
 - Logistical assistance.
 - In all of the above, international in composition.

- o INTERACTIONS WITH:
 1. U. S. Agency Interface Committee.
 2. Ad Hoc U. S. Scientific "Scoping" Group (one time only).
 3. International Scientific Steering Committee.

- o PREPARATION TIMETABLE:
 - Presentation of the initial concept to the CES working group on climate. [8 July 1988]
 - Discussion of the scope/content with Group (2). [29 July 1988]
 - Presentation of the plan to the DPC working group on climate. [12 September 1988]
 - September: Present the plan to the NAS and the principals of the CES.
 - Early fall: International connections established.
 - Late fall: First planning meeting of steering group and authors.
 - 1989: Chapter-preparation meetings.
 - Spring 1990: Review.
 - Fall 1990: Completion.

- o REPORT:
 - Available to all interested.
 - Progress briefings to Committee (1), WMO/UNEP Intergovernmental Panel, et al.
 - No interim findings/conclusions/recommendations.

U. S. AGENCY INTERFACE COMMITTEE

These individuals provide the contact points with the agencies and other governmental organizations. Generally, there will be one representative from the science or R & D side of each agency or organization. Members could include:

- o Science agencies
- o National Academy of Sciences
- o National Climate Program Office
- o Office of Science & Technology Policy
- o Committee on Earth Sciences
- o Office of Technology Assessment
- o Others, as appropriate

AD HOC U. S. SCIENTIFIC "SCOPING" GROUP

This small group of U. S. scientists provided early and initial comments on the scope, content, and approach of the above outline. The selectees were characterized by (i) being scientific leaders in a balance of climate-related fields, (ii) possible liaisons with U. S. scientific organizations, and (iii) *the willingness to provide comments and advice on short notice*. The members are also likely to be involved later as authors.

This initial "scoping" process will take place in two parts. The first took place at a meeting at the NSF on 29 July with Albritton, Watson, and the people listed below. The second step will be written comments from the group.

Baker	o <i>Expertise</i> :	physical oceanographer
	o <i>Institution</i> :	Joint Oceanographic Institute
Mahlman	o <i>Expertise</i> :	general circulation models
	o <i>Institution</i> :	NOAA Geophysical Fluid Dynamics Lab
Malone	o <i>Expertise</i> :	international institutions
	o <i>Institution</i> :	Saint Josephs College
Melillo	o <i>Expertise</i> :	ecosystem biologist
	o <i>Institution</i> :	Woods Hole
Mooney	o <i>Expertise</i> :	plant physiology
	o <i>Institution</i> :	Stanford University
Moore	o <i>Expertise</i> :	ecosystem modeling
	o <i>Institution</i> :	University of New Hampshire
Perry	o <i>Expertise</i> :	meteorologist
	o <i>Institution</i> :	National Academy of Sciences
Rosenberg	o <i>Expertise</i> :	agriculturist
	o <i>Institution</i> :	Resources For The Future

INTERNATIONAL SCIENTIFIC STEERING COMMITTEE

This group of international scientists will provide scientific guidance from the international perspective. The selectees will be characterized by (i) expertise in climate-related fields, (ii) international balance, and (iii) liaisons with international scientific organizations. They are unlikely to be involved later as authors.

The list below is only illustrative, and none on have been contacted in this regard. Many of the examples were suggested by the Ad Hoc U. S. "Scoping" Group at the meeting on 29 July 1988.

Alusa	o Expertise :	cloud physics
	o Country :	Kenya
Bolle	o Expertise :	land-atmosphere interactions
	o Country :	Austria
Bolin	o Expertise :	carbon cycle
	o Country :	Sweden
Crutzen	o Expertise :	atmospheric chemistry
	o Country :	FRG
Duick	o Expertise :	hydrology
	o Country :	DDR
Golitsyn	o Expertise :	climate modeling
	o Country :	USSR
Goudriaan	o Expertise :	ecosystem modeling
	o Country :	The Netherlands
Hassleman	o Expertise :	oceanography
	o Country :	FRG
Houghton	o Expertise :	meteorology
	o Country :	United Kingdom
Kondratyev	o Expertise :	atmospheric science
	o Country :	USSR
Landsberg	o Expertise :	forestry
	o Country :	Austria

Manabe*	o <i>Expertise</i> :	climate modelling
	o <i>Country</i> :	United States
Matsuno	o <i>Expertise</i> :	dynamics
	o <i>Country</i> :	Japan
McBain	o <i>Expertise</i> :	longe-range forecasting
	o <i>Country</i> :	Canada
McCarthy*	o <i>Expertise</i> :	biological oceanography
	o <i>Country</i> :	United States
Moore*	o <i>Expertise</i> :	ecosystem modeling
	o <i>Country</i> :	United States
Oeschger	o <i>Expertise</i> :	ice-core paleoclimatology
	o <i>Country</i> :	Switzerland
Rodda	o <i>Expertise</i> :	hydrology
	o <i>Country</i> :	United Kingdom
Salati	o <i>Expertise</i> :	Amazonia ecoscience
	o <i>Country</i> :	Brazil
Singh	o <i>Expertise</i> :	ecology
	o <i>Country</i> :	India
Sinha	o <i>Expertise</i> :	plant physiology
	o <i>Country</i> :	India
Swift	o <i>Expertise</i> :	soil science
	o <i>Country</i> :	Zimbabwe
Walker	o <i>Expertise</i> :	vegetation
	o <i>Country</i> :	Australia
Washington*	o <i>Expertise</i> :	climate modeling
	o <i>Country</i> :	United States
Wiin-Nielsen	o <i>Expertise</i> :	meteorology
	o <i>Country</i> :	Denmark
Ye	o <i>Expertise</i> :	climate dynamics
	o <i>Country</i> :	People's Republic of China

* Subject to discussions with NAS.