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Near-Term Greenhouse Gas Emissions Targets

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RESOURCES FOR THE FUTURE

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Abstract

At the present time no widely accepted temporal emissions path for greenhouse gases has been developed and adopted at either a country or a global level. What does exist is a set of near-term, country-level emissions targets associated with the first commitment period of the Kyoto Protocol and a process for the determination of targets for subsequent commitment periods. However, the first commitment period targets specified by the protocol have been heavily criticized on the grounds that they are arbitrary and ad hoc. The purpose of this paper is to examine the conceptual foundations upon which one might base a domestic climate policy for the United States and to attempt to determine whether a near-term emissions target can indeed be derived from structured decisionmaking resting upon these conceptual foundations.

Key Words: U.S. climate policy, greenhouse gas target, cost-effectiveness analysis, cost-benefit analysis

JEL Classification Numbers: Q2, Q4

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Raymond J. Kopp*

Introduction

Both domestic and international policies designed to reduce the threat of global climate change do so by limiting the atmospheric emission of anthropogenic greenhouse gases.[1] Perhaps the two most important design elements within such policies are the amount by which greenhouse gases are reduced and the time frame over which such reductions take place.

One can imagine a hypothetical policy where all greenhouse gas emissions are eliminated immediately. Such a policy would surely reduce the threat of global climate change, but the severity of the limitation on emissions combined with the immediacy of their reduction would come at great global economic cost. On the other hand, a business-as-usual policy requiring no reductions in greenhouse gases now or in the future would have no economic cost, but would do little or nothing to reduce the threat of global climate change.

Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC 1992) states the objective of the Framework is "to achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[2]

Article 2 also states that such a concentration level should be achieved within a time frame that "enables economic development to proceed in a sustainable manner." Many interpret this last phrase to suggest that stabilization of greenhouse gases should be undertaken in a

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* Senior Fellow, Resources for the Future. The author wishes to thank Richard Richels for providing data from MERGE model runs and Billy Pizer for valuable comments throughout the preparation of this paper. All errors and omisions remain the responsibility of the author.

[1] There is a second set of important policies associated with global climate change. These policies concern the adaptation of both natural and man-made systems to a changed climate. While important, these policies are not considered in this paper.

[2] See page 9 UN 1992.

manner that would not disrupt the global economy (see Wigley 2000) and therefore some balancing of climate and economic systems is envisaged.

The challenge is to design a policy that chooses a temporal path of emissions reductions balancing the economic cost of those actions against the reduced threat of global climate change.[3] This temporal path specifies annual emissions rates beginning with the present and extending into the future until concentrations have been stabilized at the desired level.

At the present time no widely accepted temporal emissions path has been developed and adopted at either a country or a global level. What does exist is a set of near-term, country-level emissions targets associated with the first commitment period of the Kyoto Protocol and a process for the determination of targets for subsequent commitment periods.[4] However, the first commitment period targets specified by the protocol have been heavily criticized on the grounds they are arbitrary and ad hoc and inconsistent with notions of economic efficiency, failing to balance economic costs with threats to the global climate system as required by Article 2 of the Framework Convention. These critics argue in favor of a process giving rise to both near-term emissions targets and full temporal emissions paths based upon an approach that would avoid arbitrary and ad hoc decisionmaking and ensure the targets meet the requirements of economic efficiency.[5]

The construction of emission targets based on a sound conceptual framework, and guaranteeing economic efficiency is a laudable goal. However, it is not immediately apparent that the difficult problem of domestic climate policy formulation lends itself to this type of rigorous construction. The scientific and economic uncertainties inherent in the problem of climate change may be so great that they represent an insurmountable barrier to the use of "structured decisionmaking."

[3] The balancing may be conducted in an analytic manner providing information and analysis to decisionmakers to be used in the political process giving rise to policy recommendations, or the balancing may be conducted entirely within a political process without the benefit of formal analysis.

[4] See UN 1997.

[5] There are six greenhouse gases covered under the Kyoto Protocol—carbon dioxide (CO_2), methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). The most important of these is carbon dioxide, and the topic of this paper concerns near-term targets for the emission of carbon dioxide.

The purpose of this short paper is to examine the conceptual foundations upon which one might base a domestic climate policy for the United States and to attempt to determine whether a near-term emissions target can indeed be derived from structured decisionmaking.

Conceptual Approaches

There are two approaches one can take in the development of a near-term policy when specifying an initial greenhouse gas emissions target and a path of future reductions. The first of these approaches is standard cost-benefit analysis as employed in federal environmental policymaking.[6] Cost-benefit analysis is the explicit balancing of the costs of a policy against its benefits. It is through this explicit balancing that cost-benefit analysis is able to provide both a greenhouse gas goal and a mechanism by which to choose among approaches to attain the goal.

In contrast to cost-benefit analysis, cost-effectiveness analysis takes the goal as given and focuses on the least-cost mitigation strategy. The balancing of costs and benefits takes place in a prior political setting where decisionmakers choose the goal and employ cost-effectiveness analysis to develop a policy to meet the goal.[7] While cost-effectiveness analysis takes the goal as given, such analysis is relevant to our current problem of setting a near-term greenhouse gas target since a near-term target can be derived from a given long-term goal such as a greenhouse gas concentration level.

Cost-Effectiveness Analysis

Article 2 of the Framework Convention suggests the use of cost-effectiveness analysis. The Article provides a target, albeit a vague one, and states the time frame over which the target is achieved should mitigate the impact the reductions in emissions would have on global economies, suggesting emissions mitigation policies that are economically efficient, that is, cost-effective.

One can establish a near-term greenhouse gas emissions target for the United States using the guidance provided by the Framework Convention. Such a process would involve the

[6] Pros and cons of cost-benefit analysis as a decisionmaking tool for the development of public policy are discussed in Kopp, Krupnick, and Toman (Kopp, Krupnick, and Toman 1997).

[7] One can imagine an iterative process where the target is set politically and the costs then assessed using formal cost-effectiveness analysis. Once the costs are known, the political process reassesses the target.

following steps. First, one must translate the vague notion of a greenhouse gas concentration level that would "prevent dangerous anthropogenic interference with the climate system" into a numeric concentration that would be achieved at some point in the future.[8] A defined concentration level defines a "carbon budget," that is, the total amount of carbon that may be emitted into the atmosphere consistent with the desired concentration target.

The next step is to determine the optimal allocation of that carbon budget over time. One can examine a range of alternative intertemporal global emission paths capable of achieving the desired concentration level. Each of these paths is subjected to an economic analysis that determines which path reaches the target at least cost. Once the least-cost path is known, we have defined the temporal path of global emissions (or emissions reductions) that is consistent with achieving the target at least cost.

The annual emissions targets derived from the least-cost path are global. In other words, they are aggregate targets for the world as a whole. To know the target that pertains to the United States, the aggregate global emissions must be divided among all emissions sources (countries). Some speak of this allocation of emissions as "burden sharing," but this is not correct. Burden sharing relates to the distribution of control costs, however, the distribution of control costs does not necessarily coincide with the distribution of emissions. That is, a country or region bearing the greatest financial burden may emit relatively large amounts of greenhouse gases but pay for greenhouse gas control in other countries where the cost of control is cheaper. Burden sharing can be thought of as the allocation of emission "rights" while the actual pattern of emissions will likely be determined by the economics of control cost.

A small literature has developed that attempts to perform the burden sharing allocation under an "equity-fairness" paradigm. [9] The dominant equity-fairness approach is based on an equilibrium condition where carbon emissions per capita are equilibrated across all countries at some point in time. This approach is known as "contraction and convergence"—implying contraction of emissions over time, converging to equal per capita shares at some point in the future. This approach clearly has notions of fairness attached, but is viewed by some as unrealistic since it does not match the benefits of a mitigation program with the costs incurred for

[8] Page 9 UN (1992).

[9] Some of the very difficult international policy issues involved in burden sharing are addressed in the recent book by Scott Barrett (Barrett 2003).

a particular country. Moreover, the literature remains relatively silent with respect to the speed with which per capita carbon emissions should approach the desired equilibrium condition.

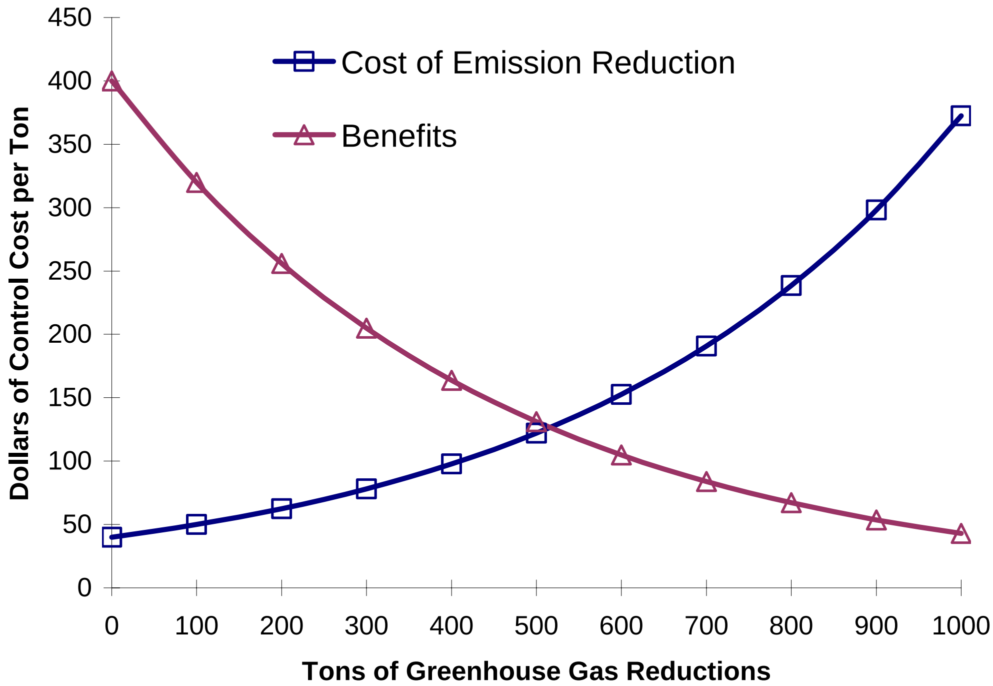
Unfortunately, as noted above burden sharing provides little or no information regarding the ultimate distribution of emissions. Thus, even if one were to accept contraction and convergence does not help us determine the paths of the U.S. emissions consistent with a stabilization goal. Given the global cost of achieving a stabilization target, one can imagine that the world will seek to attain this goal at least cost. This implies that the greatest carbon reductions will take place in those portions of the world where they are least costly. Therefore, to determine the path of U.S. emissions consistent with a particular stabilization target one must allocate the global emissions to countries on the basis of the cost of control within each country.

Cost-Benefit Analysis

Cost-benefit analysis is a flexible and powerful tool that can be used to both set emissions reduction goals as well as evaluate the economic efficiency of alternative means of attaining those goals. In its simplest form the application of cost-benefit analysis to the problem of climate policy formulation has two components. The first component involves an analysis of the cost of greenhouse gas emissions reductions, while the second component pertains to a similar analysis that quantifies in dollar terms the damage to the climate system caused by accumulating greenhouse gases.

Cost-benefit analysis can be explained with the aid of Figure 1 where the dollars of cost and benefit of greenhouse gas emissions reductions are measured on the vertical axis and the tons of reduced emissions on the horizontal. Generally speaking, the cost of the first few tons of reduction (on a per ton basis) is low, but then rises as the volume of reductions grows. The task facing the cost-benefit analyst is to move along the cost of emissions reduction curve to the point where the cost of an additional ton of greenhouse gas reduction is exactly equal to the dollar amount of the damage (the measure of benefits) that additional ton would cause to the climate system. At this point the marginal cost of reducing greenhouse gas emissions is exactly equal to the marginal benefit (in terms of reduced damage to the climate system) of reducing those emissions and thus defines the optimal emissions reduction target.

Figure 1: Cost-Benefit Analysis of Greenhouse Gas Control



The use of cost-benefit analysis in the development of climate policy is complicated by the very long-run nature of the problem and the policy actions required (extending 50 to 100 years). Over this time frame we expect new information on both costs and benefits to be made available to decisionmakers leading to reevaluations of both long-term and short-run emissions reduction goals.

Implementation

A Near-Term Target Using Cost-Effectiveness Analysis

As described above, using cost-effectiveness analysis to determine a near-term carbon reduction target for the United States begins with the numerical quantification of the desired concentration limit. Unfortunately, no body of scientific information exists that permits us to assign a numeric greenhouse gas atmospheric concentration to the goals articulated in Article 2 of the Framework Convention.

That is not to say no opinion exists regarding concentration levels. Current CO_2 concentrations are believed to be in the range of 375 ppm, in contrast to preindustrial concentrations of 280 ppm. Many in the environmental community argue strongly for a global target not exceeding 450 ppm. However, greenhouse gas concentrations in the neighborhood of 500-550 ppm (representing about a doubling of preindustrial concentrations) have been used in many climate policy scenario analyses, including the "Mitigation" volume of the Third Assessment Report produced by the Intergovernmental Panel on Climate Change (2001)[10], and continue to be the dominant concentration used for scenario analysis.[11] Lacking any firmer basis for the choice of concentration, the analysis contained in this paper utilizes a 550 ppm global long-term stabilization target.[12]

There have been several modeling exercises over the past few years designed to produce intertemporal regional and global greenhouse gas emissions paths consistent with stabilization at 550 ppm. Many of these analyses have been reported in the IPCC Third Assessment Report and three more are available in a special issue of the *Energy Journal* published in 1999. For our purposes, only those analyses conducted with the goal of modeling "optimal" emissions paths, that is, emissions paths that achieve the 550 ppm and concentration at least cost, are relevant.

Perhaps the most often cited modeling results yielding optimal emissions paths are those produced by the MERGE model authored by Alan Manne and Richard Richels (1995, 1999). The results contained in Manne and Richels (1999) describe a global emissions path that rises to approximately 10 gigatons of carbon by the year 2030, remains relatively flat from 2030 to 2050, and then declines.

As will become evident, the precise volume of peak global emissions—approximately 10 gigatons in the case of Manne and Richels (1999)—is not as important as the time frame in which the emissions need to peak to hit the 550 ppm target.[13] It is comforting to note that the

[10] The IPCC caveats its use of 550 ppm with the following footnote, "the selection of 550 ppm scenarios is based on the relatively large number of available studies that use this level and does not imply any endorsement of this particular level of CO_2 concentration stabilization." Page 117, Volume III.

[11] See for example Pacala and Socolow 2004.

[12] The cost-effectiveness analysis described below may be repeated using any desired concentration level. Lower concentration levels would give rise to more aggressive near-term carbon dioxide reduction targets.

[13] As a point of reference, global emissions peak at slightly less that 10 gigatons at 2050 in Tol (1999) and rise to just over 12 gigatons in 2050 in Peck and Teisberg (1999).

other two models analyzing a 550 ppm stabilization scenario in the *Energy Journal* special issue (Peck and Teisberg 1999,Tol 1999) depict emission peaks in 2030–2040 time frame as well.

Generally speaking, all three models depict an emissions stabilization path requiring relatively small deviations from global business as usual (BAU) until 2020. Up to this point reductions from BAU emissions on the order of 2% or 4% annually are sufficient to remain on the path. In the Manne and Richels (1999) analysis required reductions grow beyond 2020 and by 2050 require significant reductions of 30% or more from BAU.

It is important to recognize that the precise character of the optimal emissions path leading to a 550 ppm stabilization is model dependent. Other models, even those constructed along the same analytical lines as MERGE, may yield different results, suggesting more or less aggressive near-term carbon reduction goals in order to meet a 550 ppm concentration target. However, there is a consensus among models generating economically efficient optimal emissions paths leading to stabilization goals. Results from these models generally suggest small emissions reductions in the early years and increasingly larger reductions in the later years.

Given a global emissions path, our next task is to develop a comparable path for the United States. As suggested above all burden sharing schemes recognize that the item to be allocated is in some sense simply allowable emissions of greenhouse gases—not the actual emissions. Actual emissions will take place in those countries where the cost of mitigation is the highest and these countries will in one way or another "purchase" allowable emissions from countries where the cost of mitigation is low. Therefore, even if we employed a contraction-and-convergence approach to determine allowable U.S. emissions, it would not specify actual emissions and therefore not be of great value in attempting to set near-term targets.

Since the United States is the single largest emitter of greenhouse gases and will likely remain so for quite some time, a reasonable simplifying assumption would be to presuppose that the pattern of annual U.S. emissions will follow the general shape of the global 550 ppm emissions stabilization path. Under this assumption required reductions in U.S. emissions will be small in the early years from 2000 to 2020, but will become significantly larger in the 2020 to 2050 time period and beyond.

Table 1 summarizes the time path of emissions for the next century under a 550 ppm stabilization scenario. The first row represents historical and forecasted global emissions of carbon under BAU conditions, while the second row describes carbon emissions under the 550 ppm stabilization. Data for both of these rows is derived from Manne and Richels (1999). The third row depicts BAU emissions for the United States. Data from 1990–2050 is drawn from the

2004 International Energy Outlook.[14] The fourth row depicts a U.S. 550 stabilization path where the U.S. fraction of global emissions is constant (at about 22%) over the next century. The fifth row is the reduction in U.S. emissions (in millions of tons) between BAU and the 550 path, while the final row is the percent difference in U.S. emissions between BAU and the 550 path.[15]

Table 1: Emissions Paths for 550 PPM Stabilization (million metric tons of carbon)

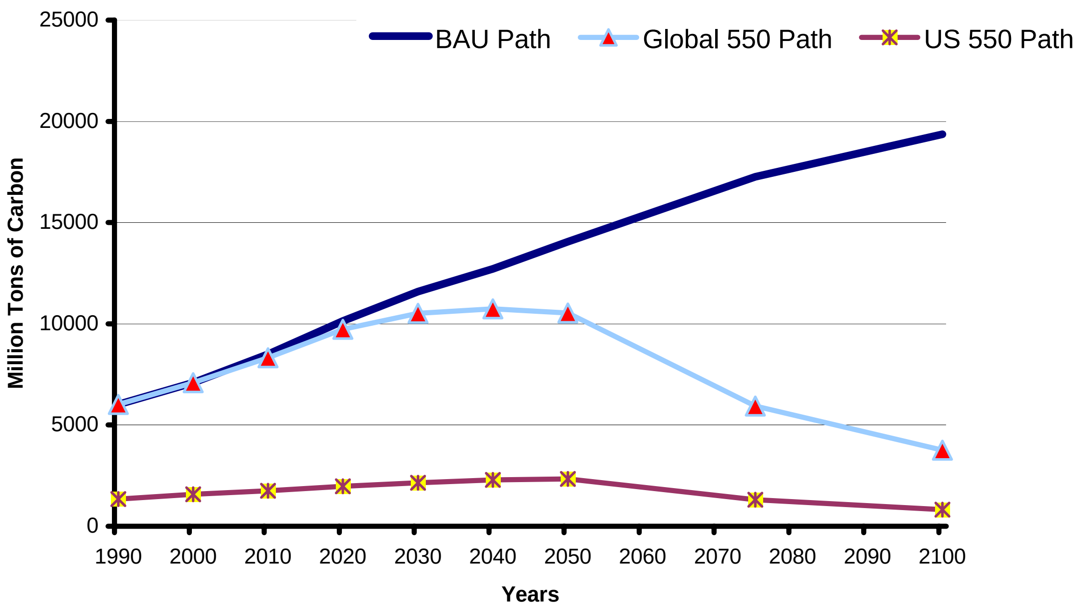
	1990	2000	2010	2020	2030	2040	2050	2075	2100
Global BAU	6,024	7,092	8,493	10,138	11,589	12,716	14,051	17,267	19,364
Global 550	6,024	7,092	8,323	9,730	10,520	10,743	10,539	5,931	3,758
US BAU	1,337	1,578	1,789	2,055	2,361	2,713	3,117	3,581	4,115
US 550	1,337	1,578	1,753	1,972	2,143	2,292	2,338	1,305	827
Reductions	0	0	36	83	218	421	779	2,276	3,288
% Difference	0%	0%	2%	4%	10%	18%	33%	174%	398%

A pictorial representation of the data contained in Table 1 is provided in Figure 2. The rising global BAU path is contrasted with the rising and then falling global 550 stabilization path and the corresponding 550 U.S. path.

[14] Emissions forecasts for the United States and the world are drawn from EIA 2004 b.

[15] The emissions path depicted by the emissions in the 550 row of the table was chosen to match the shape of the MERGE model analysis contained in Table 9 of Manne and Richels (1999).

Figure 2: BAU and 550 ppm Concentration Stabilization Emissions Paths



Context with which to assess the 550 emissions path portrayed in Table 1 and Figure 2 may be gained by comparing the required emissions reductions to those of existing domestic proposals. The McCain-Lieberman Climate Stewardship Act of 2003 called for U.S. emissions to be capped at 2000 levels in 2010.[16] If implemented this legislation would require reductions in the neighborhood of 800 million metric tons of CO_2 in 2010 (equivalent to 220 million tons of carbon). Another point of comparison is the Bush administration plan for an 18% improvement in greenhouse gas intensity—the ratio of greenhouse gas emissions to economic output—amounting to a 350 million metric ton reduction in CO_2 by 2012 (equivalent to 95 million tons of carbon).[17] The 550 ppm stabilization scenario requires relatively small reductions in 2010 on the

[16] McCain-Lieberman excludes residential and agricultural sources of greenhouse gases, as well as any entity responsible for less than 10,000 metric tons of carbon dioxide per year or its equivalent. Given these exclusions, the proposed program still covers more than 70% of all U.S. carbon dioxide and industrial greenhouse gas emissions.

[17] Information on both the McCain-Lieberman Senate legislation and the Bush administration climate policy proposals may be found in Pizer and Kopp (2003).

order of 36 million tons of carbon—less than the Bush administration and considerably less than McCain-Lieberman.

There is considerable uncertainty regarding the cost of greenhouse gas emissions reductions. However, the federal government has produced reports that can be used to assign "ballpark" estimates to the emissions reductions required under the 550 stabilization scenario presented in Table 1. In 1998 the Energy Information Agency (EIA) produced a report analyzing the cost of Kyoto compliance (EIA 1998). The cost estimates are summarized in Figure 3 reproduced below.

Information in that report suggests that the incremental cost of reducing carbon emissions by 100 million metric tons annually is on the order of $56 per ton (in 2003 dollars).[18] Assuming linearity when scaled down to reductions less than 100 million metric tons, the cost of 550 ppm stabilization reductions in 2010 would be approximately $20 per metric ton of carbon. In the context of a cap-and-trade permit system operating in a manner consistent with the emissions paths of the 550 stabilization scenario, one would expect emissions prices to rise from approximately $20 in 2010 to $50 by 2020.

It is important to recognize that the EIA cost estimates could be lower if carbon "offsets" were taken into account. These offsets might represent reductions in carbon emissions from "qualifying" projects undertaken outside U.S. borders or within the United States, but aimed at reducing greenhouse gases other than CO_2, such as methane.

If for political or other reasons one believed the United States must begin to reduce its absolute level of emissions before the 2030 to 2050 period suggested in Figure 2, the resulting emissions path would require more aggressive reductions in the early years from 2000 to 2025. Suppose the United States decided it would act ten years earlier than the rest of world and cause its emission of CO_2 to peak in 2040. This would shift the Manne-Richels 550 scenario emission path in Figure 2 to the left. If we assumed that each year's annual reductions were to come a decade earlier, the reductions in 2010 would be on the order of 83 million tons of carbon (300-plus tons of CO_2) at a cost of $50 per ton of carbon. If the United States accelerated its reduction schedule by two decades, the 2010 reductions would be on the order of 218 million tons of carbon at a cost of $120 per ton.

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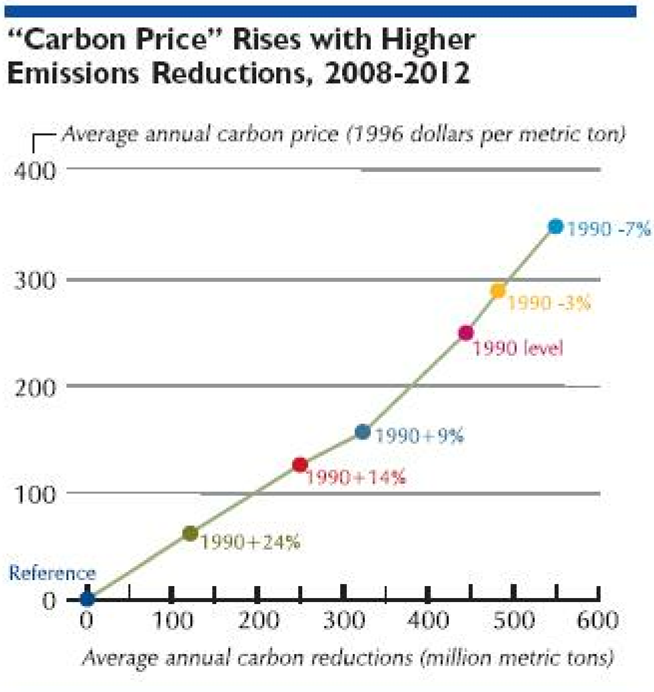
[18] The original EIA estimate was $50 in $1996. I have used GDP price deflators to convert to $2003. These deflators are drawn from Table B-7 in the 2004 Economic Report of the President (CEA 2004).

The results of this simple cost-effectiveness analysis are dependent upon three uncertain pieces of information. The first piece is the stabilization target that we have taken to be 550 ppm. We have made no attempt to suggest that this target is the one most consistent with the goal articulated in Article 2 the Framework Convention. However, for a variety of reasons it has gained popularity as a scenario to be modeled and one to be used as the basis of discussion.

The second piece of information is the result of the economic optimization model that specifies the least cost emissions path necessary to achieve the desired concentration target. Unfortunately, only a handful of models have been created that are capable of performing this type of analysis and each model operates under different assumptions. However, as noted above, three of these models—Manne and Richels (1999), Peck and Teisberg (1999) and Tol (1999)—depict the same turning point for peak global emissions, and it is this turning point that matters most in setting the near-term target. The third uncertain future of this analysis is the largely ad hoc path of U.S. emissions over the next century.

The last bit of uncertainty concerns U.S. actions. If the United States chooses to “cap” its emissions at the same time as the rest of the world (again under the Manne and Richels (1999) modeling scenario), our cost-effectiveness analysis suggests that near-term CO_2 emissions reduction targets for the United States are less than those articulated by the Bush administration and Senators McCain and Lieberman. However, if the United States chooses to accelerate its reductions by 10 years (reaching an emissions peak in 2030) the near-term reductions are in line with the administration. A peak in 2020 yields reductions in line with McCain-Lieberman.

Figure 3: EIA Estimates of the Marginal Cost of Carbon Emissions Reduction[19]



Cost-Benefit Analysis

The second approach, cost-benefit analysis, begins with a clean slate. That is, it does not require the specification of a long-term concentration target. Rather, it seeks to establish the optimal amount of greenhouse gas emissions mitigation by balancing the cost of mitigation against its benefits. In simple terms one can think of a cost-benefit analysis as composed of two tasks. One quantifies in dollar terms the damage to the climate system brought forth by an incremental (additional ton) emission of greenhouse gas. This information is used to assess the "benefits" of emissions reductions by equating the value of the ton of emissions reductions to the dollar value of the avoided damage to the climate system. One then establishes the marginal cost

[19] Figure 3 reproduced from EIA (1998).

of reducing greenhouse gas emissions, that is, the additional cost of reducing emissions by an additional ton.

Integrated Assessment

Integrated assessment models are capable of generating both marginal benefit and marginal cost schedules for greenhouse gas reductions. Given this ability, these models can identify optimal (economically efficient) concentrations of greenhouse gases as well as the economically efficient emissions paths leading to those concentrations. Obviously, the optimal concentrations produced by these models are dependent upon the characterization of benefits and costs contained within the models' structures.

One of the most well-known and widely used pair of integrated assessment models applied to the problem of global climate policy are the DICE (Nordhaus 1992, 1993, and 1994) and RICE (Nordhaus and Yang 1996) models produced by William Nordhaus and colleagues. These models capture in a consistent and integrated fashion both the cost of greenhouse gas control and the benefits that control confers on the climate system. The RICE model was run in a full optimization mode (i.e., undertaking a cost-benefit analysis) where a 100-year economically efficient emissions path was generated and used to analyze the economic efficiency of the Kyoto Protocol.[20]

These RICE model "optimal" results describe an emissions path quite different from the 550 ppm least cost path traced by the MERGE model. The RICE model's optimal path lies only slightly below business as usual. While the 550-ppm MERGE model stabilization path leads to a global emissions peak at 10 gigatons of carbon by 2050, the RICE model results provide for emissions almost 50% higher at 14.9 gigatons by 2050. In addition, rather than falling from 2050 to 2100 as suggested by the MERGE model results, emissions in the optimal RICE model scenario continue to rise to 20 gigatons by 2100 and concentrations approach 630 ppm.

The RICE model optimal emissions path does reflect decreased greenhouse gas emissions in the near term, but reductions are considerably less than those required by the 550-ppm stabilization scenario. By way of comparison, the marginal cost of greenhouse gas control along the RICE model optimal emissions path is $4 per ton in 2010 rising to $15 per ton in 2050. In

[20] See Nordhaus and Boyer (1999).

contrast, the 550-ppm scenario suggests a marginal cost of emission reduction in 2010 of approximately $20 per ton.[21]

Since the RICE model is balancing marginal costs and marginal benefits along its optimal emissions path, the marginal cost of greenhouse gas control depicted by the model in 2010 also describes the model's quantification of the economic benefits of greenhouse gas control, that is, in the neighborhood of $4 per ton.

Benefit Estimation: Market Losses

The emissions path identified by the RICE model (or any other integrated assessment model) depends to a great extent on the model's characterization of the marginal benefits of greenhouse gas emissions control. Therefore, it is important to delve into the research underpinning these important benefit estimates. It is also important to recognize at the outset that considerable uncertainty exists with respect to these estimates.

In a recent paper Robert Mendelsohn (Mendelsohn 2003) assembled several independent estimates of benefits. These estimates specified in terms of dollars per ton of carbon range from $7-$20 per ton over the next decade rising to $10-$30 per ton by 2030.[22] Others have found the benefits of greenhouse gas control to be significantly greater than those in Mendelsohn's paper. As reported by Mendelsohn in his paper, a recent study about the United Kingdom (Clarkson and Deyes 2002) sets the benefits of carbon abatement in the neighborhood of $40 per ton. This estimate has its origins in an earlier study conducted for the European Union (Eyre et al. 1997) finding the benefits of carbon abatement to be approximately $20 per ton. While there are studies showing considerably greater benefits of greenhouse gas control, for example, the same UK government study where discount rates were lowered to 1% yielding benefits on the order of $100 per ton, the low discount rates used in such studies have been the subject of criticism (Pearce 2003).

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[21] All estimates are in 2003 dollars using the GDP deflator.

[22] According to Mendelsohn these estimates are drawn from the early research conducted prior to 1996. He states in his paper that more recent work has concluded the benefits of greenhouse gas control are far less than previously thought. Mendelsohn states, "these results imply that the social costs (benefits) of carbon are currently about $1-$2 per ton. Although they will rise over time as carbon accumulates, there is every reason to expect that the social costs of carbon will remain below $10 per ton for the next 30 years." However, few of these "new"studies have yet been published.

Gillingham, Newell, and Palmer (2004) recently analyzed eight studies dating from 1994 to 1999 of the benefits of greenhouse gas emission reductions. [23] The authors conclude that current "central" estimates place the benefits between \$25 and \$30 per ton of carbon in 2003 dollars, with an overall range of \$17-\$72.

Given our current understanding of the science, if a consensus exists regarding the benefits of greenhouse gas control one would expect those estimates to fall in the range of \$5-\$30 per ton over the next decade, rising thereafter. This range places the RICE model results at the extreme low end of the spectrum.

Using estimates of the costs of greenhouse gas control provided by the Energy Information Agency, benefits in the range of \$5-\$30 per ton suggests near-term greenhouse reduction targets of 10 to 60 million tons of carbon per year (36-220 tons of CO_2). The range of these estimates overlaps those produced by the previous cost-effectiveness analysis.

Including Nonmarket Losses

In a recent paper Manne and Richels (2004) employ their MERGE model in a cost-benefit analysis of climate policy. Like RICE, MERGE is an integrated assessment model capable of balancing costs and benefits and deriving optimal emissions paths. However, unlike RICE, Manne and Richels have attempted to incorporate more information on the benefits side of the ledger.

The new paper is an outgrowth of Manne (2004) that addresses some issues of global climate policy raised by the Copenhagen Consensus Project.[24] In that paper Manne expressed his view that the range and character of the benefits of mitigating slow climate change were overly narrow and focused on "market losses" such as the avoidance of crop losses, forestry damage, shoreline erosion, and so on. Manne argued that there is good reason to believe that market losses are not the principal reason to be concerned over climate change. Rather, Manne stated, "The more worrisome issue is the type of damage for which there are no market values. The 'nonmarket damages' include human health, species losses and catastrophic risks such as the shut-down of the thermohaline circulation in the Atlantic Ocean."

[23] See table 13 of Gillingham, Newell, and Palmer (2004).

[24] See http://www.copenhagenconsensus.com.

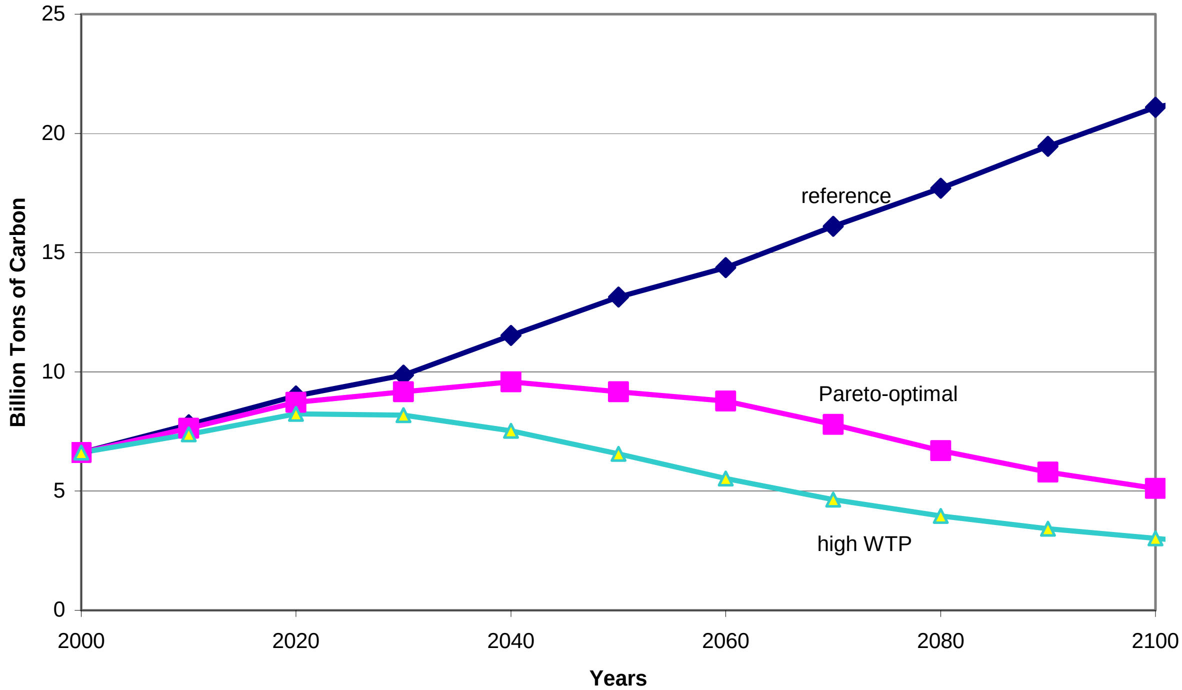
In his new paper with Richels, Manne modifies MERGE to include market and nonmarket benefits. As far as market damages are concerned, Manne and Richels assume that a doubling of CO_2 concentrations (over preindustrial levels) would cause a global warming of 2.5º C and that this amount of temperature rise would lead to GDP losses of 0.25% in the high income nations and to losses of 0.50 % in the low-income nations.

With respect to nonmarket losses, Manne and Richels assume they would increase quadratically with temperature—small losses for small changes in temperature, but increasingly larger losses for catastrophic changes. When combined with market losses, MERGE assumes that high-income countries would be willing to give up 2% of their GDP to avoid the loss. Manne and Richels state that 2% is the total GDP component that is currently devoted by the United States to all forms of environmental controls—on solids, liquids, and gases.[25] To place this assumption in context recall that current U.S. GDP is about $11.5 trillion (BEA 2004). Two percent of GDP is $2,000 per U.S. household. The average U.S. household spends about $3,000 per year on all forms of energy (EIA 2004 a) and the median U.S. household income is $43,300 (Census 2004).

MERGE runs termed the "Pareto-optimal" path are based on the above benefits assumptions and an explicit balancing of costs and benefits. A sensitivity analysis is performed by assuming that instead of 2% of GDP high-income countries were willing to give up 4% of GDP to avoid a 2.5º C degree warming. The emissions path associated with these assumptions is termed "High WTP" (willingness to pay). Figure 4 is reproduced from Manne and Richels 2004.

[25] In low-income countries with a per capita income of $25,000, a region would be willing to spend 1% of its GDP to avoid a global temperature rise of 2.5º. At $50,000 or above, the same region would be willing to pay 2%, and at $5,000 or below, willingness to pay decreases to virtually nothing.

Figure 4: MERGE Emissions Paths with Market and Nonmarket Benefits



Unfortunately, the Manne and Richels 1999 results are not fully comparable to the 2004 results due to differences in the reference scenario (specifically, the use of updated data on global emissions in the 2004 paper). That said, the shape of the Pareto-optimal path of the 2004 paper is very similar to the 550 ppm path of the authors' 1999 paper. This is particularly true of the early portion of the path from 2000 to 2040, the point at which global carbon emissions peak. The Pareto-optimal path calls for global emissions reductions from the reference case of 2% in 2010, 3% in 2020, and 7% in 2030. If these same percentages were applied to the U.S. BAU scenario they would suggest 30, 60, and 140 million tons of carbon trimmed from BAU in 2010, 2020, and 2030 respectively—very similar to the 550 stabilization path.

If nonmarket benefits approached the Manne and Richels "High WTP" levels, the economically efficient global emissions path would peak 20 years earlier (2020) and represent considerably more aggressive reductions in emissions than the 550 ppm stabilization path.

Negelected Nonuse Value

To the best of my knowledge, until the recent Manne-Richels paper all studies attempting to quantify or employ in their analysis the benefits of reduced greenhouse gas emissions have focused on what economists refer to as “use value.” Use value in the context of global climate change refers to all commercial and physical property losses due to an altered climate (market losses), plus losses to “nonmarket” goods such as recreational opportunities and other quality of life attributes. However, the proper measure of benefits should include “total value” which is composed of both use value and “nonuse value.”[26]

Nonuse value (sometimes referred to as existence value) is attached to those features of natural systems that are valued by humans, but are not directly used by humans. For example, the value societies place on the protection of endangered species, even though most members of the society have never come in contact with such species, is an example of nonuse value. The desire to be good stewards and to pass natural systems on for the enjoyment of future generations (termed bequest value) is also a component of nonuse value.

Techniques for the measurement of total value in the context of the protection of the global climate system are available and such studies have been suggested by Kopp and Portney (1999), among others. In principle, the existing use value studies would place a floor under the benefits estimated using a total value framework. It is difficult to speculate regarding the size of the additional benefits that would be associated with the nonuse component of global climate change protection without conducting such a study.

Since Manne and Richels specify nonmarket losses in a very general manner it might be argued that the Pareto-optimal and High WTP scenarios employed in the MERGE model capture use and nonuse value and thus measure the total benefits of mitigating climate change. Absent nonuse value studies, the question of whether 2-4% of GDP is regarded as likely willingness to pay on the part of rich nations to mitigate climate change is a matter of opinion. Given the current science and public attitudes, it is my opinion this represents an upper bound.

Caveats

Both cost-effectiveness analysis and cost-benefit analysis have been employed in this paper to produce near-term CO_2 abatement targets for the United States. Generally speaking, those targets are less aggressive than those of the Kyoto Protocol, the McCain-Lieberman Climate Stewardship Act of 2003, and the “intensity” targets of the Bush administration goals.

[26]See Kopp (1992) for a discussion of total value in the context of benefit-cost analysis. Also see Kopp, Krupnick and Toman (1997)

However, modeling assumptions that lead to larger marginal benefits of greenhouse gas control, e.g., Manne and Richels (2004) or require the United States to act more quickly to reduce emissions will yield targets more in line with McCain-Lieberman.

There are two broad caveats that must be associated with the analysis provided in this paper. The first concerns the magnitude of the targets produced by the two methods. The magnitude is related to the assumptions, models, and literature chosen for the analysis. Using the same analytical approaches, that is, cost-effectiveness analysis and cost-benefit analysis, the choice of different assumptions, models, and bodies of literature can give rise to different near-term targets. This fact does not represent an indictment of structured decisionmaking, but rather, underscores the inherent economic and scientific uncertainty in the analysis.

The second caveat is perhaps more important. The structure for decisionmaking provided for in the two approaches is silent regarding the transition from near-term to middle-term targets. While it is possible to trace out economically efficient emissions paths, in the manner of the MERGE model, in the real world it is difficult to know what near-term target best positions the U.S. social/political/economic system to reach the midterm and long-term goals. As many now recognize, stabilization of greenhouse gases at any concentration level requires zero net emissions in the future. That requirement translates to a global energy system that is largely devoid of carbon emissions (either through carbon capture and sequestration or fully noncarbon energy technologies). Perhaps the most important policy implication of the near-term carbon target is its ability to incentivize the U.S. economic system to undertake the massive investments in research and development necessary to produce the energy system of the future.

The important point regarding the targets developed in this paper is not the quantity of emissions reductions they call for over the next decade, but rather, is the incentive properties they provide for future action. The global climate system would likely be no worse off if U.S. climate policy provided for few if any emission reductions in the near-term as long as policies necessary to generate the R&D and investment paths required by the new energy technologies were in place. Unfortunately, we do not know if the near-term targets suggested in this paper will provide the necessary incentives for action.

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