THE HAMILTON PROJECT

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Gilbert E. Metcalf

A Proposal for a U.S. Carbon Tax Swap

An Equitable Tax Reform to Address Global Climate Change

The Brookings Institution

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A Proposal for a U.S. Carbon Tax Swap

An Equitable Tax Reform to Address Global Climate Change

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This discussion paper is a proposal from the author. As emphasized in The Hamilton Project's original strategy paper, the Project is designed in part to provide a forum for leading thinkers from across the nation to put forward innovative and potentially important economic policy ideas that share the Project's broad goals of promoting economic growth, broad-based participation in growth, and economic security. The authors are invited to express their own ideas in discussion papers, whether or not the Project's staff or advisory council agree with the specific proposals. This discussion paper is offered in that spirit.

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Abstract

This paper describes a carbon tax swap that is both revenue and distributionally neutral. The tax swap would levy a tax on greenhouse gas emissions. The revenue would be used to fund a reduction in the income tax, tied to earned income. Specifically, the proposal calls for a tax on greenhouse gas emissions at an initial rate of $15 per ton of carbon dioxide equivalent and gradually increasing over time. A refundable tax credit would be offered for sequestered greenhouse gases and other approved sequestration activities. In addition, to offset the new carbon tax, the proposal would implement an environmental tax credit in the personal income tax equal to the employer and employee payroll taxes on initial earnings up to a limit.

This paper begins with a discussion of the problem of greenhouse gas emissions and provides a rationale for setting a price on carbon emissions. It then provides a distributional analysis of the proposal described above. Following this analysis, it makes a case for why carbon pricing through a tax should be considered a viable alternative to carbon pricing through a cap-and-trade system. It concludes with a response to various objections made to carbon pricing in general and a carbon tax in particular.

Contents

1. The Problem

A consensus is emerging in the United States that global warming is an urgent problem requiring prompt attention. The majority of U.S. citizens think the government should do more about global warming, according to a recent poll (Langer 2006). Congressional leaders are following the public's suit. During the debate leading to the enactment of the Energy Policy Act of 2005, the Senate passed a Sense of the Senate climate resolution calling for progress on climate change. Several bills have been proposed in the current congressional legislative session to control greenhouse gas (GHG) emissions.[1] At the end of May 2007, President Bush called for the United States, along with other major GHG-emitting countries, to "set a long-term goal for reducing greenhouse gases" (Stolberg 2007).

This consensus is driven by a number of factors, including trends in temperature. The National Oceanic and Atmospheric Administration (NOAA) reports that "U.S. and global annual temperatures are now approximately 1.0 degrees F warmer than at the start of the 20th century, and the rate of warming has accelerated over the past 30 years, increasing globally since the mid-1970s at a rate approximately three times faster than the century-scale trend. The past nine years have all been among the 25 warmest years on record for the contiguous U.S., a streak which is unprecedented in the historical record" (NOAA 2007). NOAA's report also acknowledges that GHG emissions play a role in the rising temperatures: "A contributing factor to the unusually warm temperatures throughout 2006 also is the long-term warming trend, which has been linked to increases in greenhouse gases. This has made warmer-than-average conditions more common in the U.S. and other parts of the world" (NOAA).

The recent releases of Fourth Assessment Reports by the Intergovernmental Panel on Climate Change (IPCC) Working Groups provide additional evidence to support the role of anthropogenic warming. Working Group I describes the build-up of GHG concentrations and the role of human activity clearly: "Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture" (Intergovernmental Panel on Climate Change 2007, p. 2).

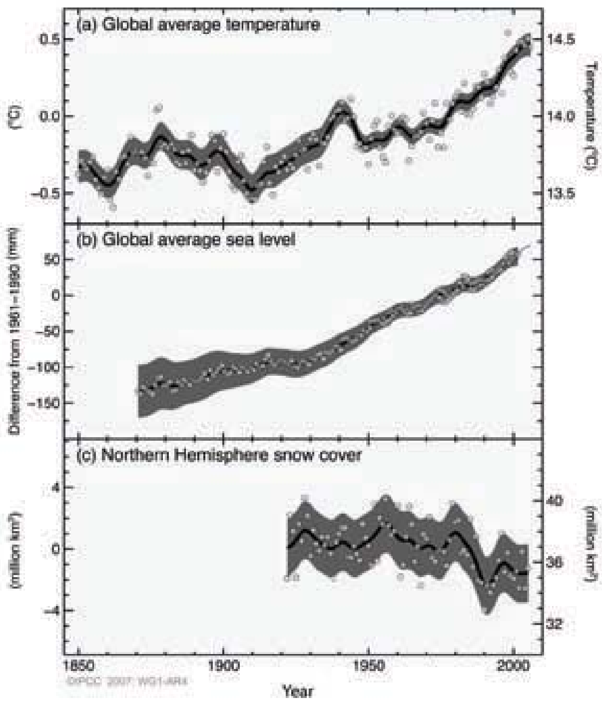
Figure 1 is from Working Group I's report (IPCC 2007a, p. 6). It provides a record of changes in temperature, sea level, and snow cover. The data points measure changes from the 1961–1990 averages. The solid lines graph smoothed decade averages, and the shading indicates uncertainty intervals.

The figure illustrates that global average temperatures have increased over the twentieth century, with accelerated warming in the past 30 years. Sea levels are also rising, with an average increase over the twentieth century of roughly 150 millimeters. Sea level rise is due to thermal expansion of the oceans and runoff from glaciers and ice caps. According to Working Group I's report, thermal expansion can account for roughly 40 percent of the explainable sea level rise (see Table SPM-1 in IPCC 2007a, p. 7). For the period 1993 to 2003, ice melts from glaciers and ice caps, as well as from the Greenland and Antarctic ice sheets, are predominantly responsible for observed sea level rise. Northern hemisphere snow cover appears to be trending downward, but

1. Paltsev et al. (2007) describe and conduct an economic analysis of climate mitigation scenarios based on these proposals.

FIGURE 1

Climate Change Record, 1850–2000



Source: IPCC (2007a).

the uncertainty is sufficiently large that one cannot rule out the absence of change in snow cover, based on the data reported in Figure 1.

Projections of future warming are less precise. The IPCC developed a number of emission scenarios in their *Special Report on Emission Scenarios* (IPCC 2000) and asked modelers to run scenarios using those assumptions.[2] Figure 2 from Intergovernmental Panel on Climate Change (2007a, p. 14) provides projections of temperature increases arising from those scenarios.

The solid lines are averages across different models of temperature changes for different scenarios relative to the 1980–1999 average temperature. The bars at right provide the likely range of temperature changes for each scenario, with the horizontal line a measure of the mean estimate in 2100.[3] Scenario A1F1 is a scenario with rapid economic growth in a fossil fuel–intensive world. In contrast, the B1 scenario models a world shifting away from energy-intensive activities toward a more service-oriented economy. Although great uncertainty is represented across (and within) the various scenarios illustrated here, none suggests that temperature will stabilize in the absence of a climate policy.

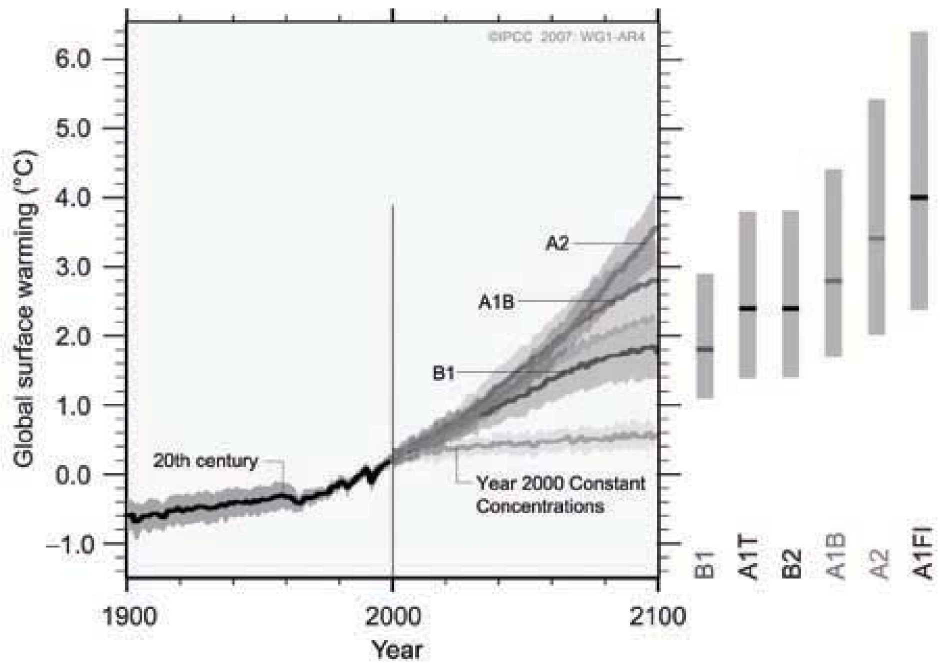
The IPCC's Working Group II focuses on the impacts of climate change. They conclude that "many natural systems are being affected by regional climate changes, particularly temperature increases" (IPCC 2007b, p. 1). The report enumerates a number of potential impacts, noting that, by 2020, "between 75 and 250 million people are projected to be exposed to an increase of water stress due to climate change. If coupled with increased demand, this will adversely affect livelihoods and exacerbate water-related problems" (p. 8). Africa is especially at risk. The report notes that "agricultural production, including access to food, in many African countries and regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020" (IPCC 2007b, p. 8).

North America will also be impacted. The report notes the issues of reduced snow pack in western mountains and decreased summertime water flows, for example. This would place additional strains on already taxed water systems in the West. The risk of forest fires will rise, and heat-sensitive crops (such as corn and soybeans) may be adversely affected. Conversely, some crops (such as oranges and

2. See Intergovernmental Panel on Climate Change (2007) for a description of the scenarios as well as a description of the *Special Report on Emission Scenarios*.
3. *Likely* is defined in the IPCC report as a probability greater than 66 percent that the actual temperature increase will be in this grey area.

FIGURE 2

Possible Surface Temperature Increases



Source: IPCC (2007a).

grapes) may experience an increase in yield with warmer temperatures, illustrating the point that climate change is a complex process with winners as well as losers.

It is difficult for several reasons to quantify the aggregate costs of the damages resulting from climate change. First, it is not easy to identify all the damages and benefits that will occur with global warming. Second, many of the damages are difficult to quantify in dollar terms. What is the dollar value of the loss of a habitat for an endangered species? Although economists have been extraordinarily ingenious in measuring nonmarket costs, this is an area fraught with great uncertainty. Third, perhaps the most significant costs of global warming are those associated with abrupt and large-scale events. How do we quantify the damages from the West Antarctic ice shield breaking off and falling into the South Pacific Ocean? And how do we assess the probability that this will occur? Many of the high-damage events that might occur with global warming are extremely low-probability events. More to the point, we don't know what the probability of these events occurring is. Unlike a spin of a roulette wheel, we cannot estimate the exact expected loss from climate change. This makes it extremely difficult to assess the aggregate damages from these potential extreme events. Fourth, the damages from global warming extend many years into the future. When confronting a stream of benefits or costs that occur over time, we generally calculate the present discounted value of this stream using a discount rate to convert future cash flows into dollar values in a base year. It is not obvious which discount rate to use for this calculation. Small differences in the rate chosen can make large differences in the present value of costs.

Focusing on total costs, Stern (2007) provides an estimate for a 2°C to 3°C increase in global temperatures by the end of the century in the range of 0 to 3 percent of world GDP. Taking account of the possibility of abrupt climate change, the estimate rises to present-value losses on the order of 5 to 10 percent of world GDP in the absence of any intervention. World GDP at market exchange rates in 2006 was $48 trillion (World Bank 2007), suggesting an aggregate present value cost on the order of $3 trillion to $5 trillion. Stern's estimates are controversial. Nordhaus (2007), for example, challenges Stern's use of a low discount rate to discount the stream of future costs from climate change to the present. Weitzman (2007b), however, argues that, although it is difficult to justify the low discount rate chosen by Stern on standard cost-benefit modeling assumptions, the high uncertainty associated with possible high-cost outcomes suggests that the urgency underlying the Stern Review's recommendations may be well-founded.

The preceding discussion suggests the large uncertainties associated with the costs of climate change, as well as the costs of mitigation. Despite these large uncertainties, it is prudent to take (some) early action before all the uncertainty is resolved. The long lags between reductions in emissions and resulting reductions in atmospheric concentrations of GHGs preclude our waiting for resolution of all the uncertainties we face. Weitzman (2007) argues that the fundamental uncertainties associated with catastrophic climate change (albeit with a low probability of occurring) trump any discussion over the appropriate discount rate to use in an intertemporal cost-benefit analysis as undertaken by Stern or others. In short, it would be prudent to take some sort of action sooner rather than later. A modest initial carbon price with a gradual ramping up over time would start the United States down a path toward GHG reductions. Such a modest initial step could be easily adjusted should future evidence suggest the need to tighten (or to relax) the carbon policy. Moreover, actions taken by the United States put us on stronger footing diplomatically as we call for other countries to take part in an international agreement to limit GHGs.

In §2, I explain why we should use carbon pricing to address climate change. In §3, I turn to my specific carbon tax proposal as a way to discourage carbon-emitting activities in the United States. In §4, I present a number of arguments that explain why a carbon tax is preferable to a cap-and-trade system. I identify concerns with a carbon tax in §5 and present some concluding comments in the final section.

2. Why Carbon Pricing?

Before turning to the proposal in detail, I address the question of why we should use a carbon pricing policy at all. We observe states and the federal government utilizing sector-based initiatives (e.g., mandates for minimum production of ethanol). Why should we use a price-based mechanism? The simple answer is that economic incentive–based policies (e.g., carbon taxes or cap-and-trade systems) are generally more efficient than regulatory approaches. Economists have long noted the advantage of incentive-based policies.[4] Policy makers were slower to respond, and the creation of the sulfur dioxide (SO_2) trading program in the Clean Air Act Amendments of 1990 was considered a watershed for market-based approaches to environmental problems. Since 1990, considerable research and some experience in the marketplace have demonstrated the power of markets and taxes in addressing environmental problems.

A primary source of efficiency gains is the way in which market-based instruments equalize the marginal costs of emissions abatement across all emitters. To see why this is important, consider a sector-specific emissions regulation on Industry A to reduce emissions by some given percentage. If all firms within that industry must meet this target, the marginal costs of emissions abatement could vary widely within the industry, with high-cost firms facing marginal abatement costs many times those for low-cost firms. All firms in Industry A would face higher abatement costs than firms in other emitting industries who face no controls on emissions. Efficiency gains would be possible if high-cost firms could reduce their pollution control by some amount, with lower-cost firms increasing their emission abatement to make up the difference. The total emissions reduction would be unchanged but overall costs of abatement would decrease. Efficiency gains are maximized when the marginal costs of abatement are equalized across all firms. With an economy-wide emissions tax or cap-and-trade system, the marginal emissions cost to a firm is equal to the emissions price or tax. Since all firms face the same cost of emissions, emissions costs at the margin would be equalized across the economy.

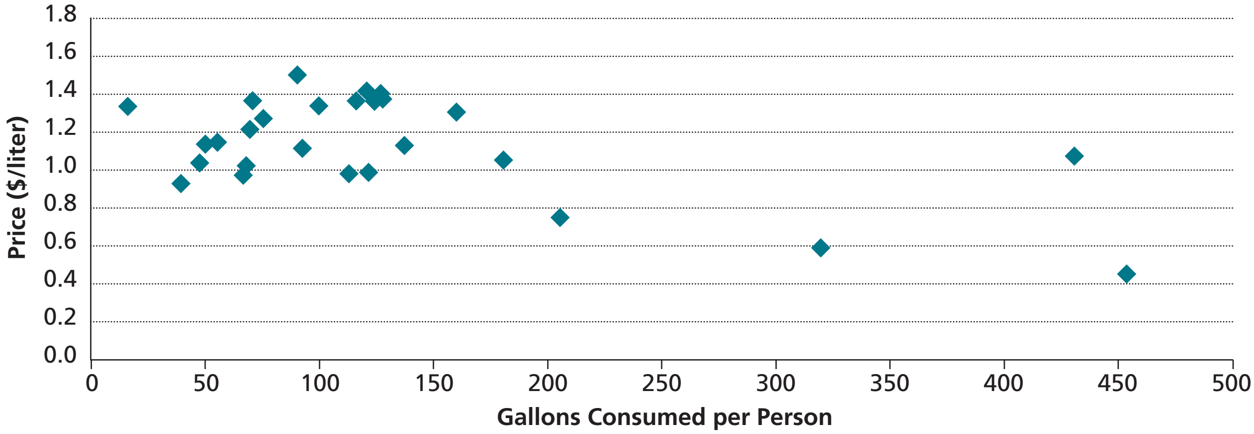
Can raising the price for carbon induce a reduction in the demand for fossil fuels? The scatterplot in Figure 3 illustrates a relationship between gasoline consumption and price. The horizontal axis is per capita gasoline consumption in 2004 across 27 developed countries, and the vertical axis shows the consumer price of gasoline in dollars per liter. The graph illustrates a negative correlation between consumption and price, and suggests that gasoline consumption would decline in response to higher prices. Of course, one must be cautious about inferring causation from this figure. High gasoline prices may induce reduced consumption, but other factors that induce reduced consumption may also be correlated with high prices.

More direct evidence on the responsiveness of energy consumption to prices is given by estimates of the price elasticity of demand where the relationship is estimated with statistical approaches that control for other factors. This statistic measures the percentage reduction in demand for energy following a 1 percent increase in price. For gasoline consumption in motor vehicles, Small and Van Dender (2007) estimate a short-run elasticity of consumption with respect to price of –0.074 and a long-run elasticity of –0.338 at prices and income in the late 1990s. This suggests that a 10 percent increase in the price of gasoline would decrease gasoline demand by 0.74 percent in the short run

4. Pigou (1938) was perhaps the first to note that taxes could be used to achieve efficiency in the presence of externalities. Dales (1968) was among the first to note that tradable permits could also be used.

FIGURE 3

Gasoline Usage and Price, 2004



Source: Consumption data from California Energy Commission (2007). Price data from IEA (2004).

and over three percent in the long run. Evidence of price responsiveness for crude oil demand in the United States suggests a comparable elasticity. Cooper (2003) estimates a short-run elasticity of –0.061 and a long-run elasticity of –0.453. Metcalf (2007b) estimates price elasticities for energy demand in general and finds a short-run elasticity of –0.11 and a long-run elasticity of –0.30. Those long-run estimates are somewhat lower than other estimates in the literature. Bjorner and Jensen (2002), for example, cite estimates from a survey by Atkinson and Manning (1995) of median energy demand elasticity estimates of –0.5.

Both the graphical data and the evidence from formal econometric analyses of demand elasticities suggest that higher prices for carbon will bring about reductions in the demand for fossil fuels. A carbon tax will raise the price of carbon, thereby inducing a reduction in carbon emissions.

3. A Carbon Tax Swap

A key element of any efficient policy to reduce GHG emissions is an increase in the price of GHG-emitting activities. This could be done by implementing a GHG cap-and-trade system or through a tax on GHG emissions. For reasons discussed in §5, I believe a carbon tax is preferable to a cap-and-trade system.[5] In this section, I describe the key elements of a carbon tax swap that is both revenue and distributionally neutral. This tax swap would levy a tax on GHG emissions, initially at $15 per ton carbon dioxide equivalent (CO_2e) and rising over time. The revenue would be used to fund a reduction in the income tax. Specifically, the tax proposal contains the following elements:

- A tax on GHG emissions at an initial rate of $15 per ton of CO_2 equivalent and gradually increasing over time
- A refundable tax credit for sequestered GHGs and other approved sequestration activities
- A refundable credit for the embedded CO_2 in exported fuels and taxation imposed on the embedded CO_2 in imported fossil fuels
- An environmental earned income tax credit in the personal income tax equal to the employer and employee payroll taxes on initial earnings up to a limit. Using 2003 emissions and earnings, the credit would offset payroll taxes paid on the first $3,660 of earnings per worker up to a maximum credit of $560 per covered worker[6]

The carbon tax rate would be set, ideally, to maximize social welfare, taking into account the dynamic nature of the problem as well as the interaction between the carbon tax and the various distortionary taxes currently in place. A starting place for thinking about the optimal tax rate is an estimate of the social marginal damages of GHG emissions denominated in dollars per ton of CO_2e.[7] Unfortunately, this is an imprecise estimate. The IPCC's Working Group II estimates a mean cost for 2005 of $12 per metric ton of CO_2, but notes that social cost estimates range from $3 to $95 per ton in a survey of 100 estimates (IPCC 2007b, p. 16). The report goes on to note that these costs are likely to underestimate the social costs of carbon because of the difficulty in quantifying many impacts.[8] Despite the uncertainties, the report suggests that the "net damage costs of climate change are likely to be significant and to increase over time" (p. 16). Nordhaus's most recent estimate using his Dynamic Integrated Model of Climate and the Economy (DICE) model, in contrast, is roughly $7 per ton CO_2e.[9] The literature does not provide a consensus view on the marginal damages of GHG emissions.

Another way to set the initial tax rate is to focus on a given stabilization target. A recent analysis by researchers at MIT suggests that an initial carbon price of $18 per ton CO_2e and rising over time at 4 percent per year (real) is consistent with the U.S. policy modeled in the recent U.S. Climate Change Science Program exercise to achieve a target by 2100 of 550 parts per million in volume CO_2 target (Paltsev et al. 2007). Whether this is a sufficiently stringent target is open to debate. Given the recent

5. To conform to popular usage, I will refer to a tax on GHG emissions as a carbon tax. As discussed below, the tax is imposed on GHGs according to the CO_2 equivalent content of the covered gases.
6. This proposal is similar to H.R. 3416 filed by Congressman John Larson (D-CT).
7. I discuss the conversion of non-CO_2 emissions into CO_2e in the appendix.
8. Stern (2007) estimates the social cost of CO_2 at $85 per ton. The Working Group II attributes its higher estimate to its explicit treatment of risk and the newer evidence on which it relies.
9. E-mail communication from Nordhaus on August 23, 2007.

TABLE 1
Short-Run Emissions Reductions With a Carbon Tax

Source	Reference	Reductions with Tax	Percentage Reduction
Emissions (mmt CO_2e)			
GHGs	8,201.5	1,151.7	14.0
CO_2 emissions	6,995.2	586.4	8.4
Other GHGs*	1,206.3	565.3	46.9
Primary Energy Use (EJ)			
Coal	25.8	3.8	14.7
Petroleum products	49.6	2.8	5.6
Natural gas	26.8	0.9	3.4

Source: Metcalf et al. (forthcoming).
* Methane, nitrous oxides, and fluorinated gases.
mmt = million metric tons, EJ = exajoules
Note: Results are for a $15 per ton CO_2e carbon tax in 2015. The tax is in 2005 dollars.

attention drawn by Weitzman (2007) to the issue of possible extreme events in the tails of the distribution of climate change impacts, it seems prudent to start the tax at a modest rate and increase it gradually over time as the economy begins to adjust to carbon pricing. Carbon stays in the atmosphere for hundreds of years. Enacting a carbon tax sooner and increasing it gradually is more cost effective than having to cut emissions drastically in the future. As new information emerges on the appropriate time path for carbon prices, this initial path can be adjusted.

3.1. A Carbon Tax

I propose a carbon tax set at a rate of $15 per ton of CO_2.[10] Emissions of CO_2 in the United States were slightly more than 6,000 million metric tons in 2005 (Energy Information Administration (2006b). At these emission levels, a charge of $15 per ton of CO_2e would raise $90.1 billion, assuming no behavioral response.[11] In response to the tax, we would expect substantial emission reductions in the long run and smaller emission reductions in the short run. Table 1 shows the short-run impact of a carbon tax imposed on all GHGs in the United States in 2015 based on modeling using the Massachusetts Institute of Technology's (MIT) Emissions Prediction and Policy Analysis (EPPA) model.[12]

The EPPA model shows a 14 percent reduction in GHG emissions. CO_2 emissions fall by 8.4 percent, and other GHGs (methane, nitrous oxides, and fluorinated gases) fall by nearly 50 percent. Carbon dioxide (CO_2) emissions account for just over one half of the CO_2-equivalent emissions reductions, while other GHGs account for the remaining half. Although CO_2 emissions make up the largest volume of anthropogenic emissions, they are less potent than other GHGs and relatively more costly to reduce. This speaks to the importance of including as many of the non-CO_2 emissions as possible in any GHG pricing plan. Early emission reductions are less costly among non-CO_2 gases, and their inclusion provides flexibility that reduces the overall costs of any given reduction in emissions.[13]

10. A carbon tax can be levied in units of carbon or CO_2. One can convert a tax rate denominated in units of CO_2 to a rate in units of carbon by multiplying by 44/12. Thus a $15 per ton CO_2 tax is equivalent to a tax rate of $55 per ton of carbon.
11. This distributional analysis focuses only on CO_2 emissions. With the broader coverage from a carbon tax (as suggested in the appendix), revenues before any behavioral response would be $100.8 billion.
12. The EPPA model is described in Paltsev et al. (2005). The EPPA model runs in five-year increments, thus one should view the short run in this model as a period of less than five years.
13. Paltsev et al. (2007) discuss this in further detail.

The lower part of Table 1 shows the reduction in fossil fuels used for energy. Based on the carbon content of these fuels (as found in Table 6-1 of Energy Information Administration 2006a), reductions in coal consumption are responsible for 59 percent, petroleum for 34 percent, and natural gas for 8 percent of energy-related CO_2 emissions reductions.

I next carry out a distributional analysis of this carbon tax reform using consumption data from 2003. I will assume that a carbon tax levied in that year would achieve the same reduction in carbon emissions as is modeled in the EPPA analysis described in Paltsev et al. (2007). With this behavioral response, the tax would collect $82.5 billion. It should be noted that this may be a conservative estimate of the initial revenue from the tax. An analysis by the EIA, for example, suggests that a $15 tax on CO_2 would reduce emissions by about 5 percent in the short run (see Energy Information Administration 2006c). With a smaller reduction in emissions, the initial carbon tax revenues would be higher.

An important design issue is whether to levy the tax upstream (fuel producers) or downstream (fuel users). For ease of administration, the tax should be levied upstream. For coal, the tax could be applied at the mine mouth for domestic coal, and at the border for imported coal. The United States had 1,415 functioning mines in 2005. The tax would be based on the amount of coal extracted (i.e., the tax should apply to mine-used coal).[14] Natural gas could be taxed at the well head or on import, or at the pipeline. Like coal, natural gas production is highly concentrated. Roughly 90 percent of gas production comes from about 110,000 wells that each produce 85,000 cubic feet of gas per day. These wells make up approximately 30 percent of the roughly 363,000 gas wells in the United States.[15] Petroleum products could be taxed on the crude as it enters the refinery or on the various products produced from crude oil along with refinery process emissions. Again, the administrative burden is not particularly cumbersome because there are roughly 150 refineries in the United States. In all cases above, the taxed firms are already reporting data to the IRS and paying taxes.

Some have argued that it would be better to levy the tax downstream because the carbon price would be more visible to end users and thus more likely to figure into energy consumption and planning decisions. Such an argument violates one of the most basic tenets of tax incidence analysis: the ultimate burden and behavioral response to a tax does not depend on where in the production process the tax is levied. Although this principle holds under perfect competition and certain forms of imperfect competition, it could fail if consumers respond to the visibility of a tax—the sort of irrational response that has been studied by behavioral economists.[16] It is doubtful that this effect could be very large in the case of a carbon tax for two reasons: First, firms are likely to advertise the embedded tax in, say, gasoline so that drivers would be aware that part of the cost of the gasoline is the tax.[17] Second, key energy consumers—electric utilities and industrial energy users—are unlikely to be affected by this behavioral phenomenon. They are more influenced by the final price of energy, whether the cost is influenced by taxes or other factors. Offsetting any apparent advantage of downstream visibility is the greater administrative burden of levying the tax on many more firms and individuals. Stavins (2007) presents information indicating that millions of point sources would fall under an inclusive downstream carbon pricing system.

14. Data are taken from the EIA's Coal Production Data Files, which are available at http://www.eia.doe.gov/cneaf/coal/page/database.html.
15. Data are from http://www.eia.doe.gov/pub/oil_gas/petrosystem/us_table.html. This percentage is based on production only from wells classified as gas rather than oil. Natural gas and oil are often produced from the same wells. Roughly 4 percent of the 336,000 wells that EIA classifies as oil wells would also be subject to reporting for natural gas production.
16. Chetty et al. (2007) and Finkelstein (2007) present evidence that the saliency of a tax increases the elasticity of demand among consumers (Chetty et al.) and among commuters on a toll road (Finkelstein).
17. Most gas stations post a highly visible sign at pumps alerting patrons to the amount of state and federal excise tax levied per gallon of gasoline.

Nonenergy carbon emissions come from a variety of sources; cement production is a significant source. Calcination of limestone to make clinker, an intermediate product in cement production, releases carbon. Applying the carbon charge to clinker production would address carbon emissions in the cement industry. Other industrial and agricultural emissions of CO_2 as well as other GHGs could be taxed either at the point of production or at the point of consumption.[18]

With the carbon tax applied at upstream points, it is important to provide refundable credits for carbon capture and storage (CCS) at downstream levels. CCS refers to technologies that remove carbon from the exhaust streams of fossil fuel burning plants and stores it underground—either locally or after transportation to a storage site—for many centuries. Electric utilities that burn coal in an advanced boiler with CCS, for example, should be allowed a tax credit equal to the tax paid on the carbon that is sequestered.[19] Similarly, fossil fuels used as feedstocks in manufacturing activities where the carbon is permanently captured should also be credit eligible. Credits for certain land-use activities, including forestry sequestration, should also be considered for credit eligibility.

3.2. An Offsetting Income Tax Cut

The carbon tax will raise the price of carbon-intensive products. In order to offset any regressivity in the carbon tax, I use the revenue to provide an offsetting cut in the income tax tied to payroll taxes paid by workers. Specifically, I propose an environmental tax credit equal to the employer and employee portions of the payroll taxes paid by the worker in the current year, up to a cap.[20] Using Consumer Expenditure Survey data for 2003 and applying the carbon tax to energy-related CO_2, the cap on rebated taxes would be \$560.[21] Capping the rebate contributes to the progressivity of the tax cut. The payroll tax cut is greatest for low-wage workers. Nearly three-quarters of the payroll taxes for a worker earning \$5,000 a year would be offset by the credit (see Table 2). At maximum covered earnings (\$90,000 in 2005), in contrast, workers would receive a tax credit equal to 4 percent of the payroll tax.

TABLE 2

Relation of the Environmental Tax Credit to Payroll Taxes

	Payroll tax		
Wages (\$)	Before credit (\$)	After credit (\$)	Reduction (%)
5,000	765	205	73
10,000	1,530	970	37
15,000	2,295	1,735	24
20,000	3,060	2,500	18
30,000	4,590	4,030	12
50,000	7,650	7,090	7
90,000	13,770	13,210	4

Source: Author's calculation.
Note: Credit of \$560 per covered worker assumed. This assumes payroll tax rules as of 2005.

3.3. Distributional Analysis of the Proposal

For a more detailed analysis of the impact on household income and spending of the carbon tax swap, I present some results from an analysis using the 2003 Consumer Expenditure Survey (CES). I begin with an analysis of the price impacts of the tax.

18. Emissions from land-use changes could also be brought into the system. Reilly and Asadoorian (2007) discuss how a cap-and-trade system could be designed to incorporate land-use changes (sinks and sources).
19. This would be similar to the credit allowed in credit-invoice value added taxes for the VAT paid at previous stages of production. See Metcalf (forthcoming).
20. This section draws on an analysis of a payroll tax cut described in Metcalf (2007d). The credit is tied to the employee and employer tax, given the finding that the burden of the employer payroll tax largely falls on workers in the form of lower wages. See Fullerton and Metcalf (2002) for a discussion of tax burdens.
21. Broadening the coverage of the carbon tax to include other gases increases revenue by roughly 13 percent and raises the cap to approximately \$630.

Assuming that the tax is fully passed forward into higher consumer prices, the direct impact of a $15 per ton CO_2 tax would be to raise the price of gasoline by 13¢ a gallon and the price of natural gas by 54¢ per thousand cubic feet. This would raise the price of gasoline by just over 4 percent based on the recent price of gasoline (national average price of $2.80 as of September 3, 2007) and the price of natural gas for industrial users by just under 7 percent (average industrial price of $7.99 in June 2007).[22] To put the gasoline price increase in perspective, prices for regular gasoline varied on a weekly basis by as much as $1.44 between the first week of January in 2005 and the last week of May in 2007. The standard deviation of gas prices over this period was 35¢.

For coal-fired electricity, the most recent Emissions & Generation Resource Integrated Database data from the Environmental Protection Agency indicate that the typical coal-fired power plant emitted 2,376 pounds of CO_2 per megawatt hour of electricity in 2004.[23] Assuming that the carbon tax is entirely passed forward, it would raise the price of this electricity by 1.78¢ per kilowatt hour, an increase of 20 percent, based on the average retail price of electricity in 2007 (year to date; EIA 2007b).

The price increases discussed at the beginning of this section are the direct impacts of the carbon tax on fuels, but because fossil fuels are used as intermediate inputs in the production of other goods (including energy products such as gasoline and electricity), the consumer impacts will differ from the carbon tax based on the embedded carbon in gasoline and other energy sources. Table 3 provides estimates of price increases for selected commodities if a carbon tax were put in place in 2003 with a rate of $15 per ton of CO_2.[24] The analysis uses U.S. input-output tables to trace through the use of fossil fuels in the production of other goods and services in the U.S. economy. The direct price impact of a carbon tax is to raise the price of gasoline by a little more than 4 percent; the overall impact is to raise the price by nearly 9 percent once the use of fossil fuels to process, among other things, petroleum into gasoline and transport it to service stations is taken into account.

TABLE 3

Consumer Price Impacts of a Carbon Tax

Commodity	Price increase (%)
Electricity and natural gas	14.1
Home heating	10.9
Gasoline	8.8
Air travel	2.2
Other commodities	0.3 to 1.0

Source: Author's calculations using the input/output accounts and the CES.
Note: A 2003 tax of $15 per ton of CO_2 (year 2005 dollars) is assumed to be passed fully forward to consumers.

Except for energy products, the carbon tax has modest impacts on consumer prices. These budget impacts for the carbon tax assume no consumer behavioral response. Consumer substitution away from more carbon-intensive products will contribute to an erosion of the carbon tax base.[25] The burden for consumers, however, will not be reduced as much as tax collections will fall. Firms incur costs to shift away from carbon-intensive inputs, costs that will be passed forward to consumers. Consumers also will engage in welfare-reducing activities as they shift their consumption activities to avoid paying the full carbon tax. Although the burden impacts reported here do not take account of the range of economic responses to the tax, the impacts provide a reasonable first approximation of the welfare impacts of a carbon tax.

In addition to any consumer substitution effects, a worldwide carbon pricing policy will reduce the de-

22. Current prices of gasoline and natural gas from the EIA Web site (www.eia.gov).
23. The Emissions & Generation Resource Integrated Database is available at http://www.epa.gov/cleanenergy/egrid/index.htm. I report average emissions for noncombined heat and power plants with electricity output in 2004 of at least 25,000 megawatts.
24. The methodology for computing price increases is detailed in Metcalf (1999).
25. I discuss the tax base implications in § 5.2.1 below.

TABLE 4

Distributional Impacts of the Carbon Tax Swap

Income group (decile)	Change in household disposable income ($)			Change as a percentage of income		
	Carbon tax	Tax credit	Net	Carbon tax	Tax credit	Net
1 (lowest)	–276	208	–68	–3.4	2.7	–0.7
2	–404	284	–120	–3.1	2.1	–1.0
3	–485	428	–57	–2.4	2.2	–0.2
4	–551	557	6	–2.0	2.1	0.1
5	–642	668	26	–1.8	1.9	0.1
6	–691	805	115	–1.5	1.8	0.3
7	–781	915	135	–1.4	1.6	0.2
8	–883	982	99	–1.2	1.4	0.2
9	–965	1,035	70	–1.1	1.1	0.0
10 (highest)	–1,224	1,093	–130	–0.8	0.8	–0.0

Source: Author's calculations.

Note: The lowest decile includes households in the 5th to 10th percentiles. Mean tax changes within each decile are reported. The columns titled "Carbon tax" report the change in household disposable income ($ or %) following price changes arising from carbon tax. The columns titled "Tax credit" report changes in household disposable income arising from the new tax credit, which equals a maximum of $560 for each worker in a household.

mand for energy and shift some of the burden of the U.S. carbon tax onto owners of fossil fuel resources. My assumption of complete forward shifting likely biases my results toward less progressivity than would occur with some backward shifting.[26]

The carbon tax reform uses the revenue from the carbon tax to reduce the income tax by funding a tax credit to workers in each household equal to their first $560 in payroll taxes, including both the employer and employee contributions. This is equivalent to exempting from payroll taxation the first $3,660 of wages per covered worker (using data from 2003).

Table 4 details the distributional impact of this carbon tax swap for households sorted on the basis of annual household income as a measure of their economic well-being.

Using an annual income measure to group households, the carbon tax in isolation is mildly regressive. The bottom half of the population faces losses in after-tax income ranging from 1.8 to 3.4 percent of its income, whereas the top half of the population faces losses between 0.8 and 1.5 percent of its income. Providing a credit of up to the first $560 of employer and employee payroll taxes offsets this regressivity quite markedly. The average credit as a fraction of income falls with increased income. The lowest income group receives a credit worth 2.7 percent of income; the highest income group receives a credit worth 0.8 percent of income. The final column in Table 4 shows that the lowest 20 percent of the population faces modest net reductions in after-tax income of between 0.7 and 1 percent of its income. Otherwise, the tax reform is essentially distributionally neutral.[27]

In Table 5, I modify the rebate of the carbon tax swap to show how the distribution of carbon taxes net of credit can be altered through policy design. The first two columns repeat net distributional information from Table 4. The next two columns

26. In the short run, the price reductions received by producers of oil, natural gas, and coal would be less than 4 percent. See Metcalf et al. (forthcoming).

27. Note that ranking households using an annual income measure biases energy-related taxes to appear more regressive than they would be if households were ranked using a measure of lifetime income. See Poterba (1989) and Metcalf (1999) for a discussion of this point.

TABLE 5

Modifying the Rebate in the Carbon Tax Swap

Income group (decile)	Earned income Net ($)	Earned income Net (%)	Earned income and Social Security Net ($)	Earned income and Social Security Net (%)	Lump sum Net ($)	Lump sum Net (%)
1 (lowest)	–68	–0.7	112	1.4	166	2.1
2	–120	–1.0	125	1.0	128	1.0
3	–57	–0.2	114	0.6	120	0.6
4	6	0.1	70	0.3	103	0.4
5	26	0.1	54	0.1	108	0.3
6	115	0.3	66	0.1	26	0.1
7	135	0.2	35	0.1	–32	–0.1
8	99	0.2	–61	–0.1	–52	–0.1
9	70	0.0	–95	–0.1	–171	–0.2
10 (highest)	–130	-0.0	–332	–0.2	–355	–0.2

Source: Author's calculations.
Note: This table reports the change in household disposable income resulting from different proposals for rebating the carbon tax. See text for descriptions of rebate proposals. The lowest decile includes households in the 5th to 10th percentiles. Mean net tax changes within each decile are reported. Positive numbers indicate an increase in disposable income and negative numbers indicate a decrease. Net (%) indicates the change as a share of income.

TABLE 6

Intracohort Variation in Carbon Tax Swap Impact

Income group (decile)	Net change in income ($) Mean	25%	75%	Std Dev	Net change in income(%) Mean	25%	75%	Std Dev
1 (lowest)	–68	168	–274	317	–0.7	2.0	–3.3	4.0
2	–120	199	–401	403	–1.0	1.6	–3.0	3.1
3	–57	251	–363	416	–0.2	1.3	–1.9	2.1
4	6	261	–243	428	0.1	1.1	–0.9	1.6
5	23	321	–152	519	0.1	0.9	–0.4	1.5
6	118	412	–118	440	0.3	0.9	–0.3	1.0
7	135	433	–142	436	0.2	0.7	–0.2	0.8
8	99	428	–200	540	0.2	0.6	–0.3	0.8
9	70	359	–137	482	0.0	0.4	–0.2	0.5
10 (highest)	–130	308	–424	718	0.0	0.2	–0.3	0.4

Source: Author's calculations.
Note: The lowest decile includes households in the 5th to 10th percentiles. Positive (negative) numbers indicate an increase (decrease) in disposable income.

TABLE 7

Distribution Across Age Groups From Different Carbon Tax Proposals

	Earned income		Earned income and Social Security		Lump sum	
Age of household head	Net ($)	Net (%)	Net ($)	Net (%)	Net ($)	Net (%)
20–40	183	0.7	–3	–0.2	133	0.8
40–55	82	0.2	–73	–0.0	–4	–0.3
55–65	–69	–0.2	–49	–0.1	–215	–0.2
> 65	–350	–1.8	180	0.9	–100	–0.2

Source: Author's calculations.
Note: Mean net changes in disposable income within each age group are reported. Positive (negative) numbers indicate an increase (decrease) in disposable income. Net (%) indicates the change as a share of income. See text for description of rebate policies.

alter the rebate to include recipients of Social Security. Social Security recipients receive a refundable tax credit equal to the maximum credit for workers.[28] Doing this lowers the maximum credit to $420. The effect is to increase the progressivity of the reform. A carbon tax combined with an environmental income tax credit is essentially distributionally neutral. In the last two columns, I replace the environmental tax credit with a per capita lump sum rebate of $274. This increases the progressivity of the reform even further.

While the carbon tax reform is essentially distributionally neutral, some variation persists within income groups, as well as across other demographic categories. Table 6 provides some information about variation in carbon tax price increases net of rebates for the different income groups. Differences within income groups are driven in part by differences in employment patterns and by differences in consumption of carbon-intensive commodities. The difference in net payments between the households in the 75th percentile and the households in the 25th percentile within an income group varies from $442 (Decile 1) to $732 (Decile 10). The difference between these two percentiles in terms of change in taxes as a share of income is 5 percent of income in the lowest decile and 0.5 percent in the top decile.

Table 7 shows that the distribution of the burden is across age groups. If the carbon tax is rebated on the basis of earned income, the benefits accrue disproportionately to households with younger heads. If a rebate is also provided to Social Security recipients, then the elderly benefit, on average, from this reform, while younger cohorts pay a modest tax on net. It is important to emphasize that even if the policy is written to provide the tax credit only on the basis of earned income, indexing will ensure that Social Security benefits rise to some extent so that the final distribution will look more like the middle set of results than the first set. Finally, a lump-sum rebate tied to household size would benefit the youngest cohorts the most.[29]

Finally, I show the distribution of the net tax under the three policy scenarios across geographic regions of the country in Table 8. The largest average difference across regions in household net disposable income is $100 when the carbon tax is rebated on the basis of earned income. Similar findings hold for the other policy scenarios. A carbon tax does not

28. It might not be necessary to provide an explicit grant to Social Security recipients because Social Security benefits are indexed for inflation. Price increases resulting from the carbon tax will automatically lead to an increase in benefits.
29. Once the reform has been in place for awhile, distributions by cohort are not particularly meaningful because households will cycle through all the cohorts eventually. Distributions by age are most relevant for thinking about the transitional aspects of the reform.

TABLE 8

Regional Distribution

Region	Earned income		Earned income and Social Security		Lump sum	
	Net ($)	Net (%)	Net ($)	Net (%)	Net ($)	Net (%)
New England	17	0.0	–36	0.2	–65	-0.1
Middle Atlantic	–9	–0.2	–13	0.2	–18	-0.2
East North Central	30	–0.2	–14	0.1	–37	-0.1
West North Central	30	0.1	52	0.5	–26	-0.2
South Atlantic	24	–0.1	17	0.3	2	0.3
East South Central	–75	–0.5	–6	0.3	–75	-0.2
West South Central	–12	0.0	–42	0.2	9	0.4
Mountain	17	0.1	46	0.5	34	0.4
Pacific	5	0.0	–4	0.2	59	0.6

Source: Author's calculations. Mean net changes in disposable income within each age group are reported. Positive (negative) numbers indicate an increase (decrease) in disposable income. Net (%) indicates the change as a share of income. The regions are defined as follows:
New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Middle Atlantic: New Jersey, New York, Pennsylvania
East North Central: Illinois, Indiana, Michigan, Ohio, Wisconsin
West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
South Atlantic: Florida, Georgia, North Carolina, South Carolina, Virginia, West Virginia
East South Central: Alabama, Kentucky, Mississippi, Tennessee
West South Central: Arkansas, Louisiana, Oklahoma, Texas
Mountain: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
Pacific: Alaska, California, Hawaii, Oregon, Washington

appear to disproportionately burden one region of the country more than any other region.

Table 9 illustrates how the tax credit is affected by changing the carbon tax rate. The credit rises slightly faster than the carbon tax rate in order to ensure that all of the revenue is recycled. If the credit rose at the same rate as the tax, revenue would be left over because there are some low-income individuals for whom the credit would exceed actual payroll taxes. A higher credit is needed so that the added rebate for individuals with high tax liability can make up for the ceiling imposed on those with low tax liability.

TABLE 9

Varying the Carbon Tax Rate

Carbon tax rate $/ton CO_2	Maximum credit	Income threshold
$5	$180	$1,176
$15	$560	$3,660
$25	$960	$6,275

Source: Author's calculations.
Note: Income threshold is the maximum wage income for which the maximum income tax credit equals payroll taxes.

The environmental tax reform illustrated in Table 4 emphasizes an essential point: a carbon tax may be regressive, but a carbon tax reform can be designed to be distributionally neutral. The use of the carbon tax revenue to offset payroll taxes makes this distributional neutrality possible. If the revenue is not rebated or if a cap-and-trade system is implemented with freely allocated permits such that the market permit price equaled $15 per ton of CO_2, the reform would raise prices (as illustrated in the second column of Table 4) but would not allow the offsetting reduction in the payroll tax to achieve distributional neutrality.[30]

30. The converse is also true. Permits in a cap-and-trade system could be auctioned and the revenue used for the payroll tax reduction described in this paper, thereby providing the same distributional outcome as under the carbon tax reform described here.

While this paper focuses on the distributional implications of a revenue-neutral carbon tax reform, let me make a few comments on efficiency issues associated with this reform. First, it is unquestionable that carbon pricing—whether through a carbon tax or a cap-and-trade system—has efficiency costs. Carbon pricing is essentially a tax on inputs used in the production process and hence gives rise to distortions.[31] Carbon pricing, however, is likely to be less costly from an efficiency point of view than an increase in gasoline taxes because the tax is more broadly focused and does not single out particular fossil fuels.[32] More to the point, the appropriate tax depends on what you want to achieve. A carbon tax more directly addresses a carbon emissions externality than taxing a proxy for carbon (e.g., gasoline). Second, the efficiency costs of carbon pricing are not that large. Paltsev et al. (2007) find welfare losses for a cap-and-trade policy similar to the carbon tax considered in this analysis to be less than 0.5 percent per year. Third, one can reduce the efficiency losses by using carbon revenue to lower other distortionary taxes. Metcalf (2007a), for example, examines the impact of a carbon tax used to finance corporate tax integration. Estimates of the marginal excess burden of taxes on income range from 0.2 to 0.4, depending on a number of factors, including whether capital or labor income taxes are changed (Ballard et al. 1985). At the upper end of this range, a carbon tax raising $82 billion could achieve an efficiency gain of more than $30 billion when used to lower income tax rates, relative to a lump-sum distribution.

Note that the core distributionally neutral reform analyzed in this paper has some modest offsetting efficiency benefits since the rebate is tied to labor supply. While the rebate is unlikely to appreciably affect labor supply of current workers, it may modestly contribute to greater labor force participation among lower-income workers.[33] To be clear, however, the reform has been designed to emphasize distributional neutrality rather than to maximize efficiency gains.

3.4. Other Policy Options

This study focuses on carbon pricing policy in general and a carbon tax in particular. A comprehensive carbon policy should consider a number of other elements. I mention three policies in particular. These policies would complement the carbon tax and contribute to reductions in carbon emissions while potentially improving energy security in the United States. First, increased spending on energy-related research and development (R&D) would be useful both in the area of renewable fuels and in CCS. To the extent that R&D is a pure public good, a role for government exists to increase the amount of R&D carried out. While the technologies for CCS are basically well understood, it is not clear how the United States will develop CCS at a scale required given projected coal consumption over the next 30 years. EIA's Annual Energy Outlook projects a 47 percent increase in coal consumption between 2005 and 2030 in its reference scenario (see Energy Information Administration 2007).

Second, the United States provides substantial energy production subsidies that contribute to a continuing reliance on fossil fuels.[34] These subsidies are often justified as encouraging energy in-

31. If there were no other distortionary taxes in effect, a carbon tax set equal to the social marginal damages of carbon emissions would be efficient. In the presence of other distortionary taxes, a carbon tax—like any environmental tax—would have first-order efficiency losses as well as benefits from the reduction in carbon emissions. The trade-off in benefits and costs of environmental taxes in the presence of other tax distortions has been extensively discussed in the double-dividend literature. See Goulder (1995) and Fullerton and Metcalf (1998) for a review of this literature.

32. On the other hand, taxing gasoline reduces congestion, accidents, and local pollution. Parry and Small (2005) note that the optimal tax on gasoline is well above current levels of taxation in the United States.

33. Meyer and Rosenbaum (2001) find that changes to the earned income tax credit had substantial effects on the labor force participation of single mothers with a participation elasticity with respect to the return to work on the order of 1.1: "[a] one thousand dollar reduction in income taxes if a woman works increases employment last week by 2.7 percentage points, and increases employment last year by 4.5 percentage points" (p. 1089).

34. Metcalf (2007c) provides a description and analysis of these subsidies.

dependence in the United States since they replace imported fuels with domestic fuels. As I argue in Metcalf (2007c), energy security is enhanced by reducing our consumption of petroleum products rather than by reducing our import share; many of these subsidization policies work at cross purposes toward that goal.

Third, enhanced support for energy efficiency investments contributes to a reduction in energy consumption and carbon emissions. Increasing energy prices through a carbon tax will contribute to increased efficiency investments, to be sure, but two factors suggest benefits from more generous tax credits for efficiency investments. First, certain sectors of the economy may not respond to energy price increases arising from a carbon policy. Commercial real estate and rental housing are sectors where the economic agent who makes efficiency investments (developer or homeowner) is not the person who benefits from the energy savings (tenant). Second, the hidden nature of many efficiency improvements makes it difficult to recapture the energy savings through their capitalization into building prices or rents. In addition, empirical work suggests that efficiency investment tax credits have a substantial impact on efficiency investments (see Hassett and Metcalf 1995).

While I think it important to consider these additional policies, it is unlikely that these policies by themselves will bring about a reduction in carbon emissions on the order needed to stabilize atmospheric concentrations. Carbon pricing will also be needed. Next I turn to why carbon pricing through a tax is preferable to a cap-and-trade approach.

4. Why Not Cap and Trade?

Carbon taxes are not the only way to raise the price of carbon emissions. Alternatively, the United States could place a limit on annual carbon emissions. An efficient way to do this is through a cap-and-trade system similar to the European Union (EU) Emissions Trading Scheme (ETS) for carbon.[35] A limit on carbon emissions would be put in place and firms would need to provide permits to the government equal in amount to the emissions from their operations. Firms would either purchase permits initially or be given the permits as part of a grandfathering process. The EU ETS and the SO_2 trading program in the United States both allocate permits to existing firms on the basis of past production. Firms holding permits could use or sell the permits. Alternatively, firms wishing to emit GHGs in excess of their permit inventory could buy permits on the open market. Whether firms are buyers or sellers of permits, the cap-and-trade system raises the marginal cost of emissions to the firm. Firms using permits forgo the opportunity to sell permits at the going rate whereas firms buying permits must make a cash outlay in order to emit carbon.

Given the experience with permit trading in the SO_2 program and the European experience with carbon trading, a number of policy makers are proposing a U.S. cap-and-trade system for carbon. Why shouldn't we go with cap and trade? I argue that a carbon tax dominates cap-and-trade systems on political, economic, administrative, and efficiency grounds.

4.1. Revenue

Permits are valuable assets. Permits could be auctioned by the government and thus raise revenue, but historically they have been given away to industry as part of a process of obtaining support for the system. Economists have long understood that one valuable use of carbon revenue (whether arising through the sale of carbon permits or a carbon tax) is to enhance efficiency in the tax system by using the proceeds to lower other distortionary taxes.[36] They note that using environmental tax revenue to reduce other distortionary taxes raises welfare more than if the revenue were used for lump-sum refunds.[37] In the context of cap-and-trade systems, selling permits and using the revenue to lower other distortionary taxes is more efficient than giving the permits away.

Unless Congress can commit to auction the permits, we run the risk that the permits will be given away, as has happened in other cap-and-trade programs.[38] In addition to the loss of substantial revenue, freely allocated permits may undermine the key goal of raising energy prices and discouraging the consumption of carbon-intensive energy. Although retail competition for electricity exists in many states (primarily in the Northeast), a large proportion of electricity consumers still operate in markets subject to state-level regulation.[39] Regulators are unlikely to allow regulated utilities to pass through the cost of permits in the form of higher electricity prices for customers if the permits are

35. Stavins (2007) describes a cap-and-trade proposal for the United States and discusses economic and administrative issues associated with implementing the system.

36. The use of environmental proceeds to lower other distortionary taxes is often referred to as the revenue recycling effect. See Goulder et al. (1997) and Fullerton and Metcalf (2001) for a discussion of the efficiency impact of environmental revenues.

37. This principle is referred to as the *weak double dividend*. See Goulder (1995) for discussion of different types of double dividends.

38. It may be that policy makers are beginning to understand the costs associated with free permit allocation. The Northeast states' Regional Greenhouse Gas Initiative calls for auctioning 100 percent of the permits. Some of the current Senate bills for cap-and-trade systems also call for auctioning some portion of the permits. The 2007 Bingaman-Specter bill (S. 1766), for example, calls for auctioning 24 percent of the permits initially, and as many as 86 percent eventually.

39. Joskow (2006) provides a current overview of the state of competition in electricity markets.

given without charge to the utilities. In that case, we close off the channel of electricity-demand reduction and only have a fuel substitution channel to achieve a reduction in carbon emissions. For those states where retail competition does exist, another problem may occur. Utilities that are given permits freely will likely raise the price of electricity to reflect the marginal cost of generation. Even if permits are given freely, the marginal cost will include the opportunity cost of giving up permits they could have sold. This increase in the price, without any commensurate increase in the utilities' real costs, will generate windfall profits. This happened during the first allocation period of the EU ETS and generated considerable political ill will toward the utilities, and led to a political discussion of re-regulation.[40]

It should be noted, however, that through the corporate income tax the government recoups some of the value of the permits freely allocated to firms. Permits freely given to firms will increase the firm's taxable income either by increasing revenue if the permits are sold or by decreasing costs if the permits are used, thereby allowing the firm to avoid incurring the cost of purchasing permits. Parry (2004) assumes that 35 percent of the value of permits is recaptured by the government through taxation of profits arising from free permits.[41]

4.2. Allocation

That permits are valuable assets also suggests that firms and industries will have considerable incentive to lobby to receive a large share of these assets. Economists call the expenditure of resources to obtain valuable assets from governments *rent seeking*. Rent seeking is a socially wasteful activity and can lead to particularly inefficient outcomes.

Moreover, standard allocation schemes are likely to lead to distributionally anomalous results. If permits must be given away rather than sold, one might argue that they should be given to the groups most likely to be hurt by the imposition of carbon pricing. Given the standard view that the price of carbon permits will likely be passed forward to final consumers in the form of higher prices, this argument would call for the permits to be given to final consumers of fossil fuel energy and electricity as well as to consumers of energy-intensive goods and services. If the U.S. SO_2 trading program and the EU ETS are any guide, permits will be given to the energy firms who are responsible for remitting the permits to the government in proportion to their fuel production or consumption rather than to the groups that bear the ultimate burden of the carbon pricing.

Dinan and Rogers (2002) and Parry (2004) consider the distributional implications of a cap-and-trade system with grandfathered permits and note that grandfathering permits creates rents that accrue to shareholders. Equities are predominantly owned by wealthier households, which means that a cap-and-trade system with grandfathered permits is likely to be regressive. We can confirm this finding with the data used in this paper. The CES on which I rely has a limited set of information on wealth holdings that can be used to distribute the value of permits across households.[42] I allocate the value of permits on the basis of these wealth holdings. Results are shown in Table 10. The reform is decidedly regressive

40. These windfall profits are simply the realization of the value of freely given permits to the European electric utilities and reflects the fact that complete grandfathering overcompensates energy industries for losses they incur through the imposition of carbon pricing. In their analysis of a cap-and-trade system, Bovenberg and Goulder (2001) find that grandfathering more than 4 percent of permits in the coal industry and 15 percent in the oil and gas industry overcompensate these industries for their losses. This occurs because most of the permit costs are passed forward to final consumers in the form of higher energy prices.

41. My analysis of grandfathered permits in the next subsection does not take into account this effect. Based on results from Parry (2004, Figure 3), this does not bias the regressivity of free distribution significantly.

42. The wealth measures are the market value of owner-occupied housing; holdings in checking, savings, and brokerage accounts; the market value of stocks and bonds; and the net assets invested in farms and businesses. I am assuming that share ownership in energy holdings is distributed as the ownership of capital in general. Note that this wealth measure may overstate the regressivity of grandfathered permits because it is not clear if the CES accurately measures the value of pension plans for workers.

TABLE 10

Distributional Impacts of a Cap and Trade System with Grandfathered Permits

Income group (decile)	Change in household disposable income ($)			Change in household disposable income as a percentage of income		
	Carbon tax	Value of grandfathered permits	Net	Carbon tax	Value of grandfathered permits	Net
1 (lowest)	–276	130	–145	–3.4	1.6	–1.8
2	–404	321	–83	–3.1	2.4	–0.6
3	–485	371	–115	–2.4	1.8	–0.6
4	–551	435	–116	–2.0	1.6	–0.4
5	–642	454	–191	–1.8	1.3	–0.5
6	–691	473	–215	–1.5	1.1	–0.5
7	–781	647	–134	–1.4	1.1	–0.2
8	–883	752	–131	–1.2	1.0	–0.2
9	–965	1,087	121	–1.1	1.2	0.1
10 (highest)	–1,224	2,191	967	–0.8	1.3	0.5

Source: Author's calculations.
Note: The lowest decile includes households in the 5th to 10th percentiles. Mean changes in disposable income within each decile are reported.

with disposable income falling most (in percentage terms) for the lowest income groups and rising only for the top two income deciles.[43]

4.3. Administration

We have a time-tested administrative structure for collecting taxes. In contrast, we have no administrative structure for running an upstream carbon cap-and-trade program. Firms that would be subject to a carbon tax are already registered with the IRS and have whole departments within their firms that carry out the record keeping and reporting for tax payments. We also have precedents for refundable credits for sequestration activities in federal fuels tax credits.

A second complicating administrative issue with cap-and-trade programs arises from the need to allocate permits. If permit allocations are to be based on historical emissions, benchmarking is required. Third, if the European experience is relevant and a downstream system is implemented in the United States, the cap-and-trade system is that much more complex. It becomes more difficult to capture a significant fraction of carbon emissions in the economy. Moreover, many more firms must fall under the umbrella of the system unless many firms are exempted.

4.4. Efficiency in the Face of Uncertainty

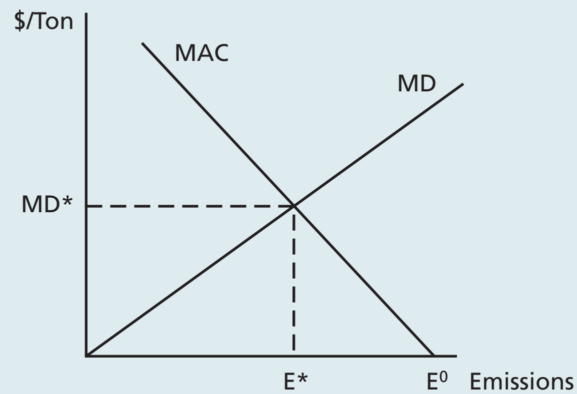
GHG emissions are an example of what economists call a *negative externality*: an activity taken by an individual or firm with social costs that exceed the private cost. In general, competitive markets will not lead to the socially optimal level of emissions in the absence of government intervention.[44] In the absence of any controls on emissions, firms will re-

43. Parry (2004) does a quintile analysis and finds that the net effect is to reduce disposable income for the lowest four quintiles and to raise disposable income for the top quintile only. Both his analysis and this analysis rely on self-reported holdings of common stocks and likely underestimated holdings of equity in pension plans. This probably biases the reform toward greater regressivity, although it is unlikely that accounting fully for pension holdings would undo the regressivity entirely.

44. Coase (1960) provides conditions under which economic agents will privately negotiate the socially optimal level of pollution. Those conditions do not hold for global GHG emissions.

lease GHGs to the point where the marginal cost of emissions equals marginal abatement costs. In Figure 4, the downward-sloping curve labeled MAC is the marginal abatement cost curve for emitters. It measures the cost of reducing emissions at the margin, given the existing level of emissions, and represents the marginal benefit of emissions for firms. If the private marginal cost of emissions is zero, firms would release E^0 tons of GHGs annually.

FIGURE 4
Determining Emission Levels



The upward-sloping line labeled MD measures the social marginal damages of emissions. In the social optimum, the social marginal damages of emissions will be set equal to the marginal abatement cost of emissions. In Figure 4, the social optimum occurs at *E** where marginal abatement costs equal marginal damages. This figure can be used to illustrate several points. First, the optimal level of emissions is positive. Choosing the socially optimal level of emissions requires balancing the benefits of using fossil fuels (inexpensive lighting and heating of homes, industrial productivity, and so on) against their environmental costs.

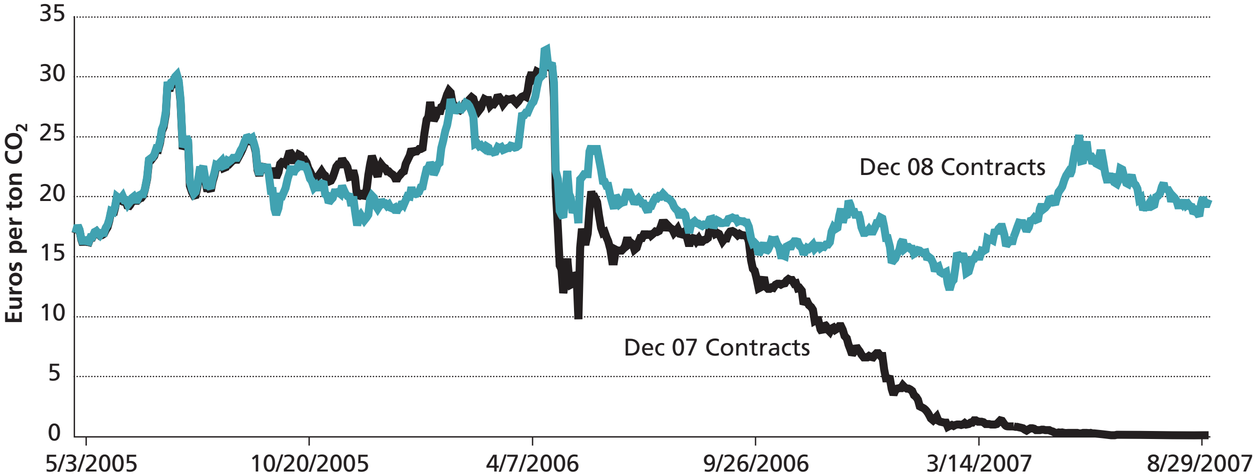
Second, a quantity control (e.g., a cap-and-trade system) or a price control (e.g., a tax) could be used to achieve the social optimum. A quantity control would limit emissions to *E** by issuing that number of permits per year. With heterogeneous firms, greater efficiencies are achieved by allowing firms to trade permits so that low-cost firms reduce emissions more than high-cost firms reduce emissions, with the latter purchasing permits from the former. In equilibrium, permit prices would settle at *MD**. A carbon tax, in contrast, would simply set a tax on emissions equal to *MD**. The tax serves to internalize the social cost of emissions for firms, which then reduce emissions in response to the higher private cost. A third point related to carbon taxes is that the optimal tax should be set to equate marginal damages with marginal abatement cost at the optimal level of emissions, not at the higher level of marginal damages and emissions in the absence of control policies.

With full information about the costs and benefits of GHG emissions, the carbon tax and the cap-and-trade system are both efficient and lead to the same outcome. With uncertainty over the marginal abatement costs of emissions, however, the two policy instruments are no longer equivalent. In a pioneering paper, Weitzman (1974) provides conditions under which a tax provides higher or lower expected social benefits than a cap-and-trade system in a world with uncertainty.[45] His analysis demonstrates the importance of the relative slopes of marginal damages and abatement costs in choosing the optimal instrument.

Weitzman's analysis needs some modification in the case of GHGs because marginal abatement costs are a function of the flow of emissions, whereas marginal damages are a function of the stock of gases in the atmosphere. Several economists have modified Weitzman's model to allow for the stock nature of GHGs. While the analysis is more complicated and involves more than simply the relative slopes of marginal abatement and damage curves, the

45. The relative advantage of price versus quantity instruments depends on uncertainty in the marginal abatement cost curve only. Uncertainty over the marginal damages of emissions affects the net benefits of an emissions control policy but does not affect the relative superiority of one policy instrument over another.

FIGURE 5
ECX Futures Contracts Settlement Prices



Source: European Climate Exchange (2007).

analyses consistently find that taxes dominate cap-and-trade systems for a broad range of parameter values consistent with scientific understanding of the global warming problem (Hoel and Karp 2002, Newell and Pizer 2003, Karp and Zhang 2005).

4.5. Price Volatility

The previous discussion suggests a further point. Carbon taxes ensure a given price for carbon emissions while permit prices in a cap-and-trade system are uncertain. Price volatility for cap-and-trade systems is well known. The EU ETS illustrated this dramatically in April 2006 when CO_2 permit prices fell sharply on the release of information indicating that the ETS Phase I permit allocations were overly generous. The December 2008 futures price fell from a peak of €32.25 on April 19 to €22.15 on April 26, and then to €17.80 on May 12. Prices rebounded briefly, but drifted downward for much of the rest of the year (Figure 5). Volatility in the Phase I permits (December 2007 contracts) was even higher. These permit prices fell from €31.50 on April 19 to €11.95 on May 3, before rebounding briefly. In late September 2006, the December 2007 contract prices again fell sharply and proceeded to fall to their recent price of €0.07 on September 17, 2007.[46]

One might argue that as we gain more information about the marginal costs of GHG emission abatement, permit allocations can be adjusted. The difficulty is that permits are valuable assets that are allocated over time horizons longer than one year.[47] Any decision to change allocations has the potential to effect a property taking. If permit caps are loosened, the value of existing permits falls. If caps are tightened someone's permits are lost.[48] Highly volatile permit prices are likely to create dissatisfaction with a cap-and-trade program and make business planning difficult.

Concern over permit price volatility has led a group of Senators to propose a Carbon Market Efficiency Board, to be modeled on the Federal Reserve Sys-

46. All price data from European Climate Exchange (2007).
47. Phase I of the EU-ETS runs from 2005 through 2007. Phase II runs from 2008 through 2012. Many argue that any post-Kyoto cap-and-trade system must consider allocation periods longer than five years to allow firms to do long-term planning. Banking across allocation periods effectively lengthens the time horizon even more. McKibbin and Wilcoxen (2007) propose a permit-based system that includes both short- and long-lived permits.
48. Offsetting this is the higher value of the remaining permits. Whether the aggregate value of the remaining permits is higher or lower depends on underlying elasticities. I thank Denny Ellerman for pointing this out.

tem.[49] This board would be able to relax borrowing limits for firms against future permits, extend the repayment period for borrowed permits, and lower the interest rate on borrowed permits in periods of high permit prices. Such a system might alleviate price volatility; at the same time, it also has the potential to increase political uncertainty and undermine the credibility of our commitment to given GHG emissions over a commitment period. Such a structure, it should be emphasized, is entirely unnecessary under a carbon tax.

Another approach to limiting volatility is to include a safety-valve provision. This allows firms to purchase an unlimited number of permits at a set price and thus sets a ceiling on the price of permits.[50] If the market price for permits is below the safety-valve price, then firms will simply purchase permits in the open market. Once permit prices reach the value of the safety valve, firms will purchase any needed permits directly from the government. In effect, a cap-and-trade system with a binding safety valve has been converted into a carbon tax while maintaining the complexity and other disadvantages of the cap-and-trade system.

4.6. Committee Jurisdiction

A final advantage of carbon taxes over cap-and-trade systems relates to the congressional committee structure. Cap-and-trade legislation is in the domain of the Committees on Energy and Commerce (House) and Energy and Natural Resources (Senate). Tax legislation is in the domain of the Committees on Ways and Means (House) and Finance (Senate). Any effort to construct a distributionally neutral cap-and-trade system will require coordination across the energy and tax committees. A distributionally neutral carbon tax, on the other hand, falls entirely within the domain of the two tax-writing committees in Congress. It may be difficult to design cap-and-trade legislation with auctioned permits in a way that doesn't avoid using the revenues for increased spending on the environment, given the proclivity of congressional committees to retain budget authorization responsibility within their committee if possible. This is not to suggest that the congressional tax committees will necessarily make efficient or distributionally neutral tax cuts, but rather that a necessary condition for a distributionally neutral cap-and-trade cum tax-reduction policy is that the energy committees share responsibility with tax-writing committees.

The numerous shortcomings of a cap-and-trade approach to reducing GHG emissions may explain why economists and policy analysts across the political spectrum have called for increases in pollution taxes in general, and a carbon tax in particular. Taxes on pollution are often referred to as Pigovian taxes in honor of Arthur C. Pigou, the great English economist from the early twentieth century who first popularized the concept. N. Gregory Mankiw, professor of economics at Harvard and a former chair of the Council of Economic Advisers under President George W. Bush, has established the Pigou Club, an "elite group of pundits and policy wonks with the good sense to advocate higher Pigovian taxes,"[51] with members across the political spectrum.

49. Senate Bill 1874 was introduced in July 2007 by Senators Mary Landrieu (D-LA), Lindsey Graham (R-SC), Blanche Lincoln (D-AR), and John Warner (R-VA).

50. Senators Bingaman and Specter's cap-and-trade bill (S. 1766) contains a "technology accelerator payment" provision. This is a safety valve and is initially set at $12 per ton CO_2 in 2012.

51. See Mankiw's blog at http://gregmankiw.blogspot.com/2006/10/pigou-club-manifesto.html for his *Wall Street Journal* column, as well as links to other discussions of Pigovian taxes.

5. Concerns with a Carbon Policy

A number of commentators have raised concerns with carbon pricing. Some of these objections pertain to both cap-and-trade systems and a carbon tax, and others pertain specifically to a carbon tax. Let me address the most common objections in turn.

5.1. Concerns Relevant for Cap-and-Trade Systems and Carbon Taxes

5.1.1. Economic Impact. One objection to a carbon charge—whether through a tradable permit or a carbon tax—is that it will hurt economic growth in the United States. Research suggests, however, that most industry groups would not be appreciably affected by a carbon tax swap for two reasons. First, the price impacts for most industries are small (see Metcalf 2007a). Second, using carbon revenues to lower other taxes ensures that the overall burdens will not rise. Offsetting the higher price of products due to carbon pricing can occur through after-tax income or lower costs from the reduction in other taxes financed by the carbon charge.

Although industries in general will not be negatively impacted by a carbon charge, some in particular—namely, coal and petroleum products—will see their product prices rise appreciably. Coal, in particular, is significantly impacted by a carbon charge, but this is the natural consequence of any policy to reduce carbon emissions in the United States. Put simply, we cannot reduce carbon emissions unless we reduce our use of coal, given current technology. It is important to note, however, that one benefit of the carbon charge is the inducement it provides to improvements in technology that allow for coal to be burned without releasing carbon. New technologies that are more efficient and that can be combined with CCS provide a future for the coal industry that is healthy and environmentally benign. Making the transition to this future will be difficult until we price coal to reflect the damages resulting from carbon emissions.

5.1.2. Distributional Impacts. Another argument commonly made against a carbon charge is that it is regressive. While the carbon charge in isolation may be regressive, a carbon charge combined with a tax decrease need not be regressive. Pairing the carbon charge with an environmental tax credit tied to payroll tax payments as described in §3.2 demonstrates that a carbon tax reform can be distributionally neutral.[52] The concern about regressivity is especially relevant for a cap-and-trade system with grandfathering. As shown in §4.2, free allocation of permits would only exacerbate the distributional concerns because the windfall rents from free distribution will predominately accrue to shareholders of energy companies.[53]

Note that I have assumed that the charge is fully passed forward to consumers in the form of higher prices. If the United States undertakes carbon pricing at the same time that other major oil consuming countries have a carbon policy in place, an increasing proportion of the charge will be passed back to petroleum producers in the form of lower rents for their oil resources as global demand for oil falls. This backward shifting will add progressivity to the charge on an international level.[54]

5.1.3. International Competitiveness. A third argument against a carbon charge is that it will put U.S.-produced carbon-intensive goods at a com-

52. I elaborate on the distributional distinction between environmental taxes and environmental tax reforms in Metcalf (1999).
53. More precisely, work by Harberger (1962) and subsequent researchers suggests that the gains will accrue to all owners of capital. The distributional implications are unchanged.
54. This is the same principle as the extraction of oil rents through an oil import tariff. See Newbery (2005) for more discussion of this point.

TABLE 11

Demand for Fossil Fuels Used in Electricity Production Relative to Reference Scenario

	2015	2020	2025	2030	2035	2040	2045	2050
Oil	1.00	0.67	0.25	0.50	0.75	0.80	0.80	0.50
Gas	1.06	1.36	2.64	2.74	2.41	2.22	2.00	1.00
Coal w/o CCS	0.88	0.72	0.38	0.40	0.54	0.58	0.55	0.33

Source: Metcalf et al. (forthcoming).
Note: This shows consumption of fossil fuels for electricity production with a $15 per ton CO_2e carbon tax in 2015 rising at 4 percent (real) until 2050 relative to consumption in a reference scenario with no carbon tax.
CCS = carbon capture and storage

petitive disadvantage with other countries that do not price carbon. Note that a carbon charge would not especially disadvantage us relative to the EU, particularly if the EU brings more of its carbon emissions within the ETS or its post-Kyoto successor. The concern about competitiveness suggests the desirability of international coordination on carbon pricing.

In lieu of an international carbon pricing system (whether it is a system of carbon taxes, cap-and-trade systems, or some combination of the two), the United States might consider taxing the embedded carbon in a few carbon-intensive imported commodities.[55] It is not clear whether a carbon tax on imported embedded carbon could be made compliant with the rules of the World Trade Organization, but note that border adjustments are equally if not more complicated with a cap-and-trade system. If permits are required for carbon-intensive imports, the border adjustment reduces permits available for domestic production. Moreover, since cap and trade is a regulatory instrument, it is not clear that it would be compliant with the World Trade Organization.

5.1.4. Oil and Gas Substitution for Coal. A carbon charge raises the price of coal significantly more than it does that of oil or natural gas. This could lead to a paradoxical result that the demand for oil and natural gas will actually go up as these fossil fuels are substituted for coal in electricity production and industrial use. Results from the EPPA model suggest this would occur for natural gas for a limited time period (see Table 11). Oil consumption initially falls by 33 percent, rises temporarily as developing countries tighten their carbon policy in 2030, and then falls again by 2050. Consumption of natural gas does increase, nearly tripling by 2030, before declining by 2050. A similar pattern holds with fossil fuels used in primary energy consumption. If energy security considerations underlie this concern with increasing demand for oil and natural gas, the results from the EPPA analysis are mixed and suggest the value of enhancing supply security for natural gas in particular in the coming decades if a carbon policy is enacted.

5.1.5. China, India, and Other Developing Countries. One question frequently raised is why the United States should implement a carbon policy before China, India, and other developing countries have done so. In part this reflects trade concerns, and in part it reflects the reality that China and India are large and growing emitters of GHGs. The answer to this question is more political than economic, but a simple and pragmatic response is that these two countries, along with other developing countries, are unlikely to opt into a scheme to control GHG emissions unless the United States makes a serious commitment to reduce its emissions. In that regard, the United States must act to some extent on faith in the hope that our participation can serve—along with multilateral persua-

55. Input-output tables could be used to estimate the embedded carbon in various imports. See Metcalf (1999) and Dinan and Rogers (2002) for applications of this methodology.

sion—to induce developing countries to participate in a global architecture to reduce emissions.[56]

It is important to emphasize that the concern over developing country participation in a global warming framework exists whether the United States engages in a cap-and-trade system or a carbon tax system. One important difference must be emphasized. As was evident in the discussions surrounding the Kyoto Protocol agreement, a global cap-and-trade system is an implicit trade agreement with the potential for large transfers from developed to developing countries. Unlike a global cap-and-trade system, a carbon tax–based international agreement would disentangle a carbon policy from a North-South transfer policy. All carbon taxes would be raised and retained within individual countries.

A related point here is that as countries begin to discuss the framework for a post-Kyoto agreement, nothing requires that all countries construct the same policy. Even if many countries were to opt for a cap-and-trade system in the post-Kyoto environment, the United States could implement a carbon tax. A multilateral system that avoids trade competition through carbon policy would seek to harmonize the price of CO_2 around the world. Thus, for example, the EU could implement a cap-and-trade system with banking. The United States could then harmonize by setting the initial tax rate at or near the initial EU permit price. Countries (or regions) could then coordinate on the desired change in carbon prices over time.

5.1.6. Intertemporal and Geographic Dispersion in Costs and Benefits. It is important to acknowledge that the benefits of reductions in GHG emissions accrue primarily to future generations and, the literature suggests, disproportionately to residents of the developing world (see, for example, Mendelsohn et al. 2006). At the same time, the costs will be disproportionately borne by developed countries and differentially across regions within those countries. This dispersion in costs and benefits will be true whether the United States implements a carbon tax or a cap-and-trade system.

5.1.7. Ethics of Carbon Pricing. A common criticism of carbon tax pricing is that we are allowing firms to pay for the right to pollute. This is an objection raised more generally against pollution taxes in contrast to command and control regulation. Carbon emissions are simply a by-product of our historic reliance on inexpensive fossil fuels to produce energy for any number of socially desirable activities. A carbon price (whether through a tax or a cap-and-trade system) serves to force consumers of carbon-intensive products to recognize the social cost of their activities. If ethics enter the picture at all it is to acknowledge that it is unethical to ignore the social costs of our behavior and that carbon pricing redresses this defect (see also Stavins 2007).

5.1.8. Disproportionately Impacted Sectors. An obvious obstacle to any carbon policy in the United States is the disproportionate impact of the policy on certain industries, with the coal industry being a prime example. As noted in §5.1.1, we simply cannot make inroads in carbon emissions without addressing CO_2 emissions from coal consumption. This suggests the need for transition assistance for coal industry workers who would be displaced as a result of a carbon policy. Such assistance need not be that expensive. Value added (labor compensation, owners' profits, and indirect business taxes) amounted to $11 billion in 2005.[57] If the share of labor compensation in coal mining value added is unchanged from 1997 when labor accounted for one-half the value added in coal mining, the maximum potential loss to labor is $6.5 billion annually.[58] This

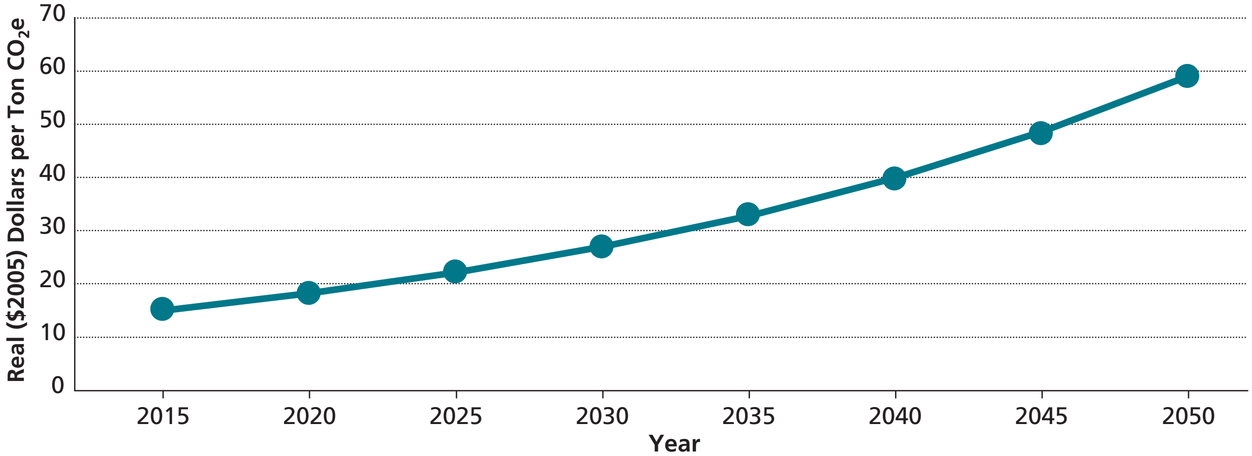
56. It is not necessarily the case that the United States must reduce emissions before large developing countries do so. Ideally, a strong and credible commitment by the United States to reduce emissions would provide the necessary impetus to induce participation by these countries.

57. Personal communication with Shawn Snyder, economist at the Bureau of Economic Analysis, August 20, 2007.

58. Owners of capital may be less affected than workers. Coal mining equipment is likely to have significant salvage value, as illustrated in a recent newspaper article (Beth Daley, "US Castoffs Resuming Dirty Career," *Boston Globe*, August 19, 2007).

FIGURE 6

Proposed Carbon Dioxide Tax Rates, 2015–2050



Source: Metcalf et al. (forthcoming).

assumes that the coal mining industry is wiped out by the policy. In reality, demand will fall sharply but not to zero, so the loss in value added will be less than $11 billion annually. Moreover, as time goes on, participants in this industry can begin to make adjustments to move into other sectors. Thus any transitional assistance should be temporary in nature with particular attention paid to those factors that are least able to transition to new jobs (e.g., older workers).[59]

The disproportionate impact of a carbon policy on the coal industry also suggests the importance of moving forward rapidly on CCS, a key element in a carbon policy. This will require R&D to understand unresolved issues in storing CO_2 for long periods of time, and will also require addressing whether the state and federal regulatory structure is adequate to the development of a national CCS system.

5.2. Concerns Specific to a Carbon Tax

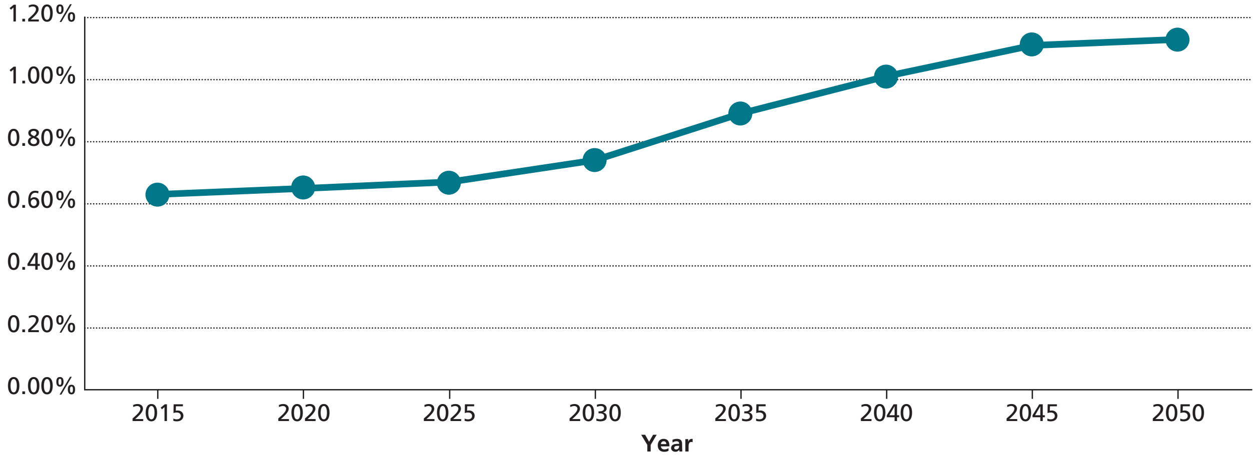
5.2.1. Tax Base Stability. Some worry that a carbon tax base may not provide a consistent and steady stream of revenue. This is of particular concern if the revenues are earmarked for tax reductions. One aspect of revenue stability is the volatility of tax collections over the business cycle. One measure of revenue stability is the coefficient of variation (CV). Lower values of the CV indicate greater revenue stability.[60] The CV for a carbon tax using historic emissions from 1959 through 2005 is 0.19, and the CV for real payroll tax collections over that period is 0.56.[61] This suggests that carbon tax collections should be even more predictable than payroll tax collections.[62]

A second aspect of tax base stability has to do with trends in carbon emissions. If the carbon tax is ef-

59. The Larson carbon tax bill (H.R. 3416) provides for 10 years of transition assistance to affected industries, with the assistance tapering off over the 10-year period.
60. *CV* is defined as the ratio of the standard deviation divided by the mean of a variable. The chance that a normally distributed random variable will be more than ± v times the mean of the random variable is roughly one-third, where v is the CV. Thus if the CV equals 0.2, the random variable will be within 20 percent of its mean value approximately two-thirds of the time.
61. Source for emissions is EIA (2006b). Source for payroll tax revenues is OMB (2007).
62. An alternative measure of revenue stability is the conditional standard deviation of the percentage change in tax revenue after controlling for trend growth. Again, lower values indicate greater revenue stability. The conditional standard deviation for the carbon tax is 0.029 while the measure for the payroll tax is 0.042. Because payroll tax rates grew between 1959 and 2005, these statistics are also reported for the period 1988–2005, a period during which little change in payroll tax rates occurred. The carbon tax continues to be less volatile than the payroll tax.

FIGURE 7

Expected Carbon Tax Revenue as a Percentage of GDP, 2015–2050



Source: Metcalf et al. (forthcoming).

fective, so the argument goes, carbon emissions will fall, as will carbon tax revenues. This is a legitimate concern, but it should be clear that a GHG emissions tax of $15 per ton CO_2e is just an initial rate. Over time, the tax will have to be raised if we are to achieve meaningful reductions in GHGs and stabilize carbon emissions. An analysis of carbon taxes in the U.S. by Metcalf et al. (forthcoming) is instructive. One of the scenarios it considers is a tax that begins at $15 per ton CO_2e rising at an annual rate of 4 percent after inflation until 2050. Figure 6 illustrates how the tax rate grows between 2015 and 2050. By 2050, it will have risen to just under $60 per ton (in 2005 dollars).

Figure 7 shows how carbon tax revenues as a share of GDP evolve between 2015 and 2050. For a tax starting at $15 per ton CO_2e, revenue will grow over time from about 0.66 percent of GDP to 1.1 percent by 2050.[63]

While these results are dependent on the assumptions built into the EPPA model and must be viewed with the same caution as any economic model providing scenarios about the future. The results, however, suggest that the tax revenue should be significant for the next several decades.

5.2.2. No Certainty of Emission Reductions with a Carbon Tax. A common criticism of carbon taxes is that they do not provide any certainty of emission reductions. A carbon tax provides certainty over the price of emissions but no certainty over emissions; a cap-and-trade system provides certainty over emissions but no certainty over the marginal cost of those emissions.[64]

What we ultimately care about, however, are the economic and ecological consequences of higher concentrations of GHGs in the atmosphere resulting from global emissions. But we have no defini-

63. Even with tax rates starting as high as $53 per ton in 2015, revenue is reasonably stable. Paltsev et al. (2007) show that a cap-and-trade system starting at this higher price generates revenue equal to just under 2 percent of GDP. The share drops a bit, and then is reasonably stable between 2015 and 2050. Revenues and revenue shares depend to some extent on carbon policy in other parts of the world. See Paltsev and colleagues for more discussion of these points.

64. As my discussion of safety valves above suggests, a cap and trade system really provides the appearance of certainty over emissions. High permit prices will undoubtedly create political pressure for more permits. Note too that if there is any risk of overallocation of permits, the tax is more certain to deliver at least some abatement (as evidenced by the overallocation of Phase I permits in the EU ETS and their current price of less than €1).

tive scientific evidence yet on the precise amount of emission reductions that are required to stabilize temperature and prevent large economic and ecological losses. To give primacy to specific emission reductions regardless of the cost is to suggest a greater certainty in the climate science than currently exists, and implicitly but implausibly makes controlling emissions the top policy priority, trumping all others. As noted in §1, it would not be prudent to wait for greater precision in the climate science before taking steps, given the long lags between emissions and climatic response, but we should not act as if we know the right level of emissions reductions to undertake. Instead, we should balance reductions against the economic cost of achieving those reductions as represented by the marginal cost of abatement. A tax does this automatically because profit-maximizing firms will operate at the point where marginal abatement costs equal the tax rate. With a clear and unambiguous schedule of carbon tax rates over time, businesses and households can rationally plan to reduce their carbon footprint through their capital purchase decisions as well as through their use of current capital.

5.2.3. Efficiency and Expediency. A final potential problem with carbon taxes relative to cap-and-trade systems is the interplay between equity and efficiency. Proponents of a cap-and-trade system may feel the need to grandfather all of the permits in the interests of political expediency. A free distribution of permits is a lump-sum distribution; the only efficiency loss is the loss of opportunity to reduce existing distortionary taxes. In order to build support for a carbon tax, on the other hand, Congress may feel it needs to exempt certain sectors of the economy from the tax. This introduces an additional distortion because any sectoral exemption from the tax means that different sources of carbon emissions are paying different tax rates. Substitution from taxed to untaxed sectors will presumably ensue, thereby creating deadweight loss. Whether the efficiency losses from partial tax exemption are more or less than the efficiency losses from full grandfathering of permits in a cap-and-trade system is an empirical matter.

6. Conclusion

Global warming is one of the greatest challenges facing our world today. The challenge arises in part from the international dimension of the problem and the inability of individual countries to solve the problem on their own. In addition, the costs and benefits of addressing global warming accrue to different groups. The Stern Review Executive Summary notes this clearly: "Climate change presents a unique challenge for economics: it is the greatest and widest-ranging market failure ever seen. The economic analysis must therefore be global, deal with long time horizons, have the economics of risk and uncertainty at centre stage, and examine the possibility of major, non-marginal change" (Stern 2007, Executive Summary, p. i).

Even within the United States, the challenges to implementing a carbon-mitigation policy are daunting. One challenge is the mistrust of global warming policy arising from the failure of the United States to participate in the Kyoto Protocol. Many have argued that the United States was outmaneuvered by the Europeans in negotiations leading up to Kyoto in what was essentially a trade negotiation (see, for example, Cooper 2006). Given the current interest in the U.S. House and Senate in carbon cap-and-trade legislation, it appears that policy makers are beginning to move beyond this mistrust.

This paper has argued that strong political, administrative, and efficiency arguments can be made for the superiority of a carbon tax to a cap-and-trade scheme. Why then the reluctance to consider a carbon tax? I think two forces help explain the preference for cap-and-trade schemes. First, the current administration has been adamant that new taxes be avoided. The focus, rather, has been on reducing current taxes to spur economic growth and avoid growth in the size of government. This proposal has been designed to avoid the issue of the appropriate level of federal tax revenues by being revenue neutral. A broader point can be made here. The revenues from a carbon tax provide fiscal flexibility. Although this proposal is for a revenue and distributionally neutral reform, new revenue sources will be needed to – among other things – fund the wars in Iraq and Afghanistan, the coming fiscal burdens of an aging population, and to reform the alternative minimum tax. Environmental revenues provide an alternative to raising income taxes or cutting critical government programs to address these fiscal concerns.

Second, received wisdom suggests that energy taxes are a difficult sell to the American public. This may be more urban legend than fact. A brief historical aside may be useful here. As part of his National Energy Program put forward in April 1977, President Jimmy Carter proposed a standby gasoline tax of 5¢ a gallon if targets for reductions in gasoline consumption were not met—this at a time when the federal excise tax on gasoline was 4¢ a gallon. Revenue would be rebated in a progressive fashion to households through the federal income tax. The National Energy Program, along with many other aspects of Carter's domestic policy agenda, did not garner the needed support in Congress to become law, but it is likely that Carter's poor relationship with Congress had more to do with the difficulties of moving his energy agenda than the standby gasoline tax.

A significant increase in the gasoline excise tax occurred in 1982 to fund the completion and extension of the Interstate Highway System when the rate was increased from 4¢ to 9¢. In 1990, it was increased further to 14¢, with half of the 5¢ increase committed to deficit reduction. Neither of these increases in themselves generated particular public outcry.[65]

65. President George H. W. Bush's more general renouncement of his commitment to no new taxes made in the 1988 election likely caused him more trouble than his increase of the gas tax.

In contrast, President Bill Clinton's proposed British thermal unit (BTU) tax in his 1994 budget submission was controversial. The proposal would have taxed energy based on the heat content of the fuel measured in BTUs. It passed the House but not the Senate. A detailed analysis of why the BTU tax failed is beyond the scope of this paper but one point is clear: the BTU tax did not have a sharply articulated focus, but rather was a compromise between a carbon tax to address global warming and a broad-based energy tax. The tax base was altered to win support from legislators in coal states. The lack of a focus and the fundamental compromise embedded in its design made it difficult to fend off requests for exemptions and other loopholes. Ultimately, the tax was replaced with the 4.3¢ per gallon increase in the federal gasoline excise tax as part of a deficit reduction package.

Some lessons emerge from this brief review of recent energy taxation. First, addressing distributional concerns over the impact of higher energy taxes is important to garner support for any energy tax. The proposal put forward in this paper addresses those concerns through the linkage between the carbon tax and the income tax. If Congress also considers transition assistance to coal miners and increased support for CCS, it will be addressing an additional distributional concern of some import.

Second, any energy tax proposal must have a clearly articulated rationale and its design must match that rationale. In that regard, a carbon tax is a vast improvement over the BTU tax proposal. Polling also supports this view. Support for an increase in the federal gasoline tax rises from 12 to 59 percent when the revenue is used to cut energy consumption and reduce global warming.[66] In this changing political climate, we may find that the conventional wisdom that cap-and-trade is the only way to control GHG emissions no longer holds and that a carbon tax becomes a credible policy choice in the ongoing policy discussion over how best to address global warming.

66. Louis Uchitelle and Megan Thee, "Americans Are Cautiously Open to Gas Tax Rise, Poll Shows," *New York Times*, February 28, 2006.

Appendix: GHG Coverage Under a Carbon Tax

Global warming is driven by a build-up of various GHGs and CO_2 in the atmosphere. Any emissions policy should take into account these other gases (methane, nitrous oxides, various fluorocarbons, and various other gases) as part of the policy. Different gases have stronger or weaker warming effects (measured as radiative forcing) and remain in the atmosphere for varying lengths of time. Methane, for example, has a forcing impact substantially higher than that of CO_2, but it has a much shorter atmospheric lifetime than does CO_2. A measure of the cumulative forcing of a given unit of a GHG emission over a fixed length of time relative to the cumulative forcing from a ton of CO_2 is often used to translate the warming impacts of GHGs into a common unit. This is referred to as the global warming potential (GWP) of a GHG. The GWP over a 100-year period commonly is used to convert emission impacts into CO_2e. Table A1 presents the GWPs for the GHGs that could be subject to the carbon tax. A tax of $15 per ton CO_2e would translate into a tax of $345 per ton of methane if the 100-year GWPs were used for the conversion.

Table A2 provides a breakdown of GHG emissions in 2005 in the United States.

TABLE A1

Global Warming Potentials (GWP)

Gas	GWP–100
Carbon dioxide	1
Methane	23
Nitrous oxide	296
HFC–23	12,000
HFC–125	3,400
HFC–134a	1,300
HFC–152a	120
Perfluoromethane	5,700
Perfuoroethane	11,900
Sulfur hexafluoride	22,200

Source: EIA 2006b, Table 4.
Note: GWPs are all relative to CO_2.

Total GHG emissions in 2005 were 7,147 million metric tons, with nearly 90 percent coming from the energy sector. An important issue is how broad the coverage of a carbon tax should be. At one end of the spectrum, all GHGs would be subject to the tax. It is extremely difficult, however, to measure and tax emissions in the agricultural sector.[67] Alternatively, one could simply include energy-related CO_2 emissions. Limiting emissions to energy-re-

TABLE A2

GHG Emissions, 2005

	Energy	Waste management and industrial	Agricultural	Total
Carbon dioxide	5,903.2	105.4	0.0	6008.6
Methane	254.8	174.0	183.0	611.8
Nitrous oxide	67.2	19.3	279.9	366.4
HFCs, PFCs, PFPEs	0.0	144.6	0.0	144.6
Sulfur hexafluoride	12.3	3.4	0.0	15.7
Total	6,237.5	446.7	462.9	7147.2

Source: EIA 2006b, p. xvi.
Note: HFCs stand for hydrofluorocarbons, PFCs for perfluorocarbons, and PFPEs for perfluoropolyethers. All fluorocarbons have been attributed to the industrial sector in this table. Amounts are in millions of metric tons CO_2e.

lated CO_2 has two drawbacks: First, it raises the cost of achieving a given percentage reduction in emissions since the policy restricts the avenues through which emission reductions can occur.[68] Second, it may well be that in the near term some of the noncarbon gases can be reduced more quickly than carbon emissions.[69] It would be administratively feasible to include energy, industrial, and waste management emissions in a carbon tax. This would increase the initial base of the tax (relative to energy-related CO_2) by 13 percent.

67. Reilly et al. (2003) discuss the difficulties of including agricultural methane and nitrous oxide in an emissions control scheme.
68. An analysis by Reilly et al. (2003) suggests that costs are reduced by one-third when all gases are included in an emissions control policy.
69. Paltsev et al. (2007) find this in their analysis of some of the current cap-and-trade proposals.

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