

FOIA MARKER

**This is not a textual record. This is used as an
administrative marker by the William J. Clinton
Presidential Library Staff.**

Collection/Record Group: Clinton Presidential Records
Subgroup/Office of Origin: Council of Economic Advisers
Series/Staff Member: Joseph Stiglitz
Subseries:

OA/ID Number: 9537
FolderID:

Folder Title:
Climate Change [2]

Stack:
S

Row:
20

Section:
5

Shelf:
2

Position:
3

Withdrawal/Redaction Sheet

Clinton Library

DOCUMENT NO. AND TYPE	SUBJECT/TITLE	DATE	RESTRICTION
001. list	Meeting on Climate Change Litigation 4:00pm Thursday, October 17, 1996 [PII] [partial] (1 page)	10/17/1996	b(6)
002. fax	Environmental Information Center Fax cover sheet [PII] [partial] (1 page)	10/17/1996	b(6)
003. fax	Natural Resources Defense Council fax cover sheet [PII] [partial] (1 page)	10/16/1996	b(6)

COLLECTION:

Clinton Presidential Records
Council of Economic Advisers
Stiglitz, Joseph
OA/Box Number: 9537

FOLDER TITLE:

Climate Change [2]

2017-1095-F

bg239

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

Freedom of Information Act - [5 U.S.C. 552(b)]

P1 National Security Classified Information [(a)(1) of the PRA]
P2 Relating to the appointment to Federal office [(a)(2) of the PRA]
P3 Release would violate a Federal statute [(a)(3) of the PRA]
P4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
P5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]
P6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

b(1) National security classified information [(b)(1) of the FOIA]
b(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
b(3) Release would violate a Federal statute [(b)(3) of the FOIA]
b(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
b(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
b(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
b(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
b(9) Release would disclose geological or geophysical information concerning wells [(b)(9) of the FOIA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Personal record misfile defined in accordance with 44 U.S.C. 2201(3).

RR. Document will be reviewed upon request.

**EUROPEAN STUDIES ON THE COSTS OF
MITIGATING CARBON EMISSIONS:
A REVIEW OF METHODS AND FINDINGS**

by

Florentin Krause

Staff scientist,

Lawrence Berkeley National Laboratory

and Director,

International Project for Sustainable Energy Paths (IPSEP)

7627 Leviston Ave., El Cerrito CA 94530 USA

+1 510 525 7530 ph./ 510 525 4446 fax

email: ipsep@igc.apc.org

URL: <http://www.igc.apc.org/eic/IPSEP.html>

Final draft, forthcoming in *Energy Policy*

ABSTRACT

Conventional wisdom has it that top-down studies of mitigation costs are too pessimistic while bottom-up studies are too optimistic. In examining mitigation cost studies for Western Europe, this paper finds this interpretation to be seriously flawed. The paper expands the analytical framework for interpreting mitigation cost studies, evaluates the treatment of no regrets options and other input assumptions in the various studies, and includes findings from recent integrated top-down/bottom-up modeling assessments not covered in the IPCC report. Based on these new elements, it is found that mitigation costs tend to be overestimated not only in top-down studies, but also in bottom-up studies. Given this pervasive bias toward pessimism, the body of existing mitigation cost assessments for Western Europe can be read as follows: Over the next three to four decades, a combination of tax shifts, market transformation instruments and policies to reform subsidies and internalize non-climatic externalities could cut carbon emissions in Western Europe by 40-50 percent relative to the base year, at no loss or at a gain in gdp. Averaged over the medium-term and including a phase-in period, an economically optimal rate of implementing Western Europe's no regrets potentials is found to be in the neighborhood of 2 percent per year relative to base year levels.

Acknowledgements/disclaimer:

The author is with the International Project for Sustainable Energy Paths and with the Energy and Environment Division of Lawrence Berkeley National Laboratory. The presentation in this paper expresses the personal views of the author alone and not those of Lawrence Berkeley National Laboratory or the IPCC. The author wishes to thank his European colleagues Carlo Carraro, Kora Cristof, Dominique Finon, Kirstin Halsnaes, Peter Hennicke, Jean-Charles Hourcade, Thomas Johansson, Leo Schrattenholzer, and Angela Tudini, as well as all other IPCC coauthors who helped assemble and interpret the mitigation cost studies reviewed in Chapters 8 and 9 and in this paper.

Artical title abbreviated as: European studies

Keywords: Mitigation costs; no regrets potentials; carbon emission reductions.

INTRODUCTION

As in the case of the North American studies, mitigation cost estimates¹ for Western Europe vary widely. For any given reduction target between stabilization of carbon emissions and a 50 percent reduction, and for time horizons between now and 2030, the highest estimates indicate significantly positive costs while the lowest estimates indicate significantly negative costs (i.e., a net economic gain from mitigation efforts, or an opportunity cost from not pursuing such measures). Moreover, though the median results from top-down studies are distinctly higher than those from bottom-up studies, there is significant overlap between their ranges: estimates from net costs to net benefits are found within both bodies of research.

This wide range of results poses a challenge. To obtain useful policy guidance, reported findings have to be further interpreted. First, it is necessary to understand how the paradigmatic differences between top-down and bottom-up studies contribute to these divergent results. Second, it is necessary to explain the differences in findings within each category of studies. Third, one has to consider possible shortcomings and biases that are common to all mitigation cost assessments, whether top-down or bottom-up.

Working Group III of the IPCC has made a first attempt to provide such interpretation and review (IPCC 1996: Chapters 8&9). This paper builds on Chapters 8 and 9 of the IPCC report but also augments it in significant ways. The paper expands the analytical framework for interpreting mitigation cost studies, offers a more detailed and comprehensive critique of bottom-up procedures, including recent empirical evidence on the economics of market transformation options, and more carefully correlates the findings of individual studies with the treatment of no regrets options and other key input assumptions. It also examines recent integrated bottom-up/top-down studies of combined fiscal and non-fiscal policy packages that were not covered in the IPCC report. These expansions not only provide a fresh view of the cost biases in top-down and bottom-up studies, but also allow considerably more definite conclusions regarding the "no regrets" potential for carbon reductions in Western Europe and by implication, in the OECD in general.

Pessimism versus optimism in mitigation cost estimates

Elsewhere in this issue, Hourcade and Robinson present the conventional wisdom, according to which top-down studies may be too pessimistic (i.e., mitigation cost estimates may be too high), while bottom-up studies may be too optimistic. This line of reasoning, which is mainly driven by alternative interpretations of the energy efficiency gap, suggests that actual mitigation costs fall somewhere in between. Symbolic of such a compromise, the Executive Summary of Working Group III arrives at a minimum consensus estimate, according to which the no regrets potential for reducing carbon emissions in OECD countries is 10-30 percent below baseline projections over the next several decades.

The present review arrives at a different assessment. It finds that both top-down studies and bottom-up studies are overly pessimistic, i.e., that *both* tend to significantly overstate mitigation costs. This alternative interpretation arises from consideration of four factors:

- A range of no regrets options that are omitted not only in top-down studies but also in bottom-up studies;

- The pessimistic estimating bias created by the omission of macroeconomic feedbacks in bottom-up studies;
- Empirical evidence from market and policy evaluation research substantiating the interpretation of the energy efficiency gap as an economic efficiency gap;
- A net bias toward pessimism created by various approximation procedures within engineering-economic life cycle cost analyses themselves.

The conventional wisdom on the supposed optimism of bottom-up studies ignores these factors.

The following paper is divided into three sections. In the first section, we review a range of generic factors that may create, individually or in combination, a bias toward optimism or pessimism in mitigation cost studies. The focus here is on bottom-up studies since these give the lowest mitigation cost estimates. In a second section, we review and interpret the results of various Western European bottom-up studies, with emphasis on multi-country analyses that put national differences into a larger perspective. In a third section, we review and interpret Western European macroeconomic studies. Here, the emphasis is on integrated bottom-up/top-down assessments, which overcome one of the main difficulties in comparing the two types of modeling analyses.

RANGE OF ZERO OR NEGATIVE-COST POLICY OPTIONS

The pivotal role of no regrets options in mitigation cost analysis arises from the fact that benefits from negative-cost measures may offset all or a portion of the impacts from measures with positive costs. If no regrets measures are not just cost-neutral but produce sizable benefits (other than climate change mitigation), even a limited supply of negative-cost emission reduction measures can generate sufficient savings to offset large emission reductions with slightly positive costs. The level of emission reductions that can be achieved at a zero total cost to the economy at large may thus be significantly greater than the reductions that can be obtained from no regrets measures alone.

Indeed, it then becomes conceivable that the entire transition to a climatically neutral level of carbon emissions could be possible at a net economic benefit to society. Such a net transition benefit could arise if savings from zero and negative cost measures over the next several decades are large enough to exceed the costs of accelerating the development and advancing the market diffusion of cheap low-carbon supplies.

Range of no regrets options

The principal energy-related policies that could reduce carbon emissions while improving economic efficiency are the following:

- 1) Energy or carbon taxes, coupled with shifts in the tax structure that reduce the overall deadweight losses of the tax system
- 2) Removal or reform of various subsidies for energy sources and technologies

- 3) Internalization of environmental externalities not related to climate change
- 4) Market transformation policies
 - a) Utility regulatory reforms that eliminate barriers to entry for generators using cogeneration and renewables-based technologies
 - b) Market transformation policies that eliminate barriers other than entry to investments in cost-effective cogeneration and other low-carbon energy supply technologies
 - c) Utility regulatory reforms and other market transformation policies that eliminate barriers to cost-effective investments in energy-efficient end-use technologies
 - d) Utility regulatory reforms and other market transformation policies that eliminate barriers to economically efficient substitutions of lower-carbon natural gas or district heat with higher carbon electricity or vice versa
- 5) Accelerated research and development (R&D) and commercialization programs for new energy efficiency and low-carbon supply technologies.

The term energy tax is used in this paper as a generic concept that may or may not include taxes differentiated by carbon content.

The term market transformation (option 4) is used here to broadly describe policy measures that reduce market failures through instruments other than changes in energy prices. The major non-price instruments include energy efficiency incentives for energy users provided by utilities and/or governments; procurement incentives for manufacturers provided by utilities and/or governments; voluntary agreements or standards between governments, professional societies, and manufacturers; and legally mandated minimum efficiency standards. Three of these four major policy instruments rely on voluntary participation by consumers and/or manufacturers.

Option 5 addresses the well-recognized pattern of private under investment in R&D, and the inability of markets to optimize the time path for the development and commercialization of competing new technologies.

THE ECONOMIC PESSIMISM OF TOP-DOWN STUDIES

It is widely agreed that top-down studies tend to overestimate mitigation costs. This bias is partly due to pervasive deficits in the analysis of no regrets options based on subsidy removal, incorporation of environmental externalities, and tax shifts, as illustrated in Table 1. The non-climatic environmental benefits of a carbon tax alone may be of the same order of magnitude as the gdp losses calculated in various top-down studies.² Similarly, the removal and reform of subsidies could produce significant emission reductions at negative net cost, especially in the context of a climate protection strategy.³

Shortcomings of top-down studies in these areas can reinforce each other. For example, non-consideration of environmental externalities, subsidies, and market transformation options may lead to grossly excessive estimates of required carbon taxes and erroneous

assessments of the gdp and welfare effects of tax shifts (see the section on top-down studies below).

Table 1 here.

In addition, the modeling procedures of top-down studies introduce several other biases toward overestimating mitigation costs, and so can the choice of model type itself.⁴ The key factors involved are inadequate treatment of saturation effects and associated structural changes in final energy demand (Swisher and Wilson 1993), omission of cost-reducing feedback effects between carbon constraints and the rate of technological innovation (Carraro 1994, Gerstenberger 1992);⁵ and implicit use of private discount rates rather than lower discount rates that may be appropriate for policy analysis (Krause et al. 1993).

Some of the differences between bottom-up and top-down analyses can be overcome by integrating the two modeling methods, as has been done in several recent Western European studies (see the last section of this paper). Such an integrated modeling approach allows the analysis of tax shift options in combination with non-fiscal measures while at the same time capturing the all-economy feedback effects of non-fiscal programs. However, the results of such integrated studies are still centrally driven by the bottom-up analysis of alternative energy systems. Thus, a central task in interpreting the existing literature on mitigation costs is the clarification of estimating biases associated with bottom-up methods.

THE ECONOMIC PESSIMISM OF BOTTOM-UP STUDIES

The view that bottom-up studies are inherently optimistic is based mainly on two assertions:

- That the economy-wide feedback effects omitted in bottom-up studies have the effect of increasing mitigation costs.
- That many of the observed market barriers to the adoption of energy efficiency technologies may not in fact represent market failures; and/or, that the implementation costs of correcting these problems would exceed the benefits of improved markets.

It is argued below that this assessment is fundamentally flawed. First, it assessment fails to consider all relevant factors that need to be taken into account in determining the net pessimism or optimism of bottom-up studies. Second, it fails to consider pertinent theoretical research and empirical research on those cost factors that are taken into account.

Pessimism due to omission of important no regrets options

For the above assessment to be conclusive, bottom-up studies would need to exhaustively cover all no regrets options. Simple inspection of available studies for Western Europe and other OECD countries shows that this is not the case. In particular, bottom-up studies routinely omit the economic benefits from three important no regrets options:

- economically advantageous tax shifts;⁶
- subsidy removal; and
- incorporation of non-climatic externalities.

As already discussed, the last two options are routinely omitted in top-down studies as well. The omission of these no regrets options represents a significant bias toward pessimism. These deficits are by themselves sufficient to put into question the claim that bottom-up studies underestimate the costs of mitigation.

Pessimism due to omission of feedback effects

Bottom-up studies represent incomplete, partial equilibrium analyses covering only the energy sector. As such, they cannot capture the impacts from substitutions of fossil fuels that occur outside the energy sector. These impacts include changes in prices, in disposable income, in trade and in the sectoral composition of gross domestic product, all of which lead to secondary changes in final energy demand. Because of these limitations, estimates from bottom-up studies are necessarily approximate. However, as discussed below and as further demonstrated by the results of integrated bottom-up/top-down studies, the net bias introduced by these limitations is toward overestimating mitigation costs.

The rebound effect

Basic economic considerations suggest that the implementation of money-saving energy efficiency options will generate a feedback effect. Provided that no compensating energy or carbon tax increases are introduced, cost-effective market transformation policies may raise the demand for energy services relative to the fixed business-as-usual level assumed in bottom-up studies, and may somewhat⁷ raise final energy demand. This rebound effect would then make somewhat larger emission reduction efforts necessary to achieve a given reduction target. In that sense, bottom-up studies could underestimate mitigation costs.

Bias toward pessimism in the context of climate protection strategies

This line of reasoning fails to account for the suppressive impact of climate stabilization strategies on the rebound effect. It also fails to take into account other feedback mechanisms that arise in this policy context and that tend to bring major reductions of mitigation costs. The net effect is an overestimation of mitigation costs.

First, as shown in theoretical research (CEC 1992, Howarth and Winslow 1994), a least-cost strategy for reducing emissions would consist of energy taxes and market transformation programs in combination. Under such a strategy, the after-tax prices of energy and fossil fuels are likely to rise significantly. These higher after-tax energy prices will tend to direct additional disposable income from cost-effective energy savings into less energy-intensive forms of consumption than found in the business-as-usual case. This will tend to suppress rebound effects.⁸

Second, even as *after-tax* energy prices rise beyond those in the reference case, the economy at large will still benefit from reduced *pre-tax* fossil fuel prices as the use of fossil fuels declines. This potentially large secondary economic benefit of emission reduction measures is not endogenously captured in bottom-up studies, which adds a systematic bias toward pessimism.⁹

Third, most bottom-up studies fail to account for the reduction in the cost of energy efficiency technologies that occurs when market transformation policies move these products from niche markets with high mark-ups into mass markets with low mark-ups. Evidence from market research suggests that this policy effect can greatly reduce the first-cost premium of energy efficiency technologies (GEA 1994). In favorable cases, it may entirely eliminate this premium, as illustrated by the experience with refrigerator efficiency standards in the U.S. (Greening et al. 1996). By contrast, bottom-up studies typically rely on data derived from current market prices, which include the high first cost premiums found under status quo conditions of limited market share.¹⁰ The use of current market prices or implausibly high mark-ups in engineering-economic analyses of mass manufacturing again creates a bias toward overestimating mitigation costs.

Finally, bottom-up models suffer from the same lack of endogenous mechanisms as top-down models when it comes to capturing the feedback effects of aggressive climate protection policies on the rate of innovation in the area of energy efficiency and low carbon supply technologies. As a result, bottom-up studies may at once underestimate the future-year resource potentials of energy efficiency and other low-carbon technology measures and overestimate the costs of these technologies.¹¹

Correcting the energy efficiency gap: adjustment costs and implementation costs

Bottom-up and top-down analysts agree that the phenomenon of the energy efficiency gap can in principle be explained by information failures, principal/agent conflicts, losses of consumer surplus, high transaction costs, bounded economic rationality, uncertainty regarding ex post performance, and a variety of combinations thereof (Jaffe and Stavins 1994, Krause et al. 1994, Sanstad and Howarth 1994).

Furthermore, it is widely agreed that policy action aimed at facilitating the adoption of technologies with lower life cycle costs can only result in net economic benefits when such action succeeds in reducing the sum of all direct plus indirect costs associated with adopting life cycle cost minimizing technologies, without creating implementation costs that exceed the benefits of such action.

Expanded empirical basis of bottom-up analysis

Many top-down analysts believe that bottom-up research overlooks or ignores the indirect and intangible cost factors not captured by life cycle cost analysis. This perception, and related claims that current markets for energy efficiency may already be economically efficient, have their origin, in part, in the failure of most bottom-up studies to connect their empirical data to a rigorous theoretical economic framework. This gap has been closed in recent work by Sanstad and Howarth (1994), who conclude that a wide range of market barriers identified in bottom-up research constitute market failures in the standard economic sense.¹²

Another outdated preconception is that bottom-up research is purely engineering-economic and thus devoid of behavioral and other data. Over the last decade, bottom-up analysis has expanded to include applied research on consumer behavior, marketing patterns and institutional conditions, and on the effectiveness of utility and government sponsored market transformation programs. This broadened body of empirical research provides persuasive and unrefuted evidence that most energy efficiency technologies and well-designed policy programs preserve or increase consumer surplus. The same evidence shows that such programs can cost-effectively reduce or eliminate transaction

costs and other adjustment costs that now prevent the adoption of economically optimal technologies (Krause et al. 1994).

Consumer surplus and preferences

Technical analysis shows that in many end-use applications, energy-efficient technologies are identical to standard versions in every respect except energy use (Koomey and Sanstad 1994). Moreover, such analysis demonstrates that many of these technologies increase utility and comfort, not diminish it. These findings are complemented by market research showing, for example, that adoption rates for energy-efficient technologies in new commercial buildings differ greatly based on whether firms owned or rented these buildings (Hines 1990). If a loss of utility, productivity, or comfort were the decisive factor in technology choice, — rather than the landlord/tenant agency problem — one would have expected the same adoption rates among both groups.

In addition, voluntary market transformation programs based on incentives and procurement competition provide a market-based testing ground in which consumer preferences and other indirect cost factors fully come to play. The high participation rates achieved in many U.S. and Western European utility demand-side management programs (Nadel 1990, Mills 1993) show that consumers and firms readily embrace energy-efficient technologies when programs are well-designed, i.e., when they effectively reduce transaction costs for testing and obtaining these devices.

Even regulatory policies based on minimum efficiency standards for buildings, vehicles, and component equipment can incorporate market-based mechanisms that safeguard against losses of consumer surplus.¹³ Such regulatory standards also are routinely subject to cost/benefit tests. A comparison with command and control regulations in the field of classical pollution control is therefore misleading.

Costs of policy implementation

The omission of program administrative costs in many bottom-up studies represents a bias toward optimism. The quantitative significance of this omission depends, in part, on the assumed mix of policies. A major portion of energy-efficiency technology options can be implemented using voluntary agreements and/or mandatory efficiency standards, for which implementation costs are typically negligible.¹⁴

Where more expensive incentive-based programs are used, administration costs have been found to add less than 15 percent on average to engineering-economic technology costs.¹⁵ The growing use of systematic process and impact evaluations has led to a falling trend as utilities and energy service companies have gained experience. More recent, third generation procurement-based programs and voluntary agreements have still lower administration costs and can approach those for regulatory standards. Overall, these findings from evaluation research suggest that for a coordinated package of voluntary and regulatory instruments, average implementation costs across all end-uses can be limited to less than five percent of technology costs. This cost correction represents at best a minor fraction of life cycle cost savings and will not substantially change the cost-effectiveness of energy efficiency options.

Biases created by other input assumptions and modeling procedures

Even if bottom-up studies were significantly optimistic in their treatment of indirect costs, this would be an insufficient basis for concluding that their mitigation cost estimates are optimistic. Rather, it is necessary to comprehensively examine the various bottom-up input assumptions and modeling procedures for additional factors that might create a bias toward pessimism or optimism. Factors that result in overestimation of mitigation costs include the following:

- Incomplete analysis of end-uses and sectors
- Incomplete or dated analysis of technology and policy options
- Neglect of demonstrated near-commercial and advanced technologies
- Omission of capital cost savings from downsizing of downstream or upstream equipment and from lower maintenance and replacement costs for such equipment
- Omission of cost savings due to changes in non-energy process requirements (labor, water, materials)
- Omission of secondary benefits due to increased consumer amenity or productivity
- Omission of credits for avoided transmission and distribution investments and O&M costs in utility systems
- Use of prototype-based costs rather than mass market costs for near-commercial technologies
- Use of discount rates higher than the social discount rate

Factors that create a bias toward optimism (i.e., underestimation of mitigation costs) are:

- Omission of policy implementation costs (see above)
- Omission of losses of consumer amenity and other indirect costs that are not offset by gains in utility and that cannot be reduced or eliminated by market transformation policies
- Overestimation of energy savings that can be achieved in practice due to inaccurate baseline data and lack of field measurements
- Insufficiently disaggregated analysis of technology cost-effectiveness by equipment type, size, intensity of utilization, and geographic location

In an in-depth analysis covering 21 costing factors including the above list, Krause et al. (1995b) find that purely engineering-economic life cycle cost estimates for efficiency improvements in Western European electricity use tend to be significantly biased toward overestimating the costs of saved energy, and thus the cost of mitigating carbon emissions.

Uncertainties about policy adoption in the political process

From a purely economic point of view, the timing of technology shifts in bottom-up scenarios is conservative in that no premature retirement of end-use equipment is assumed¹⁶ and shifts occur over two or more replacement cycles for many end-uses. The implied or assumed phase-in periods broadly match experience with introducing utility demand-side management programs and government efficiency standards in a range of end-uses. Bottom-up scenarios simply assume a much more widespread and synchronized application of these instruments.

Though the institutional capabilities for carrying out major market transformation programs have been demonstrated, scenarios based on complete economy-wide implementation of technical-economic potentials can be questioned from the point of view of political feasibility. For a given reduction target and time table, mitigation costs may rise if only a fraction of replacement investments are in fact shifted to cost-minimizing high-efficiency technologies.

This potential source of cost assessment optimism is difficult to quantify since it depends in large measure on political judgment. Furthermore, the political feasibility argument can be raised about other proposals for climate stabilizing policy action as well, such as high carbon taxes or tradeable permit systems. As discussed below, most existing bottom-up estimates are based on significantly less than the full implementation of technical-economic resource potentials.

More fundamentally, mitigation cost studies are to inform the societal policy-making process, not prejudice it. The purpose of economic assessments may be defeated when technical-economic calculations are strongly altered by assumptions about political feasibility. In a properly agnostic approach to this issue, the implementation fraction would be treated as an explicit scenario variable (see the review of individual studies below).

REVIEW OF WESTERN EUROPEAN BOTTOM-UP STUDIES

The time horizons used in the key bottom-up studies for Western Europe range from the year 2010 to 2030. Three major multi-country projects were conducted. These are the Coherence study for the Joule program of the European Commission (Coherence/CEC 1991), which covered ten European Union countries ; the ETSAP study for the IEA (Kram and Okken 1993), which covered Belgium, Italy, the Netherlands, Norway, Sweden, and Switzerland in addition to several non-European OECD countries; and the IPSEP study for the Dutch government (IPSEP 1993/1996, Krause 1995), which covered France, Germany, Italy, the Netherlands, and the United Kingdom.

In addition, a number of national bottom-up studies were undertaken. Among these, by far the most comprehensive is that of the Enquete Commission on Climate Protection of the German parliament (Enquete Commission 1995). The Enquete Commission's bottom-up scenarios were also used in an integrated bottom-up/top-down macroeconomic modeling assessments for that country (see the section below on top-down and integrated studies). Two national bottom-up studies were performed for Denmark (Morthorst 1993) and for the Netherlands (Ybema et al. 1993) as part of the UNEP country studies program (UNEP/Risø 1994). A number of further important contributions were made in sectoral

bottom-up studies such as the Swedish study of the heat and power sector (Bodlund et al. 1989, Mills et al. 1991).

The energy sector baseline: business-as-usual versus least-cost energy system

In most of the Western European bottom-up studies (i.e., in the Danish UNEP, FRG Enquete Commission, Coherence/CEC and IPSEP studies), mitigation costs are calculated relative to business-as-usual scenarios for the demand for final energy and the mix of supply sources. These business-as-usual projections not only omit most cost-effective demand-side efficiency resources but typically also fail to reflect a least-cost mix of energy supply sources.¹⁷

Despite these shortcomings — or, rather, because of them — these "conventional wisdom" scenarios arguably provide the most meaningful baseline for determining the incremental costs or benefits of alternative carbon reduction strategies. They broadly represent official energy planning and policy as pursued during the 1980s, before climate change became an important concern. The policy initiatives in the fields of energy efficiency and renewable energy that have been undertaken since then are far from sufficient to implement available technical-economic potentials. Therefore, business-as-usual projections best approximate the costs of energy services Western European nations might have incurred and/or were prepared to bear in the absence climate-oriented policy changes.

An alternative baseline definition is used in the ETSAP studies and in the Dutch UNEP study.¹⁸ Here, the reference scenario is, at least nominally, a least-cost mix obtained from a strictly economic integration of the various resource options using a linear programming model. Implicit in this least-cost baseline are technology shifts that produce substantial economic savings relative to a business-as-usual case. The substantial changes in existing energy policies that are required to bring about a least-cost baseline are, however, not detailed. These changes are reserved for the policy case in the other studies.

Economic indices for comparing study results

In exploring mitigation costs, both total costs and marginal costs of emission reductions are of interest, but the usefulness of each in comparing studies and countries depend on the type of baseline. When an optimized energy system is taken as the baseline, both the marginal and total costs of mitigation are by definition positive for all levels of emission reductions. However, when the reference case is a business-as-usual scenario, total costs may be negative or positive, depending on the reduction target and the size of negative-cost and zero-cost resource potentials. Each group of studies therefore needs to be considered separately.

Quantitative results: zero net cost reduction potential and time path

Results from the Western European bottom-up studies using a business-as-usual baseline are given in Table 2. Findings are reported in terms of the maximum analyzed percentage reduction relative to base year emissions that was found to produce a zero or negative net change in the cost of energy services relative to the baseline.¹⁹

Table 2 here.

costs enter the resource mix only when considering reductions in excess of 20-40 percent relative to base year levels.

Regardless of their magnitude, these differences in marginal costs point to the potential economic advantage of a tradable emission rights system within the European Union. However, top-down assessments also show that national differences in the energy or carbon intensity of gdp are an unreliable predictor for the relative macroeconomic impacts of carbon constraints (CEC 1992).

Analytical and data differences

The wide range of the above study results can be narrowed considerably, and thus yield more precise policy guidance, if important differences in input assumptions are taken into account. These are: incomplete coverage of end-uses and sectors, only partial policy implementation of economic resource potentials, incomplete portfolios of technology measures for the covered end-uses and sectors, and various differences in cost definitions and data.²¹

Coverage of end-uses and implementation of technical-economic potentials

The degree to which demand-side efficiency potentials were considered in each study is indicated in Table 2. The percentages represent the combined effect of the scope of the end-use analysis and of the assumed implementation of technical-economic potentials. The Coherence/CEC study covered only about a quarter of final energy consumption.²² In the Danish UNEP and FRG Enquete Commission studies, energy efficiency options for the transport sector beyond those incorporated in the baseline were neglected or their costs were not analyzed and simply assumed to be zero. The IPSEP study developed cost curves for efficiency improvements in all sectors including the transport sector.

Different assumptions were also made regarding the feasible implementation fraction. For example, the Danish UNEP study assumed close to 100 percent implementation of supply-side no regrets potentials, but only a roughly 60 percent implementation of analyzed demand-side potentials.²³ In the IPSEP study, the mobilization of efficiency and other unconventional resources was made an explicit variable. Mitigation costs were calculated assuming, respectively, 25%, 50%, 75%, and 100% mobilization of the technical-economic potentials of energy efficiency, cogeneration, and renewable resources.

Technology and cost data

Not all studies succeeded equally in developing internally consistent technology, cost, and program implementation data. The most detailed substudies on these input assumptions are found in the FRG Enquete Commission and IPSEP reports.²⁴ Comparison with the IPSEP and FRG Enquete Commission substudies suggests that the Coherence/CEC study understated cost-effective percentage efficiency improvements in the major end-uses by a factor of two or more.²⁵ The "low" and "high" sensitivity cases in the IPSEP study illustrate that feedback effects of climate policies on technology costs and fuel prices can decisively reduce total mitigation costs.²⁶

Inconsistencies in "optimized" baselines

The figures in Table 2 not only provide the absolute emission reductions that can be achieved at zero or negative net cost, but also an approximate indication of the adjustment periods needed for realizing these targets in a least-cost fashion. The following reduction ranges were obtained for the countries covered in these studies:

By about 2005-2010: 10 - >36 percent (median of 23 percent)

By about 2015-2020: >23 - 58 percent (median of 41 percent)

By about 2025-2030: >45 - >60 percent (median of >53 percent)

Averaged over the time horizon of each study, annual no regrets reduction rates are found to be a compounded 1-3 percent per year relative to the base year and 3-6 percent per year relative to the business-as-usual baselines.

The studies shown in the table were not or only partially normalized regarding economic growth, structural change, fuel prices, technology costs, policy effectiveness, etc. Despite these variations, the figures show a consistent pattern:

- Within the year 2000-2030 time frame, larger reductions become feasible at zero net cost as time horizons grow longer, despite continued economic growth.
- For any given target within the range of zero-cost reductions, mitigation costs decline as longer adjustment periods are allowed for reaching the target.

This pattern reflects the fact that all of the above bottom-up studies identify significant energy efficiency, fuel switching and cogeneration potentials that are not exploited in the reference case. Because most of these no regrets resources are introduced in the course of normal capital stock turnover, cost-effective carbon reductions "keep coming."

Quantitative results: marginal costs

Given the wide range of carbon intensities found in the status quo and baseline energy supply systems of Western European countries,²⁰ a significant range of marginal costs is to be expected. This is borne out by the results of the three multi-country projects:

- In the Coherence/CEC study, the range across nine countries is 0-40\$/ton of CO₂ for stabilization at base year levels (time horizon 2010). For a ten percent reduction, the range becomes much wider at 6-1560\$/ton of CO₂.
- In the ETSAP study, the marginal cost of limiting year 2020 emissions to 1990 levels ranges from a low of about zero (Belgium) to a high of about 700 \$/ton of CO₂ (Sweden).
- In the IPSEP study, the marginal costs of limiting year 2020 emissions to base year levels or of reducing them by 10 percent is small or negative in all five countries analyzed.

Here as elsewhere, the degree of detail and comprehensiveness in the analysis of no regrets options plays a decisive role. The negative marginal costs found in the IPSEP study arise mainly from cost-effective energy efficiency improvements and cogeneration investments not considered in the other multi-country studies. For modest targets, these negative-cost options dominate mitigation costs. Technology options of high marginal

In the ETSAP and Dutch UNEP studies, incomplete coverage of end-uses and technology and cost input data are reflected in the baseline. The "optimized" baseline projections in these studies showed flat to significantly rising final energy demand levels that really are quite close to the business-as-usual projections used in the studies summarized in Table 2. This pattern is inconsistent with a least-cost optimization of the energy system. Inspection of assumed energy efficiency potentials and costs, and comparison with the FRG Enquete Commission, Danish UNEP, and IPSEP studies indicates that with more comprehensive assessments of no regrets options, economically optimal levels of year 2020 final energy demand would have been significantly below base year levels. As a result, the ETSAP and Dutch UNEP studies are inconclusive regarding total mitigation costs.

Analysis of energy supply options

The relative contributions from demand-side efficiency and low-carbon supply options vary significantly among Western European bottom-up studies. Table 2 shows two proxy indicators, the coefficient of improvement in the average energy intensity of gdp (AEII), and assumptions regarding the future deployment of nuclear power. The AEII coefficient implied in the bottom-up studies of Table 2 is 2-5%/yr, compared to a range of 0-1%/yr assumed in most top-down studies.²⁷

The difference between the AEII coefficient and the rate of carbon reductions below the baseline indicates the extent to which shifts toward lower-carbon energy supplies augment emission reductions from energy efficiency improvements.²⁸ Here, the treatment of nuclear power is important (see Table 2). The ETSAP and Coherence/CEC studies were based on scenarios in which nuclear power was retained. The FRG Enquete Commission and IPSEP studies included scenarios in which nuclear power was phased out.²⁹

Discussion: overall results

In light of the above review of input assumptions, the zero net cost potential for reducing carbon emissions in Western Europe is probably best characterized by the higher estimates in Table 2. In view of the previously-discussed generic bias toward economic pessimism in bottom-up studies in general, even these results are likely to be conservative. Using just the median figures in Table 2, average no regrets emission reduction rates over the next three decades would be about 2 percent per year relative to the base year. Carbon emissions in 2020-2030 could be cut by about 50-60 percent relative to baseline projections at zero or negative net cost. This figure is two to five times larger than the minimum (consensus) range of the IPCC report, which suggested an OECD-wide no regrets potential of 10-30 percent relative to the business-as-usual baseline.

The above findings imply growing opportunity costs if mitigation strategies should be limited to a mere stabilization of emissions rather than progressive reductions below base year levels. Finally, several Western European bottom-up studies suggest that the region could achieve significant reductions in carbon emissions at zero or negative net cost even while phasing out nuclear power. Overall, bottom-up research indicates that Western European governments may have significantly more economic degrees of freedom in pursuing carbon reduction strategies than has been recognized to date.

REVIEW OF WESTERN EUROPEAN TOP-DOWN STUDIES

Among others, Western European top-down studies have made unique contributions in three areas. One is the early recognition and modeling of a range of tax shift options for minimizing or offsetting undesirable economic effects of energy or carbon taxes. The second is the modeling of integrated energy tax/market transformation/tax shift policies using linked bottom-up and top-down models. The third is the comparative analysis of groups of countries using one and the same modeling system.

Tax shift studies

The results of various Western European tax shift studies are reviewed in CEC (1992) and Bossier and Bréchet (1995), as well as by Hourcade and Robinson in this issue. Like corresponding work in the U.S., these studies examined modest energy or carbon taxes of typically less than 50\$/ton C that resulted in only limited emission reductions below the baseline.³⁰ They found that under these conditions, tax shifts could partially or fully offset the deadweight losses induced by the energy tax. Several modeling exercises even found a net gain in gdp for certain tax shifts and countries (IPCC 1996).

In recent U.S. theoretical work, Goulder (1994) has suggested that for larger emission reductions below the baseline, tax shifts would no longer produce economic efficiency gains. The author assumes that a much higher tax would be needed to induce larger emission reductions. He argues that revenues from such a much higher tax would exceed opportunities for offsetting highly distortionary taxes, and would create bigger deadweight losses than the existing taxes on capital and labor they would displace.

This line of reasoning overlooks four factors that are key in interpreting Western European tax shift studies. For one, climate change mitigation helps abate a number of non-climatic externalities (footnote 2 above). Second, current fossil fuel consumption, as well as energy use in general, is significantly subsidized (footnote 3 above). Third, current differences in the taxation of coal, oil, and gas bear little relationship to differences in associated externalities, and could themselves be reformed at a possible gain in welfare while reducing carbon emissions (Hoeller and Coppel 1992).

As a result of these three factors, the imposition of carbon taxes may function, in part, as a welfare and efficiency-enhancing reduction in price distortions that impede economic efficiency. Well-designed tax shifts that include subsidy removal and reform thus are likely to offer robust reductions in deadweight losses over a much wider range of tax levels than suggested by Goulder.³¹

The fourth factor is that several Western European studies analyze a range of combined fiscal and non-fiscal policy packages not modeled in U.S. tax shift exercises. Here, the non-fiscal components include market transformation programs that require no tax revenue at all (such as energy efficiency standards), as well as the direct recycling of revenues into cost-effective energy efficiency and low-carbon supply investments through an energy efficiency fund or equivalent "ear-marking." The combination of non-fiscal instruments with ear-marking of all or a portion of carbon/energy tax revenues reduces the required tax level for achieving a given reduction target (Goto 1995) and opens the possibility for large emission reductions at zero or negative net cost even when applying only a low tax (Krause et al. 1995a).

Integrated bottom-up/top-down studies

Recent theoretical economic research suggests that a combination of fiscal and market transformation policies is economically more efficient than the use of tax instruments or market transformation programs alone (CEC 1992, Howarth and Winslow 1994). This insight is reflected in various Western European policy actions or proposals, notably those of the Danish government, the European Commission, and the FRG Enquete Commission on Climate Protection, all of which emphasize packages of taxes, tax shifts, and market transformation policies. These and other policy proposals have been evaluated in a number of integrated studies³² that link bottom-up scenarios and top-down models (Bossier et al. 1995, Danish Ministry of Finance 1995, DRI 1991, Enquete Commission 1995, Godard and Beaumais 1994, Koeppl et al. 1995).

The FRG Enquete Commission study

Among the linked studies, the modeling work of the FRG Enquete Commission is particularly informative in that it was based on a detailed, well-researched bottom-up scenario and covered an extended time horizon (1987-2020). The integrated modeling work was co-authored by two institutes specializing in bottom-up research (IKE and ISI) and two macroeconomic research institutes (DIW and EWI).

Modeling methodology

The policy scenario in the FRG Enquete Commission study consisted of a linked energy tax/market transformation/tax shift approach. The energy tax was a low tax equivalent to the proposal of the European Commission. In the bottom-up assessment, two main energy sector scenarios were developed. One kept nuclear capacity constant (R1), while the other included a nuclear phase-out (R2). In both cases, year 2020 emissions were cut by 45 percent relative to 1987 (35 percent relative to 1993).

The principal modeling procedure, which is representative of other integrated studies, is illustrated in Figure 1. The bottom-up energy scenarios were translated into economic stimuli and structural changes by economic sector, using input-output methods. A neo-keynesian macro model was used to determine gdp, structural changes, employment and other macroeconomic impacts (Walz et al. 1994). Modeling uncertainties in this procedure were explored through sensitivity analyses.³³ In a separate analysis, a general equilibrium model was used to assess trade effects.

Figure 1 here.

Results

The results are summarized in Table 3. In all cases, average gdp increased, and so did employment. In most branches, production increased by 2-6 percent. Output in the fossil fuel industries declined by 3-10 percent. The electricity sector was little affected.

Table 3 here.

In the unfavorable variant, gross domestic product rose by 0.2-0.3 percent, and employment also increased by 0.2-0.3 percent, equivalent to about 100 000 jobs (averaged over the 1987-2020 period). However, measures to reduce carbon emissions were in effect being financed through a 0.6-0.7 percent reduction in private consumption.

In the favorable variant, gdp gains were larger at 0.5-0.7 percent on average, partly because the induced modernization of production facilities led to a permanent rise in productivity. Here, both private consumption and employment rose. However, the productivity gains also meant that employment impacts were no greater than under unfavorable input assumptions.

The Enquete Commission assessment also found that alternative power sector scenarios based on the phase-out, maintenance, or expansion of nuclear power had a negligible impact on gdp (Table 3). The general equilibrium modeling of the trade effects of an energy tax suggested that differences in gdp impacts for the unilateral versus coordinated EU-wide implementation of the energy tax were small, with the unilateral tax being slightly more favorable.

Short-term studies

Among integrated assessments with a short-term focus, several Western European studies analyzed how alternative energy tax exemptions for industry might affect achievable emissions and total macroeconomic costs. We briefly summarize the findings from the WIFO study, which are broadly representative.³⁴ In this modeling work, a portion of tax revenues was recycled through a fund for cost-effective energy efficiency improvements and cogeneration investments.³⁵

It was found that whenever the energy efficiency fund was part of the policy package, both gdp and employment effects were positive. If the energy efficiency programs were replaced by other forms of tax recycling or by budgetary deficit reductions, gdp and employment impacts were always negative.

A strategy that purely relied on payroll tax cuts and did not employ energy efficiency incentive programs was found to be inferior to the combined application of payroll tax cuts and an energy efficiency fund, both in emission reductions (20 percent lower) and in gdp and employment (losses rather than gains).

The study further found that a negative net cost of carbon reductions was maintained when industry exemptions from the energy tax were paired with market transformation programs. Overall emission reductions appeared more sensitive to the abandonment of the energy efficiency fund than to industry exemptions.

Discussion

These integrated studies suggest that gdp and employment impacts can be neutral or positive even when large emission reductions are pursued and over a wide range of policy combinations involving only modest energy taxes. In both studies, market transformation programs plus tax shifts resulted in macroeconomic efficiency advantages, even though the policy measures of the bottom-up scenario had the effect of somewhat *increasing* the total cost of energy services relative to the reference case.³⁶ This outcome again illustrates the importance of tax shifts, and underlines the economic pessimism of bottom-up studies, which do not incorporate tax shifts.

Given significant non-climatic externalities and inefficient subsidies, the welfare benefits of reducing carbon emissions have almost certainly been underestimated in these studies. Further enhancements of macroeconomic benefits can be expected from the modeling of bottom-up scenarios in which energy service bills show a significant decline. The trade-offs between exemptions from energy taxes and compensatory market transformation programs should be modeled in greater detail and for a larger number of countries.

SUMMARY

Conventional wisdom has it that top-down studies overestimate mitigation costs while bottom-up studies underestimate them. The analysis of relevant methods and input data in this paper indicates that this interpretation is flawed: both types of studies tend to overestimate mitigation costs, with studies based on detailed bottom-up scenarios closer to the mark.

First, virtually all mitigation cost studies for Western Europe and for the OECD in general neglect the no regrets options related to environmental double dividends and subsidy removal. Second, this pervasive no regrets deficit is compounded in bottom-up studies by the omission of tax shift options. Third, technical analysis, market research, and experience with market transformation instruments in a number of OECD countries shows the practical feasibility of improving energy efficiency and supply markets at a substantial net economic benefit, even after fully accounting for all indirect costs. Finally, the cost and technology inputs for bottom-up studies contain a wide range of conservatism that overshadow other procedures with effects in the opposite direction. In particular, the failure of bottom-up analysis to capture a number of feedback effects tends to result in a net bias toward cost pessimism.

Given these limitations, the closest approximation to the costs of mitigating carbon emissions in Western Europe is found in the more comprehensive bottom-up studies and in recent integrated bottom-up/top-down analyses. In quantitative terms, a careful and informed reading of the entire body of existing studies leads to the following conclusions: In a well-designed policy approach, carbon emissions in Western Europe could be cost-effectively reduced by a compounded 3-6 percent per year below the business-as-usual baseline, or by about 1-3 percent per year below base year levels.

With proper attention to all no regrets options, the zero net cost potential for cutting carbon emissions can be conservatively represented by the median of these ranges. For the 2020-2030 time horizons, this median corresponds to a reduction of more than 50-60 percent relative to the business-as-usual baseline. This no regrets range is at least twice as large (and significantly more narrow than) the minimum consensus figure of 10-30 percent given in the IPCC report.

This discrepancy suggests that Western Europe would incur significant opportunity costs if it should limit its mitigation efforts to a mere stabilization of emissions rather than progressive reductions below base year levels. This indication of growing opportunity costs from overly modest reduction targets clashes with recent top-down studies (Wigley et al. 1996), which suggest that a go-slow approach in early years, followed by more aggressive action in later decades, could be economically beneficial.

In summary, the wide and seemingly inconclusive range of mitigation costs found in the IPCC report transforms into a significantly more definite sign post for fashioning economically sound quantified emission reduction targets: Close examination of available studies suggests that with a combination of fiscal reforms and aggressive market transformation policies, the European Union could cut its carbon emissions over the next 30 years or so by roughly 2 percent per year relative to 1990 levels without adverse economic impacts, and possibly at a net benefit.

REFERENCES

- Bodlund, B., Miller, E., Karlsson, T., Johansson, Th. (1989) "The challenge of choice: Technology options for the Swedish Electricity Sector" - in Th. Johansson, et al. : *Electricity: Efficient end use and new generation technologies, and their planning implications*, Lund, Sweden: Lund University Press
- Bossier, F., and T. Bréchet (1995): "A fiscal reform for increasing employment and mitigating CO₂ emissions in Europe," *Energy Policy*, Vol. 23, Nr. 9
- Bossier, F., L. Lemiale, P. Van Brusselen, P. Zagamé (1995): *Efficiencia energética y nuevas tecnologías - Los efectos macroeconómicos para seis países de la Unión Europea*, report to the Commission of the European Communities (CEC), Bruxelles.
- Danish Ministry of Finance (1995) *Energy Tax on Industry in Denmark*, Copenhagen, December.
- Burniaux, J.-M., J. Martin, J. Oliveira-Martins 1992 "The Effects of Existing Distortions in Energy Markets on the Cost of Policies to Reduce CO₂ Emissions: Evidence from GREEN," in: *OECD Economic Studies*, Winter, pp. 141-165.
- Carraro, C. (1994) "Modelling Technological Progress in Top-Down Models," Invited contribution to Working Group III, IPCC, Fondazione ENI, Milano, April
- CEC (1990) "Energy for the Next Century," in: *Energy in Europe*, Commission of the European Communities, Directorate-General for Energy, Brussels, Special Issue, July
- CEC (1991) "A Community strategy to limit CO₂ emissions and improve energy efficiency," communication from the Commission to the Council, SEC(91) 1744 final, Commission of the European Communities, Brussels, 14 October
- CEC (1992) *The Climate Challenge: Economic Aspects of the Community's strategy for limiting CO₂ emissions*, report of the Commission of the European Communities Directorate-General for Economic and Financial Affairs, in: *European Economy*, Brussels, No. 51, May
- Ekins, P. (1994): "Rethinking the Costs Related to Global Warming: A survey of the issues," *Energy-Environment-Modelling Discussion Papers*, No.8, University of Cambridge, Cambridge, UK, June 1994
- Enquete Commission (1995) *Mehr Zukunft für die Erde: Nachhaltige Energiepolitik für dauerhaften Klimaschutz*, Final report of the Enquete-Commission of the 12. German Bundestag, Bonn.
- Eto, J., and S. Kito, L. Shown, R. Sonnenblick (1995) *Where did the Money Go? The Cost and Performance of the Largest Commercial Sector DSM Programs*, LBL-34967, Energy and Environment Division, Lawrence Berkeley National Laboratory, December
- GEA (1994) *Study of Efficient Washing Machines, Dishwashers and Dryers*, Interim Report, Group for Efficient Appliances (GEA), Working Group Club E^{NR}, Danish Energy Agency, Denmark, July
- Gerstenberger, W. (1992) "Relative energy prices, innovation activity and economic performance in markets for energy-sensitive products," *European Economy*, Special edition No.1
- Goddard, O., and O. Beaumais (1994) "L'économie face l'écologie," *La Découverte Française*, Paris
- Goto, N. (1995): "Macroeconomic and sectoral impacts of carbon taxation," *Energy Economics*, vol. 17, No. 4, pp. 277-292.

Goulder, L.H., (1994) "Energy Taxes: Traditional efficiency effects and Environmental Implications," in: James M. Poterba, ed., *Tax Policy and the Economy* 8, Cambridge MA, MIT Press

Greening, L., and A. Sanstad, J. McMahon (1996) "Effects of Appliance Standards on Product Price and Attributes in a Hedonistic Pricing Model," *Journal of Regulatory Economics*, forthcoming

Grubb, M., J. Edmonds, P. ten Brink and M. Morrison, (1993) "The Costs of Limiting Fossil-Fuel CO₂ Emissions: A Survey and Analysis," *Annual Review Energy Environment*, No. 18, pp. 397-478

Hines, R. (1990) "Study Shows Conservation Trends in D.C. New Construction," *Energy User News*, Vol. 15, No. 10: 4, October

Howarth, R.B., and B. Anderson (1993) "Market Barriers to Energy Efficiency," *Energy Economics*, Vol. 15, No. 4, p. 262-272

Howarth, R.B., and M. A. Winslow (1994) "Energy use and CO₂ emission reductions: integrating pricing and regulatory policies," *Energy: The International Journal*, August, p.855-867

Hoeller, P. and J. Coppel (1992): "Energy taxation and price distortions in fossil fuel markets: some implications for climate change policy," Chapter 12 in: OECD (1992), *Climate Change- Designing a Practical Tax System*, OECD Documents, Paris.

IPCC (1996) *Evaluating the Costs of Mitigation of Greenhouse Gas Emissions by Sources and Removals by Sinks*, Intergovernmental Panel on Climate Change (IPCC), Second Scientific Assessment Report, Working Group III, Cambridge University Press, Chapters 8 and 9

IPSEP (1993/1996) *Energy Policy in the Greenhouse Vol. II : The Cost of Cutting Carbon Emissions in Western Europe, Parts 1-6*, International Project for Sustainable Energy Paths, El Cerrito, CA

Jaffe, Adam.B, and Robert N. Stavins (1994) "The Energy Efficiency Gap: What does it mean?" *Energy Policy* Vol.22, No. 10, October, pp. 804-810

Joskow, P. and D.B. Marron (1993) "What Does a Negawatt Really Cost? Evidence from Utility Conservation Programs," *The Energy Journal* Vol. 13, Nr. 4

Koepl, A., and K. Kratena, C. Pichl, F. Schebeck, S. Schleicher, M. Wüger (1995) *Makroökonomische und sektorale Auswirkungen einer umweltorientierten Energiebesteuerung in Österreich*, Austrian Institut of Economic Research (WIFO), Vienna, February

Koomey, Jonatahn G., and Alan H. Sanstad (1994) "Technical evidence for assessing the performance of markets affecting energy efficiency," *Energy Policy* Vol.22, No. 10, October, pp.826-832

Kram, T. (1993) *National Energy Options for Reducing CO₂ Emissions, Volume 1: The International Connection*. A report of the Energy Technology Systems Analysis Program (ETSAP) of the International Energy Agency, Netherlands Energy Research Foundation (ECN), December.

Krause, F., and E. Haites, R. Howarth, J. Koomey (1993) *Cutting Carbon Emissions: Burden or Benefit? The Economics of Energy-Tax and Non-Price Policies: Energy Policy in the Greenhouse Vol. II, Part 1*, International Project for Sustainable Energy Paths (IPSEP), El Cerrito, CA

Krause, F. (1994) "Top-Down and Bottom-Up Methods for Calculating the Cost of Cutting Carbon Emissions: An Economic Assessment," Invited contribution to the 1995 IPCC Scientific Assessment Report, Working Group III, International Panel on Climate Change (IPCC), Toronto, Canada

Krause, F., (1995) "The cost of cutting carbon emissions: A case study of Western Europe" in: *Proceedings of the IEA Greenhouse Gas Mitigations Options Conference*, London, August 1995, Special edition of *Energy Conversion and Management*, (forthcoming)

Krause, F., (1995a) "The Cost of Cutting Carbon Emissions: A review and methodological critique of top-down and bottom-up analyses," in: *Proceedings of the World Energy Council (WEC) 16th Congress*, Tokyo, Japan

Krause, F., and D. Olivier, J. Koomey (1995b) *Negawatt Power: The Cost and Potential of Efficiency Resources in Western Europe: Energy Policy in the Greenhouse Vol. II, Part 3B*, International Project for Sustainable Energy Paths (IPSEP), El Cerrito, CA

Larsen, B. and A. Shah 1992, "World Fossil Fuel Subsidies and Global Carbon Emissions," *Policy Research Working Paper Series*, No. 1002. The World Bank, Washington, DC.

Levine, Mark D., and R. Sonnenblick (1994) "On the assessment of utility demand-side management programs" *Energy Policy* Vol.22, No. 10, October, pp.848-856

McMahon, J.E., and D. Berman, P. Chan, J. Koomey, M.D. Levine, S. Stoft (1990) "Impacts of US appliance energy performance standards on consumers, manufacturers, electric utilities, and the environment," *Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings*, Vol 7: 107-116

Michaelis, L. (1996) *OECD Project on Environmental Implications of Energy and Transport Subsidies*, Working Draft, OECD, Paris.

Mills, E., and D. Wilson, Th. Johansson (1991) "Getting started: no regrets strategies for reducing greenhouse gas emissions," *Energy Policy*, July-August 1991, p.526-542

Mills, E., (1993) "Efficient Lighting Programs in Europe: Cost effectiveness, consumer response, and market dynamics," *Energy* Vol.18, No. 2:131-144, 1993, Pergamon Press, U.K

Morthorst, P.E. (1993) "The cost of CO₂ reduction in Denmark. Methodology and results," Risø National Laboratory, UNEP, Risø-R-728 (EN)

Nadel, Steven (1990) *Lessons Learned: A Review of Utility Experience with Conservation and Load Management Programs for Commercial and Industrial Customers*, New York State Energy Research and Development Authority. March

OECD (1996) *Implementation strategies for Environmental Taxes*, OECD, Paris

Reinsch, A. and J. Considine (1992) *Challenging OPEC: World Oil Market Projections, 1992-2007*, CERI study No. 47, Canadian Energy Research Institute, Calgary, Alberta, July

Swisher, J. and D. Wilson (1993) "Top-down versus bottom-up analyses of the cost of mitigating global warming," *Energy Policy* Vol.21 No. 3: 249-262

Sanstad, A. H. and R. Howarth (1994) "'Normal' Markets, Market Imperfections, and Energy Efficiency," *Energy Policy* Vol.22, No. 10, October

Statistics Norway (1995) *Norwegian emissions of CO₂ 1987-1993, A Study of the Effect of the CO₂-tax*, Report 95/14, Section 10.

Standaert S. (1992) "The macrosectorial effects of an EC-wide energy tax: simulation experiments for 1993-2005," in: *European Economy*, Special Edition no.1, p.127-150

UNEP (1994) *UNEP Greenhouse Gas Abatement Costing Studies. Phase Two Report Part 1: Main Report*, UNEP Collaborating Centre on Energy and Environment, Risø National Laboratory, Denmark, May.

Walz, R., and M. Schon et al, (1994) *Gesamtwirtschaftliche Auswirkungen von Emissionsminderungsstrategien*, study for the Enquete Commission of the German Bundestag on Protecting the Earth Atmosphere, Karlsruhe/Berlin

Wigley, T.M., R. Richels, J.A. Edmonds, (1996): "Economic and Environmental Choices in the Stabilization of Atmospheric CO₂ Concentrations." *Nature*, Nr. 379, pp. 240-243.

Ybema, J.R., and P.A. Okken, P. Kram, (1993): "CO₂ abatement in the Netherlands. A study following UNEP guidelines," ECN-C-93-021, July, in: *UNEP GHG Abatement Costing Studies*, RISØ-UNEP Collaborative Centre, Appendix II, p. 93-101

1 In this paper, the term mitigation costs always refers to the net economic or welfare cost of reducing fossil carbon emissions after considering various double dividends but *before* considering the benefit of avoided climate changes.

2 See, for example, Barker (1993) and Ekins (1994), who finds non-climatic externality values of \$20-212 per metric ton of C for the UK and other European countries, and the review of 10 studies by Statistics Norway (1995), which finds a range of \$52-1426/tC for non-climatic environmental benefits and \$74-1630/tC for benefits from reduced traffic in that country. The latter review indicates benefits ranging from about 5 percent to more than 100 percent of gdp losses calculated for various carbon tax scenarios.

3 In such a context, subsidy removal and reform would be accompanied by the imposition of carbon/energy taxes. These ensure that the removal of supports for domestic producers, and the attendant reductions in energy prices, do not translate into increased fossil fuel consumption and emissions. Removing global subsidies to fossil fuel consumers has been estimated to be equivalent to imposing a carbon tax of 50-90\$/tC and to emission reductions below the baseline of 5-18 percent in 2010 at a net economic benefit (Larsen and Shah 1992, Burniaux et al. 1992). Though OECD energy prices are generally above world market prices, major subsidies are found even there in the form of a range of price and budgetary supports, notably for coal. Recent OECD case studies indicate that removal and reform of about \$100 billion of subsidies (defined there to include some non-climatic externalities) could yield reductions in year 2010 OECD carbon emissions of several percent below the baseline, along with positive gdp and welfare effects (Michaelis 1996).

4 Neo-keynesian macro models result in higher mitigation cost estimates than general equilibrium models, which assume greater adjustment speeds for capital stocks.

5 In the global studies reviewed by Richels and Sturm in this issue, an additional source of pessimism is the neglect of spillage effects (Krause et al. 1993), i.e., the penetration in the developing world of new low-carbon technologies first introduced in the the OECD in response to the unilateral adoption of emission constraints.

6 For a discussion of the conditions under which tax shifts can reduce deadweight losses and result in economic efficiency gains, see the section on top-down studies at the end of this paper.

7 Because any additional energy services would be provided with more efficient technologies as well, the percentage increase in final energy demand would be less than the underlying percentage increase in energy service demand.

8 A macroeconomic analysis of this suppressive effect is found in Goto (1995). See also the discussion of integrated top-down/bottom-up studies at the end of this paper.

9 For example, Reinsch and Considine (1992) estimate that even the OECD-wide adoption of the mild carbon/energy tax proposed by the European Commission (1991) would reduce pre-tax oil prices by more than 10 percent in 2007,

equivalent to a 47 billion dollar annual saving for the OECD nations, and 90 billion dollars worldwide. Though oil producing nations might attempt to defend their revenue streams through new cartel agreements, their ability to do so is questionable (CEC 1992), and would likely decrease in the face of stronger carbon constraints. Some bottom-up studies examine this effect through sensitivity tests based on lower energy price assumptions without, however, venturing beyond the range of fossil fuel price forecasts made for various rates of *growth* in fossil fuel consumption.

10 See the critique of this procedure in Krause et al. (1995b). Where allowance is made for economies of scale under changed market conditions, as in government-sponsored cost-effectiveness analyses of energy efficiency standards, the typical practice is to use "ideal" manufacturer mark-ups. These are often far in excess of what equipment producers end up being able to charge in mass market competition. See the market research in GEA (1994), and the empirical ex-post evaluation of U.S. appliance standards in Greening et al. (1996)).

11 See Gerstenberger (1992) for an empirical analysis of the effects of higher energy prices on the rate of innovation in the area of energy efficiency. Most bottom-up studies with longer time horizons (30-40 years) do capture some technology innovation effects by explicitly taking into consideration a range of advanced technologies. However, assumptions in this regard may be quite cautious and in any event, do not capture those techniques that are not yet known. Thus, bottom-up studies are likely to contain a significant bias toward cost pessimism even in this area.

12 While most economists readily concede that problems of uncertainty and high information and transaction costs are universal characteristics of 'normal' markets, some argue that these do not constitute market failures. In an in-depth theoretical economic critique of this view, Sanstad and Howarth (1994) show that the equation of 'normal' markets with economically efficient markets is a fallacy based on tautological arguments.

13 Recently proposed or enacted standards are generally formulated on a performance basis, i.e., they do not prescribe the use of any one particular technique or design. Performance-based standards give manufacturers incentives for technological creativity while providing wide latitude for preserving non-energy attributes important to consumers. Issues of consumer surplus can be, and often are, empirically assessed before standards are promulgated by first conducting voluntary incentive programs. In many cases, standards are merely used to accelerate the completion of the technology diffusion process after a technology has already been adopted by a sizable fraction of consumers and firms. Furthermore, the tandem application of incentives and standards can be used to accelerate innovation, which increases consumer surplus. Finally, market research can be used to evaluate issues of product attributes after standards have taken effect. Recent empirical work of this kind on U.S. appliance efficiency standards found no measurable negative effects on product selection and attributes (Greening et al. 1996).

14 For example, the cumulative cost of developing and implementing federal energy efficiency standards for U.S. appliances and other products amounted to 50 million dollars, equivalent to one tenth of one percent of the estimated net present value benefits of these standards in the period till 2015 (McMahon et al. 1990).

15 This figure is based on measured savings from several billion dollars of U.S. utility spending on demand-side management programs and comprehensive cost data including savings verification, free rider costs, profit incentives for utility shareholders, and program evaluation (Eto et al. 1995). Similar proportions are reported in Western European evaluation studies (Mills 1993). Earlier estimates by Joskow and Maron (1993) were based on incomplete data and have proven far too high. The costs of saved energy are reduced further when accounting for the secondary market transformation effects of incentive programs, such as 'free drivers' (Levine and Sonnenblich 1994), secondary equipment and maintenance savings, and accelerated product improvements.

16 The conservatism of this procedure is enhanced by the fact that in a number of end-uses, early replacement can be economically justified because of a favorable ratio between potential annual energy savings and the total replacement cost of the device. As discussed above, climate stabilization policies may also trigger accelerated innovation that could make some early retirement of existing end-use equipment attractive.

17 The business-as-usual supply mix typically reflects existing barriers to market entry for independent generators as well as some or all of a range of other politically determined factors that have shaped official energy planning in Western Europe. These include limitations on gas imports (all of the EU during the cold war period), preferences for use of domestic coal (e.g., Germany), and industrial strategies based on nuclear electrification (France).

18 Least-cost configurations for the energy system are also developed in the Coherence/CEC, IPSEP, and FRG Enquete Commission studies.

19 In several cases, the shown emission reductions were associated with significant net economic benefits, but no measures to obtain further emission reductions were analyzed. Here, reductions are shown with a "greater than" sign.

20 For example, in the Coherence/CEC study, year 2010 emissions correspond to a stabilization at 1988 levels for Germany (pre-1990 borders), a 5% increase for France, 12% for the UK, 24% for Italy, 30% for Spain, and 72% and 86% for the less developed countries of Greece and Portugal, respectively. For the EU-12 as a whole, the business-as-usual increase is 14% by 2010.

21 Gdp growth rates, energy demand, and fuel price projections are relatively similar across studies. For example, both the Coherence/CEC study, the FRG Enquete Commission study, and the IPSEP study derive these inputs from the projections of the European Commission.

22 Excluded from the analysis were all of industry, most of the tertiary sector, and all vehicle efficiency improvements in transport except certain modest improvements in cars.

23 Baseline energy efficiency improvements in the transport sector excluded a significant range of cost-effective or cost-neutral options, and because some other efficiency options were not analyzed, Table 2 indicates that less than half of the available cost-effective energy efficiency potential was incorporated in the mitigation cost analysis.

24 The latter study employed a number of data refinements not or only partially applied in other European bottom-up studies. These included feedback effects of climate policies on technology costs; program administration costs; credits for energy efficiency investments from secondary capital savings in upstream or downstream end-use equipment; credits for avoided transmission and distribution costs; and alternative assumptions regarding the effectiveness of policy efforts in mobilizing unconventional resources.

25 The Coherence/CEC and IPSEP studies are directly comparable in so far as both use the "Energy for the Next Century" study of the European Commission (CEC 1990) as the business-as-usual baseline. With assumed efficiency improvements relative to the baseline in the Coherence/CEC study averaging about 20 percent, and only about 25 percent of final consumption investigated, the study yields a roughly 5 percent reduction in final energy requirements below the rising projection of the business-as-usual reference case. Extrapolating the analysis to all end-uses would raise this percentage to about 20 percent. Across all end-uses, the more comprehensive and up-to-date technology cost and performance data of the IPSEP study indicate a cost-effective savings potential of 40-60 percent on a weighted average basis. Adjusted to the shorter (year 2010) time horizon of the Coherence/CEC study, this percentage is about 25-35 percent. Overall savings of 5% rather than 25-35% indicate a less than 20 percent capture of the total cost-effective potential.

26 In the study, high and low estimates were developed not only for fuel prices, but also for technology costs. Low cost assumptions were used to reflect plausible cost reductions from feedback effects of carbon constraints, while high assumptions illustrated outcomes in absence of these feedbacks.

27 See IPCC (1996), Chapter 9. The AEII coefficient is functionally identical to the coefficient of average energy efficiency improvement (AEEI) referred to in top-down studies. However, the latter name ignores that this coefficient includes both energy efficiency improvements in the technological sense and structural changes.

28 In all studies, differences also exist in the definition of the costs and potentials of low-carbon energy supply options and in the degree to which the multi-country studies succeeded in using consistent input assumptions across countries. The ETSAP and IPSEP projects used cost data that were consistently defined across countries, while the input assumptions in the national substudies of the Coherence/CEC project were determined by national teams. This led to significant differences in technology portfolios and cost estimates and to the much wider range of marginal cost estimates found in that study.

29 Zero net cost scenarios for reducing carbon emissions while phasing out nuclear power were also identified by Bodlund et al. (1989) for Sweden. The FRG Enquete Commission examined a rapid phase-out by 2005, while the IPSEP study assumed a gradual phase-out by 2020.

30 The carbon tax as originally proposed by the European Commission (CEC 1992) was to start at \$14 per metric ton of carbon in 1993 and gradually rise to \$46 per metric ton by 2000.

31 The greater recognition of externality issues related to fossil and nuclear energy explains why many of the Western European top-down studies model an energy or combined energy/carbon tax in addition to a pure carbon tax (see, e.g., Standaert 1992). While a carbon tax might be more effective in reducing CO₂ emissions than an energy tax, this advantage in the area of climate change is widely viewed as economically less important than policies that reduce risks and externalities from both fossil and nuclear energy production (CEC 1992, Enquete Commission 1995: 755, WIFO 1995).

32 The term integrated study is reserved here for macroeconomic studies in which energy sector impulses are derived from bottom-up assessments using a business-as-usual baseline.

33 Under unfavorable assumptions, energy efficiency investments were financed through reductions in private consumption. Also, energy efficiency investments were assumed to displace investments in production facilities. Furthermore, it was assumed that half the revenue from the energy/carbon tax would be used to reduce government budget deficits (without, however, lowering interest rates) and to finance government energy efficiency programs. The other half of the tax revenue was used to reduce payroll taxes. In the favorable variant, energy efficiency investments by consumers and firms were financed through increased borrowing and use of savings. This way, a reduction in private consumption was avoided. Also, energy efficiency investments in this variant did not displace investments in production. On the contrary, they were assumed to induce broader modernization investments in production facilities. Energy tax revenues were completely recycled through lower payroll taxes.

34 Of the five short-term studies referenced above, all but the DRI report arrive at a zero to slightly positive gdp impacts. The comprehensiveness and detail of underlying bottom-up scenarios vary greatly in these studies.

35 Two other studies examined programs in which some of the carbon/energy tax revenue is used to provide energy efficiency investment subsidies for industry (Bossier et al. 1995 for six EU countries and Ministry of Finance 1995 for Denmark). Various practical issues associated with "ear-marking" are discussed in OECD (1996).

36 In the near-term studies such as WIFO (1996), this increase is mainly due to the short time horizons used (as little as 5-8 years). When cost-effective investments are modeled on a year-by-year basis, much of the savings that occur after amortization are not captured. In the work of the FRG Enquete Commission, which covered a longer time horizon (1987-2020), the national energy service bill in 2020 increased due to the use of bottom-up scenarios based on the lower of the two implementation fractions shown in Table 2. For this input assumption, a reduction target of 45 percent relative to 1987 (35 percent relative to 1993) exceeds the zero net cost point, which is only 23 percent for scenario R2 (see Table 2 above).

Table 1: Scope of European top-down and integrated top-down/bottom-up mitigation cost studies: range of policy options analyzed												
	0	1	2	3	4a	4b	4c	4d	5	6	7a	7b
	Energy and/or carbon tax		Price corrections		"NO REGRETS" OPTIONS Market transformation incl. utility regulatory reform				Accel.R&D/ Commercial.	Higher-cost/ backstop technologies	Integrated assessment tax shifts + "no regrets" partial full	
	Lump-sum or revenue raising	Tax shift or mixed recycling	Subsidy removal /shifts	Incorporation of environm. externalities	Barriers to Market entry	Other barriers cogeneration & renewables	End-use barriers energy efficiency	fuel switching	Efficiency, low-carbon supplies	Efficiency, low-carbon supplies	Options 0-1 with any of 4 and 5	Options 0-1 with all of 2-6
Multi-country studies												
Non-US OECD	Yes	-	-	-	-	-	-	-	-	(Yes)	No	No
EU multi-member studies	Yes	Yes			(Yes)	(Yes)	(Yes)	-	-	-	(Yes)	No
National studies												
Austria	Yes	Yes	-	-	(Yes)	(Yes)	(Yes)	(Yes)	-	-	(Yes)	No
Belgium	Yes	Yes	-	-					-	-	No	No
Denmark	Yes	Yes			(Yes)	(Yes)	(Yes)	(Yes)			(Yes)	No
Finland	Yes	-	-	-	-	-	-	-	-	-	No	No
France	Yes	Yes	-	-	-	-	(Yes)	-	-	-	(Yes)	No
FRG	Yes	Yes	(Yes)	-	Yes	Yes	Yes	(Yes)		-	Yes	No
Italy	Yes	Yes		-	-	-	-	-	-	-	No	No
Netherlands	Yes	Yes	-	-	-	-	-	-	-	-	No	No
Norway	Yes	Yes	-	(Yes)	-	-	-	-	-	-	No	No
Portugal	Yes	-	-	-	-	-	-	-	-	-	No	No
Spain	Yes	-	-	-	-	-	-	-	-	-	No	No
Sweden	Yes	Yes	-	-	-	-	-	-	-	-	No	No
Switzerland	Yes	Yes	-	-	-	-	-	-	-	-	No	No
UK	Yes	Yes	-	-	-	-	-	-	-	-	No	No

Notes:

Yes in parentheses indicates that the option was only partially considered (e.g., based on only one or a few programs, technologies, end-uses, or sectors).
Sample of studies based on Grubb, et. al. (1993); IPCC (1996), ch. 9; and individual studies referenced in this paper.

Table 2: Zero or negative net cost carbon reduction potentials in Western European bottom-up studies

STUDY	COUNTRY	INPUT ASSUMPTIONS				Zero cost reduction in carbon emissions			AEII final energy /gdp %/yr	Avg. rate of C reduction	
		Time horizon	C-growth factor in BAU baseline	Implementation of DSE potentials	Phase-out of nuclear power?	2005/2010 % below base year	2015/2020 % below base year	2025/2030 % below base year		below base year %/yr	below baseline %/yr
EU-5 Coherence/CEC Country-by-country	F, G, I, NL, UK	2010	1.09 1.00 - 1.24	<25%	No	23 10-36			2.7%	1.3%	4.5%
EU-5 IPSEP	F, G, I, NL, UK	2020/30	1.22	50% 100%	Yes Yes		>26 >58	>60	4.2% 5.1%	1.0% 2.9%	4.2% 6.2%
FRG Enquete Commission	Germany	2020	0.99	50% 75%	Yes No	14	23 >39		3.1% 3.5%	1.0% 1.8%	3.0% 3.9%
Risø/UNEP	Denmark	2030	1.16	<0.45	not applicable	>21		>45	2.1%	1.5%	3.2%
Range						10-36	23- >58	>45- >60	2.1% - 5.1%	1% - 2.9%	3% - 6.2%
Median						18	>41	>53	3.6%	2.0%	4.6%

- (1) BAU = Business-as-usual scenario. Table excludes studies using an optimized energy system as the reference case.
- (2) DSE = Demand-side efficiency. Defined here as potentials beyond those already implemented in the business-as-usual scenario, based on IPSEP estimates.
- (3) AEII = Average rate of energy intensity improvement, based on energy consumption per unit of gdp. Includes both energy efficiency gains and structural change.
- (4) Enquete Commission study refers to Germany after reunification. 1993 base year eliminates post-1990 "wall-fall" contraction of baseline emissions.
- (5) Implementation fractions for Coherence/CEC, Danish and FRG study accounts for efficiency potentials not incorporated into baseline or policy case.
- (6) High implementation fraction for FRG study assumes some modal shifts and more vehicle efficiency improvements at zero net cost (R1V scenario).
- (7) Coherence/CEC results shown for EU-5 only to facilitate comparison with IPSEP study. EU-5 represents about three quarters of total EU carbon emissions.

Table 3: Macroeconomic impacts of reducing German carbon emissions by 35 percent below the 1993 baseline

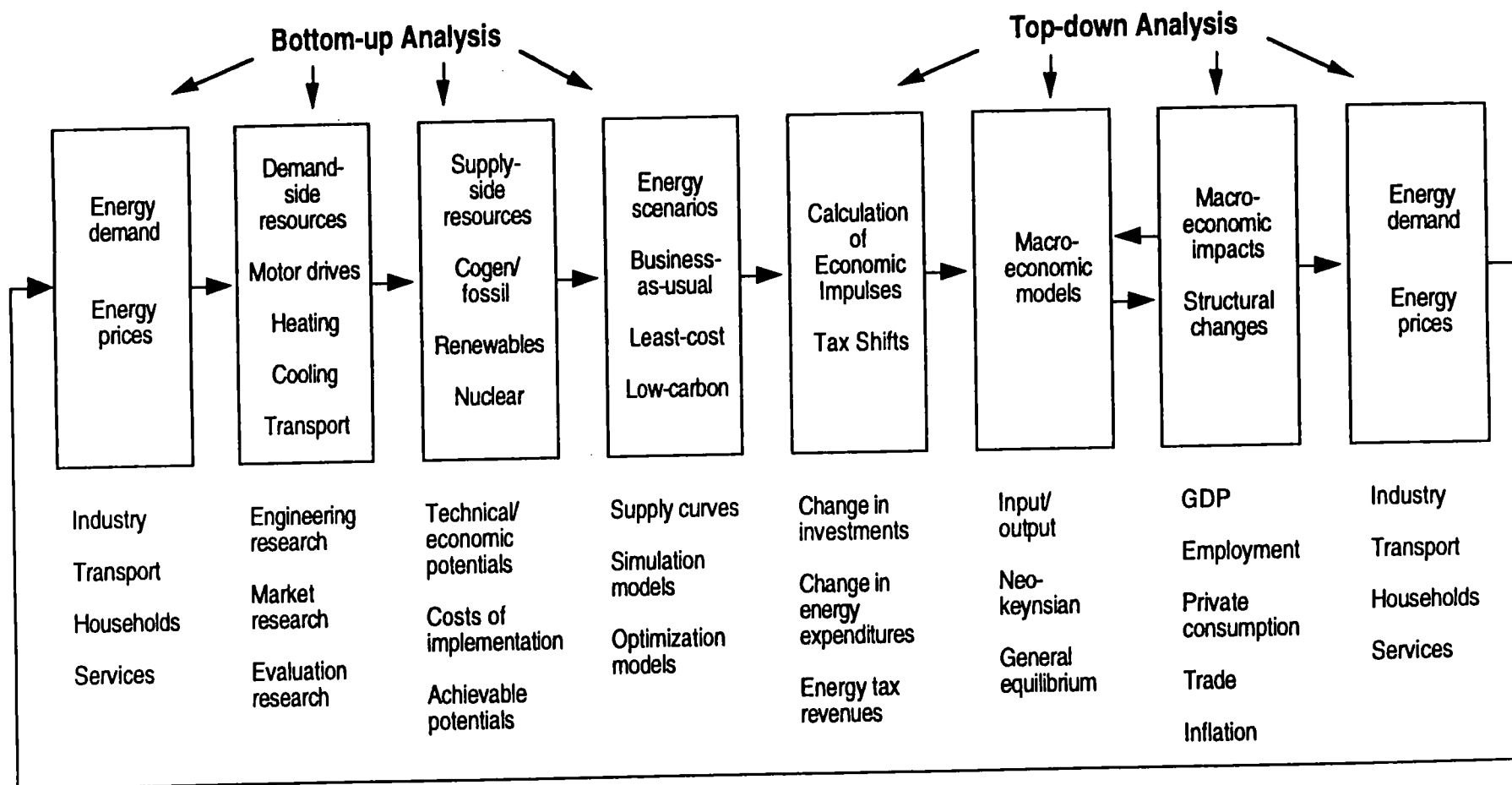
		1995		2005		2020		Average	
		(R 1)	(R 2)	(R 1)	(R 2)	(R 1)	(R 2)	(R 1)	(R 2)
GDP	favorable	1.3%	2.0%	0.7%	0.9%	0.3%	0.1%	0.5%	0.7%
	unfavorable	0.9%	1.3%	0.2%	0.4%	0.1%	0.1%	0.2%	0.3%
Private consumption	favorable	1.2%	1.9%	0.3%	0.5%	0.1%	0.1%	0.4%	0.5%
	unfavorable	-0.1%	-0.1%	-1.0%	-1.0%	-0.6%	-0.5%	-0.7%	-0.6%
Employment	favorable	0.5%	0.7%	0.1%	0.7%	-0.1%	0.0%	0.2%	0.3%
	unfavorable	0.3%	0.5%	0.1%	0.2%	0.1%	0.2%	0.2%	0.3%

R1= with nuclear power constant

R2= with nuclear power phased out by 2005

Source: Enquete Commission (1995), p. 871-876.

Figure 1: Modelling approach in integrated bottom-up/top-down studies



CUTTING CARBON EMISSIONS: BURDEN OR BENEFIT?

The Impact of Energy
Taxes and Regulatory
Reforms on Climate,
Growth, and Jobs

EXECUTIVE
SUMMARY

ENERGY POLICY
IN THE
GREENHOUSE
VOLUME II PART I



INTERNATIONAL PROJECT FOR SUSTAINABLE ENERGY PATHS

ENERGY POLICY IN THE GREENHOUSE

VOLUME II, PART 1

**CUTTING CARBON EMISSIONS:
BURDEN OR BENEFIT?**

EXECUTIVE SUMMARY

by

Florentin Krause

(Principal Investigator)

with

Jonathan Koomey and Alan Sanstad

IPSEP

INTERNATIONAL PROJECT FOR SUSTAINABLE ENERGY PATHS

7627 Leviston Ave, El Cerrito California 94530

510/525-7530 Phone / 510/525-4446 Fax

Acknowledgements:

This report summarizes two previous publications. One is Volume Two, Part 1 of the IPSEP study on Energy Policy in the Greenhouse. The second is a paper on the top-down versus bottom-up debate, which was written as an invited contribution to the second scientific assessment report of the Intergovernmental Panel on Climate Change (IPCC), Working Group III. Both the present summary and these previous works benefitted greatly from comments by many colleagues. Special thanks go to Erik Haites, Richard Howarth, A.K. Sanghi, and Ernst Ulrich von Weizsäcker.

The research summarized in this report was made possible by a grant from the Dutch Ministry of Housing, Physical Planning, and Environment. The preparation and distribution of this summary was also supported by the Educational Foundation of America, the W. Alton Jones Foundation, and the German Marshall Fund of the U.S.

TABLE OF CONTENTS

SHORT SUMMARY	i
A. INTRODUCTION.....	1
CUTTING EMISSIONS: HOW SOON BY HOW MUCH?	1
IPSEP WARMING LIMIT VS IPCC SCENARIOS	2
B. MITIGATION COST ASSESSMENTS: THE TOP-DOWN VERSUS BOTTOM- UP DEBATE.....	4
TWO MODELING APPROACHES	5
WHY RESULTS DIFFER.....	6
C. HOW ENERGY MARKETS FAIL.....	7
THE EFFICIENCY GAP	7
PAYBACK REQUIREMENTS AND IMPLICIT DISCOUNT RATES.....	8
WHAT DOES THE EFFICIENCY GAP MEAN?	9
DEFICITS OF TOP-DOWN VIEW OF MARKET EFFICIENCY	10
BENEFITS OF MARKET TRANSFORMATION: AN ILLUSTRATION	12
RELATIVE EFFECTIVENESS OF PRICE AND NON-PRICE POLICIES.....	14
D. RESULTS FROM TOP-DOWN STUDIES	15
STUDIES BASED ON LUMP-SUM RECYCLING	16
TAX SHIFT STUDIES	19
E. BOTTOM-UP STUDIES.....	21
RESULTS FROM BOTTOM-UP STUDIES.....	24
COMPARISON OF BOTTOM-UP STUDIES WITH EACH OTHER.....	25
ILLUSTRATION: A CASE STUDY OF WESTERN EUROPE.....	27
F. COMBINED TAX SHIFT/BOTTOM-UP APPROACHES.....	28
THE TRUST FUND APPROACH.....	28
MARKET TRANSFORMATION AND ECOLOGICAL TAX REFORM	30
G. CONCLUSIONS: CARBON REDUCTIONS AT A PROFIT	31
F. SELECTED REFERENCES:.....	33

LIST OF TABLES AND FIGURES

FIGURE 1: DEPENDENCE OF COST-EFFECTIVE ENERGY EFFICIENCY POTENTIALS ON THE IMPLICIT DISCOUNT RATE.....	13
FIGURE 2A AND B: MARGINAL COST CURVE FOR EMISSION REDUCTION MEASURES, TOP-DOWN POLICY FRAMEWORK	15
TABLE 1: RESULTS FROM TOP-DOWN STUDIES USING LUMP-SUM RECYCLING: REQUIRED CARBON TAXES AND IMPACTS ON U.S. GDP IN 2010	17
TABLE 2: RESULTS FROM TOP-DOWN STUDIES USING ALTERNATIVE CARBON TAX RECYCLING METHODS: GNP AND EMPLOYMENT IMPACTS	20
FIGURE 2C AND D: MARGINAL COST CURVE FOR EMISSION REDUCTION MEASURES, BOTTOM-UP POLICY FRAMEWORK	22
TABLE 3: ZERO NET COST REDUCTION POTENTIALS IN BOTTOM-UP STUDIES	23
FIGURE 3: SENSITIVITY ANALYSIS OF THE COST OF CARBON REDUCTIONS IN EC-5, ALL SECTORS.....	26
FIGURE 4: COMPARISON OF GENERAL REVENUE TAX AND TRUST FUND APPROACH.....	29

SHORT SUMMARY

This document summarizes findings from an international review of several dozen studies on the cost of reducing carbon emissions in industrialized countries. These studies were prompted by concerns that global warming may cause the flooding of populous coastal areas, destruction of forests and agricultural lands, economic dislocation and geopolitical instability.

Our review shows that with well-designed policies, industrialized countries could achieve major reductions in carbon emissions at zero or negative net cost — and this before considering the benefit of avoided damages from global climate change.

This encouraging conclusion is at odds with the findings of certain macroeconomic (top-down) studies according to which cutting carbon emissions would inherently lead to economic losses. Closer examination reveals that these studies reflect a private perspective on economic efficiency rather than the societal perspective on which public policies need to be based. They also rely on two flawed assumptions: that the current technological systems for producing energy and converting it into final energy services are already as energy-efficient as economically optimal; and that the current patterns of taxation of capital, labor, pollution, and energy are already economically efficient. Once these assumptions are replaced by more realistic descriptions, and once a societal perspective is taken, predicted economic losses turn into opportunities for economic gains.

Reducing emissions while saving money

A large body of empirical evidence shows that the competition between energy supplies and energy efficiency investments is severely hampered by market and institutional failures and other economic efficiency problems. Many of these problems can be ameliorated at a profit to consumers and firms through so-called market transformation policies. These measures include financial incentives for manufacturers of more energy efficient products ("golden carrots"), least cost planning reforms that establish utility payments to buyers of more energy efficient equipment and buildings ("demand-side management"), government rebates for efficient vehicles paid for by fees on inefficient ones ("feebates"), and stringent building, appliance, and automobile efficiency standards ("sticks").

These market transformation policies create new, more effective channels for the competition between energy supplies and energy efficiency investments. They drastically reduce the various uncertainties and information and transaction costs currently associated with these investments. Utility regulatory reform can also reduce impediments to cost-effective low-carbon cogeneration of heat and power and to renewables-based generation that is already economically competitive. Furthermore, R&D policies can accelerate the commercialization of cheap carbon-free technologies over time.

In addition, top-down studies show that shifts of taxes from capital or payrolls to energy or carbon emissions can improve the economic efficiency of tax structures and boost economic growth. The mere removal of subsidies for fossil fuels would reduce global carbon emissions. These gains from tax policies can offset higher energy costs, or

augment the benefits of reduced energy service costs when market transformation policies are implemented as well.

Several secondary benefits arise. Lower fossil fuel use reduces the pre-tax prices for fossil fuels as well as societal costs for air pollution control. Market transformations also lower the price of energy efficiency technologies and renewables-based energy supplies.

All in all, these policy options represent a large potential for reducing carbon emissions at zero or negative cost when compared to a policy of inaction. This "no regrets" potential already exists today and grows over time as capital stocks turn over. Its implementation in the near-to-medium term can result in sizable economic benefits during the transition to a low-carbon future. Implementation is not dependent on the fruits of intensified R&D efforts, though such efforts can add to the total potential over time. The sooner the transition to an economically efficient low-carbon future is begun, the greater the economic and climatic benefits.

Economically sound reduction targets for industrialized countries

Our review finds that the macroeconomic modeling studies on which most governments have relied so far systematically overestimate mitigation costs because they fail to capture key "no regrets" policy options. So-called bottom-up modeling studies based on engineering-economics and end-use market data partially correct for this flaw. But most still overestimate mitigation costs because they do not account for policy feedbacks on fuel and technology prices, or for secondary air pollution benefits.

At the same time, bottom-up studies may somewhat underestimate the time needed to achieve a given percentage emission reduction. If one accounts for these biases, the international body of top-down and bottom-up cost assessments can be interpreted as follows:

- OECD countries could, over the next 30-50 years, cut their carbon emissions by 50 percent or more below 1990 levels. This emission reduction could be achieved at negative net cost, i.e. while increasing economic output and employment.
- As an intermediate goal, the 20 percent reduction level first recommended in the 1988 international Toronto conference could be realized over the next 20 years or so without generating a net economic burden, and most likely at a significant economic and employment benefit.

Policy requirements

For the purposes of practical implementation, a powerful combined carbon reduction strategy could be fashioned by emphasizing market transformation policies, such as energy efficiency standards, utility demand-side management programs, and other incentive programs and regulatory reforms, while complementing them with energy taxes and tax shift policies.

Policy makers can realize assured economic benefits if they focus first on the most cost-effective "no regrets" measures and carefully employ proven designs for regulatory and incentive programs. A trust fund linked to such programs could induce large emission

reductions while requiring much lower energy taxes than suggested in most top-down studies. A trust fund approach could also be linked with broader ecological tax reform, with benefits for the effectiveness of both. Such a course promises to enhance economic growth and employment, stimulate technological development, and slow the rate of greenhouse gas emissions.

Global prospects

Given the strong influence of technological changes in industrialized countries on investments in developing countries, the prospect arises for extending this result to the world as a whole. If R&D successes resulting from vigorous carbon reduction strategies in OECD countries are transferred to developing countries and incorporated into capital stocks there, the emission reductions mandated by the IPCC scientific assessments of the global warming threat — 50 percent or more on a global basis — should be achievable without impeding the economic goals of developing countries, and again at zero or negative net mitigation cost.

Directions for future policy research

In commissioning future studies to better quantify "no regrets" opportunities, both types of energy analyses should be employed, but much greater emphasis should be placed on bottom-up methods. Because macroeconomic modeling studies fail to capture the potential benefits of carbon reduction strategies, their usefulness for guiding climate policy without linkage to bottom-up analyses must be called into question.

The bottom-up approach best conforms with the fundamental requirement that public policy should be based on a societal perspective on economic efficiency. It also best conforms with the requirement that public policy should facilitate cost-minimizing behavior in optimal markets, not perpetuate historic patterns of private decision-making shaped by impaired markets. Therefore, a bottom-up analysis of optimal energy services, efficiency levels, and policies should form the core of credible greenhouse policy cost assessments. In future bottom-up research, greater emphasis should be placed on field experimentation with actual market transformation programs, using careful monitoring to evaluate alternative program designs.

Top-down models are best used for establishing an all-economy reference case and for business-as-usual projections of future energy demand. Top-down models may also elucidate fiscal policy measures, "no regrets" options from tax shift reforms, and certain near-term distributional and competitiveness impacts. If modified to accept bottom-up calculations as exogenous inputs, they may be useful for estimating the macroeconomic impacts of bottom-up energy sector policies, including feedback effects of changed energy bills and energy prices.

CUTTING CARBON EMISSIONS: BURDEN OR BENEFIT?

A. INTRODUCTION

A U.N.-sanctioned report by the Intergovernmental Panel on Climate Change (IPCC) has found that carbon emissions from the consumption of fossil fuels — the dominant driver of the global warming threat — will need to be cut by 50 to 80 percent below present levels in order to stabilize the concentration of carbon dioxide in the Earth's atmosphere. But rather than declining, emissions continue to increase, and are projected to do so over most of the next century if no policy action is taken.

CUTTING EMISSIONS: HOW SOON BY HOW MUCH?

While the IPCC report establishes an emission rate at which concentrations would stabilize, it does not specify any timetable for turning present trends around and achieving the necessary cuts. But the magnitude of the global warming threat increases with cumulative emissions. This suggests that abatement will be most effective if large reductions are achieved as soon as possible.

Shortcomings of cost-benefit analysis

Some research institutes have engaged in attempts to calculate "optimal" reduction paths using so-called "integrated assessment models" in which the economy, agriculture, forests, the energy sector, and the climate system are linked. The determination of an "optimal" path is based on cost-benefit analysis. Unfortunately, cost benefit analysis does not provide a sound basis for policy-making, for these reasons:

- Arbitrariness in the choice of discount rate. The present value of the damages that could be avoided through policy action is extremely

sensitive to the discount rate since impacts persist over a long time. Though it is agreed that the social discount rate must have a low value, there is no hard and fast rule for what the social discount rate should be. Even for the narrow range of 2 to 5 percent that is normally considered, the scale of "economically justified" policy action can differ enormously.

- Inherent uncertainties in the physical impacts of climate change, combined with threats of catastrophic events. Possible catastrophic outcomes of climate change include the rapid break-up of the Antarctic ice sheet, run-away warming, massive forest die-back and species loss, and a weakening of the Gulf stream that moderates Western Europe's climate.
- Inherent uncertainties in monetizing the benefits of mitigation policies. Avoided damages and risks from climate change are dominated by the economic values attributed to complex and potentially catastrophic impacts for which a market-based valuation is practically impossible.

An economic treatment of potential damages also seriously fails to address the moral dimension of the global warming issue. What if the global climate "flips" suddenly within a few decades, as recent research suggests may have happened in the past? Is it acceptable to expose humankind to such catastrophic events on the basis of the simple arithmetic of integrated assessment models, in which large catastrophic damages may be multiplied with small assumed probabilities to yield a negligible economic value for these risks? Some have dubbed this "the Chernobyl approach to global warming."

Further moral questions arise in assessing the climate change problem: Can the value of a life lost to coastal flooding in Bangladesh be measured by that country's per capita economic output? Are present generations justified in using economic discounting procedures that make future damages appear small though the impact on future generations will be large? Can negligible or even beneficial impacts in some regions be used to justify damages and dislocations imposed on people in other regions of the world?

For all of the above reasons, it is widely agreed among economists that the precautionary principle has to be used in developing responses to climate change.

IPSEP WARMING LIMIT VS IPCC SCENARIOS

Following the precautionary principle, a warming limit approach has been taken in IPSEP's research. Climate stabilization goals are developed in a risk-averse fashion that prudently seeks to protect the public from catastrophic outcomes. Mitigation strategies are then developed in a least-cost fashion. This approach is based on the following criteria:

- 1) A focus on the down-side risks of climate change, i.e., the potential for catastrophic impacts.
- 2) The adoption of a global warming limit that minimizes exposure to these down-side risks. This limit can then be translated through climate modeling into permissible remaining carbon emissions during the transition period.

- 3) The use of those values from the current uncertainty range in climate and carbon cycle modeling that will minimize public risks, i.e., values representing the high end of the range.
- 4) The translation of permissible remaining carbon emissions into a timetable for emission reductions.
- 5) The iterative adjustment of these climatic targets on the basis of detailed mitigation cost assessments. This iteration aims to assure that the speed of carbon reductions remains economically feasible.

The first four steps of this modelling approach were implemented in the early phase of the IPSEP project and were summarized in a 1989 report (Volume One). It started from a prudent warming limit of 2°C for the magnitude of warming, in order not to exceed the range of temperatures experienced since the onset of human civilization. Furthermore, the rate of adding warming commitments was limited to 0.1°C/decade, in order to ensure that forest systems would be able to adapt and migrate without massive breakdowns.

Assuming a risk-averse climate model sensitivity of 4.5°C and assuming that greenhouse gases other than fossil carbon emissions would be quickly controlled, IPSEP's first study found that the world's cumulative fossil carbon emissions between 1985 and 2100 would have to be limited to 300-450 billion metric tons of C (btC). This fossil carbon budget is equivalent to 50-75 years of fossil fuel consumption at present levels.

By comparison, the six scenarios for 1990-2100 carbon emissions as developed in the IPCC reports are not derived from a risk limit, but reflect a range of "business-as-usual" projections that were considered plausible according to the judgments of various analysts. They assume that no initiatives will be taken to reduce emissions of greenhouse gases. The IPCC scenarios represent cumulative emissions of 800-1800 billion tons. Due to these much higher levels of cumulative fossil fuel consumption, the IPCC assessment predicts a mid-range warming of 3°C by 2100 as the most likely outcome, with the high end of the range exceeding 5°C.

Thus, the worst-case warming in the IPCC scenarios would be 2.5 times as large as under the IPSEP limit. The difference in warming risk is even larger. It can be gleaned from the fact that a 5°C warmer climate would take the earth back in history some 10 million years, compared to only about 100,000 years for the IPSEP limit. These figures show that there is a major difference between the two approaches to policy development.

Reduction targets for industrialized countries

The IPSEP study further established that industrial countries have already consumed more than their fair share of the climatic resource if historic fossil fuel consumption is considered in allocating the global carbon emission budget. In a pragmatic approach, industrialized countries would phase out most fossil fuel use by gradually introducing emission-reducing technologies in the course of capital stock turnover. If pursued with vigor, industrial countries would need about half the global carbon budget for their transition.

The other half of the global carbon budget was found to be sufficient to support economic growth in the developing countries provided that state-of-the-art low-carbon technologies were quickly transferred to these countries.

Finally, Volume One derived an approximate timetable for reducing emissions in the OECD countries. Taking into account capital turnover rates, it was estimated that OECD countries should stabilize fossil carbon emission levels (high end of range in parentheses)

- at base year levels before (by) the turn of the century,
- cut emissions by 20 percent below baseline levels by about the year 2005 (2020), and
- cut them by 50 percent by the year 2020 (2040).

These findings suggest that it is important to focus on energy policies that can cut carbon emissions by large percentages as soon as possible. To remain on schedule, industrialized countries should consider adopting the so-called Toronto target, which calls for a 20 percent reduction within the first decade of the next century.

By contrast, the focus of most current government action plans is on only the most modest steps, such as a freezing of emissions at 1990 levels by the year 2000. Commitments to go beyond this level and actually cut emissions in the following decades, or commitments to at least maintain emissions at 1990 levels, have not yet been made.

The current hesitancy of many governments reflects, in part, a widespread presumption about the likely cost of more ambitious targets, i.e., that any significant reductions would be expensive, and that they could have negative competitiveness impacts.

A follow-up study in the IPSEP series (Volume Two, Part 1) has examined these economic concerns on the basis of recent studies on the cost of reducing carbon emissions for various OECD countries. The studies on this issue, both by IPSEP and by other analysts, provide a basis for dealing with step five in the above methodology: they allow governments to determine what further emission reduction commitments they could reasonably make. The following summary reviews this body of work, making use, in part, of the forthcoming 1995 IPCC report (Working Group III).

B. MITIGATION COST ASSESSMENTS: THE TOP-DOWN VERSUS BOTTOM-UP DEBATE

Policy-makers in industrialized countries are interested in identifying those kinds of measures that could reduce greenhouse gas emissions at least economic cost and with the smallest distributional impacts. Ideally, they would like to reduce emissions without impairing economic activity, or better yet, achieve emission reductions while enhancing economic output. Such economically advantageous zero or negative net cost options are sometimes referred to as "no regrets" options. The designation "no regrets" refers to the fact that such options allow present generations to avoid economic burdens from climate stabilization efforts whose benefits may in large part accrue to future generations.

To explore the possibilities for "no regrets" carbon reduction policies, it is necessary to

- (1) perform assessments on the basis of the *social discount rate*. A social discounting convention recognizes that climate change is a matter of public policy.

- (2) model the impact of alternative policy options on the *energy service markets* in which energy-efficiency improvements compete with alternative energy supplies, and
- (3) model the *interactions* of these micro-economic processes with all other sectors of the economy under alternative tax policies.

Since reductions in carbon emissions involve changes in the energy system, cost assessments of climate policies must sensibly rely on models used for the development of energy policies. Unfortunately, established energy modeling techniques have two basic problems in meeting the above analytic requirements. First, two alternative approaches exist that give divergent results on the costs of reducing carbon emissions. And second, only one of these two approaches allows discount rates to be set in accordance with the requirements of climate policy analysis, i.e. at the social discount rate.

TWO MODELING APPROACHES

Given that aggregate energy demand arises from applications of several hundred end-use technologies and many types of users, no single modeling system is available to perform an integrated analysis of both the arena of end-use markets and the arena of all-economy interactions. Notably, it has proved difficult to match technological descriptions of the energy system with economic production functions in which all manner of technologies are represented amorously as capital. As a result, two specialized approaches have been developed.

Top-down modeling studies use econometric or generalized macroeconomic models. They focus on the interaction between the energy sector and the economy at large. Calculated policy impacts are based on historic relationships between energy consumption and economic output. Policy costs are calculated in terms of changes in gdp.

Bottom-up approaches focus on the energy sector alone. They are based on highly disaggregated engineering-economic studies of energy supply and end-use technologies, and on micro-economic studies of end-use markets. Up to several hundred end-use categories and technology measures are considered. Policy costs are calculated as changes in the total societal bill for energy services, which reflects life-cycle costs. The macroeconomic impact of these changes have to be calculated using top-down methods.

Top-down assessments simulate cross-cutting economic instruments. The two main instruments of this type are a cap on emissions linked to a system of tradeable emission rights, and an energy or carbon tax. These cross-cutting measures are assumed to be most economically efficient and effective. Since a tax is more easily simulated in top-down models, policies are framed in terms of energy and carbon taxes.

According to bottom-up assessments, a range of market transformation policies based on incentives and regulations is economically more efficient. As a result, non-price policies receive primary emphasis, though the effects of higher energy prices on the cost-effectiveness of mitigation investments are also calculated.

Divergent results

A review of work to date on the mitigation of carbon emissions shows that despite wide variations within each type of economic assessment, the cost and policy conclusions from top-down studies clash with the findings from bottom-up assessments. For any given time horizon and geographic region, bottom-up analyses find that significant carbon reductions could be achieved at a net economic benefit. When mitigation costs do turn positive, they tend to remain well below those found in top-down studies, irrespective of geographic scope, of the size of the reduction target, or of its timing.

Increased computing power is allowing top-down models to incorporate greater sectoral detail, and bottom-up analyses to incorporate more precise descriptions of behavioral aspects. Nevertheless, the divergence in calculated mitigation costs is persisting because each approach continues to be based on divergent assumptions about economically efficient energy policies.

WHY RESULTS DIFFER

If policy makers are to make use of these divergent economic cost assessments, they need to recognize two major differences in modeling assumptions between top-down and bottom-up assessments: The first difference has to do with the choice of discount rate, the second has to do with alternative views of the economic efficiency of energy markets.

Private versus social discount rates

When it comes to assessing climate policies, top-down models have an a priori limitation that has been little recognized to date: by their very nature, these models reflect a private perspective on costs, since historic data are implicitly based on the private discount rates used by people and firms in past decisions on energy and energy efficiency investments.

This feature throws into question the applicability and usefulness of top-down models for assessing public policies to prevent climate change. As already mentioned, these policies should be based on the social discount rate. Since private discount rates are usually significantly higher than social discount rates, the cost of capital investments for substituting fossil fuels may be greatly overestimated in the top-down approach.

By contrast, the discount rate is an explicit variable in bottom-up assessments, where it enters as a parameter in all life cycle cost comparisons. Most bottom-up analyses use a discount rate that is close to the social discount rate. Thus, the conformance of bottom-up methods with the requirements of public policy making is principally assured.

Analysis of energy service markets

A second root of the differences between top-down and bottom-up assessments is a disagreement over the economic efficiency of energy markets, in particular the energy service markets in which consumers and firms choose between investments in greater energy efficiency and purchases of more energy supplies.

These divergent views of energy markets are fundamental to the calculation of policy costs. They determine whether the reference case already represents an economic optimum or not. If so, policy interventions to reduce carbon emissions have an economic cost, since they disturb an optimal trajectory.

If not, significant carbon reductions should be obtainable simply through policies to improve the economic efficiency of energy service markets. Put another way, carbon reduction policies might improve economic efficiency, resulting in net economic benefits even before any avoided damages and risks from climate change are considered.

It is acknowledged by both top-down and bottom-up analysts that some "no regrets" opportunities exist on account of environmental externalities other than climate change and synergisms between reduced fossil fuel use and classical air pollution control efforts. The removal of fossil fuel price subsidies alone has been estimated to reduce global carbon emissions by five to 20 percent. Improved utility sector regulation based on least cost planning reforms and generation markets offers additional opportunities.

These corrections can make important differences in cost assessments and are often neglected. However, the central analytical difference between the two approaches lies elsewhere. It is crystallized in two competing interpretations of a phenomenon known as the "energy efficiency gap." The empirical data regarding this efficiency gap have been generated from engineering-economic bottom-up research.

C. HOW ENERGY MARKETS FAIL

THE EFFICIENCY GAP

Commercially available end-use devices (appliances, cars, industrial machinery, buildings, air conditioning and heating systems, etc.) often show a wide range of technological designs, energy efficiencies, first costs, and life cycle costs. Further efficiency resources emerge over time, as technical innovation allows the design of better end-use devices that are more energy-efficient and cheaper to operate.

Expected market patterns

If energy purchases and efficiency investments were traded off in well-functioning markets, one would expect those end-use technologies with the lowest life cycle costs to have a dominant market share. For example, refrigerator purchases in Western Europe would mainly consist of units that use only half as much electricity as the units actually bought.

Similarly, if technology diffusion is free from barriers to economically efficient innovations, one would expect energy-efficient innovations that lower life cycle costs to quickly show up in new commercial products and penetrate into the capital-stock at a speed not too different from the rate of replacement plus expansion of that stock.

Empirical findings

Reality presents a different picture. According to a large number of end-use market studies, the process of diffusion of energy-efficient technologies does not follow this pattern. The observed evolution of market shares for these energy efficient products indicates two major problems:

- Most off-the-shelf, commercially available energy-efficient products with distinct life-cycle cost advantages command only small and often stagnating market shares.
- Known energy-efficient technical design options show up in new commercial products only with great delay, and sometimes not at all. Once they do, they are often relegated to niche markets with high mark-ups.

The effect of these patterns on energy-using capital stocks can be described as representing an efficiency gap, i.e., a gap between life-cycle-cost minimizing levels of energy efficiency and actual levels of energy efficiency.

PAYBACK REQUIREMENTS AND IMPLICIT DISCOUNT RATES

The significance of these observed market patterns for the question of market efficiency is most easily understood if they are described in terms of the payback requirements consumers and firms apply to energy efficiency investments, or in terms of the discount rates implied in their investment choices. The latter formulation also allows one to compare the private discount rates used in energy efficiency choices with the social discount rate that should be considered in public policy decisions.

The payback gap

End-use market research shows that consumers and firms are generally not motivated to pay for the extra first cost of energy-efficient devices unless the payback time is very short — less than two to three years, sometimes as little as a month.

This behavior leads to significantly higher energy demand than would be the case if longer payback periods were accepted. It is not limited to residential and small commercial customers, but also describes most energy efficiency decision-making by large industrial and commercial firms. And though significant variations in payback requirements occur by customer type, end-use and technology, these differences are swamped when compared to payback criteria for energy supply investments.

Utilities and energy producers expect supply-side investments in power plants, pipelines, refineries, and the like to pay back over 15-20 years or more, not in a matter of months or two to three years. There appears to be a great asymmetry between economic investment criteria on the demand side and the supply side.

Implicit discount rates

In financial terms, short payback requirements are equivalent to using high discount rates for the invested capital. For typical investment lives, the discount rates implied in payback requirements of 1-4 years are about 30 to 160 percent. By contrast, utility investments are undertaken on the basis of real discount rates in the neighborhood of 5-7 percent, or 2-4 percent on debt-financed investments. These supply-side discount rates are thus close to the social discount rate, which is often estimated to be 2-5 percent for climate change and 2-10 percent for energy-related investments.

This means that consumers and firms implicitly or explicitly apply discount rates for their efficiency investments that are one to two orders of magnitude greater than those used by energy suppliers. Moreover, implicit consumer discount rates are far higher than the average real rates of return they can hope to earn from financial investments, or than the social discount rate at which mitigation measures would be evaluated from a societal perspective.

WHAT DOES THE EFFICIENCY GAP MEAN?

The role of intangible costs

Interpretations of observed market behavior must take into account that consumer decisions are shaped not just by tangible (life cycle) costs reflected in prices, but also by intangible costs. The efficiency gap is easily explained if it is assumed that market transactions involve major and pervasive intangible costs.

The most important categories of intangible costs are losses of consumer surplus and transaction costs. Consumers may also partially base their decisions on criteria and cognitive processes that cannot be described by standard economic concepts, a phenomenon known as bounded economic rationality.

Consumer surplus is the value consumers get in excess of the market price of energy-using equipment. When purchasing more energy-efficient equipment, reduced consumer surplus could result from (1) loss of convenience, comfort, reliability, appearance, product selection, precision of functioning, or any other form of amenity in the provision of energy services such as warmth, ventilation, lighting, cooling, transportation, etc.; and (2) other indirect costs that are borne by the purchaser of the equipment, such as work disruptions or costs related to the assembly or installation of energy-efficient technologies in individual premises.

The term "transaction costs" is often imprecisely used to characterize a broad category of indirect costs that includes both information costs and costs related to risk and uncertainty. They comprise costs for obtaining reliable information on products, evaluating their applicability to consumers' particular circumstances, verifying manufacturer claims, finding vendors and trustworthy installers, etc., and making decisions in the face of uncertainties about the future benefits of more efficient equipment.

The top-down view: current markets are efficient

The top-down modeling approach is based on the assumption that energy markets yield economically efficient outcomes despite the presence of large intangible costs. High transaction costs are characterized as a "normal" feature of optimally functioning markets that requires no policy attention. It is assumed that government policy measures cannot cost-effectively alter these "normal" market conditions. Because transaction costs are seen as irreducible, it is argued that they are not a sign of market failure.

Some top-down analysts also assert that a significant (if unspecified) share of intangible costs stems from problems of loss of consumer surplus rather than from transaction costs. In other words, something is believed to be inherently "wrong" with energy efficiency technologies. Again, it is asserted that policy action cannot reduce these costs. This view of market efficiency is fundamental to all studies in which econometric calculations of energy demand are presented as least-cost outcomes.

DEFICITS OF TOP-DOWN VIEW OF MARKET EFFICIENCY

The use of top-down modeling for calculating the cost of greenhouse gas mitigation has come under increasing criticism. First, even if end-use markets were economically efficient from the perspective of private decision makers, the need for policy intervention still arises in so far as private decisions do not take into account society's interest to mitigate climate change. Given the need for policy intervention, energy options would have to be evaluated from a societal perspective. This would make privately optimal market outcomes suboptimal, and would open the possibility for policy interventions that have a negative net cost to society.

A similar argument arises when alternative models of economic development are considered. For example, a society may choose to build compact cities and to invest in high-amenity public transportation systems simply to increase the attractiveness of urban life and limit impacts from noise-, smog-, and accident-producing cars. If this line of development becomes the "business-as-usual" reference case, the resulting cost of carbon reductions may differ significantly from comparisons with a standard model of urban sprawl (see Part 4 of the IPSEP study).

But even from a private cost perspective, serious theoretical and empirical deficits of the top-down hypothesis have been documented in several recent in-depth reviews dealing with the issues of market barriers, market failures, intangible costs, and bounded economic rationality.

Theoretical deficits

The top-down interpretation of the energy efficiency gap is based on theoretical arguments that appeal to the standard neoclassical theory of welfare economics. According to that theory the decentralized decisions of market participants *in a system of complete and perfect markets* automatically lead to a welfare-maximizing allocation of resources. Some economists have generalized this theorem, which was formulated for a highly stylized economy in equilibrium, into a general "rebuttable presumption" that markets should be assumed to be efficient unless proven otherwise.

Relying on this presumption, top-down studies fail to offer empirical evidence that energy service markets can be reasonably described as complete and perfect, or that they cannot be made to work more efficiently. Nor do econometric studies acknowledge that the neoclassical equilibrium theory of welfare economics cannot be reasonably used to determine whether current patterns of technology innovation and commercial diffusion are economically efficient. Whereas neoclassical theory is formulated for an abstract model of an economy in complete equilibrium, technology innovation is decidedly non-equilibrium in nature.

The most cogent theoretical critiques of top-down analyses compare the standard neoclassical model of a market economy with more recent market theories, notably those based on modern information economics. Research on information economics shows that the purported economic efficiency of market outcomes is destroyed by uncertainties about the future benefits of alternative investment choices and by conditions of asymmetrically distributed information. As readily acknowledged by top-down analysts, both problems are ubiquitous in energy end-use markets.

The same work shows that high transaction costs are not a "normal" expression of "the" market, a formulation that would imply universal, ahistoric, and unchangeable market institutions. Rather, these more recent theories argue that markets are best conceived of as institutional and regulatory arrangements for the interaction among consumers, vendors, installers, financing institutions, manufacturers, renters, owners, and energy suppliers in which transaction costs can differ widely. High intangible costs are then an expression of ineffective, historically grown transactional arrangements that limit the competition between energy efficiency and energy supplies.

The purpose of economically rational policy then is to encourage market configurations in which transaction costs are minimized. So long as transaction costs can be reduced, policy action could increase economic welfare.

Empirical deficits

An empirical challenge to the standard theoretical model of the economy is found in data obtained from recent policy programs, notably energy efficiency standards and incentives-and procurement-based demand-side management (DSM) programs. Notably in the U.S., the expanding use of incentives-based utility demand-side management programs and mandatory energy efficiency standards has generated a wealth of such data. These so-called market transformation programs were explicitly designed to reduce or eliminate information costs, transaction costs, and risks and uncertainties for consumers and firms. Data from evaluation research on these programs can be used to determine the role of four explanatory factors for the presence of the efficiency gap:

- Losses or gains in consumer surplus
- Market failures in established markets for energy efficient technologies
- Diffusion barriers in the process of transforming new energy-efficient technologies into commercial products
- Bounded economic rationality, i.e., consumer behavior that is partially or wholly based on non-economic decision-making rules and social and psychological factors.

This evaluation research confirms that the efficiency gap is mainly caused by transaction costs and information problems, and that programs can reduce these intangible costs. The same research also shows that problems of bounded economic rationality are significant. Experience with appliance labeling programs suggests that these problems cannot be overcome by the mere provision of information, such as energy consumption ratings or labels for end-use devices. Finally, evaluation research provides detailed data on the administrative and other indirect costs of energy efficiency standards and utility incentive programs. In well-designed programs, these are found to be minor.

Summary: three rebuttable presumptions

The findings of these theoretical and empirical analyses can be summarized in the form of three alternative "rebuttable presumptions:"

- 1) The energy efficiency gap cannot be explained by losses of consumer surplus. With few exceptions, energy efficient products are amenity-neutral or increase utility. Moreover, market transformation programs accelerate the replacement of less effective products with better designs.
- 2) The energy efficiency gap is mainly an economic efficiency gap. It is caused by transaction costs, information problems, and other features of end-use markets that represent market failures in the standard economic sense. "Normal" energy service markets do not produce welfare-maximizing outcomes.
- 3) Proven, well-designed regulatory and incentives policies can cost-effectively reduce these market problems. Even after carefully accounting for all indirect policy costs, significant net benefits of improved economic efficiency remain.

Market patterns as presently observed can thus be described as leading to an economically wasteful allocation of capital in the energy sector.

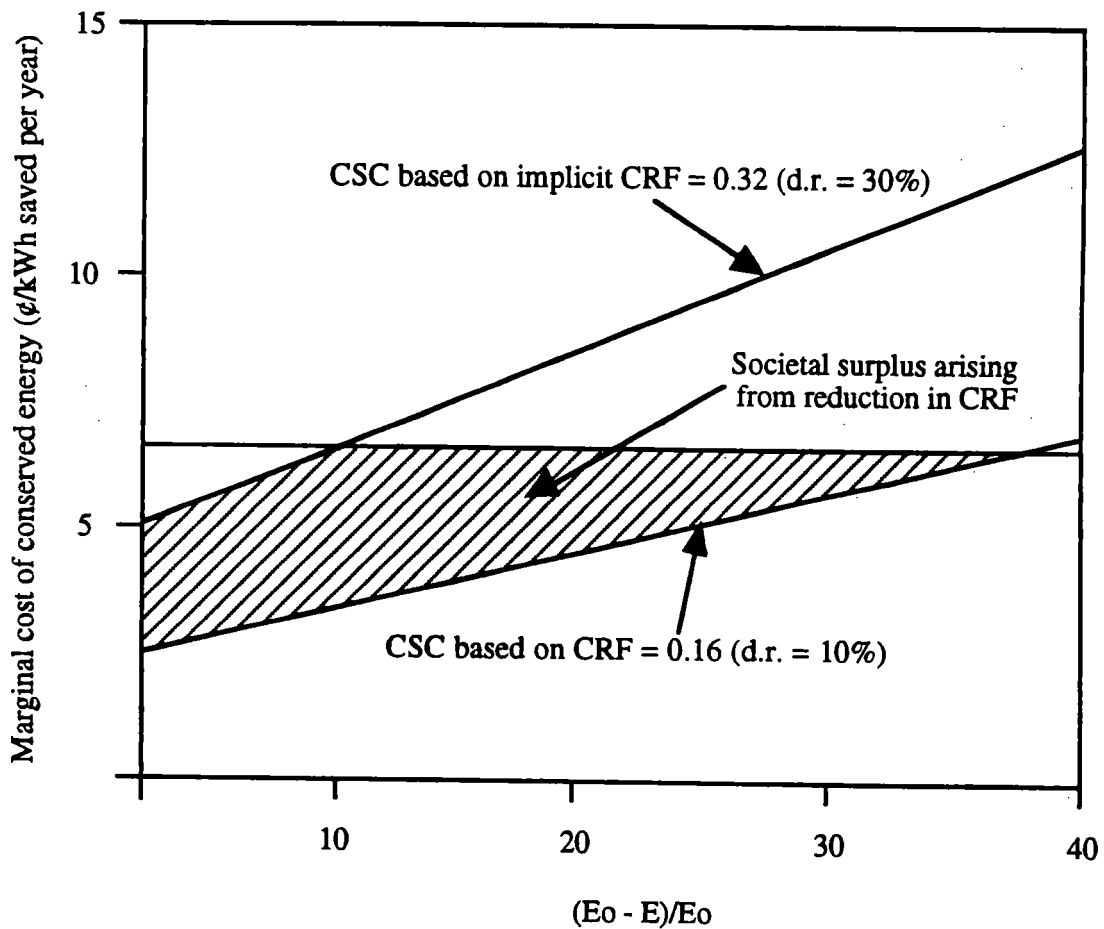
BENEFITS OF MARKET TRANSFORMATION: AN ILLUSTRATION

The economic effect of market transformation policies is schematically illustrated in Figure 1. The graph shows two stylized supply curves of energy efficiency improvements (conservation supply curves or CSCs) that differ only in the discount rate with which efficiency investments are evaluated. In each supply curve, energy efficiency options are shown in levelized form, based on the capital recovery factor (CRF). The levelization of investments in the top curve is based on a roughly four-year payback (i.e., a discount rate of 30 percent), as minimally required by most industrial and commercial firms. Most energy efficiency investments are based on shorter than four-year payback times, implying higher discount rates than 30 percent.

The price of energy in the reference case (levelized over the life of the efficiency investment) is shown as a horizontal line. For this price, economically worthwhile energy efficiency improvements are defined by the point at which the supply curve intersects with the horizontal energy price line. Worthwhile energy savings from efficiency improvements amount to about ten percent in this example.

The second supply curve covers the same energy efficiency investments, but is based on a 10 percent real discount rate. This discount rate is a conservative proxy for the economic criteria that might be used in designing incentives programs and mandatory efficiency standards. Consumers and firms do not change their payback requirements, but end up applying this lower discount rate implicitly by including in their calculus financial incentives or by purchasing equipment that is subject to mandated efficiency standards.¹

Figure 1: Dependence of cost-effective energy efficiency potentials on the implicit discount rate.



Total energy savings per year (as a percent of base consumption)

Note: CCE calculated assuming project life = 10 years

¹ This 10 percent real discount rate is closer to (though still higher than) the average rate of return on capital in energy supply investments. The choice of a somewhat higher value allows for administrative costs and any unresolved uncertainties that may be associated with the effectiveness of the market transformation policy.

Based on this discount rate, savings of about 38 percent are economically worthwhile at reference level energy prices — an increase of roughly 28 percentage points. This is almost a fourfold increase of the cost-effective efficiency resource. The net economic benefit of moving from status-quo market conditions (high implicit discount rates) to improved transactional arrangements (low implicit discount rates) is illustrated by the shaded area in the graph.

Secondary economic benefits

This calculation does not capture several secondary benefits. Among them are reductions in the cost of energy-efficient equipment as this equipment is shifted from niche markets into the bulk market where competition is most intense; reductions in energy prices due to lowered growth in energy demand; and accelerations in the process of energy efficiency innovation, which leads to further savings relative to the reference case.

Also neglected are increased levels of energy service demand as a portion of the economic savings flow back into energy consumption. Though such "take-back" effects somewhat diminish the percentage energy savings obtained from market transformation policies in the aggregate, they represent an economic benefit in that they reflect an increase in welfare over business-as-usual scenarios. At the same time, saturation effects tend to limit such take-back effects to small corrections.

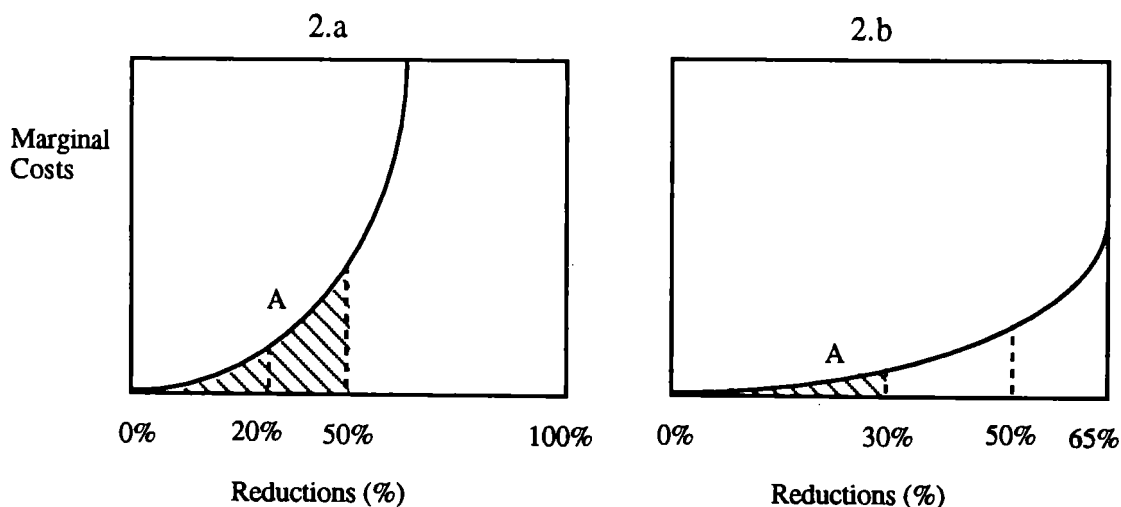
RELATIVE EFFECTIVENESS OF PRICE AND NON-PRICE POLICIES

The graph in Figure 1 shows that in the presence of significant market failures, price-based policies are considerably less effective than non-price policies. Suppose the illustrative 38 percent savings from market transformation policies were to be matched by energy pricing policies. For this to occur, the levelized price of energy in Figure 1 would have to be about twice as high.

Even then, price policies would not necessarily catch up with non-price options. At higher prices, the market transformation policies would themselves unlock greater savings. In fact, for one and the same price change, market transformation policies may lead to a much larger increase in cost-effective savings: the slope of the energy efficiency supply curve representing these policies is more shallow, i.e., more price-sensitive. Only once technical options are exhausted do prices become more effective in limiting energy demand. However, at this point, it is the consumption of energy services itself that will be rationed.

Of course, the most effective approach would be to combine price changes with market transformation policies. Here one needs to recognize that these non-price policies may create their own energy price effects. If financial incentives for energy efficiency investments are funded through energy or carbon taxes or through fees that go into a trust fund, this funding mechanism will at once somewhat increase the tax portion of the price of energy and reduce energy bills.

Figure 2a and b: Marginal Cost Curve for Emission Reduction Measures, Top-Down Policy Framework



D. RESULTS FROM TOP-DOWN STUDIES

FUNDAMENTALS

The fundamental assumption built into macroeconomic models that energy markets are efficient means that any significant reduction in fossil fuel consumption will lead to economic losses. This modeling assumption implies a marginal cost curve for carbon reductions as shown in stylized form in Figure 2a and 2b. The important question in the top-down approach is not whether losses will be incurred, but how large these will be for a given reduction target and time horizon.

Given the assumption that end-use markets are self-optimizing in response to prices alone, a cost-minimizing policy is one that affects all economic decisions on the basis of one and the same price signal. A cross-cutting ("Pigouvian") energy or carbon tax is such an instrument.

The models thus calculate the tax needed to achieve a certain level of emission reduction, or conversely, the emission reduction expected from a certain level of a tax. The cost to society of emission reductions is then calculated on the basis of changes in economic output, employment, and other macroeconomic indicators relative to an already economically optimal reference case.

Representation of energy efficiency

In macroeconomic models, energy efficiency gains are represented by two factors. One is an econometric coefficient for autonomous energy efficiency improvements (AEEI). The second factor representing energy efficiency gains is the price elasticity of energy demand. The AEEI coefficient describes energy efficiency improvements in terms of changes in the relationship between energy use and gdp (e/gdp ratio). The coefficient is used to capture, all at once and without distinguishing among them, technological innovation in energy efficiency, the speed at which more efficient devices penetrate capital stocks, structural changes in energy service demand, and saturation effects. The detailed factors shaping end-use markets or technology diffusion, and non-price policies that could modify that process, are not modeled.

Higher energy prices from the imposition of a tax translate into substitutions of energy by capital (i.e., energy-efficient technologies) and/or labor. The corresponding econometric coefficient (ESUB) includes other adjustments that may occur in response to higher energy prices, such as lower growth in capital investments or reduced consumption and comfort levels.

Types of models and modeling studies

In macroeconomic studies, the sheer complexity of modeling the economy at large leads to wide differences among models. Top-down models can be classified by the type of model used (neo-keynesian, computable general equilibrium, long-term) and by the derivation of key coefficients (e.g., econometric versus assumed AEEI).

Compounding the problem of model differences, the economic impacts of cutting carbon emissions turn out to be sensitive to the manner in which energy or carbon tax revenues are recycled into the economy. Early studies in the U.S. relied mainly on so-called lump-sum recycling in which all marginal tax rates remain unchanged. This modeling convention results in particularly high cost estimates. Subsequent U.S. studies, and much analytic work in Europe, have focused on shifts in the tax structure that might compensate for the deadweight losses of energy or carbon taxes. Lump-sum studies continue to be frequently cited by analysts associated with the energy industry.

To simplify the interpretation of these modeling studies, it is necessary to separate the influence of input assumptions from the influence of model choice. Two useful comparisons of this kind have recently been made in the U.S. The 12th Energy Modeling Forum (EMF) at Stanford University performed analyses with 14 top-down models on the basis of standardized scenarios and input parameters.

The EMF work examined lump-sum recycling only. In a follow-up work sponsored by the U.S. Environmental Protection Agency (EPA), six alternative tax recycling options were compared using two neo-keynesian and two computable general equilibrium models for the U.S. Similar if less extensive work has been done in Europe.

STUDIES BASED ON LUMP-SUM RECYCLING

In the EMF exercise, the following parameters were standardized: gdp and population growth, the fossil fuel resource base, and the cost and availability of long-term supply options.

The costs of carbon-free backstop technologies were assumed to be \$100/bbl for transport fuels and 7.5 ¢/kWh for power supplies. These assumptions made the carbon-free backstop resources more expensive than conventional supplies. Carbon-free backstop technologies were assumed to become available in 2010, but were restricted by capital turnover in their speed of penetration. In addition, conventional resources were available at rising marginal costs. Fossil fuel prices stabilized after 2030.

For the period from 1990 to 2050, a reference case was compared with scenarios in which (1) emissions were stabilized at 1990 levels by 2000, (2) cut by 20 percent by 2010 and stabilized at that level thereafter, and (3) cut further to reach 50 percent of 1990 levels in 2050.

Table 1: Results from top-down studies using lump-sum recycling: required carbon taxes and impacts on U.S. GDP in 2010

Model	Carbon tax in \$/ton C		Impact in % of gdp (- loss, + gain)	
	stabilization	20% reduction	stabilization	20% reduction
CTRM	150	260	0.2	1
DGEM	20	50	0.6	1.7
ERM	70	160	0.4	1.1
Fossil 2	80	250	0.2	1.4
Gemini	120	330		
Global 2100	110	240	0.7	1.5
Global Macro	20	130		
Goulder	20	50	0.3	1.2
Green	80	170	0.2	0.9
MWC	70	180	0.5	1.1

Source of data: IPCC (1995)

Results: required energy and carbon taxes

Table 1 compares model results for the stabilization and 20 percent reduction scenarios. Estimates for needed carbon taxes range from \$20 to \$140 per ton to hold emissions at 1990 levels in 2010. Estimates for reducing emissions by 20 percent below 1990 levels in 2010 range from \$50 to \$330 per ton. For reaching a 50 percent reduction in 2050, taxes would have to double again.

In the EMF-12 exercise, more than 60 percent of the emission reductions came from policy-induced declines in the energy/gdp ratio. The remainder is due to declining carbon burdens of the energy supply mix.

This predominance of efficiency over supply substitutions is also borne out by several top-down exercises that investigated the difference between carbon taxes and energy taxes in Europe. Depending on the model and the country, emission reductions from an energy tax range from half to more than 90 percent of reductions achieved with a carbon tax.

Results: Gdp impacts

The EMF comparison, which did not examine changes in the tax structure, suggested that stabilization might result in a mean gdp loss of 0.5 percent in 2010. For a 20 percent reduction in 2010, the gdp loss was estimated as 1.25 percent. When maintaining or increasing these emission levels with continued economic growth until 2050, losses rise to more than 2-3 percent in 2050.

In each case, predicted losses varied severalfold among different models, indicating the large uncertainties involved in macroeconomic modeling. The size of predicted losses is generally greater when using neo-keynesian models than when using computable general equilibrium models.

Overall, the gdp losses are rather small, particularly when considering the inherent uncertainties in macroeconomic modeling calculations. For example, in an economy that grows by 2 percent a year, a loss of two percent of gross domestic product in the year 2010 would do no more than to postpone the consumption level expected for 2010 to the year 2011.

Backstop-related costs versus transition costs

Partly in response to criticism from technology experts, EMF undertook a sensitivity exercise for the 20 percent reduction scenario. In this exercise, the carbon-free backstop technologies were assumed to be cheaper than conventional supplies.

This exercise highlights the contribution to predicted gdp losses that stems from the transition period in which the backstop technologies are not yet available, yet emissions are held down as the economy continues to grow. About 35 percent of the gdp losses turn out to be such near-to medium-term transition costs unrelated to backstop costs.

This significant contribution from transition costs is fundamental for understanding the lump-sum studies. It explains why net losses are predicted even when the carbon-free backstop resource is no more costly than fossil fuels or, going further, if that backstop resource is cheaper than fossil fuels: The benefit of such a cheaper backstop resource would accrue only in the longer-term. After discounting, the present-value benefit would be small and, according to the EMF calculations, not sufficient to offset the predicted near-term transition costs.

Could costs be negative?

The transition costs in top-down models strongly depend on the assumed AEEI coefficient. The high transition cost estimates found in typical assessments are based on

econometrically estimated AEEI coefficients ranging from as little as zero to at most 1.5%/yr.

Some top-down modelers accept that the AEEI coefficient could be treated as a variable parameter reflecting the impact of energy efficiency policies, though they don't give up the efficient-market hypothesis. Instead, a larger efficiency gain is assumed to be available from "autonomous" changes that have a zero net cost. The effect is a significant reduction in transition costs.

If a high AEEI value (i.e., a value of 3-4%, consonant with the rate of energy efficiency improvements found feasible in bottom-up studies) were combined with the early introduction of cheap backstop technologies, top-down models could yield a negative net cost outcome without tax shift policies. However, even then, top-down calculations do not capture the cost savings available from market transformation programs.

Discussion: Economics of delayed control

If transition costs are significant, as in the modeling calculations reviewed so far, it might appear advantageous to delay emission reductions. Indeed, arguments of this type are often presented in public policy fora. However, quite apart from issues of irreversibility of climate change and intergenerational equity, such claims are under challenge from tax shift studies and bottom-up studies.

In effect, tax shift studies suggest that the deadweight losses of energy or carbon taxes can be offset by changes in other tax rates. Bottom-up studies suggest that much or all of the transition costs of top-down studies can be converted into transition benefits (see below). If reduction policies can bring net economic benefits, delayed control would incur unnecessary economic losses.

TAX SHIFT STUDIES

Macroeconomic tax recycling analyses do not, as bottom-up studies do, challenge the fundamental top-down propositions: that energy service markets are economically efficient, and that carbon emission reductions will lead to higher expenditures for energy services. Rather they seek to compensate for the deadweight losses of energy or carbon taxes by displacing other kinds of taxes that currently produce "fiscal drag," i.e., inefficiencies in the economy at large that are related to the relative taxes on capital, labor, and pollution.

In particular, these studies investigate the recycling of carbon taxes into tax relief for workers (personal income tax, employee-paid payroll tax), businesses (employer-paid payroll tax, corporate income tax, investment tax), governments (deficit reduction, revenue enhancement), and combinations thereof.

Results: Gdp and employment impacts

Table 2 shows representative results from European and U.S. studies. All these studies show that negative economic impacts from carbon reduction policies could be largely or completely offset through recycling schemes, and could even lead to net economic gains.

Table 2: Gnp and employment impacts from alternative carbon tax recycling

		Percent of discounted constant price GNP (- loss, + gain)						
		DRI USA	LINK USA	J/W USA	Goulder USA	HERMES EC 4	QUEST EC 12	HERMES-LINK EC 6
Lump sum tax cuts	gnp	-0.58%	-0.46%	-0.62%	-0.24%			
Revenue Raising	gnp	-0.40%	-1.02%		-0.24%	-1.60%	-1.20%	
	employment					-0.90%	-0.40%	
Personal Income Tax Cuts	gnp	-0.56%	-0.53%	-0.16%	-0.16%	-0.30%	-1.10%	
	employment					0%	0%	
Corporate Income Tax Cuts	gnp	0.40%	-0.11%	0.60%	-0.17%			
Payroll Tax Cuts	gnp				-0.18%			
(Employee Only)	gnp	-0.58%	-0.53%					
(Employer Only)	gnp	0.19%	-0.25%			-0.20%	-0.70%	0.15%
	employment					0%	-0.30%	0.64%
Investment Tax Credit	gnp	1.55%	1.67%		0.00%			

Source of data: IPCC (1995)

For example, of the four U.S. models tested in the EPA exercise, each model was able to identify at least one recycling scheme that resulted in either a net gain or in zero net costs. Similarly, in the European studies, where employment was a primary concern, each found at least one recycling option that would have no effect or positive effects on employment. However, depending on which model was used, different tax recycling policies were found to be most beneficial.

Discussion

Tax shift studies point to the fact that assessments based on lump-sum recycling seriously overstate the cost of reducing carbon emissions. They show that even within the world of econometric top-down assessments, the economic impacts of carbon reduction policies can be beneficial, and in any case, strongly depend on the type of policy pursued.

It might be argued that the benefits realized from shifting to a carbon tax cannot be claimed as a benefit of climate change policies. However, very few other potential tax sources are available for raising comparably large revenues. Furthermore, the restructuring of marginal tax rates ought to be considered an integral component of any significant energy tax initiative. The revenue streams associated with calculated or proposed energy or carbon taxes would be so large as to significantly alter the tax structure in the economy, notably if net tax burdens are to be kept the same (i.e., under a revenue-neutral tax).

From the perspective of policy development, the exclusion of tax shifts in the early U.S. cost assessments thus turns out to be an important shortcoming. While lump-sum recycling represents a useful intermediate analytic step when one seeks to study model differences, the practical requirements of policy-making can only be addressed by more sophisticated approaches based on tax shifts.

E. BOTTOM-UP STUDIES

FUNDAMENTALS

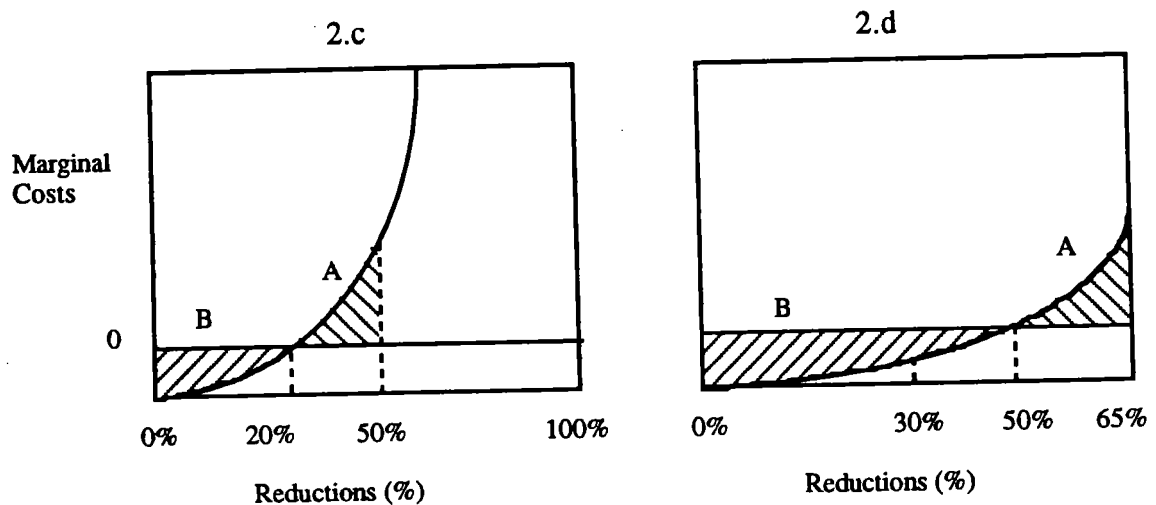
The defining feature of bottom-up studies is the procedure for calculating economically efficient levels of future energy demand.² The basic input are supply curves of saved energy. These are developed on the basis of life-cycle cost comparisons of currently available and emerging technologies for appliances, buildings, vehicles, industrial

² The term "bottom-up" analysis as used here is reserved for only those analyses which rely on highly disaggregated end-use market and technology data. The term is sometimes erroneously used for studies simply because they use formal energy sector models based on linear programming (LP). In these models (e.g. MARKAL or EFOM), conventional supply technologies are represented in detail. However, the representation of end-use markets and demand-side efficiency potentials is inadequate without significant complementary analysis outside these formal modeling frameworks. Whether such studies classify as bottom-up then depends on the level of such exogenous end-use analysis.

equipment, and other end-use devices, and on the basis of policy assumptions. From there, energy demand is matched with an economically optimized mix of supply sources and technologies to calculate total energy requirements and energy expenditures for the economy. A step-by-step procedure is given in the IPSEP report (Parts 1, 3B, and 3C).

Because energy service markets are found to be economically inefficient, bottom-up studies emphasize a range of non-fiscal measures and place only secondary importance on energy price signals. The non-fiscal measures on the demand-side include financial incentives for energy-saving investments, legislated minimum efficiency standards for energy-using equipment, and a variety of regulatory reforms to increase economic efficiency in the utility sector.

Figure 2c and d: Marginal Cost Curve for Emission Reduction Measures, Bottom-up Policy Framework



Because substantial opportunities exist to improve the efficiency of energy service markets, significant emission reductions can be achieved at a negative net cost compared to the business-as-usual case. However, the least-cost case does not exhaust the potential for emission reductions that can be realized while still keeping total costs of energy services at or below those of the reference case. Any net savings from market transformation policies can be put to use to pay for more expensive carbon reduction measures, such as renewable energy supplies that are not yet cost-competitive. The zero net cost potential of carbon emission reductions is then the point where savings from unrealized cost-effective efficiency measures and supply resources are just offset by expenditures for more expensive resources. The shaded areas in Figures 2c and d above illustrate this effect.

Bottom-up studies may also include policies to reduce market failures and/or technology diffusion barriers on the supply-side. In particular, these studies often simulate utility regulatory reforms that increase access of cogenerators and renewables-based small power producers to the electricity grid. Similarly, they may identify more cost-efficient R&D priorities and commercialization programs that could yield better-hedged, diversified technology portfolios and faster innovation than found in traditional programs.

Reflecting this policy focus, the discount rate for life cycle cost comparisons is harmonized between supply-side and demand-side investments. The use of the same low discount rates for supply-side and demand-side investments reflects the removal of intangible costs through market transformation policies. The administrative costs for these policies are incorporated as an explicit cost component in the life-cycle cost analysis for the various technology options.

The resulting marginal cost curve for emission reductions is shown in Figure 2c and d. With intangible costs much reduced, a considerable portion of available measures has negative net costs. Again, different assessments may give smaller or larger negative-net cost potentials.

Determination of policy costs: least cost and least carbon scenarios

The economic benefit of optimizing energy markets and technology mixes is calculated by comparing the cost of energy services based on least-cost supply mixes and least-cost levels of energy demand to the business-as-usual case in which current trends and historic patterns are continued into the future.

Table 3: Zero net cost reduction potentials in bottom-up studies

Study	Country	Zero cost reduction in carbon emissions below base year (%)			
		2000	2005/2010	2015/2020	2025/2030
ASE 1991	USA		>26	>53	>82
Chandler & Nichols 1990	USA	0			
Chandler&Kolar 1990	USA		>0		
DPA 1989	Canada		>13		
Lovins 1991	USA			58	
Mills et al. 1991	USA	21			
NAS 1991	USA			>24	
OTA 1991	USA			>23	
Rubin et al. 1992	USA			35	
RIGES	USA				>61
FFEF	USA				>75
SEI/Greenpeace 1993	USA				74
Krause et al. 1993	EC-5			>26 - >58	>60
FRG Enquete 1992	FRG		30		
Mills et al. 1991	Sweden		>35		
CEC/Russ et al. 1991	FRG		>25		
UNEP Risø 1993	Denmark		>21		>45
Range		0-21	0->35	>23-58	>45->82
Median		11	>18	>41	>64

Source of data: IPCC (1995)

RESULTS FROM BOTTOM-UP STUDIES

A list of recent bottom-up studies is given in Table 3. The list emphasizes studies that cover all sectors of the economy. Excluded from the table are studies in which it is assumed that energy service markets are economically efficient in the reference case.

Results are reported in terms of the percentage reduction below the level of base year emissions that was found to have zero net cost. In first approximation, this result for life cycle costs can be assumed to be equivalent to a zero net change in gdp. The base year variously ranged from 1985 to 1990. For studies where only negative net costs were reported, reductions are shown with a "greater than" sign.

The table focuses on OECD countries. Studies for developing countries show that bottom-up policies can result in large economic savings and significantly lower growth in emissions there as well. However, the metric of comparison chosen here — zero net cost reductions below the baseline year — is not meaningful for them.

Impact of time horizons

The following reductions were found to result in zero net costs:

- By the turn of the century: 0-21 percent (median of 11 percent)
- By about 2005-2010: >0-58 percent (median of 29 percent)
- By about 2015-2020: >23->58 percent (median of 41 percent)
- By about 2025-2030: >45->82 percent (median of 64 percent)

The studies were not normalized in terms of economic growth, structural change, fuel prices, technology costs, policy effectiveness, etc. As a result, the above reduction ranges are wider than a coordinated analysis based on uniform assumptions would have found.

Despite these wide variations, the figures show a consistent pattern:

- Within the 1990-2030 time frame, larger reductions become feasible at zero net cost as time horizons grow longer. And
- for any given reduction target, mitigation costs decline as longer adjustment periods are allowed.

This pattern reflects two major factors: first, bottom-up studies identify large energy efficiency potentials that are not exploited in the reference case. Second, most energy efficiency improvements are introduced at the "natural" rate of capital stock turnover, with the more long-lived capital goods lasting twenty to thirty years or more. Due to this synchronicity, cost-effective efficiency improvements "keep coming." As a result, most or all of the transition costs encountered with top-down policies become transition benefits. In addition, cheap cogeneration opportunities that are not included in the reference case can be an important negative-net-cost contribution. This technology has significant cost-effective resource potentials and is available in the near- to medium-term.

COMPARISON OF BOTTOM-UP STUDIES WITH EACH OTHER

Like top-down studies, bottom-up studies result in a wide range of reduction cost estimates. But while the results of top-down studies are centrally shaped by the internal structure of the formal models employed in them, the use of formal models and the choice of such models is only of secondary importance here. Instead, input assumptions are dominant. Inspection of available studies shows that for a given time horizon and geographic region, divergent results arise mainly from two differences:

- quality of the technical analysis from which supply curves for energy efficiency and supplies from cogeneration and renewables are derived;
- assumed effectiveness of policy instruments in mobilizing the economically cost-effective resource potential.

Differences in technical analysis

Of the technical factors, the most important ones appear to be the level of detail in analyzing and representing supply curves for technology options, notably those for demand-side efficiency improvements. Bottom-up studies that rely on more detailed and comprehensive assessments of these options will tend to arrive at larger efficiency potentials and lower costs of saved energy than less detailed studies. Even then, uncertain baseline data for equipment use and efficiency in individual end-uses leave some room for disagreement among technologists.

The treatment of administrative policy costs can also be important. Most bottom-up analyses assume that energy efficiency standards would be the main policy tool. These have negligible administrative costs, but such costs can be more substantial in some types of incentives programs. State-of-the-art studies give a differentiated treatment.

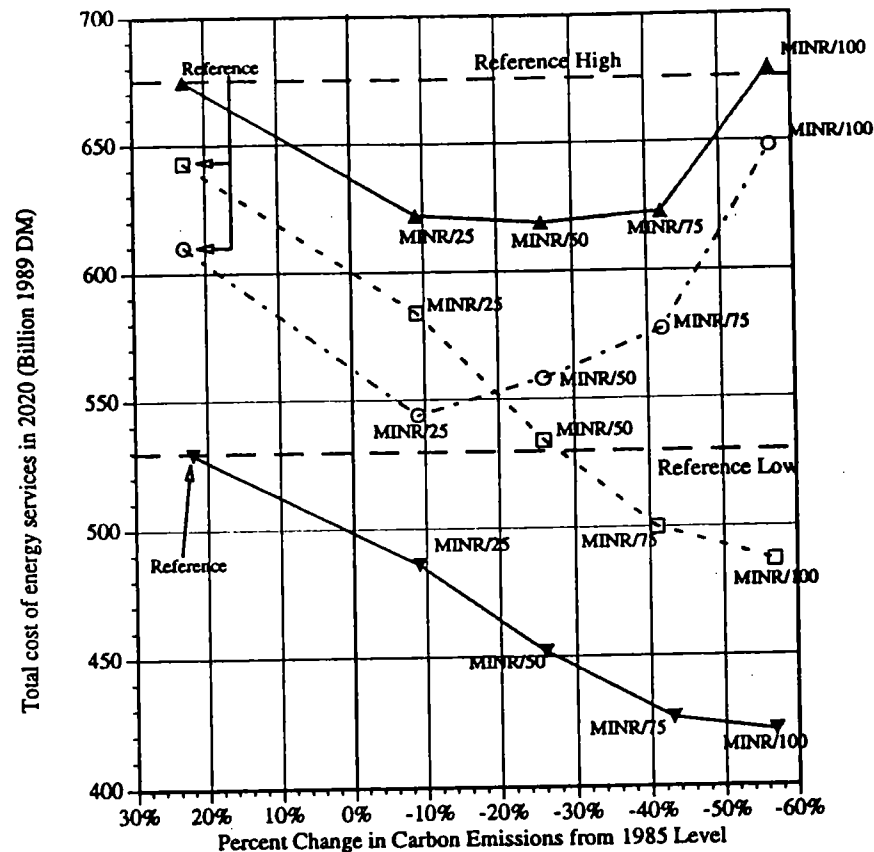
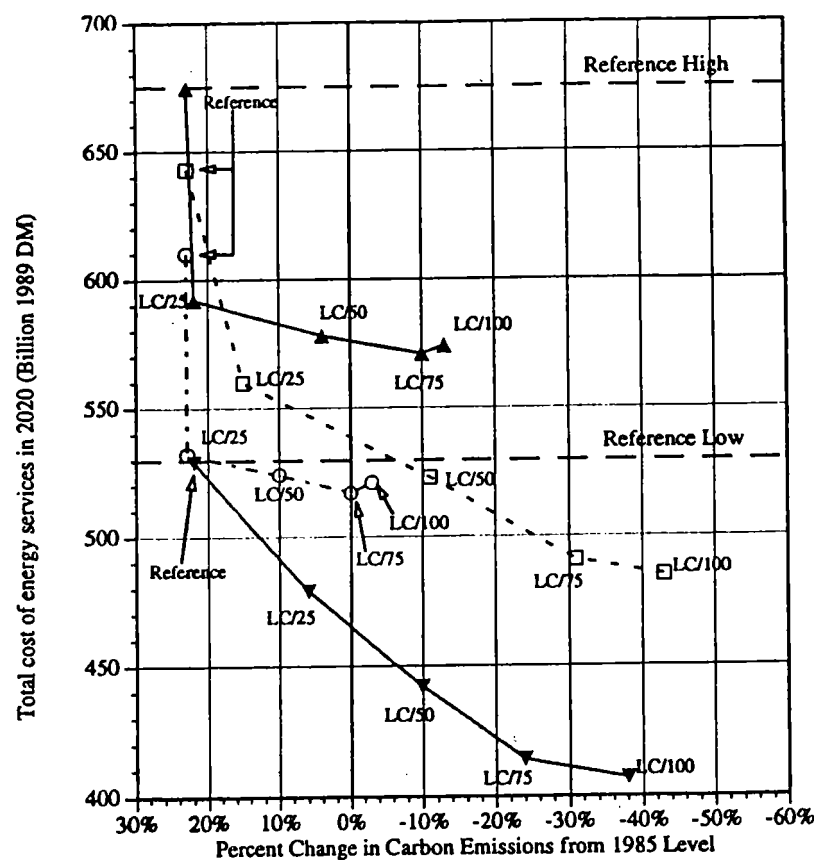
Depending on the scope of the study, additional "no regrets" opportunities may be quantified. These are lower generating costs from utility regulatory reforms; savings in acid rain and other pollution control expenditures from reduced fossil fuel use, the cost-reducing effects of monetizing environmental externalities (other than climate change), and increased cost-effectiveness of non-fossil options when removing fossil fuel price subsidies.

Most bottom-up studies do not quantify the feedback effect from lower energy demand on fuel prices, or the further effect of lower fuel prices and energy service costs on cost-effective energy efficiency levels and energy demand. As a result, bottom-up studies may at once underestimate feasible economic savings from carbon reductions and overestimate the amount of emission reductions that market transformation policies can bring.

Differences in assumed policy effectiveness

All bottom-up scenarios of future energy demand assume that policy intervention can at least partially shift investment behaviors of consumers and firms from historically suboptimal patterns to economically optimal choices. At one end of the spectrum, it is assumed that policies will shift every replacement purchase or expansion of end-use equipment that will occur over the time period studied. For short time horizons (10-20

Figure 3: Sensitivity Analysis of the Cost of Carbon Reductions in EC-5, All Sectors



- □ - Low Capital Cost/High Fuel Price Case
- ○ - High Capital Cost/Low Fuel Price Case
- ▼ - Low Capital Cost/Low Fuel Price Case
- ▲ - High Capital Cost/High Fuel Price Case

1985 EC-5 Carbon emissions = 532 Mt C

years), this assumption implies that a complete shift to efficient equipment will be achieved within one cycle of capital stock turnover. This assumption is almost certainly too optimistic.

At the other end of the spectrum, some bottom-up studies take a very pessimistic view in which current political difficulties are assumed to limit the more widespread application of market transformation policies. As a result, savings remain far below their potential.

A compromise position is found in studies using longer time horizons (30-40 years or more). Over these longer periods, most capital goods will be replaced more than once, and many several times. Here, least-cost efficiency levels can be achieved within the time horizon even if policies do not shift all or most investments the first time around. The assumption about the effectiveness of policies is thus more realistic in these studies.

ILLUSTRATION: A CASE STUDY OF WESTERN EUROPE

An illustration of the kinds of results one might obtain when combining a sophisticated technology and cost analysis with alternative explicit assumptions about policy effectiveness is found in the IPSEP study for five West European countries (France, Germany, Italy, the Netherlands, and the UK). The study applies various innovative analytic features that were developed in the U.S. utility and regulatory practice of least cost or integrated resource planning.

The study is based on a technically comprehensive supply curve analysis of energy efficiency options which incorporates administrative policy costs, transmission and distribution benefits, as well as feedbacks between policies and fuel prices and technology costs. To avoid the problems encountered in other European multi-country studies, where inconsistent treatments of technology cost and performance data was a problem, the costs and potentials for conventional fossil supplies, nuclear power, demand-side efficiency, cogeneration, and renewables potentials are developed in several detailed substudies.

Uncertainties are modeled for both fuel prices, technology costs, and administrative costs, using high/low sensitivity ranges for these parameters. In order to address uncertainties about the effectiveness of policy programs, the sensitivity analysis is extended to the implementation aspect. The effectiveness of market transformation policies is expressed in terms of the maximum technical or economic potential of each constrained resource, i.e., as the fraction of these resource potentials assumed to be mobilized by 2020. Scenario results are then given for 25%, 50%, 75%, and 100% effectiveness.

Both a least cost, least carbon, and minimum risk scenario case are considered. In the minimum risk case, reductions in carbon emissions are accompanied by a phase-out of nuclear power. Figure 3 shows results for the least cost and minimum risk cases for the five countries combined.

Results: Least cost case

Assuming full availability of efficiency potentials (100% points in the graph), a least cost scenario would at a minimum stabilize 2020 emissions at 1985 levels, and could lead to reductions of about 40 percent. Energy service costs would drop by 15-23 percent relative to the reference case.

Results: minimum risk case

In the minimum risk case, emissions in 2020 would be about 40 percent below 1985 levels. In the worst case, zero total costs are reached for a 45 percent reduction. Costs would be six percent higher. In the more plausible case of low fuel and technology costs, even a 60 percent reduction would be obtained at more than a 20 percent savings in energy bills.

Feedback effects

Of the four high/low permutations, the combination of low fossil fuel prices and high costs for carbon-free resource options (efficiency, renewables, nuclear) represents the high end of the sensitivity range. Given that a carbon reduction policy would reduce fossil fuel demand and stimulate technology development, the most plausible case is a combination of low fossil fuel prices and low costs for carbon-free resources.

F. COMBINED TAX SHIFT/BOTTOM-UP APPROACHES

From the results of the studies presented so far it is evident that a particularly powerful and cost-effective carbon reduction strategy could be fashioned by reducing market and regulatory failures in the energy sector and by also implementing beneficial tax shifts. Both policies are growth-enhancing, and if carbon taxes finance programs to correct market failures, they could become mutually reinforcing.

THE TRUST FUND APPROACH

Energy or carbon taxes could be used as a trust fund to directly finance bottom-up programs that correct market failures. This trust-fund linkage of taxes to market transformation instruments would drastically lower required energy price hikes for achieving large emission reductions. Reliance on much reduced energy price signals would also greatly diminish distributional and competitiveness problems that arise from general revenue taxes. These problems have created major political stumbling blocks for economically efficient energy and climate policies.

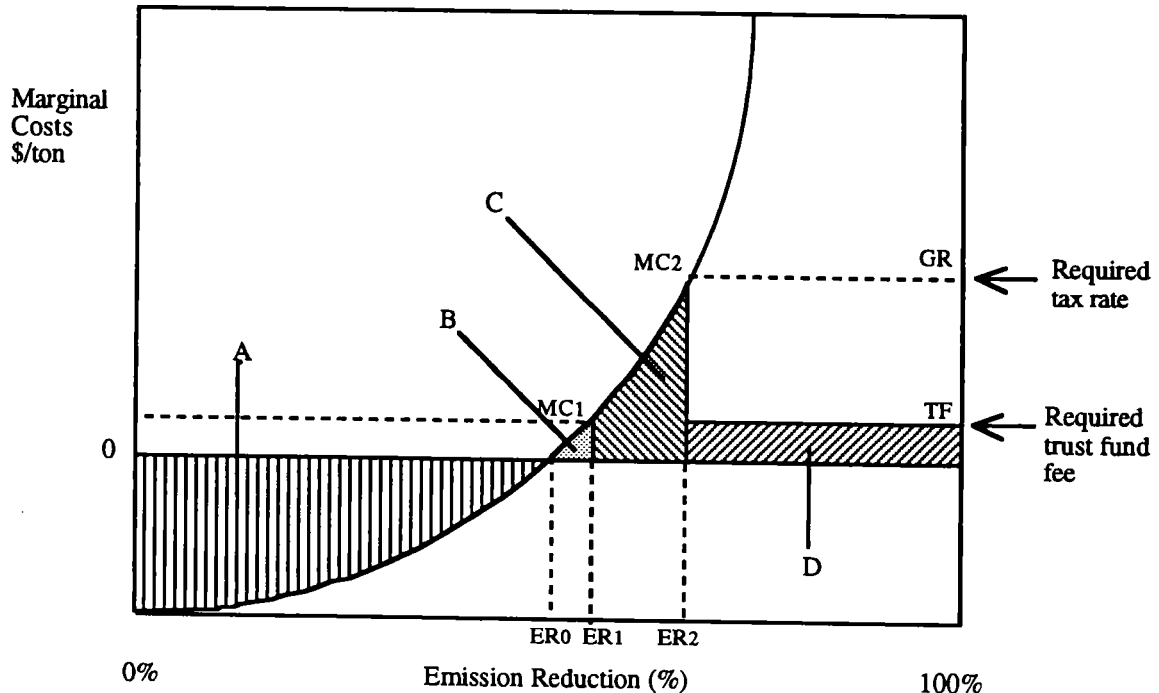
Illustration

The trust fund approach is illustrated in Figure 4, which shows the marginal cost curve for reducing carbon emissions as defined in the bottom-up framework. First, the fee encourages implementation of the negative cost portion of the marginal cost curve, thus reducing energy use and emissions. The fee revenue flows into a trust fund and provides market-correcting financial incentives for cost-effective investments, in a manner similar to utility demand-side management programs that are financed through electricity rates. Other technology measures can be implemented through efficiency standards for manufacturers. To accelerate innovation, financial incentives for product improvements can additionally be given through the procurement process, along the lines of recent "golden carrots"

programs. The fee and trust fund incentives can be complemented by traditional regulatory measures such as efficiency or emissions standards.

The impact of the required fees on energy prices is modest. At the same time, the societal energy bill would decline by an amount equivalent to the shaded area A. Carbon emissions, reduced to point E_0 in the graph, would be lowered to a significantly greater degree than under a general-revenue tax of the same magnitude.

Figure 4: Comparison of general revenue tax and trust fund approach



- A = Savings from negative-cost measures
- B = Total cost of measures implemented in response to price effect of trust fund fee
- C,D = Total costs of additional positive-cost measures
- MC = Marginal cost of abatement measures
- GR = General revenue tax rate
- TF = Trust fund fee

An additional carbon reduction increment can then be obtained from the positive-cost portion of the supply curve. Some such investments will be triggered by the already mentioned increase of energy prices that is needed to finance incentives programs for negative-cost measures (measures with marginal costs up to MC_1 , area B). To decrease emissions to point E_2 , a general revenue tax would have to be set equal to the marginal cost MC_2 of the last measure needed to realize this reduction target. The corresponding tax rate is indicated as GR on the right-hand axis of the graph.

These additional carbon reduction measures could instead be mobilized by raising a fee sufficient to pay for these investments. This trust fund fee would be significantly lower than a general revenue tax. It would have to merely raise enough revenue to pay for the *average* cost of the measures up to MC₂, which is indicated by the shaded area B in the graph. If this revenue is spread over remaining emissions (area B transposed into area C), the required trust fund fee — indicated as point TR on the right-hand axis — is only a fraction of the general revenue tax.

As this positive-cost portion of the supply curve is implemented, the societal bill for energy services goes up. However, the total cost of carbon reductions will remain negative until all the energy bill savings from the negative-cost portion of the supply curve (area A) are offset by positive-cost measures (areas B plus C).

Reducing competitiveness and distributional impacts

The trust fund approach reduces competitiveness concerns and distributional problems, as illustrated by the graph. Under a general revenue tax, the monies collected would be severalfold more than the amount needed to pay for the necessary investments. For each dollar spent on abatement, several dollars of taxes would have to be raised. This overcollection translates into greater competitiveness problems for the more energy intensive industries and into greater distributional equity problems for poor households. Though these problems can be addressed through additional government fiscal policies, the trust fund approach minimizes these effects.

MARKET TRANSFORMATION AND ECOLOGICAL TAX REFORM

A broadly parallel policy option for combining bottom-up policies with tax instruments arises from the discussion on ecological tax reform. The goal of this reform is to encourage employment and discourage environmentally harmful energy use and other environmental externalities. The proposed method is a tax shift that reduces payroll taxes while increasing the price of energy.

The energy tax is conceived of as a general revenue tax. As a result, significantly higher tax levels are envisioned than in a trust fund approach. The resulting competitiveness impacts on energy-intensive industries are seen as a beneficial stimulus for structural changes in the economy that are considered desirable for mature export-oriented industrialized countries. Accelerated structural changes could therefore be growth- and employment-enhancing and improve overall competitiveness in the longer run.

Again, these and other possible economic benefits of ecological tax reform would be transformed into assured efficiency gains and significantly larger emission reductions through market transformation policies. To link ecological tax reform with market transformation programs, a portion of the tax revenues could again be channeled into a trust fund, with the remainder used to lower payroll taxes. The stronger price signals from the general revenue tax reinforce the economic attractiveness of market transformation policies. They also provide an immediate cross-cutting energy efficiency stimulus while the necessary institutional mechanisms for standards and incentives programs are still being developed. Again, large emission reductions could be achieved while at the same time enhancing economic output.

G. CONCLUSIONS: CARBON REDUCTIONS AT A PROFIT

The competition between energy supplies and investments in greater energy efficiency suffers from a range of market and institutional failures and other economic efficiency problems. Many of these problems can be ameliorated at a profit to society through market transformation policies that reduce the energy bills of consumers and firms, such as targeted energy efficiency incentives and standards. In addition, tax shift policies can improve the efficiency of tax structures, and R&D policies can accelerate the commercialization of cheaper technologies.

All in all, these policy options represent a large potential for reducing carbon emissions at zero or negative cost relative to a policy of inaction. This "no regrets" potential already exists today and grows over time as capital stocks are replaced. Its implementation in the near-to-medium term can result in sizable economic benefits during the transition to a low-carbon future. It is not dependent on the fruits of intensified R&D efforts, though such efforts will add to it over time. The sooner the transition to more efficient energy service markets is begun, the greater the economic and climatic benefits.

The economic cost of "wait and see"

Given these opportunities, the postponement of emission reduction measures would unnecessarily increase the costs of climate stabilization, and not, as some top-down studies have suggested, offer economic benefits. The high transition costs calculated in many top-down modeling exercises are misleading. These imputed costs are not inherent to the task of cutting carbon emissions. Rather, they reflect an outdated theoretical view of energy service markets that has been called into question by recent empirical research and policy experience. Transition costs rather than benefits are the predictable outflow of the narrow emphasis on tax instruments found in top-down studies, compounded in many cases by a focus on inefficient forms of recycling carbon tax revenues.

Economically sound reduction targets for industrialized countries

In interpreting the mitigation cost assessments reviewed in this report, it is important to recognize the effects of these problems and other key differences on the results of top-down and bottom-up studies. The macroeconomic top-down modeling studies on which most governments have relied so far systematically overestimate mitigation costs because they fail to capture key "no regrets" policy options. Bottom-up modeling studies correct for this flaw, but often still overestimate costs. Thus, policy makers would continue to overestimate the true cost of mitigation if they were to simply "split the difference" between the results of top-down studies and bottom-up studies. At the same time, bottom-up studies covering near-term time horizons may somewhat underestimate the time needed to achieve a given percentage emission reduction.

If one accounts for these factors, the international body of top-down and bottom-up cost assessments can be interpreted as follows:

- OECD countries could, over the next 30-50 years, cut their carbon emissions by 50 percent or more below 1990 levels. With an integrated set of tax shift and non-price policies, this emission reduction could be achieved at negative net cost, i.e. while increasing economic output and employment.

- As an intermediate goal, the 20 percent reduction level first recommended in the 1988 international Toronto conference could be realized over the next 20 years or so without generating a net economic burden, and likely at a significant economic and employment benefit.

Global prospects

Given the strong influence of technological changes in industrialized countries on investments in developing countries, the prospect arises for extending this result to the world as a whole. Considering the likelihood of R&D successes in reducing the cost of carbon-free renewable energy options, it appears that the emission reductions mandated by the IPCC scientific assessments — 50 percent or more on a global basis — could be achieved by the middle of the next century, and again at zero net mitigation cost or at a net economic benefit for both industrialized and developing countries.

Directions for future policy research

In commissioning future studies to better quantify "no regrets" opportunities, both types of energy analyses should be employed, but much greater emphasis should be placed on bottom-up methods. Because macroeconomic modeling studies fail to capture the potential benefits of carbon reduction strategies, their usefulness for guiding climate policy without linkage to bottom-up analyses must be called into question.

The bottom-up approach best conforms with the fundamental requirement that public policy should be based on a societal perspective on economic efficiency. It also best conforms with the requirement that public policy should facilitate cost-minimizing behavior in optimal markets, not perpetuate historic patterns of private decision-making shaped by impaired markets. Therefore, a bottom-up analysis of optimal energy services, efficiency levels, and policies should form the core of credible greenhouse policy cost assessments. In future bottom-up research, greater emphasis should be placed on field experimentation with actual market transformation programs, using careful monitoring to evaluate alternative program designs.

Top-down models are best used for establishing an all-economy reference case and for business-as-usual projections of future energy demand. Top-down models may also elucidate fiscal policy measures, "no regrets" options from tax shift reforms, and certain near-term distributional and competitiveness impacts. If modified to accept bottom-up calculations as exogenous inputs, they may be useful for estimating the macroeconomic impacts of bottom-up energy sector policies, including feedback effects of changed energy bills and energy prices.

Practical next steps

For the purposes of practical implementation, a powerful combined carbon reduction strategy could be fashioned by combining tax shift and market transformation policies. Both policies can be growth-enhancing. A trust fund linked to such programs could achieve large emission reductions while requiring much lower energy taxes than suggested in most top-down studies. A trust fund approach could also be linked with broader ecological tax reform, with benefits for the effectiveness of both. Such a course promises to enhance economic growth and employment, stimulate technological development, and slow the rate of greenhouse gas emissions.

F. SELECTED REFERENCES:

- Cline, W.R. 1992, *The Economics of Global Warming*, Institute for International Economics, Washington, DC, June.
- DeCanio, S.J. 1993: "Barriers within firms to energy efficiency investments," *Energy Policy*, Vol. 21, Nr. 9, pp. 906-914, September.
- EMF 1993, *Reducing Global Carbon Emissions — Costs and Policy Options*, Energy Modeling Forum Nr. 12, Stanford University, Stanford.
- Eto, J., E. Vine, L. Shown, R. Sonnenblick, C. Payne 1994, *The Cost and Performance of Utility Commercial Lighting Programs*, LBL-34967, Energy and Environment Division, Lawrence Berkeley Laboratory.
- Grubb, M. et al. 1993: "The Costs of Limiting Fossil-Fuel CO₂-Emissions: A Survey and Analysis," in Socolow, R.H., Anderson, D., Harte, J. (eds), *Annual Review of Energy and the Environment*, vol. 18, pp. 397-478.
- Hirst, E. and Brown, M. 1990: "Closing the Efficiency Gap: Barriers to the Efficient Use of Energy," *Resources, Conservation, and Recycling*, Vol.3, No.4, June, pp. 267-281.
- Howarth, R.B. and B. Anderson 1993: "Market Barriers to Energy Efficiency," *Energy Economics*, October.
- Howarth, R.B. and M. Winslow 1994: "Energy Use and Climate Stabilization: Integrating Pricing and Regulatory Policies," *Energy: The International Journal*.
- IPCC 1995, "Evaluating the Costs of Mitigation of Greenhouse Gas Emissions by Sources and Removals by Sinks," Intergovernmental Panel on Climate Change (IPCC), *Second Scientific Assessment Report*, Working Group III, Chapters 8 and 9, forthcoming.
- IPCC 1990, *Climate Change: The IPCC Scientific Assessment*, Intergovernmental Panel on Climate Change, WMO/UNEP, Geneva, August.
- IPSEP 1994/1995, *The Cost of Cutting Carbon Emissions in Western Europe, Energy Policy in the Greenhouse, Vol. II, Parts 2-6*, Report to the Dutch Ministry of Environment by the International Project for Sustainable Energy Paths, El Cerrito, CA.
- IPSEP 1993, *Cutting Carbon Emissions: Burden or Benefit? Energy Policy in the Greenhouse, Volume II, Part 1*, Report to the Dutch Ministry of Environment by the International Project for Sustainable Energy Paths, El Cerrito, CA.
- IPSEP 1989, *Energy Policy in the Greenhouse, Volume I: From Warming Fate to Warming Limit: Benchmarks for a Global Climate Convention*, Report to the Dutch

ENERGY POLICY IN THE GREENHOUSE

Volume II:

The Cost of Cutting Carbon Emissions

by F. Krause, J. Koomey, D. Olivier with H. Becht, D. Bleviss, G. Onufrio, P. Radanne

PART 1 — CUTTING CARBON EMISSIONS: BURDEN OR BENEFIT?

Background: buying insurance and "no regrets" measures — Results from top-down and bottom-up estimates of the cost of carbon reductions — International dynamics of trade and technological competition — Unilateral reduction targets and leakage effects — The top-down approach and the efficient-market assumption — Carbon tax recycling and ecological tax reform — Evidence for energy market failures and "no regrets" options — The bottom-up approach: market correction and market creation through non-fiscal policies — Integration: bottom-up policies plus a low energy/carbon tax. 120 pp.

PART 2 — THE COST OF CARBON REDUCTIONS IN WESTERN EUROPE

Status quo emission patterns — A business-as-usual energy future: the EC Commission reference case — Calculating the cost of alternative energy futures: IPSEP methodology — Overall results: potential for emission reductions at negative to zero net cost — Sensitivity cases and results by sector — Implications for employment and classical air pollution problems — Economic and emission impacts of a nuclear phase-out — Implications of carbon reduction strategies for gas demand — Feedback effects on fossil fuel prices — Implementation policies: a mixed bag approach — Supply security and international cooperation. 120 pp.

PART 3A — THE ELECTRICITY SECTOR

Developing integrated resource plans: Methodology — Summary of conventional and low-carbon electricity resource options — Western Europe's electricity bill: Cost comparison of least-cost, minimum carbon, and minimum risk scenarios — Role of demand-side resources, cogeneration, and dispatchable and non-dispatchable renewables — Sensitivity cases and impacts of monetized externality costs — Implications for regulatory policy: least cost planning versus deregulation. 120 pp.

PART 3B — ELECTRICAL EFFICIENCY

What do demand-side resources cost?: Methodology — Electrical efficiency potentials in Western Europe: industrial sector, residential sector, other end-uses — Transmission/distribution credits and administrative costs — Supply curves and sensitivity cases — Experience with innovative utility and government demand-side management programs — Role of integrated resource planning reforms. 120 pp.

PART 3C — FOSSIL GENERATION

Comparing the costs of supply technologies: Methodology — Modularity-related system costs and benefits — Monetized externality costs — Fossil fuel price scenarios — Dependency on energy policies and carbon reduction goals — Gas supplies in and around Western Europe — Policy reforms: restructuring and integrated resource planning for the gas sector — Costs of conventional and advanced coal- and gas-fired plants — Cost and potential of industrial and district heating cogeneration — Carbon scrubbing technologies — Policy options: deregulation, competitive bidding, and other reforms. 250 pp.

PART 3D — RENEWABLE POWER

The system cost and value of non-dispatchable renewables: Methodology — Cost and potential of wind power in Western Europe — Cost and potential of hydropower — Cost and potential of solar thermal and photovoltaic power — Cost and potential of biomass-fired generation — Other renewables — R&D policy, market creation programs, and utility regulatory reforms. 120 pp.

PART 3E — NUCLEAR POWER

The true cost of nuclear power: Methodology issues — Nuclear power costs in France: official estimates versus field experience — Indirect economic and environmental impacts of the French nuclear program — Nuclear power costs in Germany — The British privatization experience: a market test — External costs of nuclear power — Levelized costs of worst-case accidents — Advanced reactors — Expected resource contribution — Policies for internalizing nuclear externality costs. 120 pp.

PART 4 — THE TRANSPORT SECTOR

Sustainable mobility, least-cost access, and integrated transportation planning — Trends in transportation demand, energy use and emissions — The monetized external costs of road transport — Costs and potential of energy-efficient vehicle technologies — Technical efficiency gains versus operating efficiency losses from congestion — Traffic management, speed limits, and down-sizing — Electric vehicles: implications for gas and electricity demand — Costs and potential of mode shifting from road to rail — Cost comparisons of integrated scenarios — Near-term policy options: Gasoline tax, feebates, efficiency standards, and road freight regulations — Long-term policy options: the city with few cars. 200 pp.

PART 5 — THE BUILDING SECTOR

Status quo energy use for space heating — Cost comparison of alternative heating systems — Interactions between heating system costs and building shell efficiency — High-efficiency buildings and indoor air quality — Internal gains and efficient electric appliances — The zero energy home — Cost-effectiveness of advanced techniques by EC climate zone — Cost-effectiveness of district heating — Energy efficiency in commercial and industrial buildings — Supply curve of demand-side efficiency resources — Fuel switching and cogeneration — Cost comparisons of integrated scenarios — Policy needs and options. 120 pp.

PART 6 — THE INDUSTRY SECTOR

The changing energy intensity of industrial production — The business-as-usual scenario: impacts of structural change on energy demand — Costs and savings potentials from new fuel and electric processes by sector — Cost and potential of cross-cutting efficiency measures — Supply curve of demand-side efficiency resources — Fuel switching and cogeneration — Cost comparisons of integrated scenarios — Impacts of a carbon tax on the competitiveness of individual industries — Policy implications. 120 pp.

Ministry of Environment by the International Project for Sustainable Energy Paths,
El Cerrito, CA.

- Koomey, Jonathan and Alan S. Sanstad 1994: "Technical evidence for assessing the performance of markets affecting energy efficiency," *Energy Policy* Vol. 22, Nr.10, pp. 826-832.
- Krause, F. et al. 1994: "Top-Down and Bottom-Up Methods for Calculating the Cost of Cutting Carbon Emissions: An Economic Assessment," Invited contribution to the 1995 IPCC Scientific Assessment, Working Group III, Intergovernmental Panel on Climate Change (IPCC), Toronto, Canada.
- Krause, F., J. Koomey, D. Olivier 1992, "Incorporating Global Warming Externalities through Environmental Least Cost Planning: A Case Study of Western Europe, in: O. Hohmeyer, R.L. Ottinger (Eds.), *Social Costs of Energy: Present Status and Future Trends*, Springer, New York, Heidelberg.
- Krause, Florentin, Ed Vine and Sunita Gandhi. 1989. *Program Experience and its Regulatory Implications: A Case Study of Utility Lighting Efficiency Programs*. Lawrence Berkeley Laboratory. LBL-28268. October.
- Krause, F. and J. Eto 1988, *Least-Cost Utility Planning - A Handbook for Public Utility Commissioners. Volume Two: The Demand-Side: Conceptual and Methodological Issues*, National Association of Regulatory Utility Commissioners (NARUC), Washington, DC, December.
- Levine, Mark D. and R. Sonnenblick 1994: "On the assessment of utility demand-side management programs," *Energy Policy* Vol. 22, Nr.10, pp. 848-856.
- Nadel, S. 1992: "Utility Demand-Side Management Experience and Potential - A Critical Review," *Annual Reviews of Energy and the Environment*, 17: pp. 507-535.
- Ross, Marc. 1986. "Capital Budgeting Processes at Twelve Large Manufacturers." *Financial Management*. (Winter 1986), pp. 15-22.
- Shakleton, R. et al. 1992: "The Efficiency Value of Carbon Tax Revenue," U.S. Environmental Protection Agency (EPA), Paper presented at the Energy Modelling Forum, Stanford University, Stanford, CA.
- Stiglitz, J.E. 1991: "The Invisible Hand and Modern Welfare Economics," in Vines, D. & Stevenson, A.A. (eds.), *Information, Strategy and Public Policy*, Oxford: Basil and Blackwell.
- Train, Kenneth. 1985. "Discount Rates in Consumers' Energy- Related Decisions: A Review of the Literature." *Energy*. Vol. 10, nr. 12, p. 1234.

Withdrawal/Redaction Marker

Clinton Library

DOCUMENT NO. AND TYPE	SUBJECT/TITLE	DATE	RESTRICTION
--------------------------	---------------	------	-------------

001. list	Meeting on Climate Change Litigation 4:00pm Thursday, October 17, 1996 [PII] [partial] (1 page)	10/17/1996	b(6)
-----------	---	------------	------

COLLECTION:

Clinton Presidential Records
Council of Economic Advisers
Stiglitz, Joseph
OA/Box Number: 9537

FOLDER TITLE:

Climate Change [2]

2017-1095-F
bg239

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

- P1 National Security Classified Information [(a)(1) of the PRA]
- P2 Relating to the appointment to Federal office [(a)(2) of the PRA]
- P3 Release would violate a Federal statute [(a)(3) of the PRA]
- P4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
- P5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]
- P6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Personal record misfile defined in accordance with 44 U.S.C. 2201(3).

RR. Document will be reviewed upon request.

Freedom of Information Act - [5 U.S.C. 552(b)]

- b(1) National security classified information [(b)(1) of the FOIA]
- b(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
- b(3) Release would violate a Federal statute [(b)(3) of the FOIA]
- b(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
- b(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
- b(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
- b(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
- b(9) Release would disclose geological or geophysical information concerning wells [(b)(9) of the FOIA]

Meeting on Climate Change Litigation
4:00 p.m., Thursday, October 17, 1996

Attendees:

2 Dr. Dale Jorgenson
Chairman
Department of Economics
Harvard University

3 Dr. Florentin Krause
Staff Scientist
Lawrence Berkeley Laboratory

1 Philip E. Clapp
Executive Director
Environmental Information Center

4 Dr. Daniel Lashof
Senior Scientist
Natural Resources Defense Council

(b)(6)

(b)(6)

(b)(6)

(b)(6)

Cleared
for 4 pm [001]

Withdrawal/Redaction Marker

Clinton Library

DOCUMENT NO. AND TYPE	SUBJECT/TITLE	DATE	RESTRICTION
002. fax	Environmental Information Center Fax cover sheet [PII] [partial] (1 page)	10/17/1996	b(6)

COLLECTION:

Clinton Presidential Records
Council of Economic Advisers
Stiglitz, Joseph
OA/Box Number: 9537

FOLDER TITLE:

Climate Change [2]

2017-1095-F
bg239

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

- P1 National Security Classified Information [(a)(1) of the PRA]
- P2 Relating to the appointment to Federal office [(a)(2) of the PRA]
- P3 Release would violate a Federal statute [(a)(3) of the PRA]
- P4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
- P5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]
- P6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

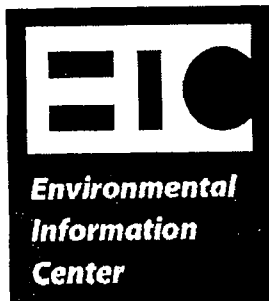
C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Personal record misfile defined in accordance with 44 U.S.C. 2201(3).

RR. Document will be reviewed upon request.

Freedom of Information Act - [5 U.S.C. 552(b)]

- b(1) National security classified information [(b)(1) of the FOIA]
- b(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
- b(3) Release would violate a Federal statute [(b)(3) of the FOIA]
- b(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
- b(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
- b(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
- b(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
- b(9) Release would disclose geological or geophysical information concerning wells [(b)(9) of the FOIA]



1400 16th Street, NW
Suite 330, Box 5
Washington, DC 20036-2266
Phone 202.797.6500

Fax 202.797.6501
Email eicinfo@acpa.com or
[first initial] + [lastname]@acpa.com
Web <http://www.igc.apc.org/eic>



FAX COVER SHEET

Fax to: Sandy in Dr. Stiglitz office

Date: 10.17.96

Fax Number: 202 395-6958

From: Angie Greene

Pages: 1

The following people will be visiting the offices of Dr. Stiglitz today at 4.00 p.m.

Name	Date of Birth
------	---------------

Philip E. Clapp	
-----------------	--

Dale Jorgenson	(b)(6)
----------------	--------

Florentin Krause	
------------------	--

[002]

Dan Lashoff is the fourth member of the party. However, I believe that his assistant has already sent you his particulars. If you need to verify this, his office number is 202 289-6868.

If you have any further questions, please call me at 202 797-6524.

Dr. Florentin Krause, Director
International Project for Sustainable Energy Paths (IPSEP)
7627 Leviston Ave, El Cerrito, CA 94530 USA
Tel. (510) 525 7530, Fax (510) 525 4446
email: ipsep@igc.apc.org

To: *JOSEPH STIGLITZ*
COUNCIL OF ECONOMIC ADVISORS
OLD EXECUTIVE OFFICE BLDG.
WASHINGTON, DC 20502

Date: *15 OCT 96*

Dear Dr. Stiglitz,
In preparation for your meeting with him,
Dr. Krause asked that I send the enclosed materials.

With regards,

Sarah S. Davis

Sarah S. Davis
IPSEP Publications Director

Withdrawal/Redaction Marker

Clinton Library

DOCUMENT NO. AND TYPE	SUBJECT/TITLE	DATE	RESTRICTION
003. fax	Natural Resources Defense Council fax cover sheet [PII] [partial] (1 page)	10/16/1996	b(6)

COLLECTION:

Clinton Presidential Records
Council of Economic Advisers
Stiglitz, Joseph
OA/Box Number: 9537

FOLDER TITLE:

Climate Change [2]

2017-1095-F
bg239

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

- P1 National Security Classified Information [(a)(1) of the PRA]
- P2 Relating to the appointment to Federal office [(a)(2) of the PRA]
- P3 Release would violate a Federal statute [(a)(3) of the PRA]
- P4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
- P5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]
- P6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Personal record misfile defined in accordance with 44 U.S.C. 2201(3).

RR. Document will be reviewed upon request.

Freedom of Information Act - [5 U.S.C. 552(b)]

- b(1) National security classified information [(b)(1) of the FOIA]
- b(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
- b(3) Release would violate a Federal statute [(b)(3) of the FOIA]
- b(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
- b(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
- b(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
- b(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
- b(9) Release would disclose geological or geophysical information concerning wells [(b)(9) of the FOIA]

The Natural Resources Defense Council

1200 New York Avenue, N.W.

Suite 400

Washington, DC 20005

Phone: (202) 289-6868

Fax: (202) 289-1060

Date: 10/16/96

To:

Michelle Julia

Fax #:

395-6958

From:

Deborah Faulkner

Phone: 202-289-6868

Total pages of fax (including cover): 2

Message:

Don Harlow's birthdate -

(b)(6)

[003]



**Environmental
Information
Center**

1400 16th Street, NW
Suite 330, Box 5
Washington, DC 20036-2266
Phone 202.797.6500

Fax 202.797.6501
Email eicinfo@acpa.com or
[first initial]+[lastname]@acpa.com
Web <http://www.igc.apc.org/eic>

October 1, 1996

Ms. Michele Jolin
Chief of Staff
Counsel of Economic Advisors
OEB Room 314
Washington, D.C. 20500

Dear Michele:

Per your request, I have enclosed a brief biography of Dale Jorgenson and Florentin Krause, the two economists that we would like Mr. Stiglitz to meet with concerning the economics of climate change mitigation. As you will see from his biography, Dr. Jorgenson is the Chairman of Harvard's Department of Economics and a co-author of a macroeconomic model that I understand to be under consideration by the Interagency Task Force. Dr. Krause is a Staff Scientist at the Lawrence Berkeley Laboratory, the Director of the International Project for Sustainable Energy Paths and one of the lead authors of the IPCC Working Group III report on the economics of mitigating climate change.

I greatly appreciate your help in setting up the meeting. I will speak with you soon.

Sincerely yours

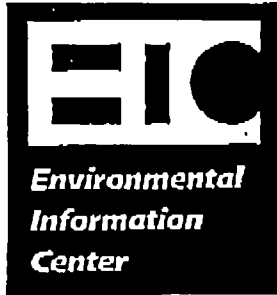
Doug Kendall

Enclosures

*Alice -
This has
been scheduled
for 4PM ON Oct. 11.
Would you
please pass
this info on
to Ray Brink
and Alicia?
Thanks -
M*

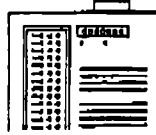
OCT.-01'96(TUE) 15:42

cc: Alicia Munoz
Ray Priner P 001



1400 16th Street, NW
Suite 330, Box 5
Washington, DC 20036-2266
Phone 202.797.6500

Fax 202.797.6530
Email eicinfo@acpa.com or
[first initial] + [lastname]@acpa.com
Web <http://www.igc.apc.org/eic>



FAX COVER SHEET

Fax to: Michele John

Date: 10/1/96

Fax Number: 202 393-6958

From: Doug Kendall

Pages Incl. Cover: 5

Comments:



**Environmental
Information
Center**

1400 16th Street, NW
Suite 330, Box 5
Washington, DC 20036-2266
Phone 202.797.6500

Fax 202.797.6501
Email eicinfo@acpa.com or
[first initial] + [lastname]@acpa.com
Web <http://www.igc.apc.org/eic>



FAX COVER SHEET

Fax to: Michele Jolin
Date: 10.16.96
Fax Number: 202 395-6958
From: Doug Kendall
Pages + This Cover: 2

Michele:

Here is the bio for Phil Clapp, Executive Director, Environmental Information Center.

Phil is attending the meeting with Dr. Stiglitz, tomorrow at 4.00 p.m.

If you need anything further, please call me.

Doug.

Clinton Presidential Records Digital Records Marker

This is not a presidential record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

This marker identifies the place of a publication.

Publications have not been scanned in their entirety for the purpose of digitization. To see the full publication please search online or visit the Clinton Presidential Library's Research Room.

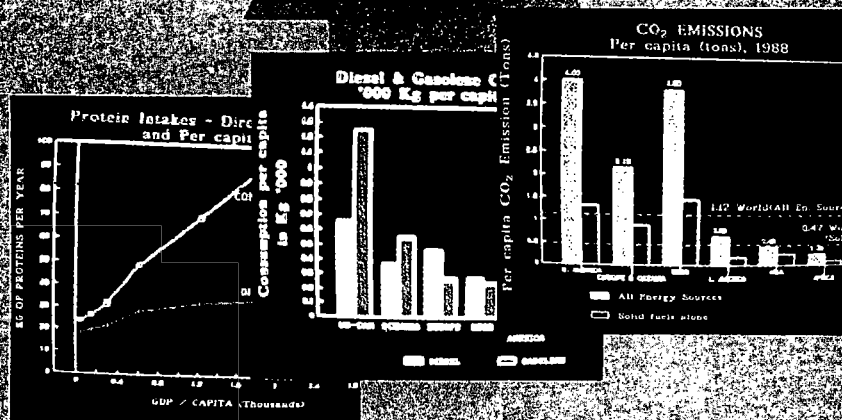
Consumption Patterns:
The Driving Force of Environmental
Stress October 1991

(14)

CONSUMPTION PATTERNS

THE DRIVING FORCE OF ENVIRONMENTAL STRESS

Jyoti Parikh
Kirit Parikh
Subir Gokarn
J.P. Painuly
Bibhas Saha
Vibhooti Shukla



Indira Gandhi Institute of Development Research

Gen. A. K. Vaidya Marg, Goregaon (East), Bombay - 400 065 (INDIA)



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

July 18, 1996

TO: Jack Lew
Bob Rubin
✓ Joe Stiglitz
Laura Tyson
Katie McGinty
Kitty Higgins
John Angell
Carol Rasco
Larry Haas

FROM: TJ GLAUTHIER *AMJ for TJ*

SUBJECT: MINISTERIAL DECLARATION AND U.S. STATEMENT TO THE CLIMATE
CHANGE CONFERENCE IN GENEVA

Attached you will find the Ministerial Declaration adopted this afternoon at the Climate Change Conference in Geneva as well as a statement by Assistant Secretary Claussen. Assistant Secretary Claussen's statement was developed in cooperation with the business community and other U.S. representatives attending the conference.

Members of the environmental community are pleased with the Declaration and Assistant Secretary Claussen's statement. Reception in the business community, however, is mixed. Some in business are pleased. Others, while concerned with the potential long-term commitments, seem reasonably satisfied with the additional statement by Assistant Secretary Claussen which emphasizes the importance of emissions trading and flexibility in any long-term commitments.

There are no "actual" commitments in either the Declaration or the statement. Rather, the Ministerial Declaration and Assistant Secretary Claussen's statement put forth a set of principles for negotiations to the protocol over the next year to 18 months.

Attachments

cc: Dan Tarullo
Elgie Holstein
Elizabeth Drye

United States
Statement to the COP
July 18, 1996

Thank You Mr Chairman.

The U.S. would like to whole-heartedly endorse this excellent declaration. In our view, this declaration makes three critical points:

- First, we must move forward on the basis of the new and compelling scientific evidence;
- Second, next steps should focus on legally binding targets; and
- Third, the process needs to move forward rapidly to complete its critical work by COP-3 in Japan next year.

See below for clarification

We would also like to add one point that was not specified in the declaration. We believe, and we made clear yesterday, that our negotiated outcome must ensure maximum national flexibility for all Parties to implement their medium-term, legally binding commitments. We also need to continue working toward a longer term concentration goal. To this end, we believe the inclusion of activities implemented jointly on a global basis, and international emissions trading must be part of any future regime. We believe these views are fully reflected in the language of this admirable declaration.

Thank You.

We would also like to add one point that was not specified in the declaration. We believe, and we made clear yesterday that our negotiated outcome must...

18 July 1996, 12:00

MINISTERIAL DECLARATION

The Ministers and other heads of delegations present at the second session of the Conference of the Parties to the United Nations Framework Convention on Climate Change,

Noting that this, our meeting at Ministerial level under the Convention, is a demonstration of our intention to continue to take an active and constructive role in addressing the threat of climate change,

1. Recall Article 2 of the Convention; the principles of equity and of common but differentiated responsibilities and respective capabilities in Article 3.1 of the Convention; and the provisions of Article 3.3 concerning precautionary measures; as well as the specific national and regional development priorities, objectives and circumstances of the Parties to the Convention;

2. Recognize and endorse the Second Assessment Report of the IPCC as currently the most comprehensive and authoritative assessment of the science of climate change, its impacts and response options now available. Ministers believe that the Second Assessment Report should provide a scientific basis for urgently strengthening action at the global, regional and national levels, particularly action by Annex I Parties to limit and reduce emissions of greenhouse gases, and for all Parties to support the development of a Protocol or another legal instrument; and note the findings of the IPCC, in particular the following:

- The balance of evidence suggests a discernible human influence on global climate. Without specific policies to mitigate climate change, the global average surface temperature relative to 1990 is projected to increase by about 2C (between 1C and 3.5C) by 2100; average sea level is projected to rise by about 50 centimetres (between 15 and 95 centimetres) above present levels by 2100. Stabilisation of atmospheric concentrations at twice pre-industrial levels will eventually require global emissions to be less than 50 per cent of current levels;

- The projected changes in climate will result in significant, often adverse, impacts on many ecological systems and socio-economic sectors, including food supply and water resources, and on human health. In some cases, the impacts are potentially irreversible; developing countries and small island countries are typically more vulnerable to climate change;

- Significant reductions in net greenhouse gas emissions are technically possible and economically feasible by utilising an array of technology policy measures that accelerate technology development, diffusion and transfer; and significant no regrets opportunities are available in most countries to reduce net greenhouse gas emissions.

3. Believe that the findings of the Second Assessment Report indicate that the continued rise of greenhouse gas concentrations in the atmosphere will lead to dangerous interference with the climate system, given the serious risk of an increase in temperature and particularly the very high rate of temperature change;

4. Recognize also the need for continuing work by the IPCC to further reduce scientific uncertainties, in particular regarding socio-economic and environmental impacts on developing countries, including those vulnerable to drought, desertification or sea-level rise;

5. Reaffirm the existing commitments under the Convention, including those intended to demonstrate that Annex I Parties are taking the lead in modifying longer-term trends in emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol, and agree to strengthen the process under the Convention for the regular review of the implementation of present and future commitments;

6. Take note that Annex I Parties are fulfilling their commitments to implement national policies and measures on the mitigation of climate change. Also take note that this is not the only commitment that Annex I Parties have made and that many of these Parties need to make additional efforts to overcome difficulties that they face in achieving the aim of returning their emissions of greenhouse gases to 1990 levels by 2000;

7. Acknowledge the considerable work done by the Ad Hoc Group on the Berlin Mandate (AGBM) since the first session of the Conference of the Parties, including the substantive proposals presented by a number of Parties, and call on all Parties to come forward with proposals to facilitate substantive negotiations beginning at the fifth session of AGBM in December 1996.

8. Instruct their representatives to accelerate negotiations on the text of a legally-binding protocol or another legal instrument to be completed in due time for adoption at the third session of the Conference of the Parties. The outcome should fully encompass the remit of the Berlin Mandate, in particular:

- commitments for Annex I Parties regarding:

- policies and measures including, as appropriate, regarding energy, transport, industry, agriculture, forestry, waste management, economic instruments, institutions and mechanisms;
- quantified legally-binding objectives for emission limitations and significant overall reductions within specified timeframes, such as 2005, 2010, 2020, with respect to their anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol;

- commitments for all Parties on continuing to advance the implementation of existing commitments in Article 4.1;

- a mechanism to allow the regular review and strengthening of the commitments embodied in a Protocol or other legal instrument;

- commitments to a global effort to speed up the development, application, diffusion and transfer of climate-friendly technologies, practices and processes; in this regard, further concrete action should be taken.

9. Welcome the efforts of developing country Parties to implement the Convention and thus to address climate change and its adverse impacts and, to this end, to make their initial national communications in accordance with guidelines adopted by the Conference of the Parties at its second session; and call on the GEF to provide expeditious and timely support to these Parties and initiate work towards a full replenishment in 1997;

10. Recognize that the continuing advancement of existing commitments by developing country Parties, in the context of their national priorities for sustainable development, requires determined and timely action, in particular by Annex II Parties. Access to financial resources and to environmentally-sound technologies consistent with Articles 4.3, 4.4, 4.5 and 4.7 will be most critical;

11. Thank the Government of the Swiss Confederation for its contribution to the work of the second session of the Conference of the Parties in Geneva and look forward to meeting again at the third session in Kyoto, in 1997, thanks to the generous offer of the Government of Japan.

.....

CC: RP

July 16, 1996

MEMORANDUM

SUBJECT: Background Materials on U.S. Policy at Climate Change Negotiations

FROM: Steve Seidel, Special Coordinator for Climate Change, CEQ *Seidel*

TO: Joseph Stiglitz/Alicia Munnell, CEA ✓
Jack Gibbons/Rosina Bierbaum, OSTP
T.J. Glauthier/Bob Tucillo, OMB
Laura Tyson/Elgie Holstein, NEC
Jennifer Haverkamp, USTR
Leon Fuerth/Pete Jordan, OVP
David Sandalow, NSC/CEQ
Charlie Rawls, USDA
Marc Chupka/Dirk Forrister, DOE
David Gardner/Mary Nichols, EPA
Ev Ehrlich/Jeffrey Hunker, Commerce
Rafe Pomerance, State
Josh Gottbaum, Treasury
Frank Krusei, DOT
Lois Schiffer, Justice
Brooke Yeager, Interior

Attached are Undersecretary Wirth's Ministerial Statement and related background material for your information. The statement is embargoed until after it is delivered this Wednesday morning, July 17 at about 11 am in Geneva. Press inquiries can be directed to Nick Burns at State Dept.

**TALKING POINTS
STATEMENT TO INDUSTRY/NGOs ON U.S. INTERVENTION
AT CLIMATE CHANGE NEGOTIATIONS**

- This morning, the United States will make a significant statement outlining future directions for the climate change negotiations that will take place over the next 18 months.
- Under the 1992 Framework Convention on Climate Change (signed by the Bush Administration) the major industrialized nations agreed to a non-binding greenhouse gas emissions reduction target. Today, at the Second Conference of the Parties to the Convention, the U.S. will propose that negotiations for post-2000 emissions reductions focused on realistic, binding commitments that will produce real environmental benefits.
- Arriving at the decision to propose this kind of framework -- and deciding upon specific targets in the future -- is the result of extensive on-going analysis and assessment by the Clinton Administration. In response to last Spring's agreed Berlin Mandate, the Administration has embarked on an ambitious analytic review and outreach effort.
- These efforts have included extensive analysis by the major technical agencies and experts -- including the Department of Energy, EPA, Commerce, CEA and others. We also have held a major workshop on analysis and assessment, which included presentations from more than 50 experts from inside and outside of government about technical issues associated with our emissions trends and capability to reduce emissions in the next century. Complementing these efforts have been a series of roundtable discussions that Assistant Secretary Eileen Claussen has hosted with industry, NGOs and other experts.
- Internationally, analysis and assessment that has been undertaken by the Organization for Economic Cooperation and Development (OECD). Ongoing efforts have also been underway in other institutions, such as the IEA.
- Together with the on-going international scientific process, our analytical efforts have led us to today's decision to call for a new direction in the structure of emissions reduction targets under the Convention. Let me touch briefly on our rationale behind our decision.
- The first and foremost reason for launching this new direction is the science. The recently issued second assessment report of the Intergovernmental Panel on Climate Change has reinforced the strong concerns already established by the international scientific community about likelihood and implications of climate change, as well as the role of human activities in influencing such changes.
- Second, the existing framework of non-binding targets has failed. Most developed nations, including the US will not achieve the goal

set for the year 2000. If we want to be serious about reducing emissions in the future, we have to face up to the fact that the current structure has been largely unsuccessful and that we need to adopt a new course.

- Third, non-binding goals lead to uneven results. Countries treat non-binding goals with varying degrees of effort, seriousness and success. Clear, realistic and agreed objectives are needed to ensure that all nations will honor their commitments to reduce emissions. This is important for environmental and competitiveness reasons.
- In view of these points, we are calling for a shift in the Climate Convention's framework -- from one based on rhetorical, non-binding goals, to one based on realistic, binding commitments that produce real environmental benefits. We believe decisions about the most appropriate measures required to meet the agreed targets should be left to individual governments. We are calling for the maximum use of cost-effective and flexible policies (including emissions trading among nations) to achieve the greatest reductions at the lowest cost; while opposing rigid, binding policies and measures.
- We are convinced that the target must be both realistic and binding because it is only through the surety of a commitment of this nature that governments will take their obligations seriously and the only way we can be assured of progress.
- We are also convinced that it is the target that should be binding, not the individual measures, thus allowing maximum flexibility in implementation. Continued use of non-binding targets that are not met makes a mockery of the treaty process. It leaves the impression that rhetoric is what counts rather than real emission reductions -- an outcome that is both unacceptable and counterproductive.
- We have not yet proposed a specific target and timetable, but intend to do so following the completion of on-going analysis and assessment. It is important to note, however, that our analysis has determined that some of the proposals containing targets and timetables that have been tabled to date (e.g. the AOSIS protocol) are unrealistic and unsupportable. Furthermore, we are not wedded to the current target and timetable structure. A target must set a clear and binding commitment, but it could be defined in a number of ways (for example, as a multi-year rolling average).
- Finally, let me take this opportunity announce that in order to coordinate the intensive effort that we anticipate in the weeks and months ahead, we are pleased that the Undersecretary of Commerce for Economic Affairs, Dr. Everett Ehrlich, has agreed to chair the interagency analytic effort. U/S Ehrlich brings extensive public and private sector experience to this task and we are fortunate to have him.

Geneva Climate Change Negotiations

- Q: What are the new elements of United States climate change policy announced in Geneva today by Undersecretary Wirth?
- A: -- UNDER THE 1992 FRAMEWORK CONVENTION ON CLIMATE CHANGE, SIGNED BY THE BUSH ADMINISTRATION, THE MAJOR INDUSTRIALIZED COUNTRIES AGREED TO A NON-BINDING GREENHOUSE GAS EMISSION REDUCTION TARGET. TODAY, AT THE SECOND CONFERENCE OF THE PARTIES TO THE CONVENTION, THE UNITED STATES PROPOSED STRENGTHENING THAT EARLIER AGREEMENT BY SHIFTING THE FRAMEWORK FROM NON-BINDING COMMITMENTS TO BINDING ONES.
- WE HAVE ALSO CALLED FOR THE MAXIMUM USE OF COST-EFFECTIVE AND FLEXIBLE POLICIES TO ACHIEVE THE GREATEST REDUCTIONS AT THE LOWEST COST AND HAVE OPPOSED THE USE OF RIGID REGULATORY APPROACHES.
- THIS ROUND OF NEGOTIATIONS IS SCHEDULED TO REACH A NEW AGREEMENT IN THE FALL OF 1997.
- Q: Why did the United States call for binding targets for future emissions reductions?
- A: -- THE EXISTING FRAMEWORK (A NON-BINDING TARGET OF RETURNING EMISSIONS TO 1990 LEVELS BY THE YEAR 2000) HAS BEEN LARGELY UNSUCCESSFUL. MOST DEVELOPED NATIONS, INCLUDING THE UNITED STATES, WILL NOT ACHIEVE THIS GOAL. A BINDING, YET REALISTIC TARGET, WILL REQUIRE A GREATER COMMITMENT BY NATIONS TO REDUCE GREENHOUSE GAS EMISSIONS.
- THE MOST RECENT SCIENTIFIC REPORT, WITH PARTICIPATION FROM 2,500 OF THE WORLD'S LEADING CLIMATE EXPERTS, REINFORCES THE VALIDITY OF THE CLIMATE CHANGE THREAT AND DEMONSTRATES THAT A STRONGER COMMITMENT TO REDUCE EMISSIONS IS NEEDED.
- A FAILURE TO TAKE MEANINGFUL ACTIONS NOW WOULD SUBJECT FUTURE GENERATIONS TO UNACCEPTABLE ECONOMIC COSTS, HUMAN HEALTH PROBLEMS, AND ENVIRONMENTAL HARM.
- Q: Aren't there still a lot of questions in the scientific community about whether climate change is a legitimate threat?
- A: -- NO. THE SCIENTIFIC FINDINGS FROM THE WORLD'S CLIMATE EXPERTS ARE CLEAR: HUMAN BEINGS ARE ALTERING THE EARTH'S NATURAL CLIMATE SYSTEM.
- WHILE A FEW SKEPTICS WOULD ARGUE CLIMATE CHANGE WILL BE TOO SMALL TO MATTER, THEIR CASE HAS FOUND LITTLE CREDIBILITY AMONG INDEPENDENT SCIENTISTS.
- Q: Why is it that the U.S. proposal would place additional obligations on our industry while exempting developing countries who will soon be responsible for over half of global greenhouse gas emissions?
- A: -- WE HAVE SAID THROUGHOUT THAT WHILE THE RESPONSIBILITIES OF DEVELOPED AND DEVELOPING COUNTRIES ARE DIFFERENT, ALL NATIONS MUST TAKE STEPS TO REDUCE GREENHOUSE GAS EMISSIONS. ADDRESSING CLIMATE CHANGE IS A GLOBAL CHALLENGE REQUIRING THE PARTICIPATION OF EVERY NATION.

-2-

-- GIVEN OUR FAR GREATER RESOURCES AND TECHNOLOGICAL KNOW-HOW, DEVELOPED COUNTRIES MUST TAKE THE LEAD IN REDUCING GREENHOUSE GAS EMISSIONS.

-- AT THE SAME TIME, EVEN THE EXISTING REQUIREMENTS OF THE CLIMATE CONVENTION DO NOT GIVE DEVELOPING COUNTRIES A FREE RIDE -- THEY TOO MUST DEVELOP PLANS AND TAKE ACTIONS TO REDUCE THEIR EMISSIONS.

Q: Is it true, as some claim, that U.S. proposals will cause a large increase in energy costs to consumers and reduce GDP growth by several percent?

A: -- WHILE THE U.S. HAS PROPOSED A FRAMEWORK FOR THE NEGOTIATIONS, WE HAVE NOT PROPOSED A SPECIFIC TARGET OR TIMETABLE BECAUSE WE HAVE NOT YET COMPLETED OUR ONGOING ANALYSIS AND ASSESSMENT PROCESS.

-- THUS, ANY ESTIMATES OF COSTS ARE SIMPLY EXAMPLES OF SPECIAL INTERESTS "CRYING WOLF." WE ARE CURRENTLY CAREFULLY ANALYZING COST IMPACTS AND BELIEVE THAT COST-EFFECTIVE ACTIONS ARE POSSIBLE THAT WILL RESULT IN SUBSTANTIAL LONG-TERM BENEFITS WITHOUT HARMING THE ECONOMY.

final draft 7/15/96 12:00 noon

The Honorable Timothy E. Wirth
on behalf of the United States of America

Second Conference of the Parties
Framework Convention on Climate Change

Geneva, Switzerland
July 17, 1996

Thank you, Mr. Chairman. Let me begin by congratulating you, Mr. Chimutengwende, on your selection as Chair of the Conference. My government appreciates your willingness to assume this important role and the leadership you have brought to this task. I also want to take this opportunity to congratulate the distinguished representative from Germany, Angela Merkle, for the remarkable job that she did in guiding the work under this Convention over the past several years. The task of moving forward more than 150 nations is difficult enough. In this instance, however, the challenge has been compounded by the fact that we are dealing with what is probably the most complicated scientific, environmental, economic and political challenge in history. The international community is in your debt for hosting us and helping us reach the mandate agreed upon in Berlin last year.

Since Berlin, our deliberations have benefitted from the careful, comprehensive and uncompromised work of the Intergovernmental Panel on Climate Change, whose efforts serve as the foundation for international concern and whose clear warnings about current trends are the basis for the sense of urgency which my government holds in these matters. We are not swayed by and strongly object to the recent allegations about the integrity of the IPCC's conclusions. These concerns were raised not by the scientists involved in the IPCC; not by participating governments, but rather by naysayers and special interests bent on belittling, attacking and obfuscating climate change science. So let's take a false issue off the table, there can be no question but that the IPCC's findings meet the highest standards of scientific integrity.

In the ongoing scientific effort, Mr. Chairman, I want to note that the United States is proud of the more than \$1 billion annual investment it has been making in recent years on global change research. This is a cost we have taken on in order to enhance our own and the world's understanding of the Earth's atmospheric, oceanic and biological systems and represents not only the seriousness with which we view these matters, but also the willingness of President Clinton and the American people to help pioneer progress on behalf of the environment.

My government took very seriously the IPCC's recently issued Second Assessment Report, which underscored and amplified the panel's initial work -- refining estimates and revealing new understandings that serve to signal even louder alarm bells. From our perspective, the most salient of these findings are as follows:

- The chemical composition of the atmosphere is being altered by anthropogenic emissions of greenhouse gases.
- The continued buildup of these gases will enhance the natural greenhouse effect and cause the global climate to change.
- Based on these facts and additional underlying science, the second assessment reported that "the balance of evidence suggests that there is a discernible human influence on global climate." This seemingly innocuous comment is in fact a remarkable statement: for the first time ever, the world's scientists have reached the unavoidable conclusion that the world's changing climatic conditions are more than the natural variability of weather. Human beings are altering the Earth's natural climate system.

In turn, the best scientific evidence indicates that human-induced climate change, if allowed to continue unabated, could have profound consequences for the economy and the quality of life of future generations:

Human health is at risk from projected increases in the spread of diseases like malaria, yellow fever and cholera;
Food security is threatened in certain regions of the world;
Water resources are expected to be increasingly stressed, with substantial economic, social and environmental costs in regions that are already water-limited, and perhaps even political costs where there is already conflict over limited resources.
Coastal areas -- where a large percentage of the global population lives -- are at risk from sea level rise.

In our opinion, the IPCC has clearly demonstrated to policymakers that action must be taken to address this challenge and that, as agreed in Berlin, more needs to be done through the Convention. This problem cannot be wished away. The science cannot be ignored and is increasingly compelling. The obligation of policymakers is to respond with the same thoughtfulness that has characterized the work of the world's scientific community.

Unhappily, Mr. Chairman, while the established international scientific process is working well, the international policy process, as established under the Convention, has not been as successful. The shortcomings of the Convention -- its failure to address the post-2000 period, for example -- were well explored in Berlin and do not bear repeating today. The most salient fact is now more apparent than ever: the current Convention structure has not achieved the results that were anticipated and planned for in good faith; few

nations in either the developed or developing world have been fully successful in meeting their commitments under articles 4.1 and 4.2 of the Convention. We have to do better.

Over the past year, the United States has been engaged at home and internationally in serious analysis of the successes and failures of the current Convention structure, as well as of the practicality of the various proposals for next steps that have been put forward in recent discussions. While we still have much work to do, our analysis and consideration of this issue to date have led us to certain conclusions about the form of an agreement we hope these negotiations will consider and pursue. In the months ahead, our ongoing analysis and assessment will allow us to more precisely articulate the specific contents that the United States could support.

We begin, Mr. Chairman, from the following base set of principles, which will guide our consideration of proposals and which we believe should guide our multilateral negotiations:

- First, our negotiations must be about proposals that will result in protection of human health and the environment. The current structure has been largely unsuccessful in this regard. We are not interested in grand rhetorical goals that are impossible to realize. We want the negotiations to focus on outcomes that are real and achievable. Sound policies pursued in the near term will allow us to avoid the prospect of truly draconian and economically disruptive policies in the future. Measured adjustments now and in the years ahead will enable all nations to reduce emissions in an economically sensible manner. Denial and delay will only make our economies vulnerable in the future.
- Second, the United States will continue to seek solutions that are flexible and cost-effective, as we have consistently. We will not accept proposals that are offered for competitive, not environmental reasons. Serious proposals in the future must not be thinly veiled attempts to gain economic advantage. This is a global problem with global impacts and therefore requires solutions that are fair, and that will ensure prosperity -- now and in the future -- for all the world's people.
- And third, the agreement should lay the foundation for continuing progress by all nations in the future. The United States is immovable in its belief that international cooperation on this challenge remains critical to any effective response and that all nations -- developed and developing -- will have to become more ambitious in contributing to the solution to this challenge as we move forward. We believe that, while this is a long-term challenge, short-term signals about the importance of this challenge must be sent unmistakably to the public and private

sectors everywhere. Climate change is a serious problem and will require sustained long-term investment and the full creativity of the marketplace to be addressed successfully.

President Clinton has urged all Americans and all nations to prepare their economies for the 21st century. Meeting this challenge requires that the genius of the private sector be brought to bear on the challenge of developing the technologies that are necessary to ensure our long-term environmental and economic prosperity.

Based on these principles -- encompassing environmental protection, economic prosperity, flexibility, fairness and comprehensiveness -- the United States recommends that future negotiations focus on an agreement that sets a realistic, verifiable and binding medium-term emissions target. We believe that the medium-term target must be met through maximum flexibility in the selection of implementation measures, including the use of (measures such as) reliable joint implementation and trading mechanisms. In addition, our view is that it will be necessary to continue working toward a longer-term concentration goal (e.g. for the next 50-100 years), as set out in the Convention's objective, recognizing that scientific understanding and technology will improve over time. Working toward such a goal would better establish the long-term, global nature of the problem.

Having outlined in broad terms the basic components of an agreement we could support, I want to underscore the expectation of the United States that the agreement be realistic and achievable. Our preliminary analysis of the targets that have been tabled for consideration to date suggests that these proposals are neither realistic nor achievable -- either because they would compromise other important principles, such as the need for flexibility in time and place of implementation, or because they involve timeframes and objectives that are not consistent with national and international prosperity. Our job in the months ahead is to search for agreement on a next step that will produce results that are consistent with our environmental and economic aspirations.

Others have suggested that the negotiations move toward consideration of some ambitious mandatory, internationally coordinated policies and measures. In particular, suggestions are emerging for annexes to the agreement outlining specific actions that relevant Parties would be required to undertake, such as, for example, agreed fiscal or regulatory policies. In our view, the significant differences in national circumstances and individual national approaches to these matters suggest that few, if any individual measures are likely to be applicable to all countries. Therefore, the United States opposes mandatory harmonized policies and measures. We are open to the possibility of exploring consensus on agreed procedural measures, for example those that might be necessary to implement an international trading regime or ensure enhanced reporting.

Finally, Mr. Chairman, I want to discuss what has been and remains a difficult component of the negotiations but it is essential if we are to make progress over the long-term in preventing harmful climate changes. The United States is committed in these negotiations to ensuring that all countries -- developed and developing -- take steps to limit emissions, consistent with the mandate agreed upon last year in Berlin. We look forward to working together to develop strategies for advancing implementation of this Convention. While we recognize that developed countries have the responsibility to lead, we also believe that this effort must be a partnership with all nations contributing to the Convention's objective. We stand ready to continue our efforts to provide technical expertise to work with developing countries to reduce greenhouse gas emissions. This will be a major issue in the months ahead and we expect it to be taken up in earnest, as with the other issues I have mentioned, in December.

In summary, we have come to the conclusion that the current structure of the Convention is less than ideal. Performance under the current regime -- or lack thereof -- suggests that a new model must be considered. Next steps must be structured in a way that will help produce the desired results -- not just more rhetoric. We believe that circumstances warrant the adoption of a realistic but binding target, leaving it to individual governments to decide the most appropriate measures needed to meet the agreed target. We are convinced that the target must be both realistic and binding because it is only through the surety of a commitment of this nature that governments will take their obligations seriously and the only way we can be assured of progress.

We are also convinced that it is the target that should be binding, not the individual measures, thus allowing maximum flexibility in implementation. Continued use of non-binding targets that are not met makes a mockery of the treaty process. It leaves the impression that rhetoric is what counts rather than real emission reductions -- an outcome that is both unacceptable and counterproductive.

Mr. Chairman, the United States is committed to making the international climate change process work. As I indicated today, the science is increasingly convincing: it is evident that concern about global warming is real and that we must continue to take steps to address this problem consistent with our long-term economic and environmental aspirations. Working together, it is imperative that we marshal the creativity and will that is necessary to address this far-reaching challenge in an aggressive manner. The United States will be participating in this effort with a view towards negotiating an agreement that is comprehensive, flexible, fair and certain. In this way, we hope to outline an agreement that will help prepare our country and the world -- environmentally and economically -- for the next century.

Draft 7/16

CLIMATE CHANGE NEGOTIATIONS
BACKGROUND QUESTIONS AND ANSWERS

BINDING TARGET

Q. Why did the U.S. propose that any emission target be binding?

A. Our proposal called for setting a realistic binding target and timetable for reductions. We think the current framework, which relies on a non-binding aim, inevitably leads to more rhetoric than action and therefore does not effectively advance the goals of reducing the health and environmental risks from climate change.

Q. Why should a binding target make any difference?

A. Many environmental and other related international agreements contain binding commitments (e.g., Montreal Protocol, CITES, London Dumping, etc.). Given the latest scientific evidence, which supports the need for stronger action, we believe a change in the Convention's framework to a binding commitment would shift the discussion from what might be done to what can realistically and will be done.

Q. Won't a binding commitment hurt US competitiveness?

A. No. The idea behind a binding agreement is to encourage compliance. Non-binding agreements may be viewed differently by different countries. We want all developed countries to face a clear commitment and to play by the same rules. We think this will ultimately work to the benefit of U.S. competitiveness and the environment.

Q. How would a binding commitment be enforced? Would it entail penalties?

A. Environmental agreements employ a number of measures from political and moral persuasion to the use of penalties. We need to carefully balance our desire to encourage others to comply, with our interests in maintaining flexibility at home. We do not at this time have a specific position on which compliance measures would be most appropriate.

DEVELOPING COUNTRIES

Q: Why were developing countries "exempt" from any requirements under the Berlin Mandate?

A: Developing countries do not get a "free ride" under the terms of the Berlin Mandate. They must take steps to "advance" their commitments under Article 4.1 which specifically calls on them to take actions to limit greenhouse gas emissions.

Q: But the Berlin Mandate makes clear any "new" commitments would apply only to developed countries. This would include the U.S. proposal to make any target binding. Won't this just make the competitiveness problems worse?

A: Developed nations have both greater resources and technological know-how to deal with concerns about climate change, and the U.S. is still the largest single emitter of greenhouse gas emissions. For example, carbon dioxide emissions from the U.S. auto fleet alone are larger than total emissions of carbon dioxide from energy from the entire continent of Africa. Per capita emissions of carbon dioxide from energy from the U.S. are: 8 times greater than China; 20 times greater than those from India; and 14 times greater than Brazil. We have to lead in addressing this problem. The failure of most developed countries to meet their 2000 goal of stabilization sends exactly the wrong signal about the seriousness of this problem. How can we expect the developing countries to take actions until we demonstrate that we are willing to act?

We think shifting to a binding aim will demonstrate our increased concern and political commitment to take realistic action. We will make certain that U.S. economic interests, including our competitiveness, are fully protected in the context of setting a specific target and timetable and insuring that maximum flexibility is permitted in meeting those limitations.

Q: What do we expect developing countries to do under their existing commitments?

A: Positive steps are being taken in four areas:

1. Convention Requirements: all nations are required to report on inventories of greenhouse and to adopt policies and measures that reduce emissions of greenhouse gases.

2. Bilateral efforts: the U.S. has established its Country Studies program to provide technical support to developing countries in preparing their country studies and action plans. AID, DOE and EPA all have active bi-lateral programs in developing countries aimed at reducing greenhouse gas emissions.

3. The Global Environmental Facility has been supporting projects and institutional building in developing countries aimed at facilitating actions under the Convention. Unfortunately, Congressional funding for the GEF has been 70% below the Administration's request.

4. We have been supporting efforts by U.S. industry in the area of export promotion of greenhouse friendly technology -- a win-win for the economy and the environment. As part of this effort, we have established an extensive pilot program on joint implementation.

Q: Since developing countries will soon be responsible for over half of total global emissions, how can we solve this problem without their full cooperation?

A: We cannot. That is why it is so critical that steps be taken to continue to engage them in the process and overtime to encourage greater use of greenhouse friendly technologies. But we cannot expect them to take this issue seriously unless and until we demonstrate leadership.

MISCELLANEOUS QUESTIONS

Q: Given that over 100 CEOs from industry wrote to the President urging a "go-slow" policy to avoid actions that could harm the economy, isn't the Administration concerned about the costs of moving forward?

A: The Administration believes that inaction at this time, in light of the growing scientific evidence of climate change, would be inexcusable. Instead, the Administration supports a framework for progress based on realistic binding actions that can be achieved consistent with continued economic prosperity.

Q: Seventeen Republican Senators wrote the President urging that we suspend the negotiations until scientific and economic issues have been resolved? Doesn't that make sense?

A: Some Senators have taken many extreme views during the past year against common sense actions to protect the environment. This letter demonstrates that while they may be trying to change their tune, the substance of what they want has not changed. They would want to base climate policy on the views of a handful of skeptics largely supported by global fossil fuel interests while turning their back on the view held by the vast majority of the 2,500 climate scientists that forms a strong basis for further action.

Q: What if key assumptions (e.g., energy prices, economic growth) underlying the setting of a target prove wrong making it much harder and more costly to meet? Shouldn't we condition meeting any binding target on the validity of these key assumptions over time?

A: The United States has cautioned that any target should be realistic, based on a clear view of what can be achieved.

Furthermore, we have urged in our proposed framework, that flexible, cost-effective approaches be fully utilized including such possibilities as joint implementation, verifiable banking and trading, and targets defined as rolling multi-year averages. Combining realistic targets with flexible implementation should provide adequate safeguards against unintended impacts of meeting a binding target.

Q: It's now a year into analysis and assessment. Why isn't the U.S. prepared to propose a specific target and timetable? What, if anything has the U.S. learned during this time?

A: The June analytical workshop included the presentation of over 50 studies related to next steps under the Berlin Mandate. These analyses are now being reviewed and further refined. Based on our work to date we have developed some tentative conclusions including:

- the current framework based on a non-binding aim has not proven equal to the task of achieving a serious political commitment to reducing emissions;

- flexible approaches over considerable cost-effective opportunities that should be incorporated into any future agreement;

- a target and timetable offers greater prospects for success than any harmonized sector specific controls.

Q: What do we mean by a target? Does this mean a specific emission limitation in a specific year?

A: Not necessarily. We believe that a target must set a clear and binding objective but that it could be defined in a number of potentially attractive cost effective and flexible ways. For example, a target could be a multi-year rolling average to minimize concerns about short-term variations due to weather or economic conditions. It could be met through trading of reductions over time (e.g., through banked reductions) or through verifiable reductions in another country.

Q: ARE DEVELOPING COUNTRY COMMITMENTS CONTINGENT UNDER THE CONVENTION ON ANNEX I COUNTRIES PROVIDING MONEY AND TECHNOLOGIES AS DEVELOPING COUNTRIES SEEM TO CONTEND?

A: No. In Article 4.7 of the convention, it is acknowledged that the extent to which developing countries can effectively implement their commitments depends on the effective implementation, by developed countries, of their commitments mentioned in the Convention with regard to financial assistance and technological

transfer.

Obviously, our support for the Global Environment Facility and our on-going Country Studies Program will serve as incentives for developing countries which might not otherwise have the resources or the administrative wherewithal to carry out their commitments under the convention.

Q: WHAT CONSIDERATION HAVE YOU GIVEN TO THE TYPE OF INSTRUMENT THAT SHOULD BE REPORTED BY THE AGBM?

A: We have given considerable thought to the various options for the type of instrument that might emerge from the AGBM process. At this point, we have not foreclosed options as among possible legal instruments, with the exception of an annex. As may be recalled, it was the United States that insisted that the Berlin Mandate leave open the question whether the process should lead to a protocol or other type of legal instrument.

has moved
into new
phase - stay
tuned

8/3

MS

MEMORANDUM

COUNCIL OF ECONOMIC ADVISERS

FEBRUARY 23, 1995

Climate Change
- What is status?
- Should JES read?

MEMORANDUM TO: JOE STIGLITZ
FROM: MIKE TOMAN *MAT*
SUBJECT: POST-2000 CLIMATE CHANGE REPORT

As I imagine you know, this report was intended to be a follow-up to the Climate change Action Plan, but more sweeping in its vision and less preoccupied with a numerical GHG reduction goal. I have attached a copy of the current version of the report, which is very much a work in progress. Note that it consists of an introduction, a discussion of the science, a very brief discussion of the economics, a decision framework, a discussion of policy measures, and recommendations. Most if not all of these sections remain the subject of nontrivial contention among the staff.

Typically in such a case we would bring options forward to the Deputies, including you. In this case, however, there are other factors at work. Several of the parties involved are not that eager even to have a report, and if they would approve one, it would probably bear very little resemblance to what we would support. For example, there is no agreement on how to treat the economic policy measures. The very brief discussion on the economics was made brief so as to not draw too much attention, and to avoid intractable debates on how bad damages might be. All of this reflects a mixture of concern about the political winds blowing around climate change and the inherent hostility of many to economic reasoning on climate. A further issue is that the Conference of Parties (COP1) in Berlin is less than a month away. There was a time when at least some of the post-2000 players wanted to have a report out before Berlin, but support for this view has ebbed. If the report is not out by COP1, there is a lot less impetus to have it out any time soon.

My view is that we want a good report -- one that provides proper treatment of the economic issues in particular -- but if the most likely outcome is not a good report, it might be better to give the process a chance to die on its own. Based on what you see in the attached and other considerations, do you want me on your behalf to argue strenuously for a quick completion? Do you want me to argue for completion, but not push the timing? Do you want me to try to intervene on specific elements of the current text (I can brief you further on how we ended up where we are, at your convenience)? Or do you want me to lie low and let nature take its course? Thanks for your advice.

I. Introduction

Increases in world population and industrial activities during the last century are affecting the environment at all geographical scales from local to regional to global. Scientists, governments, industry and environmental groups have recognized that one of the most important global issues is climate change. The Earth's climate is predicted to warm several degrees over the next century due to the continued release of heat-trapping gases into the atmosphere from a variety of human activities. The effects of climate change (increasing temperatures, rising sealevel and changes in precipitation patterns) may adversely affect ecological systems and socio-economic sectors.

While much is known about the greenhouse affect, a significant number of uncertainties remain particularly about regional impacts and rates of change. However, it is clear that "greenhouse gas" policies cannot await the time when full impacts are evident. The lag time between emission of the gases and their impact is on the order of decades to centuries; so too is the time needed to reverse any effects. Thus, policy decisions in the near-term will have long-term consequences.

The potential seriousness of human-induced climate change was recognized at the Earth Summit in Rio de Janeiro, Brazil in 1992 when the United States joined more than 150 countries in signing the Framework Convention on Climate Change. In 1993, the United States was the fourth country to ratify the Convention, which had as its major objective (Article 2),

"stabilization of greenhouse concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner".

Several key components of the climate system have time scales ranging from decades to millennia: 1) stabilization of atmospheric concentrations of CO₂ takes centuries after stabilization of emissions; 2) sea level takes centuries to stabilize with a new equilibrium climate; 4) turnover of the capital stock responsible for emissions of greenhouse gases (e.g., power plants) takes many decades; 5) damaged ecological systems take decades to centuries to restore 6) species extinction can never be reversed. However, the time needed to adapt to some of these effects could be much shorter.

In October 1993, the President announced a Climate Change Action Plan that met the twin challenges of responding to the threat of global warming and strengthening the economy. This Plan of cost-effective domestic measures sought to return US emissions to 1990 levels in the year 2000. It included all greenhouse gases, all sectors of the economy, and was largely based on fostering voluntary partnerships with business. When the Plan was released the Administration realized that this was only the first step. The President directed the White House National

Economic Council, the Office on Environmental Policy, and the Office of Science and Technology to co-chair a long-term strategy working group to:

"examine all budget, technology, R&D, regulatory and economic policies that could impact greenhouse emissions beyond the year 2000".

In order to keep the Post-2000 exercise closely aligned with the international climate treaty process, the National Security Council was added as an additional co-chair. This report represents the initial recommendations of the working group. In addition to this work, there are several other ongoing studies that are also examining approaches to reduce greenhouse gas emissions: 1) the policy dialogue committee to assist in the development of measures to significantly reduce greenhouse gas emissions from personal motor vehicles; 2) the Department of Energy National Energy Policy Plan; and 3) the President's Council on Sustainable Development.

Recent analyses suggest that U.S. greenhouse gas emissions will rise several hundred million metric tons of carbon equivalent (MMTce) above 1990 levels over the next few decades. Clearly, curbing the rising trend of greenhouse gas emissions after the year 2000 will require measures beyond those included in the 1993 Plan. The Post-2000 analysis looks out to the year 2030 in order to think long-term and strategically about emissions reductions. Over such a time frame, there is a significant potential for R&D to alter our technological opportunities for emissions reductions. This analysis is based on a Decision Framework, also described here, that provides a coherent basis for policy evaluation.

This report briefly presents:

- the current state of scientific understanding
 - a decision framework that can be used to assist in policy formulation
 - an analysis of the cost-effectiveness of technological and market policy options,
- and
- a set of recommendations.

CLIMATE CHANGE: STATE OF KNOWLEDGE

Introduction

The Earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere. The buildup of greenhouse gases--primarily carbon dioxide, methane, nitrous oxide and chlorofluorocarbons--is changing the radiation balance of the planet. The basic heat-trapping property of these greenhouse gases is essentially undisputed. However, there is considerable scientific uncertainty about exactly how and when the Earth's climate will respond to enhanced greenhouse gases. The direct effects of climate change will include changes in temperature, precipitation, soil moisture and sea level. Such changes could have adverse effects on ecological systems, human health and socio-economic sectors. Human-induced climate change is a complex problem, which can impact the economy and the

quality of life for this and future generations. The lag time between emission of the gases and their impact is on the order of decades to centuries; so too is the time needed to reverse any effects. Thus, policy decisions in the near-term will have long-term consequences.

The Climate System

A natural greenhouse effect keeps the Earth 33°C warmer than it otherwise would be. Without this, life as we know it would not be possible. Water vapor, carbon dioxide, and other trace gases trap heat as it is re-radiated from the Earth back to space. However, since pre-industrial times, human activities have added to the natural greenhouse effect by releasing additional greenhouse gases to the atmosphere. The burning of fossil fuels (coal, oil, and gas) for energy is the primary source of emissions; changing land use patterns through agriculture and deforestation also contributes a significant share. Current global emissions of carbon dioxide from energy use are approximately 6 gigatons of carbon (GtC) per year.

Future greenhouse gas emissions are sensitive to changes in demographic, economic, technological, policy and institutional developments. By the year 2025, world emissions could range from 8 to 15 GtC per year. In the year 2100, world emissions are projected to range from 5 to 36 GtC per year, depending on energy use. The U.S. and the rest of the OECD countries currently contribute about 40 percent of global carbon dioxide emissions. Future growth in emissions from OECD countries is predicted to be significantly smaller than growth in developing countries and countries with economies in transition.

Since the pre-industrial era, atmospheric concentrations of carbon dioxide have increased by nearly 30 percent, methane concentrations have doubled, and nitrous oxide concentrations have risen by 15 percent. These increases result in a radiative forcing or heat-trapping of energy equivalent to about 2.8 watts per square meter (Wm^{-2}). A significant fraction of warming may have been masked by increased levels of traditional air pollutants--sulfates and carbonaceous aerosols particularly in the Northern hemisphere, which reflect incoming solar radiation and alter the reflective properties of clouds. Aerosols are short-lived and vary regionally, hence they should not be regarded as a simple offset to greenhouse gas forcing. Calculations suggest that the projected increases in atmospheric concentrations of greenhouse gases alone will result in an additional radiative forcing of about 3 to 8.0 Wm^{-2} by 2100. For a given concentration of greenhouse gases, the resulting increase in radiation can be predicted with precision; but the resulting impact on climate is more uncertain.

Model calculations, based on plausible ranges of future emissions and climate sensitivities, suggest that the global surface temperature could increase an average of $0.9 - 5.0^{\circ}\text{C}$ by 2100, with significant variation by region. (This estimate does not account for offsets from aerosols which would somewhat lower these values.) Global-average temperature changes of this magnitude would be greater than recent natural fluctuations and would occur at a rate significantly faster than any observed changes in the last 10,000 years. The U.S. and high latitudes are projected to warm more than the global average.

Model calculations also suggest that the rate of evaporation will increase as the climate warms, leading to an increase in average global precipitation. While precipitation at high

4

latitudes is expected to increase, much of the precipitation increase may fall over the oceans. The models also suggest that the frequency of intense rainfall will increase, and there will be a marked decrease in soil moisture over some mid-latitude continental regions during summer.

Sea level is projected to increase by several tens of centimeters by the end of the next century, due primarily to the thermal expansion of the oceans and the melting of glaciers and ice sheets.

Calculations of climate change at the regional scale are significantly less reliable than average global values, and it is unclear whether climate will become more variable. The frequency and intensity of extreme weather events of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency of hot or cold spells, and the intensity of associated fires and pest outbreaks) could increase.

Global mean surface temperatures have increased between 0.3 and 0.6°C over the past century, despite marked regional, seasonal and diurnal differences.

There is consistency between the observed global average temperature trend over this period and model simulations of the warming due to greenhouse gases if allowance is made for the increasing evidence of a cooling effect due to anthropogenic aerosols and stratospheric ozone depletion. However, the warming is also at the upper end of the range of temperature fluctuations observed in the pre-industrial record. Thus, the observed temperature increase could be largely due to natural variability; alternatively, variability and other human factors could have offset a still larger human-induced warming. The unequivocal detection of the enhanced greenhouse effect from observations is likely to require another decade or more of data.

The 9 warmest years this century have all occurred since 1980. 1994 was the 3rd or 4th warmest year on record, suggesting the atmosphere has rebounded from the transient cooling of 0.5°C caused by Mount Pinatubo and simulated by the models.

Several ancillary pieces of evidence consistent with warming, such as a decrease in Northern Hemisphere snow cover, a simultaneous decrease in Arctic sea ice, continued melting of alpine glaciers, and a rise of sea level have also been corroborated. The frequency of extreme rainfall events has increased throughout much of the country suggestive of an intensification of the hydrologic cycle.

Carbon cycle models imply that limiting atmospheric concentrations of CO₂ to any level below 750 parts per million by volume (ppmv), about three times the pre-industrial level, would require emissions worldwide to eventually drop below 1990 levels. The longer emissions continue to increase, the greater reductions would eventually have to be to stabilize concentrations at a given level.

While much is already known about the greenhouse effect, substantial reduction of key uncertainties (detailed quantification of the timing, magnitude and regional patterns of climate change) may require a decade or more. Accurate predictions are limited by our knowledge of

5

the future emissions and atmospheric concentrations of carbon dioxide, aerosols and other greenhouse gases, the role of clouds and water vapor, and the role of the oceans.

Impacts of climate change

Climate change poses threats to resources both domestically and internationally. These threats could have significant, but uncertain, socioeconomic consequences. Changes in temperature, precipitation and sea level can add to existing stresses on resources caused by other influences such as population growth, land use changes, and pollution.

Overall, various strategies for coping with climate change can be identified for "intensively managed" systems (such as agriculture, water resources and developed coastlines). For these systems, technological and management options exist to some extent today, although they may be costly to implement. By comparison, fewer options can be identified for natural systems (such as wetlands, and wilderness areas).

Temperature changes of the magnitude expected from the enhanced greenhouse effect have occurred in the past, but the previous changes took place over centuries or millennia instead of decades. Rates of natural migration and adaptation of species and communities appear to be much slower than the predicted rate of climate change. As a result, populations of many species and inhabited ranges could change as the climate to which they are adapted effectively shifts northward or to higher elevations.

One of the consequences of global climate change may be increases in the frequency of extreme weather events, particularly droughts and floods. These events, when they do occur, can be costly. For example:

- Damages from the Mississippi River flooding in 1993 are estimated to range from \$10 billion to \$20 billion.
- Almost \$4 billion in Federal payments went to farmers suffering crop losses during the 1988 drought.

Examples of the kinds of effects that may result from climate change include:

Water Resources

- Changes in precipitation and increased evaporation from higher temperatures can affect water supplies and water quality posing threats to hydropower, irrigation, fisheries, and drinking water.
- Floods are more likely because the frequency of intense rainfall is predicted to increase.
- Droughts are likely to be more severe because warmer temperatures

6

increase evaporation rates, and thereby lead to drier soils during periods of little or no rain.

- Climate change would be likely to add to the stress in several U.S. river basins such as the Great Basin, California, Missouri, Arkansas, Texas Gulf, Rio Grande, and Lower Colorado.

Coastal Resources

- A 50 cm rise in sea level by the year 2100, which is within the range projected by the IPCC, could inundate more than 5,000 mi² of dryland and an additional 4000 mi² of wetlands in the U.S. if no protective actions are taken.
- Areas at highest risk from sea level rise are areas currently experiencing rapid erosion rates and with very low geographic relief, such as parts of the U.S. Atlantic and Gulf coasts.
- Internationally, parts of many low-lying areas such as parts of the Maldives, Egypt, and Bangladesh would be completely inundated and uninhabitable by a similar sea level rise.

Health

- Climate change may shift the range of infectious diseases with likely increased risks of malaria and dengue in the United States. Changing temperatures and precipitation patterns may produce new breeding sites for pests and pathogens.
- Climate change may increase heat-stress mortality, particularly in the very young and very old.

Agriculture

- Large areas of the eastern and central United States face moderate to severe drying. Drought losses could become more frequent particularly in the Great Plains.
- Changes in management practices and technological advances might reduce or eliminate many of the potentially negative impacts of climate change in the agricultural sector.
- Agricultural production in developing countries is likely to be more vulnerable to climate change given that they have relatively fewer economic resources.

2

Forests

- Climate change over the next several decades might shift the ideal range for some North American forest species as much as 300 miles (500 kilometers) to the north, exceeding the ability of forests and other ecological communities to migrate.
- Forest damage from fire and diebacks driven by drought, insects and disease could increase.
- The most vulnerable forest resources are those in regions subject to increased moisture stress, as in the dry continental interiors.

Energy and Transportation

- Warmer temperatures will increase cooling demand but decrease heating requirements.
- Changes in water availability may affect reliability of hydropower output.
- Warming should lead to fewer disruptions of winter transportation but increased droughts and floods may interfere with water transport.

8

ECONOMIC IMPACTS OF CLIMATE CHANGE

These potential impacts of climate change are a public policy issue, not just a scientific curiosity, because humans depend heavily on natural resources and ecological systems that could be affected by climate change for a variety of activities. Natural and ecological systems provide raw materials for production, consumption, and waste sinks, recreational experiences, well-being and indirect benefits from weather conditions (including conditions mediating spread of diseases).

A small but growing economics literature attempts to calculate the potential economic effects from climate change, both in the aggregate and for specific sectors or resources. The few aggregate estimates that exist estimate potential damages from a doubling of CO₂ concentration on the order of 1-2 percent of GDP for developed countries, with somewhat larger damages for developing countries given their greater relative dependence on natural systems for economic goods, their less adaptive economic institutions, and their more limited scientific and technological infrastructure.

A closer inspection reveals wide variation in the aggregate estimates looking across sectors. Some estimates attribute the greatest damages to agriculture and forestry, others to human health, and still others to the consequences of sea level rise. Many sectors have not been studied including some which could show positive gains from a climate change. Moreover, many impacts have been assessed by only a few studies, often with heavy reliance on judgment and little ability to capture natural adaptive responses by individuals and institutions. This dispersion reveals the lack of robustness in the current state of knowledge. Findings from impact studies for sectors that are relatively more easy to analyze, such as agriculture, coastal development, and electricity use, also differ in their conclusions, with more recent findings indicating lower or negative impacts particularly when possibilities for adaptation and technological innovation are taken into account.

The foregoing picture of uncertain and possibly small costs from climate change is not the whole story. Estimates of significant adaptation potential assume a relatively smooth path of climate change and natural system response. Even for managed systems like agriculture and developed coastal areas, rapid, unanticipated changes at a large scale could give rise to very substantial adjustment costs. In addition, unmanaged systems like wetlands that provide valuable services to humans also could be substantially perturbed by climate change. Such systems may be subject to substantial discontinuities in their responses and require long periods for recovery of functions. Since our knowledge of how these natural systems work is limited, it is more difficult to argue confidently about the capacity for adaptation under circumstances of a quick or a large scale change in climate.

Draft 1/26

III. DECISION FRAMEWORK

The watchword of the scientific model of climate change is uncertainty. Substantial resolution of key uncertainties -- in emissions trajectories, atmospheric chemistry, ecosystem responses, and damage functions for environmental and human well-being -- will require some years. In the meantime, it will be prudent to recognize a wide range of scientific viewpoints, to treat differences among them as uncertainty, and to narrow those differences as rapidly as possible.

The corresponding watchword of a decision framework for climate change is insurance. It will be prudent to act in the face of diminishing uncertainty, not only to keep reducing it but also to buy protection against the remaining downside. Such action will walk a line between complacency and alarmism -- fortunately a fairly broad path.

Many decision-makers must walk this path. The decision framework described here is designed to serve the U.S. Government, which has national decision-making responsibility, but must exercise it within the context of international agreement and domestic support. Accordingly, the decision framework addresses the issue as global. And it envisages a systematic, transparent, inclusive policy discussion in this country to develop national positions going into the international arena.

A. Principles. Four principles guide the decision framework:

1. **Rationality.** Responding to climate change is a question of making sensible decisions in the face of uncertainty. Sensible means taking robust action in light of remaining uncertainty, while working to reduce that uncertainty where the value of doing so is greatest -- be it in objective knowledge of physical science or market economics, or in more subjective appreciation of individual and social risk preferences, intergenerational equity, or valuation of non-market goods.

2. **Beneficiality.** As with any other regulation of environmental externalities, there is no point setting a climate change objective that is not thought to be beneficial. People will differ substantially on the value of many things, and aggregating and weighing those values, even notionally, will be challenging. But that does not alter the fundamental conceptual validity of the decision rule -- that the perceived benefits of an action, comprehensively conceived, should be seen to have a value that justifies the projected costs.

3. **Cost-Effectiveness.** For a threat of the potential magnitude of climate change, the luxury of taking wasteful measures because they are achievable technically or supported politically is not available. Measures capable of delivering big mitigation gains per unit invested need to be pursued, whether the remaining hurdles are technological, economic, political or diplomatic.

4. **Continuity.** An appropriate response path to climate change will not be blown around by periodic weather phenomena or political cycles. Correspondingly, an appropriate decision-making framework will not be an advocacy tool -- it will neither understate nor overstate uncertainty at any point in time, but allow for progressive response to accumulating information without leaving any reasonable viewpoint behind.

B. Structure. In concept, responding to climate change is a world-scale problem of sequential decision-making under uncertainty, where information is developed and measures are taken over time to generate the largest possible expected benefits from the measures themselves, and from the ultimate objective they finally reach. In the case of climate change:

The ultimate objective is the stabilization of greenhouse gas concentrations below the level of dangerous anthropogenic interference with the climate system.

Measures are cost-effective emissions reduction or adaptation actions taken to advance toward the ultimate objective.

Aims are interim points on the path to the ultimate objective, beginning with the initial aim of reducing emission to 1990 levels by the year 2000.

The purpose of the decision framework is to make the best sequential decisions as to measures, aims and ultimate objective, based on systematic increases in information over time. The framework can be implemented in the following manner:

1. **Determine if any steps are appropriate.**

To do this, use the existing state of science to bound the space of remaining uncertainty. There are currently bounds on the range of plausible future emissions trajectories which could eventuate if no new mitigation measures are undertaken. These bounds in turn generate a range of possible damages to the human and natural environment. If this latter range includes some damages for which the global benefits of avoidance exceed the costs, then mitigation steps are in order. With remaining uncertainty as large as it currently is, this is, unsurprisingly, the case at the moment. The wide range of possible damages exceeds the cost-benefit threshold of known mitigation measures, making mitigation appropriate.

2. **Identify the best steps to take.**

The first set of steps to pursue are "win-win" steps that both reduce emissions or their impacts and increase economic efficiency. This is likely to be a very substantial set worldwide, taking into account a) market imperfections in the distribution of knowledge and capital, and b) market distortions

in the form of government policy interventions such as energy use subsidies. Voluntary actions involving the private sector are a potential group of "win-win" measures.

These "win-win" steps have by definition negative costs, so they will not constitute the full set of appropriate steps unless they eliminate all possible positive-damage emissions. If this is not the case, further steps are called for as insurance against a downside result, assuming that beneficial insurance is available in the form of additional current mitigation measures or investments to develop attractive options for the future such as efficient new technologies.

Where information to support a useful assessment of benefits is not available, insurance steps need to be selected from the low end of the cost curve first, and costs kept low while information is developed to help establish and narrow the range of plausible cost-benefit thresholds.

3. Develop information to reduce uncertainty, starting with the most valuable information first.

Move as quickly as possible from a low-cost criterion for measure selection to a beneficial criterion -- that is, adjust the envelope from inexpensive to worthwhile. Set aims periodically that are conservatively within the apparent range of beneficial outcomes. Develop information over time that will allow decision-makers to move beyond accumulating individual measures, each judged separately to be beneficial, toward determining a robust sequence of aims leading to an optimum ultimate objective. Particularly valuable will be information comparing the trajectory of future climate change damage with that of new technology introduction. Also important will be national cost and emissions data to support international agreement on equitable allocation of funding for minimum-cost mitigation activity.

4. Agree on distribution of minimized global mitigation costs.

The world will be better off as a whole to the extent that global knowledge is developed and utilized to pursue the most cost-effective mitigation measures wherever they are found internationally. In this way, the total mitigation bill will be minimized. However, the question of who pays the bill will remain as an important matter for international deliberation; agreement on that matter will constitute a practical definition of equity. Ideally, the world can enjoy both efficiency and equity without having to compromise one for the other. With adequate information and agreement, a benchmark for this ideal result can be set in the form of mitigation benefits and costs associated with an optimized global emissions cap with tradable emissions permits (efficiency) and an internationally-negotiated initial allotment of permits (equity).

IV. POLICY MEASURES

Moving from concept to action requires an examination of specific options for limiting greenhouse gas emissions in the post-2000 period. To this end, an interagency assessment team (IAT) responded to the charge from the President that it "...examine all budget, technology, R&D, regulatory, and economic policies that could impact greenhouse gas emission levels beyond the year 2000" (Climate Change Action Plan, page 30). Several interagency subgroups submitted analyses to the IAT for screening. The range of options considered included increased buildings efficiency, biomass fuels, carbon sequestration, increased use of natural gas, controls on greenhouse gas emissions other than CO₂, and changes in economic incentives. The intent was to identify promising targets for further technical, economic, and political refinement based on the significance and cost-effectiveness of the potential emissions reductions, with particular interest in measures that would generate significant ancillary benefits (such as pollution reduction and economic development benefits).

This exercise was very different from the Climate Action Plan (CCAP), which sought to aggregate as much "low cost" emission reduction potential as possible in less than a decade in order to return emissions to 1990 levels by the year 2000. Options did not need to have long-term emissions reduction potential nor achieve any particular level of reduction to be included in the CCAP. The Post-2000 analysis did not set an emissions target. Instead it focussed on options with substantial emissions reductions that could be sustained or increased over several decades. The time frame for the assessment was 2000-2030, allowing ample time for the development and substantial introduction of new technologies in response to changes in technical knowledge or economic incentives.

In order to pass the IAT screening, proposed measures had to offer the prospect of at least 7 million metric tons of carbon equivalent (MMTce) annually by 2030, at an average discounted cost over the period of no more than \$50/Tce. Costs were discounted at a 7 percent annual real (inflation-adjusted) rate. This is the rate used by the federal government for discounting. Individuals' discount rates can be expected to be higher, reflecting actual or perceived uncertainties in the performance of technologies for reducing greenhouse gases.

Below, we focus primarily on measures that unequivocally passed the IAT screening. More detail on these measures is provided in Attachments 1-4. A variety of other measures reviewed by the IAT also could be promising but require further analysis to form a judgment about their cost and potential for greenhouse gas reductions. Attachment 5 provides a summary of these measures.

Substantial reductions in U.S. emissions are possible in the buildings sector by improving energy efficiency through innovation, education, and changes in building codes (see Attachment 1).

Buildings account for about a third of energy use in the U.S. and also about a third of CO₂ emissions. Constructing buildings that are 80% more efficient than the average built today is technically feasible; however, there is currently little incentive to do so. Recognizing this, a Consortium of Building Industries has approached the Administration with an initiative to promote a variety of improvements in buildings including a 50% reduction in energy use of new buildings to be achieved over the next several decades. The interagency analysis submitted to the IAT suggests even if we only achieve a third to two-thirds of available technical potential, a package of buildings measures could deliver an average of X-Y MMTcE of greenhouse gas reductions per year over 2000-2030, depending on the degree of penetration of improved efficiency investments in new and existing buildings. The reductions ramp up substantially over time as the efficiency measures become better established in older buildings and more new efficient buildings are built, reaching A-B MMTcE by 2030. In addition to greenhouse gas reductions, such measures would reduce overall energy use thus and the release of traditional air pollutants. The costs of carbon reduction from this option appear fairly low with a 7 percent discount rate, on the order of \$2/TcE, reflecting the expenses incurred in developing new building efficiency technologies and disseminating them. However, convincing individuals to implement these technologies may be difficult, and any additional costs of doing so are not included in the estimate above.

A second technology measure that could be promising is market penetration of biomass fuels for power generation (see Attachment 2). Developing a nonfossil fuel source that can supply baseload electricity would reduce emissions of traditional air pollutants as well as greenhouse gas emissions. Biomass fuels introduction also could provide a variety of immediate benefits apart from greenhouse gas reductions, such as diversification of income sources for rural economies and reductions in damages from soil erosion. This measure could deliver on the order of X MMTcE of greenhouse gas reduction on average over 2000-2030, and up to Z MMTcE by 2030, from displacement of coal used in power generation boilers, plus a fixed amount of carbon sequestration of Y MMTcE over the first W years of the program from converting other lands to biomass feedstock production.

The cost per ton of biomass fuel introduction remains uncertain. The equivalent of a 0.5 cents/kwh subsidy of electricity prices might be needed to make biomass competitive, at least initially (currently, there is a 1.5 cent/kwh subsidy for renewables which will expire in the year 2000). With this subsidy over 200-2030, the average discounted cost of carbon reduction would be on the order of \$13/TcE on average, though the marginal cost of carbon reduction in later years, after the initial costs of introducing the technology are sunk, would be much lower -- on the order of \$A/TcE. The size of the subsidy would depend in part on trends in

fossil fuel prices and progress in biomass technology; with higher coal prices biomass fuels could rapidly become cost-competitive after the turn of the century, making the cost of carbon reduction minimal.

(Italics indicate disputed text)
The IAT also reviewed the potential for cost-effective emissions reductions through changes in economic incentives (see Attachment 3). This category includes a variety of direct and indirect increases in the cost of greenhouse gas discharges, including greenhouse gas "caps" with tradable emissions rights such as the program the U.S. has adopted to control SO₂ emissions. As a very substantial literature already has pointed out, policies that rely on economic incentives are by their very nature capable of producing cost-effective outcomes because they allow individual sources of greenhouse gas emissions to determine the cheapest means of limiting those emissions, and they provide powerful inducements for the development of lower-cost strategies for restricting emissions -- including the technological measures screened by the IAT. Despite the relatively undisputed economic efficiency of such instruments, their political unpalatability is equally well-known.

Analyses of incentive-based policies often focus on direct carbon taxes or emissions caps with tradable emissions allowances. These policies do in fact have great potential to generate substantial reductions in greenhouse gas emissions at relatively low cost, though the costs are uncertain and vary with the stringency of the control program. For example, a study by the Energy Modeling Forum suggests a best estimate of \$50-80/TcE to fully stabilize emissions at 1990 levels out to 2025, even before long-term changes in land use and the benefits of lowering other taxes with the proceeds of a carbon tax are taken into account. A much lower tax, on the order of \$5/TcE, could still save on the order of 50 MMTcE.
[CHECK]

Other, more targeted policies also have substantial potential for cost-effective greenhouse gas reduction, often with negligible or even negative costs in that they correct other market failures and thus contribute economic benefits independent of their effects on greenhouse gases. Examples include (a) shifts to greater reliance on user fees for road construction and maintenance and reductions in tax benefits for private parking expenses, policies that make clearer the true social costs of road use; (b) rebated mileage-based charges for a portion of vehicle insurance costs, a policy that could reduce the number of uninsured drivers; (c) reductions in lingering distortions in electricity pricing through below-market financing and limits on interregional trade; and (d) changes in pricing for disposal of municipal solid waste that signal the true social cost of waste disposal. These policies alone could generate reductions on the order of X MMTcE/yr by 2010, and proportionately more in later years.

The focus in the previous paragraphs has been on initiatives to

19

reduce greenhouse gas emissions in the U.S. The IAT also examined several ideas for activities to reduce emissions in other countries as part of a global strategy for cost-effective action. One such policy, to disseminate technical assistance on greenhouse gas policy planning and to facilitate the transfer of cost-effective lower-emissions technologies to other countries, already is under active consideration by the U.S. (see Attachment 4). The size of greenhouse gas reductions from such measures remains speculative, but if properly done they offer significant win-win potential. Such efforts also provide a solid footing for the U.S. Joint Implementation Plan.

V. RECOMMENDATIONS

(1) Adopt the post-2000 decision framework. The framework developed in this report provides for rational structuring of goals and responses over time, taking into account the current levels of uncertainty about climate change risks and response options and the opportunities for reducing these uncertainties over time. It also recognizes the inherently global nature of climate change.

(2) Continue research. By providing increased information about climate change risks and response options, research offers a key opportunity for refining climate change policies over time. Research plans prepared by the U.S. Global Change Research Program and the work of the Intergovernmental Panel on Climate Change should be continued, with added emphasis on ecological and socioeconomic analysis to clarify the vulnerabilities associated with climate change.

(3) Purchase insurance. The U.S. should go beyond "no-regrets" measures to invest today in low-cost policies that will reduce the risk that climate change may pose to future human well-being. In addition to research, insurance measures should include efforts to develop lower-carbon energy technologies and improved means for adapting to unavoidable effects of climate change.

(4) Seek cost-effective measures, including consideration of joint benefits. U.S. policies should seek to achieve greenhouse gas reductions at the lowest cost, taking into account additional benefits that may accompany the policies such as economic development and reduction of conventional pollution problems.

(5) Work internationally. Given the global nature of climate change, the U.S. should continue to participate actively in efforts by the Framework Convention on Climate Change to define the aims of the Convention, and it should take the lead in promoting cost-effective and equitable international measures. Specifically, the U.S. should continue to support developing country efforts to assess their own prospects for technological and economic measures to reduce emissions; international efforts to promote the

development and diffusion of cost-effective technologies for greenhouse gas reduction; and expanded efforts at joint implementation.

(6) Begin implementation of some post-2000 U.S. strategies. Start-up efforts for programs in enhancing buildings efficiency and biomass fuels should be undertaken in FY 1996, while efforts continue to refine the potential of these measures and their implementation. The efforts should include R&D and the establishment of cooperative efforts with the buildings industry and localities to determine how cost-effective buildings programs could be structured.

(7) Refine other post-2000 options. A number of other technology policies, including carbon sequestration and reductions in methane emissions, could be promising but require further technical and economic development. *Policies based on economic incentives can generate significant reductions in emissions at very low cost and thus should not be excluded from the "tool kit" of potential options.* The primary obstacle to these policies is political acceptability.

(8) Coordinate U.S. climate change activities. Climate change is a major element of at least four current activities: the President's advisory committee on reducing greenhouse gases from personal transportation, the President's Council on Sustainable Development, the National Energy Policy Plan, and the engagement by the U.S. in the activities of the Framework Convention on Climate Change. Successful coordination of these and other processes in the years ahead is crucial to the substantive and political success of U.S. climate change policy. Building on the experience of the post-2000 process, a committee composed of the heads of the CEQ, NEC, NSC, OSTP, and CEA should be given the task of carrying out this coordinating function.

Attachment 1

17

Buildings

Buildings can be cost-effectively built to use about half the energy of the typical new unit. Typical buildings can be maintained in ways that require only about 70% - 90% of the energy used by an average building. Wide dissemination of these best practices, however, requires the value of efficiency improvements to be reflected in building sale/resale values. As a result, Post-2000 initiatives are intended to provide:

1. **Consistent performance.** Actual performance for energy using equipment (where market acceptance has been strong) is fairly reliable. Investments in efficiency improvements in building shells and design, however, can be risky, even for new buildings. Many improvements depend upon the skill of installation or application; and the level of quality is often difficult or impossible to verify. (classic lemons problem) Existing retrofit "house doctoring" techniques have impressive average returns to investment, but highly variable individual performance.
 2. **Measurable and controllable energy service production.** Except for some subportions of the commercial buildings sector, the ability to measure actual energy performance is virtually non-existent, as is the ability to readily deliver energy services where and when they are needed within a building. Without "dash board" readings of performance, finding and fixing equipment or system failures is a relatively random, high-cost exercise. Finally, because the cost of producing various energy services is largely unknown to the purchaser, making energy service choices is like buying groceries without prices on individuals foods, only a total bill.
 3. **Financing terms comparable to other real estate investments.** For home purchases, EEMs stretch income allowance but upfront efficiency costs may disqualify based on down payment requirements. For efficiency improvements for existing homes, the mortgage interest deduction is allowed only if the project is financed through a mortgage escrow or an available equity line of credit; in addition, there is no specific loan geared to efficiency improvements such as exist for new car purchases.
- An additional market aspect can be important in realizing efficiency improvements beyond those that are cost-effective to the individual owner:
4. **Benefits recognized in local planning.** Local planning often shapes the availability of resources such as district heating and cooling, the extent of the heat island effect for the locality, and trade-offs between density and infrastructure loads. Localities covered by clean air plans also have a specific incentive to reduce specific sources of energy use.

Post-2000 Initiatives include amplifications of existing initiatives as well as new ones.

Estimated emissions reduction are 24-40 million metric tons of carbon per year (MMTC/yr) in 2010 and 70-100 MMTC/yr in 2030.

Extensions of existing initiatives

RESEARCH: Additional research on more efficient energy using equipment and building components; research on optimum building design, including building cost savings from combined and optimized subsystems. (increases technical potential)

CODES AND STANDARDS. Additional assistance in code compliance through integration of model code requirements in design and inspection tools (such as CAD programs); updating of existing

equipment standards per existing legislation. (eliminates some additional sub-standard products and practices; improves ability to verify)

INFORMATION: Use of Home Energy Rating Systems (HERs) as a tool to document state-by-state improvements, effectiveness of code compliance. (reinforces code compliance, improves ability to verify) Promote final development and use of uniform monitoring and verification protocol for commercial sector performance contracts. Encourage states to include information about HERs ratings in standard sale, financing, and appraisal forms. Provide training for appraisers in use of HERs information.

FINANCE: Exclude cost of efficiency improvements (beyond code) from down payment requirements for EEMs. Require disclosure of availability of EEMs (perhaps at time of qualification or pre-qualification of loan) (improves financing terms)

COMMUNITY: Dissemination of results of rating and certification for cool roofs, along with model specification for local requirements; assistance in including cool communities initiatives in clean air plans. (increases community influence on energy choices)

New initiatives

RESEARCH AND DEVELOPMENT: R&D directed towards consistency of building performance, with an emphasis on shells that automatically incorporate efficiency improvements (e.g., replacing add-on caulking), system designs that perform well consistently and under varying conditions; reliable add-ons for broad spectrum of existing units (e.g., self-sealing duct liners). (improves consistency of performance)

CODES AND STANDARDS: Extension of equipment standards to plug-in transformers. Publication of cost-effective model code provisions whether or not approved by voluntary associations. (improves ability to verify)

INFORMATION: Development of formats and protocols for monitoring and control equipment, as well as on-line information about energy and equipment prices, development of software to integrate individual and energy/product price information to facilitate least cost energy choices. Includes standards for reporting of equipment performance and maintenance needs (think of as a dynamic performance label). Requirements for more useful information included in utility bills. In addition to providing information to individual consumers who might use it, this initiative could help encourage utilities or future energy "brokers" to include efficiency improvements and building maintenance as part of their services. (improves monitoring and controls)

FINANCE: "Energy efficiency loans" (EEL) offered to home owners are being piloted by Fannie Mae through selected utilities. Provision of such loans through utilities, state and local agencies, or contracts for equipment and shell improvements and secured by through utility account (?) could make financing for efficiency improvements available when it is most needed -- at the time of equipment replacement or other home improvement. The loans would be available at rates somewhere between mortgage rates and unsecured rates. The unpaid portion could be due at the time of sale. If made eligible for the mortgage interest deduction, the energy efficiency loan could help overcome the difficulties of wrapping such improvements into the home sale/purchase in order to qualify for the deduction. To be eligible, improvements in equipment would have to exceed minimum standard or market average by a specified amount (see procurement challenge for federal government for model);

improvements to shell and design would have to include specified improvements (could be based on experience of weatherization program). HERs would not be required, could require minimum level of training or certification of contractor to be eligible to offer.

COMMUNITIES: Technical assistance to localities on incorporating district heating and cooling in planning and zoning; loans for efficiency improvements for publicly-assisted housing; technical assistance for adoption of retrofit codes for commercial and residential building sales. Assistance in including these efforts in clean air plans would provide clear incentive to participate for non-compliance regions. (increases community influence on energy choices, eliminates gross deficiencies at time of sale)

Bigger-picture developments

The extent to which these initiatives are successful depend not only on the initiatives themselves, but overall changes in the buildings sector. Efficiency improvements are much more likely to be realized if they are part of overall changes in building sector practices that reduce building costs and improve performance. The Committee on Civilian Industrial Technologies (CCIT) subcommittee on Construction and Buildings focus on new ways of constructing buildings that reduce their construction and operating costs across-the-board and general tendency towards "smarter" buildings are expamples of changes in the sector that could carry efficiency improvements beyond those that sell themselves today.

Modeling Specifications

	Post-2000 + CCAP	CCIT Goal
New buildings	70% of 1995 ave. new building energy use by 2025	50% of 1995 ave. new building energy use by 2025
Existing buildings		
Shell	80% of implied base case energy load by 2025	70% of implied base case energy load by 2025
Heating equipment	90% of base case by 2010	90% of base case by 2010
Cooling equipment	85% of base case by 2010	85% of base case by 2010
Other	base case	90% of base case by 2025

A Bioenergy Initiative (BEI) would underwrite part of the cost of research, development and demonstration for high-yield energy crops and high-efficiency bioenergy conversion technologies. Ultimately, the objective of the BEI would be to create a bioenergy industry that produces liquid fuels and electricity from energy crops at competitive prices. By supplanting a portion of fossil fuel use, increased use of bioenergy crops could help reduce carbon dioxide emissions and other types of energy-related pollution while stimulating America's rural communities. In addition, growing bioenergy crops on agricultural lands would reduce soil erosion and water pollution from the use of agriculture chemicals. Growing fuel crops may also increase biodiversity on lands currently in traditional crops.

Although there is a great deal of uncertainty surrounding future likely developments in energy supply and demand over the next few decades, bioenergy experts have achieved some agreements about the potential for bioenergy. A feasibility assessment undertaken jointly by the Departments of Energy and Agriculture, the Environmental Protection Agency, and industry and academic experts concluded that energy from biomass represents a significant potential energy resource that, over the long run, could enter the market at prices approaching those projected for fossil fuels, with little impact on food prices. Research sponsored by the Department of Energy suggests that improved strains of energy crops, particularly switchgrasses and certain hybrid willow and poplar species, could be produced in large quantities within the next quarter century at prices that would be nearly competitive with conventional fossil fuels as inputs for electric power generation. An aggressive RD&D program could easily boost yields for some of these crops from the current levels of 3-5 dry tons per acre per year, to 5-8 dry tons per acre per year in 2025, depending on the species and region. Under these conditions in 2025, fuelstocks could be delivered to electric power generators at prices in the range of \$1.40 to \$2.25 per million BTU.

The assessment suggests that an enhanced RD&D program costing approximately \$250 million could catalyze the commercial development of gasification/combined cycle (IGCC) power generation technologies that would yield 30% conversion efficiency improvements over current technologies using bioenergy crops as inputs. Preliminary analysis using comprehensive models of the electricity sector suggests that if the goals of the BEI are met, biomass electricity production would begin to appear in limited quantities between 2005 and 2010. By 2025, electricity production from biomass could expand to supply about 7 percent of U.S. energy use. This quantity of bioenergy is comparable to current supplies of hydroelectric or nuclear power, or about one-fourth of current coal use. The current best estimate is that this level of production would require subsidies of about \$0.005 per kilowatt hour for biomass-based electricity.¹

A successful bioenergy program of the magnitude envisioned could lead to reductions in U.S. greenhouse gas emissions of up to 100 to 150 MMTC per year by 2025, with an additional 215 MMTC sequestered in new growing stock, at a discounted cost of approximately \$15/metric ton. Furthermore, commercial bioenergy technology could be

¹This is considerably less than the current \$0.015 per kilowatt hour subsidy in place to encourage renewables. This subsidy will expire in the year 2000.

21

marketed worldwide, with further large emissions reductions.

Other research suggests that enhanced R&D could also yield vastly improved technologies for converting lignocellulosic crops into liquid fuels at prices competitive with those projected for fossil fuels. If the conversion technologies are brought to commercial feasibility, liquid fuels from biomass could enter the market in large quantities after 2010, providing up to 14 billion gallons of fuel by 2025. However, there is likely to be a trade-off between electricity and liquid fuels production from bioenergy crops, and this trade-off has not been reliably assessed.

22

ATTACHMENT 3: ECONOMIC INCENTIVES[needs work]

Previous studies of economy-wide carbon taxes indicate that their potential for cost-effective GHG limitation is very large. A "best estimate" of the cost of stabilizing emissions through such measures is on the order of \$50-80/TcE, before allowing for revenue recycling or the potential for reforestation. These estimates have significant uncertainty, however, with published estimates ranging from very low to over \$200/TcE for stabilization. With more modest GHG reduction targets than complete stabilization, substantially lower costs are possible. Economy-wide GHG caps with trading are capable of the same cost-effectiveness, while also being capable of addressing distributional concerns through the initial endowment of permits.

In addition to these economy-wide measures, the IAT examined the potential of a variety of more targeted measures, especially in the transportation sector. These include: full road financing through user fees (7-20 MMTcE in 2010; elimination of parking subsidies (11-33 MMTcE in 2010); gasoline surcharge/rebate program of \$.25/gal for licensed drivers (6-11 MMTcE in 2010 if applied to one-quarter of all drivers -- also increases incentives to be insured); an increase of \$.12/gal in the national gasoline tax (18-32 MMTcE in 2010). All of these programs would yield correspondingly larger reductions by 2030, with higher VMT. Longer-term changes in land use could have significant but harder-to-quantify reductions in transport-related emissions. finally, elimination of remaining subsidies to electricity producers and financing of black lung disability benefits through a coal surcharge could generate on the order of 10 MMTcE/yr of emissions reductions at very low social cost, though sectoral and regional interests would be greatly affected.

23

ATTACHMENT 4: INTERNATIONAL TECHNOLOGY INITIATIVE

[TO BE SUPPLIED BY SANDALOW]

(24)

ATTACHMENT 5: OTHER POLICY MEASURES SCREENED BY THE IAT

A. Carbon Sequestration (Tree Planting)

Increased tree planting on marginal lands could generate cumulative emissions sequestration in the low case considered of 160 MMTce with moderate acreage (5.25 million acres), or up to 750 MMTce with higher acreage (9 million acres) and more intensive per-acre sequestration. These are interim policies in that they do not promote permanent annual reductions in net emissions (net sequestration ceases when the steady-state tree growth is reached). Costs are on the order of \$2-7/Tce. Sequestration programs in other countries also could be promising interim measures, but their costs are much more uncertain.

B. Increased Natural Gas Utilization

A variety of efforts could expand use of natural gas in lieu of coal. These include R&D for advance gas-using systems (e.g., in power generation and transport); measures to expand gas supply and deliverability, which expand gas demand either by lowering its price or reducing uncertainty about its availability; and lowering of regulatory barriers to the same end. At least some of the R&D initiatives appear to have a high cost per ton of GHGs avoided, and the ultimate demand response to the supply and regulatory initiatives remains unclear. This suite of policies requires further development.

C. Technical and Institutional Measures in Transportation

No policies for personal transportation were considered, since these are the purview of the President's Advisory Committee for Reducing[finish]. GHG reductions could be achieved by increased fuel efficiency of freight vehicles and enhanced intermodalism in freight transport, but their size and cost are unclear. This suite of policies requires further development.

D. Non-CO₂ Options

A variety of policies to reduce methane emissions from landfills, coal mines, and agriculture were considered, along with programs for reducing use of HFCs and N₂O. While the HFCs proposal seems too costly (especially since these chemicals have just been developed to implement the CFC phaseout), the others all could be promising, both in the U.S. and internationally. However, the costs remain uncertain. This suite of policies requires further development.

July 27, 1995

To: Jack Gibbons
From: Bob Watson, Rosina Bierbaum

Re: Releasing the Climate Change Action Plan Gap Analyses now

CONS:

Not promised until October. Complete back-up analysis and paper won't be ready until then.

There are many more reasons why the current analysis underestimates the gap than overestimates it.

Early release opens door to NGO reanalysis of gap-- potentially with different results and/or blame attribution.

We have no suggestions on how to fill the gap yet.

Early release may encourage NGOs to propose options to fill the gap between now and 2000. Because no substantial tech options exist (in the next 4 years), proposals will likely include problematic financial mechanisms to which we will need to develop responses.

Could backfire. 50% of the gap is due to budget. 50% can be blamed on Administration.

Using Climate change to try and push DOE budgets back up may not be best strategy. OSTP has been trying to sell Environment broadly to build support. Climate Change is not compelling on many parts of the Hill.

May not put our best foot forward. Principals should think about whether gap release should be released with something positive (e.g., buildings initiative, our Post-2000 first steps, Post-2000 report, etc.)

Pros:

Could help build support for CCAP budgets.

Can blame Congress for 50% of the gap due to budget cuts

Although we have missed the full House marks, we may have some impact on the Senate.