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November 19, 1997

Jeffrey A. Frankel
Chief Economist
Council of Economic Advisers
Old Executive Office Building, Room 314
Washington, DC 20500

Dear ~~Jeffrey~~, Jeff,

As we draw nearer to the December 1997 U.N. Framework Convention on Climate Change in Kyoto, opponents of a global climate treaty are stepping up their efforts to delay U.S. action. While some are calling for delay in hopes of derailing climate action by the United States, others are motivated by the belief that immediate action will endanger the American economy. They advocate a strategy of doing less now and more later. They claim that delay would be better for the U.S. economy since it would mean that sudden changes in the capital stock would be avoided, and would allow time for technological advances that promise to make future reductions in greenhouse gas emissions less expensive than today.

In this new report, *Climate Protection Policies: Can We Afford to Delay?*, I explain why delaying policy implementation threatens to make climate protection more, not less, costly, and to exacerbate the effects of climate change. Findings include:

The Costs of Delay. More compelling than the fear that early action will cause premature retirement of capital stock is the fact that without early action we will continue to invest in inefficient capital stock too carbon-intensive to be economical in the next century. The longer we wait, the greater the accumulation of fossil fuel-dependent machinery, equipment and core infrastructure, and the more disruptive and expensive future greenhouse gas reductions will be. Furthermore, the argument that we should wait until technological advances make green house gas emission reductions cheaper is based on a false premise. Without a clear, immediate policy signal, research and development efforts will continue to focus on fossil fuel-based systems and technologies, rather than in renewable energy and energy efficiency alternatives. As a consequence we will be increasingly locked into technologies that depend on conventional fuels. Early implementation of economic incentives—such as a cap and trade policy—would alter present investment patterns and encourage more rapid development of renewable and energy conservation technologies.

Global Implication of Delay. Delay by the U.S. will have global implications since other nations, developing countries in particular, are unlikely to take action unless the United States first commits to do so. Without early action by the U.S., green house gas emissions worldwide will continue to rise in both industrialized and developing nations.

Potential Early Action Benefits. Without early action, the potential additional benefits from climate protection policies, such as reduced air pollution and savings from energy efficiency will be lost. Furthermore, the seriousness of the ecological consequences of climate change will be determined not only by the build up of greenhouse gases in the atmosphere, but also by the pace of that build up. Early action is key to slowing the pace of change.

Unfortunately, we have no idea what constitutes a "safe" long-term concentration of greenhouse gases. However, the longer we delay making reductions in greenhouse gas emissions, the greater the risks of serious and irreversible consequences. The arguments for early action on climate change are compelling. With world leader poised to make decisions in Kyoto about how to maintain the health of Earth's climate system, the time to act is now.

I hope you will find *Climate Protection Policies: Can We Afford to Delay?* helpful, and I welcome your comments and reactions.

Sincerely,

Duncan

Duncan Austin
Associate

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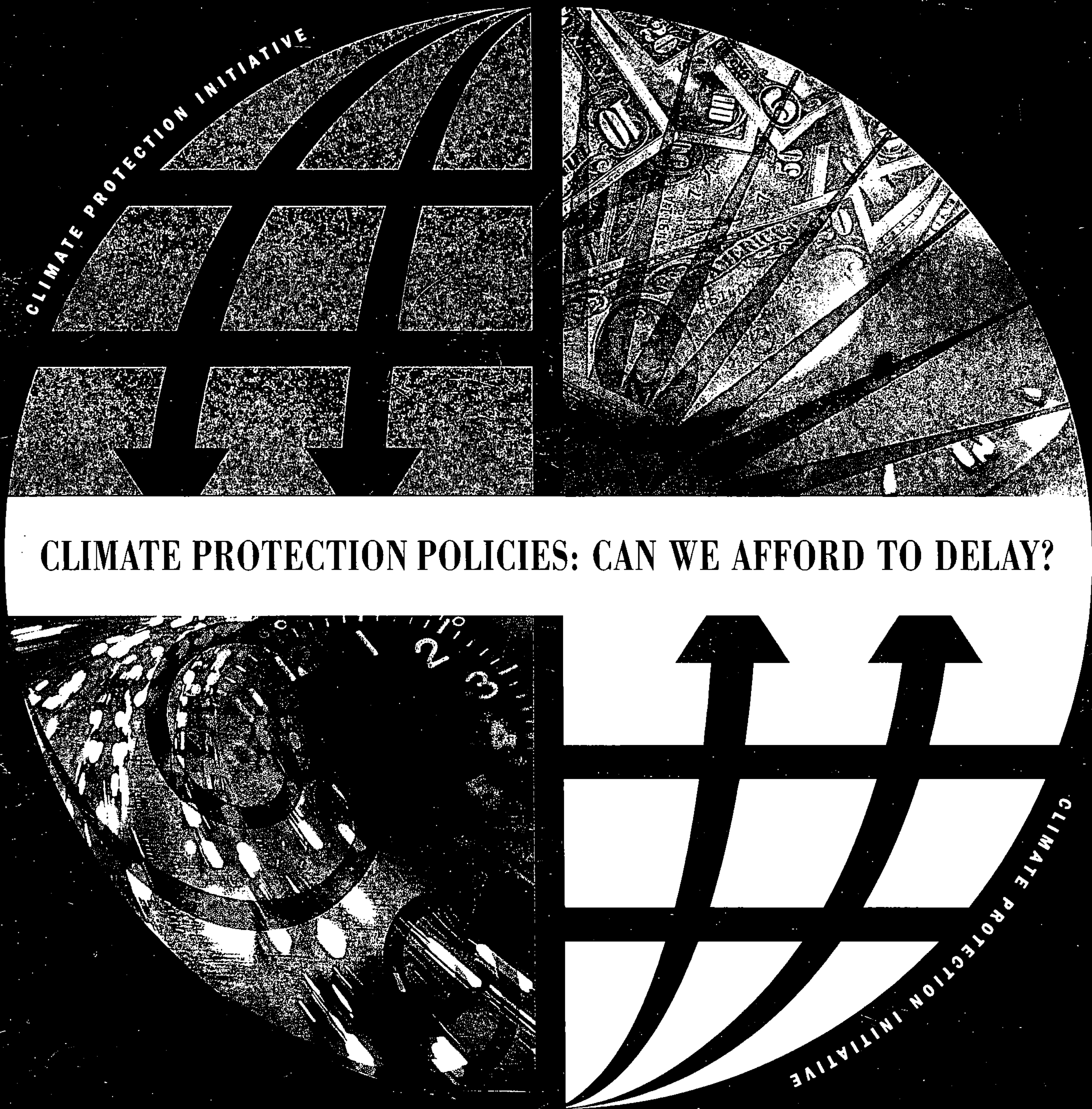

CLIMATE PROTECTION POLICIES: CAN WE AFFORD TO DELAY?

DUNCAN AUSTIN

CLIMATE ISSUES BRIEF

RESOURCES
FOR THE FUTURE

THE BENEFITS OF REDUCED AIR POLLUTANTS IN THE U.S. FROM GREENHOUSE GAS MITIGATION POLICIES

Dallas Burtraw and Michael A. Toman

Climate Issues Brief No. 7

October 1997

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Climate Issue Briefs are short reports produced as part of RFF's Climate Economics and Policy Program to provide topical, timely information and analysis to a broad nontechnical audience.

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THE BENEFITS OF REDUCED AIR POLLUTANTS IN THE U.S. FROM GREENHOUSE GAS MITIGATION POLICIES

Dallas Burtraw and Michael Toman, Resources for the Future

INTRODUCTION

To a large extent, policies for limiting emissions of greenhouse gases (GHGs) have been analyzed in terms of their costs and potential for reducing the rate of increase in atmospheric concentrations of these gases. However, actions to slow atmospheric GHG accumulation could also reduce "conventional" environmental pollutants. The benefits that result would be "ancillary" to GHG abatement and could be manifested in several ways. Moreover, these benefits would tend to accrue in the near term, while any benefits from reduced climate change mostly accrue over a time frame of several decades or longer. In addition, ancillary benefits accrue largely to those countries undertaking mitigation action, in contrast to the benefits of reduced climate change risks that accrue at a global level.

A failure to adequately consider these ancillary benefits could lead to an incorrect assessment of the "net costs" of mitigation policies and an incorrect identification of "no regrets" levels of GHG mitigation. It also could lead to the choice of an unnecessarily expensive policy because of its failure to fully exploit potential ancillary benefits. To illustrate these issues, we consider how lower GHG levels resulting from less fossil fuel use could reduce various "criteria" air pollutants (as defined in the Clean Air Act). The pollutants of interest include sulfur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), particulates (PM), and tropospheric ozone (O_3). Lead (Pb) also is an important criteria pollutant and is included in ancillary benefits calculations but, given the stringency of existing control measures, the additional lead reduction benefits from GHG policies probably are small.

The discussion indicates that the average ancillary benefits derived from modest shrinkage in GHG emissions themselves are likely to be modest, when measured in terms of benefits per ton of carbon reduction but they are still worth taking into account. Larger ancillary benefits per ton of carbon reduction could be obtained with more aggressive GHG controls or in locations with high levels of exposure to damages from criteria pollutants, though these benefits themselves are not enough to offset the costs of abatement. In either case, considerable uncertainty about the size of ancillary benefits precludes identification of a single "best estimate" of their magnitude.

ADVERSE ENVIRONMENTAL EFFECTS OF CONVENTIONAL POLLUTANTS

Extensive scientific literature exists on the adverse human health effects of exposure to criteria air pollutants. These effects are widely seen as significant, though their size depends on the amount and duration of exposure to specific pollutants, and the nature of the exposed population, among other factors. They include, among other things, the initiation or aggravation of various pulmonary disorders, as well as cardiovascular problems; they result in premature mortality as well as illness.

Reductions in premature mortality from reduced exposure to various forms of particulates typically account for about 75-85 percent of all estimated benefits in economic assessments of improved air quality. The pollutants described as particulates take a number of forms and arise from a number of sources. Particulates include soot emitted directly from the combustion process, soil dust (often mobilized in the air by human activities), and secondary pollutants such as sulfate and nitrate aerosols that form chemically in the atmosphere from SO_2 and NO_X. The various particulate substances are found in different proportions in different areas, and they have different degrees of impact on human health. Of the various types of particulates, sulfate and nitrate aerosols and their potency raise particular concern.

Another secondary pollutant that impairs human respiration is O_3, which is formed from the mixing of NO_X and volatile hydrocarbons (VOCs) in sunlight. While some short-term adverse health effects arise from increases in O_3 concentrations, little evidence indicates that ozone is associated with long-term illness or premature mortality for most of the population, and consequently O_3 receives much less weight than particulates in economic analysis. CO, while obviously fatal at high concentrations, has much more limited health effects (primarily related to cardiovascular systems) at ambient exposure levels normally encountered. Moreover, CO emissions are decreasing over time as new vehicles with low emissions replace older vehicles.

At high enough concentrations, criteria air pollutants can also damage ecosystems. NO_X and SO_2 are precursors to acidic deposition (commonly referred to as "acid rain") that has adverse effects on some forest species and aquatic wildlife. Atmospheric deposition of nitrogen also is a potentially significant contributor to damaging algae blooms in certain estuaries (e.g., the Chesapeake Bay). Both SO_2 and O_3 can produce foliar damage in a number of crops and trees; O_3 is responsible for agricultural yield losses in the United States valued at several billion dollars each year, while the damages to forests and other ecosystems is still being assessed.

Criteria air pollutants also impair visibility and damage materials, affecting both aesthetic and property values. Airborne sulfur and nitrogen compounds, for example, tend to impair visibility, as do PM and ground–level O_3. PM soils buildings, statues, and monuments and acid rain accelerates their decay.

The vast majority of the U.S. economy's GHG emissions arise from fossil fuel combustion. Natural gas (methane) is the least carbon-intensive fossil fuel per unit of energy content. Methane also is a relatively "clean" fuel among conventional pollutants. The main pollutants resulting from its combustion are relatively small amounts of NO_X. Petroleum products have intermediate carbon intensity and can generate significant emissions of PM, SO_2, NO_X, VOCs, and (in older cars) CO, again in the absence of effective emissions controls. Coal is the most carbon-intensive of the fossil fuels, and its combustion also generates relatively high emissions of criteria pollutants (especially SO_2, NO_X, and PM) in the absence of effective emissions controls. However, current regulatory standards require very stringent controls on gases, dust, and soot from stationary sources like power plants and these controls reduce emissions substantially.

The most likely sources of particulate reductions to be had from GHG policies that affect energy use are reduced emissions of SO_2 and NO_X that form sulfate and nitrate aerosols, and reduced soot from diesel engine emissions. Previous studies indicate that significant reductions in NO_X and CO are possible as a result of policies aimed primarily at reducing carbon emissions. Reductions in VOCs or direct particulate emissions from carbon policies may be much smaller than the NO_X and CO reductions, depending on the policies pursued.

The effects of GHG policies on SO_2 emissions depend on the scale of GHG reductions pursued and the interaction of such policies with the cap on SO_2 emissions from electric utilities in the United States. With this cap, aggregate SO_2 emissions from electric utilities (the major source category in thecountry) are not likely to change much as a result of smaller-scale GHG emissions reductions, though GHG policies could lower the cost of complying with the SO_2 cap by reducing the use of coal and thus the demand for SO_2 emission allowances. However, if climate policies are sufficiently stringent that utilities substitute away from coal—so much that the level of SO_2 emissions falls below the annual emissions cap—then ancillary benefits from further reductions in SO_2 would be achieved.

The actual extent of emissions reductions depends critically on both the type of fuel used and on the technologies employed for combusting fossil fuels and trapping pollutants in the waste gas stream. The economic benefits of emission reductions depend critically on geographic location. For example, far more people are affected by emissions from a power plant located in New York than New Mexico. Failure to account for growth in population which increases the number of exposed individuals will understate the long-term benefits of emissions reductions. This caveat is particularly challenging since climate policy inherently is a long-term effort.

While most analyses (including this one) focus on the ancillary benefits of GHG reduction, policies also could give rise to ancillary costs. For example, a shift from coal to less carbon-intensive renewable biomass production for electricity generation could increase particulate emissions in the absence of adequate control equipment. Better building insulation can add to indoor air pollution, including radon, and switching from coal to gas raises the specter of fugitive emissions of methane, a more potent greenhouse gas than CO_2. In addition, relatively expensive GHG mitigation policies could have some negative side effects on health by reducing the resources available to households for other health-improving investments. (This effect could be particularly important in assessing ancillary benefits in poorer countries with limited capital resources.)

Finally, a tightening of pollution standards (such as the nation's new air quality standards for ozone and particulates) and improvements in environmental performance will mean that ancillary benefits from climate policies will actually be smaller than projected by models that fail to take these abatement measures into account. However, tighter standards with respect to conventional pollutants also will raise the relative cost of using more carbon-intensive fuels. This means that tougher conventional standards will lower the opportunity costs of GHG emission reductions (for example, through fuel switching) in the future as well, a point not accounted for in many models for assessing the cost of GHG policies.

ESTIMATES OF ANCILLARY BENEFITS

Table 1 summarizes a variety of ancillary benefit estimates, expressed in the common metric of dollars per ton reduction of carbon emissions. (References for the estimates are included in the "Further Readings" section at the end of this paper.) In every case the original studies that produced these data identified a wide range of possible estimates around the midpoint estimate for ancillary benefits per ton of carbon emission reduction that we report. Lower and upper bounds for each estimate vary from the midpoints by a factor of 2 to 10 or more.

Table 1 indicates a large variation even among the midpoint estimates in previous studies. A number of differences in the analyses help to explain the different results. These include differences in the modeling of criteria pollutant emissions reductions from GHG abatement, the estimation of health impacts from the criteria pollutant changes, and the evaluation of these impacts. An important element here is the treatment (or lack thereof) of locational differences. Another reason for the variation among studies is differences in the coverage of sectors, pollutants, and impacts. For example, one study considers a small voluntary program, while others consider the entire electricity sector or the economy as a whole. Some studies include a few of the larger health impacts, while others attempt a more comprehensive accounting of ancillary benefits.

Treatment of the aggregate cap on SO_2 emissions created under Title IV of the 1990 Clean Air Act Amendments presents another important distinction among the studies. When the cap is binding, emission reductions in one location are canceled out in another. On the other hand, however, reductions at one location are likely to reduce the need for investment in SO_2 abatement elsewhere. Though important, this cost saving is considerably smaller than the additional health benefit that would accrue if total SO_2 emissions were reduced below the cap. In contrast, a larger-scale GHG policy could lead to a reduction in coal use of sufficient magnitude that total SO_2 emissions could fall below the cap, resulting in a decline in the fine sulfate particles that are implicated in increased premature mortality. (For example, the Clinton Administration's unpublished analysis of the impacts of stabilizing GHG emissions at 1990 levels in 2010 calculates large SO_2 emissions reductions, on the order of 4 million tons, and calculates a very large benefit from NO_X and SO_2 reductions.) Similar issues would emerge if EPA increased its use of economic incentive approaches such as cap-and-trade regulation of NO_X to cut other pollutants.

Table 1: Comparisons of Estimates of Ancillary Benefits per ton of Carbon Reduction.

Source (explained in Further Reading)	**Targeted sectors, pollutants and policy**	**Average ancillary benefit per ton carbon reduction (1992$)**
(1) ICF/ PREMIERE	Nationwide Motor Challenge voluntary program (industry), analyzed at regional level; only health effects from NO_x changes valued, including secondary particulates, excluding ozone effects	$2.88
(2) Dowlatabadi et al./PREMIERE	Nationwide seasonal gas burn in place of coal, analyzed at regional level; health effects from NO_x changes valued using PREMIERE, including secondary nitrates, excluding ozone effects	$2.64
(3) EXMOD	Reduced utilization of existing coal steam plant at a suburban New York location; only PM, NO_x and SO_2 (under emission cap) changes valued (based on 1992 average emissions), including secondary particulates and ozone effects; all health, visibility and environmental effects that could be quantified are included	$23.96
(4) Coal/PREMIERE	Equal percentage reduction in utilization of all existing (1994) coal plants in U.S. analyzed at state level; only health effects from NO_x changes valued, including secondary particulates and excluding ozone	$7.02
(5) Coal/ PREMIERE/RIA	Equal percentage reduction in utilization of all existing (1994) coal plants in U.S. analyzed at state level; only NO_x related mortality changes valued, including secondary particulates and excluding ozone, using new EPA RIA estimates of impacts and valuations	$23.92
(6) Goulder/ Scheraga and Leary	Economy-wide carbon tax with stabilization at 1990 levels in 2000; human health effects calculated from reduced total emissions of all criteria pollutants, no secondary particulates or ozone.	$29.84
(7) Boyd *et al.*	Economy-wide carbon tax; human health and visibility effects calculated from reduced total emissions of all criteria pollutants	$35.58
(8) Viscusi *et al.*	Equal percentage reduction in utilization of existing (1980 average) coal steam plants nationwide; human health and visibility effects calculated from reduced total emissions of all criteria pollutants	$78.85

EVALUATING THE ESTIMATES

How does one make sense of the welter of estimates in Table 1? Firm conclusions are all but impossible to draw, given the current state of knowledge. Accordingly, we do not believe it is possible at this time to identify a single numerical "best estimate" of benefits per ton of carbon reduced for any particular GHG limitation, let alone for all possible GHG limitations. As discussed in more detail below, however, we believe that modest but nonetheless important ancillary benefits per ton of carbon emission reduction would result from a modest level of GHG control, and that the benefits might be more than modest in certain locations (those with denser populations and greater exposures to damaging criteria pollutants). The benefits per ton of carbon reduction could be larger with a greater degree of GHG control, though it is difficult to gauge by how much.

In identifying the large uncertainties surrounding current estimates of ancillary benefits, we have focused especially on the location of emissions reductions, the role of the SO_2 emissions cap, and the means by which emissions reductions are achieved (e.g., voluntary versus involuntary measures, and comprehensive measures versus measures that allow increases in emissions from uncovered sources). Lying behind these factors are basic questions about trends in criteria pollutant emissions, the location of these emissions, the incidence of their adverse effects, and the economic valuation of avoided adverse impacts. Finally, the literature provides little in the way of estimates for ancillary benefits other than those associated with the electricity sector. A more reliable and comprehensive set of estimates must await analysis of how GHG abatement policies would affect other emissions sources, among other advances in knowledge.

Having said this, if one's goal is to identify the ancillary benefit per ton of carbon reductions for a *modest* carbon abatement program, we have greater confidence in the first four estimates in Table 1, all of which reflect the impact of GHG reductions in the electricity sector. These estimates reflect the most detailed methodologies, including locational differences in emissions and exposures, and they take into account the role of the SO_2 cap in limiting ancillary benefits. Note that these estimates suggest modest (less than \$10/ton) benefits on average for the United States as a whole, though benefits could be significantly higher in certain areas. The higher fifth estimate in the table reflects alternative assumptions about the scale of health impacts, the role of nitrates, and the economic valuation of impacts. The difference illustrates that ancillary benefits are sensitive to such assumptions, but given the controversy surrounding these specific assumptions, we put less stock in it.

However, the applicability of all these results is necessarily limited. Specific utility-sector policies for CO_2 reduction may have different effects in different geographic areas than assumed in these estimates, and may include changes not anticipated in the use of other technologies besides coal-fired plants. For example, an energy efficiency policy could reduce use of low-emitting gas as well. Moreover, health of course is not the only environmental benefit. GHG policies affecting other sectors – notably transportation – could also generate ancillary environmental benefits not captured in the utility sector analyses. Finally, benefits would be larger with nonmarginal GHG mitigation policies that drive SO_2 emissions below the regulatory cap.

In light of these limitations, it is tempting to embrace the last three studies in Table 1 that attempt to describe the effects of nonmarginal, economy-wide GHG reductions and include a variety of pollutants and impacts. However, the methodologies in these studies simply compute a total economic benefit from a national reduction in criteria pollutant emissions. They lack attention to locational differences in emissions and exposures, and they inherently overestimate the total ancillary benefits from SO_2 reduction by failing to take into account the effect of the SO_2 cap. Moreover, the assessments and valuations of health impacts in these studies are based on literature from the 1980s, while the field has developed rapidly in recent years. Finally, the ancillary benefits from a comprehensive carbon tax may not reflect the benefits generated by other, less comprehensive and cost-effective policies.

It is of some interest to compare the various figures in Table 1 with the costs of GHG abatement, although it is difficult to formulate such a comparison with the simple per-unit values we have calculated for a number of reasons. The models used to estimate abatement costs give a wide range of answers, depending on various critical assumptions made and on the level of abatement undertaken.

Both the Clinton Administration's analysis and a 1993 study by the Energy Modeling Forum suggest that the *marginal* cost of achieving *stabilization* of U.S. emissions at 1990 levels in the year 2010 might be on the order of \$100/ton (Costs could be lower with greater technical progress or robust international GHG emissions trading but they could be higher if domestic GHG policies are poorly designed or technical progress lags). The marginal costs of smaller initial reductions are likely to be considerably lower; indeed there is reason to think they would be close to zero (some would even argue less than zero, though we remain skeptical). This low cost suggests that the ancillary environmental benefits of even \$3/ton of carbon reduced, let alone \$7-10/ton, could have a significant effect on the volume of emissions reduction that is "no regret." On the other hand, ancillary benefits of even \$25/ton of carbon removed are clearly smaller than the marginal cost of significant GHG reductions, and even the prospect of additional ancillary benefits from sulfate reductions with a nonbinding SO_2 cap would not close the gap. Nevertheless, in assessing the cost of GHG control for comparison with subjective estimates of the value of climate change risk reduction, these ancillary benefits clearly warrant attention.

LESSONS FOR POLICY

Some insights can be derived from our analysis and applied to the design of policy, though they must be interpreted with care. Ancillary benefits may be larger for GHG policies that more heavily target coal use, but the reason has at least as much to do with the continued use of old, relatively polluting boilers as with the coal itself. And GHG abatement policies that have relatively greater effects and impose greater costs on newer plants will have the perverse effect of creating a new bias against construction of new facilities, resulting in continued use of older facilities and lower ancillary benefits.

GHG mitigation that occurs in areas especially conducive to the formation of secondary pollutants (ozone and secondary PM) will, compared with other options, confer larger ancillary benefits. Similarly, GHG mitigation that occurs at sources whose emissions affect large populations and ones that are subject to high levels of pollution also will tend to confer larger benefits than where populations are small and pollution is less.

The possible trend in ancillary benefits over time also is of interest. It is often argued that abatement costs associated with a goal like GHG emissions stabilization will rise over time because of growing energy demand, though technical progress and ultimately a transition to noncarbon backstop energy resources should ease the trend. One might also expect the ancillary benefits of GHG control to rise over time as well. This is because of growth in population density and congestion, as well as growth in income can be expected to increase public willingness to pay for environmental protection.

Last but not least, it is important to be cautious about the implications of ancillary benefits with regard to the desired level of GHG control. Put simply, when ancillary benefits are taken into account the GHG policies that have the lowest net cost to society do not necessarily target the least expensive sources for reducing carbon emissions. Nor do they necessarily maximize the ancillary benefits of GHG control. Ancillary benefits are important enough that they should be considered jointly with the costs of carbon reduction to identify the preferred policies for society. At the same time, the choice of policies can have important distributional effects, both in economic costs and ancillary benefits that must be considered as well. These distributional issues are an important topic for further research.

FURTHER READING

General (Technical) Readings

This paper is based on a longer technical report issued as RFF Discussion Paper 98-01. Additional references include:

"Economic Effects of Global Climate Change Policies: Results of the Research Efforts of the Interagency Analytical Team," draft manuscript, May 30 1997. (Can be downloaded from *Weathervane*, RFF's climate economics and policy site on the World Wide Web: http://www.weathervane.rff.org.)

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Table 1 source information

(1) ICF/PREMIERE:

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(2) Dowlatabadi et al./PREMIERE:

Dowlatabadi, Hadi, F. Ted Tschang, Stuart Siegel. 1993. "Estimating the Ancillary Benefits of Selected Carbon Dioxide Mitigation Strategies: Electricity Sector," Prepared for the Climate Change Division, U.S. Environmental Protection Agency. August 5.

Results from this study were combined with analysis using the PREMIERE model cited below.

(3) EXMOD:

Hagler Bailly. 1995. *Human Health Benefits Assessment of the Acid Rain Provisions of the 1990 Clean Air Act Amendments.* Prepared by Hagler Bailly Consulting, Inc., Boulder, Colorado, under subcontract to ICF Incorporated, Fairfax, Virginia, for U.S. Environmental Protection Agency, Acid Rain Division. Final Report.

(4) Coal/PREMIERE:

Palmer, Karen L., and Dallas Burtraw. 1997. "Electricity Restructuring and Regional Air Pollution," *Resources and Energy*, vol. 19, nos.1-2, (March), pp. 139-174.

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U.S. Environmental Protection Agency (USEPA). 1996. "Regulatory Impact Analysis for Proposed Particulate Matter National Ambient Air Quality Standard (Draft)," prepared by Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards, USEPA, Research Triangle Park, N.C. (December.)

(6) Goulder/Scheraga and Leary:

Goulder, Lawrence H. 1993. "Economy-Wide Emissions Impacts of Alternative Energy Tax Proposals," Draft Report submitted to Adaptation Branch, Climate Change Division, U.S. Environmental Protection Agency, July.

Scheraga, Joel D., and Susan S. Herrod. 1993. "Assessment of the Reductions in Criteria Air Pollutant Emissions Associated with Potential CO2 Mitigation Strategies," Draft Report, Office of Policy, Planning and Evaluation, Climate Change Division, U.S. Environmental Protection Agency, Washington, D.C., August.

Scheraga, Joel D., and Neil A. Leary. 1993. "Costs and Side Benefits of Using Energy Taxes to Mitigate Global Climate Change," *Proceedings 1993 National Tax Journal*, pp. 133-138.

(7) Boyd *et al.*:

Boyd, Roy, Kerry Krutilla, and W. Kip Viscusi. 1995. "Energy Taxation as a Policy Instrument to Reduce CO2 Emissions: A Net Benefit Analysis," *Journal of Environmental Economics and Management*, vol. 29, no. 1 (January), pp. 1-24.

(8) Viscusi *et al.*:

Viscusi, W. Kip, Wesley A. Magat, Alan Carlin, and Mark K. Dreyfus. 1994. "Environmentally Responsible Energy Pricing," *The Energy Journal* vol. 15, no. 2, pp. 23-42.

About Resources for the Future

Resources for the Future (RFF) is an independent, nonprofit research organization that aims to help people make better decisions about the conservation and use of their natural resources and the environment. For the past 45 years, researchers at RFF have conducted environmental economics research and policy analysis involving such issues as forests, water, energy, minerals, transportation, sustainable development, and air pollution. They also have examined, from a variety of perspectives, such topics as government regulation, risk, ecosystems and biodiversity, climate, hazardous waste management, technology, and outer space.

While many RFF staff members are economists by training, other researchers hold advanced degrees in ecology, city and regional planning, engineering, American government, and public policy and management. RFF neither lobbies nor takes positions on specific legislative or regulatory proposals. Its operating budget is derived in approximately equal amounts from three sources: investment income from a reserve fund; government grants; and contributions from corporations, foundations, and individuals (corporate support cannot be earmarked for specific research projects). Some 45 percent of RFF's total funding is unrestricted.

The latest RFF news and information is available on the internet at http://www.rff.org.

About RFF's Climate Economics and Policy Program

As international debate intensifies over possible agreements to limit emissions of greenhouse gases, Resources for the Future (RFF) launched its Climate Economics and Policy Program in October 1996 to increase understanding and knowledge of the complex issues that must be addressed to design appropriate domestic and international policies that are effective, reliable, and cost-efficient. The program responds to both the long-term debate about climate change, and the specific debates surrounding the negotiations being carried out under the United Nations Framework Convention on Climate Change.

The publication of the Second Assessment Report of the Intergovernmental Panel on Climate Change signaled the beginning of a broader agenda of research and debate on global climate change. While there is still scientific uncertainty about the magnitude of climate change risks, the world's policy makers are now shifting more of their attention to debating appropriate policy responses.

RFF brings a well recognized and respected reputation for objectivity to this debate. The Climate Economics and Policy Program integrates the many different aspects of climate change with ongoing basic and applied research at RFF involving energy markets, water and forest resource management, air pollution, environmental regulation, and sustainable development.

PROGRAM AREAS. Drawing on RFF's strengths in environmental and natural resource assessment, economic analysis, and policy design, the climate program focuses on five main areas:

- Economic and environmental consequences of climate change and policies to deal with climate change.
- Domestic and international policy design issues.
- Interactions between climate change and other policies.
- Equity, efficiency, and other criteria used in decisionmaking.
- Development of analytical tools.

PROGRAM OUTPUTS. RFF's climate program includes original basic and applied research, policy analysis, and educational outreach.

Research. Integrating basic and applied research on the economic implications of global climate change with ecological, engineering, scientific, environmental health, geographical, international, and other considerations, an initial set of research projects underway at RFF include:

- Bringing Uncertainty into the Equation When Calculating Climate Change Risks
- Discounting in Intergenerational Decisionmaking (workshop)

- more -

- Economic Analysis of Greenhouse Gas Emissions Trading
- Effective Environmental Policy in the Presence of Distorting Taxes
- Electricity Restructuring and the Costs of Controlling CO_2
- Environmental Consequences of Tax System Reform
- Impacts of Climate Change Mitigation on Other Environmental Problems
- Importance of Technical Change in the Economics of Carbon Policy (workshop)
- International Cooperation for Effective and Economic Greenhouse Gas Limitation
- Vulnerability of Low-Income Households to the Hydrologic Effects of Climate Change

Policy analysis. As a response to questions arising in the ongoing international negotiations, RFF will issue a series of short papers on a variety of issues related to policy in 1997. These studies will be based on original research combined with critical reviews of existing literature. Potential questions to be addressed include:

- How should the climate problem be thought about in general?
- How might a domestic emissions trading program be established?
- How does the performance of revenue-raising and non-revenue-raising policy instruments compare?
- How should emissions reductions be scheduled over time?
- What is the potential for technical innovation to substantially lower the cost of greenhouse gas limitations, and what government policies can tap that potential?
- What are the strengths and weaknesses of different modeling approaches for assessing the economic costs of greenhouse gas limitations?

Educational outreach. RFF regularly shares its climate change findings with members of the academic, business and environmental communities, and representatives of local, national and international governments by publishing and disseminating discussion papers and convening educational forums on selected topics. To support a well-informed public, RFF provides regular reports of its climate change activities to the news media, posts program updates and activities on RFF's internet home page (http://www.rff.org), and will provide educational materials for lay audiences on the economics of climate change.