Reacting to Greenhouse Gas Emissions: 
A Carbon Tax to Meet Emission Targets

Gilbert E. Metcalf  
Department of Economics  
Tufts University  

March 30, 2009

Abstract

In previous papers I have described a revenue and distributionally neutral approach to reducing U.S. greenhouse gas emissions that uses a carbon tax. The revenue from the carbon tax is used to finance an environmental earned income tax credit designed to be distributionally neutral. The carbon tax reform proposal is also revenue neutral and avoids conflating carbon policy with debates over the appropriate size of the federal budget. This paper describes a variant to address concerns of environmentalists that a carbon tax does not provide certainty of emission reductions over the control period. The Responsive Emissions Autonomous Carbon Tax (REACT) combines the short-run price stability of a carbon tax with the long-run certainty of emission reductions over a control period.

Joshua Lund-Wilde has provided excellent research assistance on this paper.
I. Introduction

Conventional wisdom holds that a carbon tax is not a politically viable option for controlling carbon emissions because the tax makes overly explicit the costs associated with controlling GHG emissions. While this has perhaps been true historically, it is also true that any form of carbon pricing has not been politically viable in the United States up until now. However, as the political discussion and consideration of carbon pricing schemes has progressed over the last year and a half, it has become clear that a thoughtfully designed carbon tax would address many of the concerns of those who oppose carbon pricing in general while overcoming many of the shortcomings of a cap and trade system. Indeed, the most serious cap and trade proposals include features that make them "feel" like a tax while looking like a cap and trade system.

This paper takes a different perspective. It designs a carbon tax to have the most desirable properties of a tax while also incorporating the most desirable feature of a pure cap and trade system. In particular the tax is designed to meet strict cumulative emission caps over a control period, in this paper from 2012 to 2050. It does this by adjusting the rate of growth of the tax at periodic intervals (in benchmark years) to rise more rapidly if cumulative emissions are falling short of legislatively specified targets.

By building the adjustment process into the law, we reduce uncertainty over administrative responses in the future and avoid the need to delegate tax writing authority to other agencies. Congress can, of course, revisit the targets over time as additional information about the damages of climate change or the costs of abatement.
II. The Responsive Emissions Autonomous Carbon Tax (REACT)

A. Main Design Elements

Cap and trade proposals have the apparent virtue that emissions are subject to a hard cap over some control period.¹ A carbon tax in contrast has a set price path but no certainty over emission limits. To address the concern that a carbon tax does not create sure emission limits over the control period, I describe a hybrid carbon tax called the Responsive Emissions Autonomous Carbon Tax (REACT). REACT eliminates short-run price volatility while ensuring that long-run emission limits are met.

The profile of tax rates over time is an essential design provision of any carbon tax. REACT takes the following approach:

- An initial tax and standard growth rate for the tax is set for the first year of a control period.
- Benchmark targets for cumulative emissions are set for the control period. The law could require that the targets be met at annual, five-year, ten-year or some other time interval.
- If cumulative emissions exceed the target in the given years, the growth rate of the tax would increase from its standard growth rate to a higher catch-up rate until cumulative emissions fall below the target again.

With a high enough catch-up rate, we can be reasonably sure that we will meet emission caps by mid-century in a similar fashion to current cap-and-trade proposals. This suggested approach ensures that long-run targets are met while price stability is achieved in the short run. Given the ability to predict emissions in the short run and the transparent nature of the tax, firms would be able to predict with considerable certainty what the growth rate of the tax will be in the near term thereby providing greater clarity for their planning purposes.

¹ This assumes no cost containment provisions that soften the cap. I discuss these further below.
Additional elements of REACT are designed to ensure the double neutrality in revenue and income distribution. Specifically, REACT contains the following additional elements:

- A refundable tax credit is provided for permanently sequestered greenhouse gas emissions.
- A border tax is imposed on the embedded CO$_2$ in imported fossil fuels and select carbon intensive inputs.$^2$
- An environmental earned income tax credit on personal income taxes equal to the employer and employee payroll taxes on initial earnings, up to a limit.

B. Additional Considerations

The previous subsection describes the essential elements of REACT. Next I turn to a more detailed discussion of key issues.

1. Administrative Issues$^3$

There are two principles, one physical and one economic, which allow us to substantially reduce the collection and enforcement costs for a tax on emissions from fossil fuels. The first is that a unit of fossil fuel will emit the same amount of carbon regardless of when or where it is burned. For carbon emissions from fossil fuel combustion, there is a perfect correspondence between input and output. Therefore, we can tax the input – the fossil fuel – rather than the output – the emission. The exception to this rule is for fossil fuel permanently sequestered, such as fuel used for tar or carbon that is captured and stored. As discussed above, a credit should be given for carbon that is permanently captured and stored.

---

$^2$ See Metcalf and Weisbach (forthcoming) for more on this point.

$^3$ This section draws in part from Metcalf and Weisbach (forthcoming).
The second principle is that the incidence of a tax (and its efficiency effects) is unrelated to the statutory obligation to remit the tax. This means that we can impose the tax (choose the remitting entity) to minimize collection and monitoring costs and to ensure maximum coverage. In general, imposing the tax upstream (i.e., at the earliest point in the production process) will achieve these goals as there are (1) far fewer upstream producers than there are downstream consumers and (2) because of economies of scale in tax administration, the cost will be lower per unit of tax.

These two principles lead to the conclusion that the administrative costs a carbon tax can be reduced through upstream implementation on fuel producers rather than downstream on fuel users. The tax could be applied at the mine mouth for domestic coal, and at the border for imported coal. There were 1,438 operating mines in the U.S. in 2006.\(^4\) Almost all coal used in the U.S. is produced here and there are very few exports. Taxing at the mine would capture virtually 100 percent of U.S. coal production. Moreover coal mines are potential sources of methane, either captured and put into the pipeline system or released into the air. If it is captured, this source of methane may not need to be processed. Therefore, having mines as taxpayers may create synergy – they can pay the tax on this source of natural gas or methane as well. If it is not captured, coal mines should pay a tax on any release. Coal-bed methane emissions were around 58.5 million metric tons of CO\(_2\) equivalents, so imposing this tax will be important.

Natural gas could be taxed at the operator level or on import. Operators already pay state severance taxes, which means that they have the administrative capacity to pay the tax and states are already collecting the necessary data. Although there are many small operators, taxing the top 500 would capture almost all the natural gas produced in

\(^4\) Energy Information Administration, Annual Coal Report (2007)
the United States. Imported gas could be taxed at one of fifty-five locations where natural gas (or liquefied natural gas) can be imported or exported, consisting of six liquefied natural gas facilities and forty-nine pipeline border points.

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. A carbon tax would likely create less of an administrative burden than creating an entirely new accounting scheme for carbon allowances.

Non-energy carbon emissions come from a variety of sources, predominantly iron, steel, and cement production. These CO₂ emissions, along with many other GHGs, could be taxed either at the point of production or at the point of consumption. Metcalf and Weisbach (forthcoming) estimate that roughly 90 percent of U.S. GHGs could be brought into the tax base at relatively low cost.

With the carbon tax applied at upstream points, it is important to provide tax credits for carbon capture and storage (CCS) at downstream levels and for fossil fuels used as feedstocks in manufacturing activities where the carbon is permanently stored. CCS refers to technologies that remove carbon from the exhaust streams of fossil fuel burning plants and store 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. Since firms that engage in sequestration activities (e.g. coal-fired electric
power plants) may not be the firms subject to the carbon tax (e.g. coal mines), allowing the permits to be traded would ensure that the credits for sequestration would have full value. Thus coal companies with carbon tax liability could purchase carbon tax credits from downstream firms that earn the credits for sequestering CO₂.⁵ Credits for certain land-use activities, including forestry sequestration, should also be considered for credit eligibility. This would be a way of allowing sectors not covered by the carbon tax to opt in to the system and receive payments for approved carbon reducing activities.

2. *An Offsetting Income Tax Cut*

The carbon tax will raise the price of carbon-intensive products. In order to address any regressivity in the carbon tax, the reform proposed here uses the tax revenue to provide an offsetting cut in the income tax tied to payroll taxes. Specifically, an environmental earned income tax credit is allowed that is equal to the employer and employee portion of the payroll taxes paid by the worker in the current year, up to a cap. The cap serves two purposes. First, it contributes to the progressivity of the rebate by putting a limit on the rebate for higher income workers. Second, it ensures revenue neutrality by putting a limit on the aggregate rebate to workers. The credit would be designed to ensure that households with very low income tax liability would still be able to receive the credit. In this regard, the environmental earned income tax credit would operate like the current earned income tax credit. This is essentially the approach taken in the Making Work Pay tax credit in the 2009 stimulus package (*need full reference*).

---

⁵ Alternatively, firms with carbon tax credits could receive a refund from the IRS directly, thereby obviating the need for tradability. This would be similar to the treatment of zero-rated firms who receive a credit for a Value Added Tax (VAT) paid at earlier stages of production but pay no gross VAT on their value added.
Setting the cap depends on the amount of carbon tax revenue collected and the number of workers and hours worked. A higher cap will be more costly and could lead to the rebate exceeding the carbon tax revenue. Using data from the Consumer Expenditure Survey for 2003 and applying the carbon tax to energy related CO₂, I calculate that the revenue-neutral cap on rebated taxes for that year would be $560 per worker. Broadening the coverage of the carbon tax to include other GHGs would increase revenue by roughly 13 percent and raise the cap to approximately $630. 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. In contrast, at maximum covered earnings ($90,000 in 2005), workers would receive a tax credit equal to 4 percent of the payroll tax.

This distributionally neutral reform 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 contribute to greater labor force participation among lower-income workers.⁶ To be clear, however, the reform has been designed to emphasize distributional neutrality rather than to maximize efficiency gains. Below I provide some distributional results to illustrate how one might achieve revenue and distributional neutrality in REACT.

### III. Elements of a Hybrid Carbon Tax

REACT is a hybrid carbon tax that combines short-run price stability (feature of a carbon tax) with long-run certainty of emission limits over the control horizon (feature of a hard cap-and-trade system). By adjusting the growth rate of the tax between a standard

---

⁶ For example, Meyer and Rosenbaum (2001) find that changes to the earned income tax credit had substantial effects on the labor force participation of single mothers.
growth rate and a higher "catch-up" rate, it can meet long-run emission targets while providing price predictability. Given the ability to predict emissions in the short run and the transparent nature of the tax, firms would be able to predict with considerable certainty what the growth rate of the tax will be in the near term thereby providing greater clarity for their planning purposes.

As an example of how REACT could be designed, assume benchmark targets based on the permit allocations in the Warner-Lieberman Climate Security Act of 2007 (S. 2191). Also assume that the tax goes into effect in 2012 with a control period running through 2050. The standard growth rate for the tax is 4 percent (plus inflation) and a higher catch-up rate of 10 percent (plus inflation). The catch-up rate is triggered when cumulative emissions in any year exceed cumulative target emissions.

Figure x. Representative Carbon Tax Paths
Figure x above illustrates two possible paths for the carbon tax between the 2012 and 2050. The smooth path shows a carbon tax that starts at $81.50 and rises at 4 percent (real) each year to 2050. The tax rate in the final control year is $378. The less smooth line illustrates a REACT tax rate that is designed to achieve the cumulative emission reductions called for in the Climate Security Act of 2007. There are a number of years in which the tax grows at a 10 percent annual growth rate reverting to the 4 percent rate in those years in which the cumulative emission targets are met.\(^7\) The tax rate in 2050 is $592 in this case. The higher tax rate assures that the cumulative emission cap over the control period is met.

I ran simulations of this tax assuming that emissions follow the following stochastic process:

\[ \ln E_t = \alpha + \beta_1 t + \beta_2 P_t + u_t, \]

where \(u_t\) is a AR(1) process with autoregressive parameter 0.2 and standard deviation of the independent shock equal to 0.14. The regression in equation (1) was fitted to the data from various runs of the carbon tax in Metcalf et al. (2008). Observations from all carbon tax runs in that paper were included in a single regression.\(^8\) Regression results are shown in Table X.

---

\(^7\) This simulated price path checks emissions against the targets in each year. The tax could be modified to check the targets every five years or some other interval.

\(^8\) Strictly speaking, such a regression is not a valid representation of the emission process given the differential technology responses that can occur in different tax simulations of the EPPA model. For my purposes I simply need a reduced form relationship between emissions and price to illustrate how the REACT tax might operate.
Table x. Emissions Response to Carbon Prices

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Price</td>
<td>-0.0035 (.00026)</td>
</tr>
<tr>
<td>Year</td>
<td>0.0084 (.0023)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-8.205 (4.588)</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.824</td>
</tr>
</tbody>
</table>

Source: Author's computations based on data in Metcalf, et al. (2008).

Based on the response of emissions to a carbon price as given in Table x, I simulate 1,000 runs of the REACT tax to provide a sense of how we might meet the cumulative emission targets described above given different realizations of emissions. Over the 1,000 runs, the average number of years that the tax is growing at the higher catch-up rate is 7.9 ranging from a low of 4 years out of the 38 control years to a high of 12. Figure x displays information on the range of tax rates between 2012 and 2050 based on the stochastic nature of emissions as modeled above.
In each year the box and whiskers graph shows the distribution of tax rates across the 1,000 simulation runs. The box provides the interquartile range (25\textsuperscript{th} percentile at the lower end of the box and 75\textsuperscript{th} percentile at the upper end of the box) along with the median value (line inside of box). The "whiskers" show the range of adjacent values and the dots show any outlying values.\textsuperscript{9} The lower end of the whisker (or outlying value) in each year is the value of the carbon tax if no adjustment is made to allow cumulative emissions to catch up to the targets in each year. The simulation indicates that a "bad" state of the world (in which emissions were especially high – say due to unexpected and persistent outages of nuclear power plants or especially hot weather) could lead to a carbon tax rate as high as $740 based on the responsiveness of emissions to the tax and the stochastic nature of emissions posited for this example.

\textsuperscript{9} Adjacent values are those that are no more than 1.5 times the interquartile range (IQR) away from the 25\textsuperscript{th} or 75\textsuperscript{th} percentiles. Outliers are more than 3 times the IQR in distance from the 25\textsuperscript{th} or 75\textsuperscript{th} percentiles.
This modeling has not taken into account an important behavioral effect that may occur. Firms may anticipate cumulative emissions rising to the point where they may trigger a shift to the high growth rate in the tax and undertake additional abatement activities to avoid this outcome. Further modeling is needed to understand whether this is a potentially significant response or not.

add some discussion of CBO proposal on managed prices and McDermott bill

The REACT approach addresses the objection that a carbon tax does not ensure a hard cap on greenhouse gas emissions over the control period. An overall cap can be maintained while insulating consumers and businesses from short-run fluctuations in carbon prices that add volatility to energy prices and undermine support for climate change legislation. It does this with a transparent mechanism for adjusting the price of emissions over the control period.

IV. Distributional Analysis of the Carbon Tax Proposal

This section describes the distributional impacts of the proposed carbon tax swap.\textsuperscript{10} I present results from an analysis using the 2003 Consumer Expenditure Survey (CES). The CES provides very detailed expenditure data at the household level that allows me to track spending on energy and other commodities whose prices may be increased by a carbon tax. I begin with an analysis of the price impacts of the tax.

Table 3 provides estimates of price increases for selected commodities if a carbon tax of $15 per ton of CO\textsubscript{2} were implemented in 2003 based on the methodology of Metcalf (1999). This methodology 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

\textsuperscript{10} This section draws on Metcalf (2007b)
The overall price impact of a carbon tax is to raise the price of gasoline by nearly 9 percent once it is taken into account that fossil fuels are used, among other things, to process petroleum into gasoline and transport it to service stations.

Table 3. Consumer Price Impacts of a Carbon Tax

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Price increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity and natural gas</td>
<td>14.1</td>
</tr>
<tr>
<td>Home heating</td>
<td>10.9</td>
</tr>
<tr>
<td>Gasoline</td>
<td>8.8</td>
</tr>
<tr>
<td>Air travel</td>
<td>2.2</td>
</tr>
<tr>
<td>Other commodities</td>
<td>0.3 to 1.0</td>
</tr>
</tbody>
</table>

*Source:* Author’s calculations using the input/output accounts and the Consumer Expenditure Survey.

*Note:* A 2003 tax of $15 per metric ton of CO₂ (year 2005 dollars) is assumed to be passed fully forward to consumers.

Except for energy products, the carbon tax appears to have only 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. 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 will also 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 demand 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. In the short run, the price reductions received by producers of oil, natural gas, and coal would be less than 4 percent based on the analysis in Metcalf, et al. (2008).

Assuming that the tax is fully passed forward into higher consumer prices, the direct impact of a $15 per ton CO₂ 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 under 7 percent, based on the price of gasoline in 2003, and the price of natural gas for industrial users by 9 percent. Based on data from EPA's Emissions & Generation Resource Integrated Database, the carbon tax would raise the price of coal fired electricity by 1.78¢ per kilowatt hour, an increase of 24 percent, based on the average retail price of electricity in 2003.

As described above, the proposed carbon tax uses the revenue from the carbon tax to reduce the payroll tax by providing a rebate to workers in each household that is equal to their first $560 in payroll taxes (including the employer portion of the tax). This is equivalent to exempting from payroll taxation the first $3,660 of wages per covered worker in 2003.

Table 4 details the distributional impact of this carbon tax swap on households based on annual household income.

---

### Table 4. Distributional Impacts of the Carbon Tax Swap

<table>
<thead>
<tr>
<th>Income Group (decile)</th>
<th>Carbon Tax</th>
<th>Tax Credit</th>
<th>Net</th>
<th>Include Social Security</th>
<th>Lump Sum Rebate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (lowest)</td>
<td>-3.4%</td>
<td>2.7%</td>
<td>-0.7%</td>
<td>1.4%</td>
<td>2.1%</td>
</tr>
<tr>
<td>2</td>
<td>-3.1%</td>
<td>2.1%</td>
<td>-1.0%</td>
<td>1.0%</td>
<td>1.0%</td>
</tr>
<tr>
<td>3</td>
<td>-2.4%</td>
<td>2.2%</td>
<td>-0.2%</td>
<td>0.6%</td>
<td>0.6%</td>
</tr>
<tr>
<td>4</td>
<td>-2.0%</td>
<td>2.1%</td>
<td>0.1%</td>
<td>0.3%</td>
<td>0.4%</td>
</tr>
<tr>
<td>5</td>
<td>-1.8%</td>
<td>1.9%</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.3%</td>
</tr>
<tr>
<td>6</td>
<td>-1.5%</td>
<td>1.8%</td>
<td>0.3%</td>
<td>0.1%</td>
<td>0.1%</td>
</tr>
<tr>
<td>7</td>
<td>-1.4%</td>
<td>1.6%</td>
<td>0.2%</td>
<td>0.1%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>8</td>
<td>-1.2%</td>
<td>1.4%</td>
<td>0.2%</td>
<td>-0.1%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>9</td>
<td>-1.1%</td>
<td>1.1%</td>
<td>0.0%</td>
<td>-0.1%</td>
<td>-0.2%</td>
</tr>
<tr>
<td>10 (highest)</td>
<td>-0.8%</td>
<td>0.8%</td>
<td>0.0%</td>
<td>-0.2%</td>
<td>-0.2%</td>
</tr>
</tbody>
</table>

Source: Metcalf (2007b). This table presents percentage changes in disposable income due to carbon tax.

Using an annual income measure to group households, the carbon tax in isolation is 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 largely offsets this regressivity. The average credit as a fraction of income falls with income, with the lowest income group receiving a credit worth 2.7 percent of income and the highest income group receiving a credit worth 0.8 percent of income. The third column in Table 4 (labeled Net) 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.\footnote{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 Hassett, Mathur and Metcalf (2009) for more discussion of this point.}

In the last two columns of Table 4 I modify the rebate component of the carbon tax to show how the distribution of carbon taxes net of the tax credit can be altered through policy design. First I extend the rebate to include recipients of Social Security. Social Security recipients receive a lump sum rebate equal to the maximum credit for workers. This could be done by increasing monthly Social Security checks by the amount of the rebate divided by twelve. Unlike the income tax-based approach, this would require an explicit bookkeeping adjustment to reflect a transfer of funds from the general fund to the Social Security Trust Fund to prevent the rebate affecting balances in this latter fund.

Broadening the recipient pool lowers the maximum credit or rebate to $420. The effect is to increase the progressivity of the reform. A carbon tax combined with an earned income tax credit is essentially distributionally neutral. In the final column, I replace the environmental tax credit with a per capita lump sum rebate of $274. This increases the progressivity of the reform even further. Note though that the costs of administering a carbon tax with a lump sum rebate will be higher given the need to track people in households not currently in the federal tax system.

Table 4 illustrates the trade-off between distributional and efficiency concerns. As noted above, the rebate was tied to earned income to provide a modest incentive to labor supply. Providing a lump-sum rebate of the tax revenue to households would
increase the progressivity of the reform but at the cost of losing the labor supply incentive.

The environmental tax reform illustrated in Table 4 emphasizes an essential point: while a carbon tax itself may be regressive, a carbon tax policy 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 were not rebated or if a cap-and-trade system were implemented with freely allocated permits such that the market permit price equaled $15 per ton of CO₂, the reform would raise prices (as illustrated in the second column of Table 5) but would not provide the offsetting reduction in the payroll tax to achieve distributional neutrality.

V. Advantages of a Carbon Tax

In the past several years, momentum has developed for a national cap and trade program in the United States and several proposals have been put forward (see Paltsev et al. (, 2007). While cap and trade has considerable support in the policy community, a carbon tax should remain on the table as a policy option. The recent discussion in the Senate of the Lieberman-Warner cap and trade bill illustrates policymakers’ concerns about the trading prices for emissions permits.¹³

The carbon tax proposal here has several important advantages over cap and trade. First, REACT provides for a clear price signal while committing to cumulative caps over a control period. Setting a clear price on emissions provides the impetus for

¹³ The Lieberman-Warner Climate Security Act (S. 2191) implements a cap and trade system on fossil fuel related gases primarily at the upstream level (with the major exception of coal where it is implemented on large coal using facilities). Hydrofluorocarbons are covered under a separate cap. Initially a little over one-fifth of the permits would be auctioned with this share rising to just over seventy percent by 2031. See Appendix D to Paltsev et al. (2007) for a detailed analysis of this bill.
emitters to begin to reduce emissions through process changes and investment. Second, a commitment to a revenue and distributionally neutral carbon tax could create political discipline that limits the scope of discussion and focuses the policy debate. President Ronald Reagan placed similar constraints on the tax reform debate that contributed to the successful enactment of the Tax Reform Act of 1986. Finally, administrative concerns suggest a carbon tax can be put in place more rapidly than a cap and trade system. I discuss in greater detail below these and other advantages of a carbon tax over a cap and trade system.

A. Revenue

A cap and trade system is built around the instrument of tradable permits. Permits are valuable assets. They can be auctioned by the government, thus raising revenue. But historically they have been given away to industry as part of a process of obtaining support for the system. To be fair, prior domestic cap and trade programs were an order of magnitude smaller than any potential carbon cap and trade program. Thus, given the revenues involved, auctioning permits in those programs was simply not that important.

The stakes are higher with a carbon cap and trade bill and the need for fiscal discipline that much greater. The debate last year over the Boxer Amendment to the Lieberman-Warner Bill is instructive. The bill set very specific uses for the freely allocated permits as well as for spending from auctioning. In effect the bill implemented a large-scale set of revenue and spending programs that circumvented the normal committee process.

The Congressional Budget Office recognized these indirect revenue implications of cap and trade bills with its decision in late 2007 to begin counting freely allocated
permits as revenue and offsetting spending (see the CBO cost estimate of S. 2191 released on April 10, 2008). One could push this point further and argue that any new major revenue source – such as arises from a tradable permit system whether the permits are auctioned or freely allocated – should go through the usual Congressional budget process. This ensures that Congress weighs the best use of funds from the initiative against all the pressing budget needs. This is precisely the process that would occur with a carbon tax.

This is not to suggest that proponents of carbon pricing couldn't propose fiscal constraints on the use of carbon revenue. On the contrary, the constraint to be revenue and distributionally neutral could be imposed and might provide appropriate fiscal discipline that would contribute to support for the passage of a cap and trade bill. Note though that the incentives for this sort of discipline may be stronger for a tax than a cap and trade bill. Any tax bill, including a carbon tax, would emerge from the House Committee on Ways and Means, which initiates all tax legislation in the House, and the Senate Finance Committee, which controls tax legislation in the upper chamber. Members of these committees can more easily impose the revenue and distributional neutrality constraint than can members of the House Committee on Energy and Commerce or the Senate Committee on Environment and Public Works, which are responsible for cap and trade legislation. These committees have a narrower fiscal focus and the natural incentive for committee members is to spend revenues on programs under their purview.
B. Administration

We have a time-tested administrative structure for collecting taxes that can ramp up a carbon tax in relatively short order. 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. Coal producers already pay an excise tax to fund the Black Lung Trust Fund and oil producers pay a tax to fund the Oil Spill Trust Fund (see Metcalf (2007a) for a description of these funds). We also have precedents for refundable credits for sequestration activities in federal fuels tax credits. In contrast, we have no administrative structure for running an upstream carbon cap-and-trade program. A report by the Congressional Budget Office (2008) details the lead-time required to establish allocations. All this suggests that we can implement carbon pricing through a tax more quickly than through a cap and trade system.

C. Price Volatility

Price uncertainty is a significant concern with cap-and-trade programs. At the outset, it is important to distinguish between short-run and long-run price uncertainty. Short-run price uncertainty (or volatility) can reflect short-term weather conditions, equipment outages and other temporary phenomena. It is not desirable for firms to face fluctuating prices on a daily (or perhaps hourly) basis due to these sorts of phenomena.

Long-run price uncertainty reflects our inability to predict whether and when various technologies to reduce greenhouse gas emissions come on line. Considerable uncertainty exists, for example, over the feasibility of carbon capture and storage at scale. Similarly political and technological constraints on nuclear power could significantly affect long-run permit prices.
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 CO2 permit prices fell sharply on the release of information indicating that the ETS Phase I permit allocations were overly generous. The December 2009 futures price fell from a peak of €32.90 on April 20 to €18.90 on May 3. Prices rebounded briefly but drifted downward for much of the rest of the year (Figure 1). They then gradually rose during 2007 and reached a peak of €30.53 on July 1, 2008. Since then the price collapsed to a low of €8.20 on Feb. 12, 2009. Currently they are hovering in the range of €12 per ton.

The permit price volatility experienced in the Europe’s cap-and-trade program is not unique. NOx prices in the Northeast states' Ozone Transport Commission jumped to nearly $8,000 per ton in early 1999 before falling back to more typical levels between $1,000 and $2,000 per ton. Permit prices for the California Regional Clean Air Incentives Market (RECLAIM) rose abruptly from under $5,000 per ton of NOx to nearly $45,000 per ton in the summer of 2000. Permit prices in EPA's Acid Rain Program rose
to nearly $1,600 per ton SO$_2$ in late 2005 from a price of roughly $900 at the beginning of the year.

Unexpectedly high permit prices have the potential to erode political support for the program and led in the RECLAIM market to a relaxation of the permit cap in response to the high prices. The response in the RECLAIM market in particular should provide a cautionary note for policy makers. Highly volatile permit prices are likely to create dissatisfaction with a cap-and-trade program and make business long run investment planning difficult.

D. Alternative Cost Containment Approaches

Provisions to limit short run volatility will be essential to build political and popular support for any climate change legislation. The first point to make here is that cost containment provisions are entirely unnecessary under a carbon tax. Second, while various approaches exist for reducing short run volatility in a cap-and-trade system, all such approaches come with some degree of complexity and uncertainty over their ultimate ability to dampen price volatility.

One approach to limiting volatility is to include a “safety-valve” provision – perhaps with a price floor combined with a ceiling. This allows firms to purchase an unlimited number of permits at a set price and thus sets a ceiling on the price of permits. 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. A floor

---

14 See, for example, Dallas Burtraw's testimony to the Committee on Ways and Means on Sept. 18, 2008.
price on emissions – as contained in the symmetrical safety valve proposal – is equivalent to a cap-and-trade system combined with a carbon tax set at the floor price.

If one is going to take the cap-and-trade approach the safety valve approach has much to commend. It is transparent and it puts clear limits on the upside and downside price movement. If the safety valve is binding then, in effect, the cap-and-trade system has been converted into a carbon tax. But it does so while maintaining the complexity of the cap-and-trade system.

One problem with the traditional safety valve approach is that anticipation of future government policy to reduce emissions creates an arbitrage opportunity. If a cap-and-trade program with unlimited banking is designed, then incentives will exist to bank low price permits in anticipation of future tightening of the cap. While one can require that any permits purchased through a safety valve be used in the year they are purchased, they can still free up other permits to be banked for the future thereby achieving the result of substituting low price permits for future higher price permits.

One way to address this concern is to limit the number of permits that may be purchased at the safety valve price. This is the approach that a strategic allowance reserve policy takes.15

Putting constraints on the number of safety valve permits that may be purchased may address the arbitrage opportunity raised by the anticipation of future policy tightening. But it also raises its own issues. Many of the cap-and-trade policies currently under consideration call for extremely sharp reductions in emissions (more precisely

allowance allocations) by the middle of the century. Various analyses of these policies suggest that allowance banking will be sizable in the early phase of the program.¹⁶ Making more permits available in the present through an allowance reserve that borrows against future allocations may simply lead to further banking to offset anticipated higher future prices due to a tightening of the future cap. In other words the reserve may be ineffective at damping price volatility.

VI. Objections to a Carbon Tax

This section responds to a number of arguments that have been made against using carbon taxes as an instrument for carbon pricing in the United States. I do not consider objections that have been raised to carbon pricing in general. For a discussion of those issues, see Metcalf (2007c).

A. No Binding Cap on Emissions

A common criticism of carbon taxes is that they do not provide any binding cap on emissions. The REACT proposal squarely addresses this criticism by building into the tax code predictable and automatic rate adjustments that keep emissions on target to significant reductions. The mechanism is transparent and provides firms with clarity for planning purposes.

B. Tipping Points

Tipping points provide an important qualification to the efficiency argument for taxes that was discussed above. Tipping points are discontinuities in marginal damages

that may arise if critical concentrations of GHGs lead to temperature increases that are sufficiently high to cause large-scale and abrupt climate change. The existence of a tipping point, it is argued, favors cap and trade type programs to ensure that we avoid crossing such a threshold.

The problem with this argument is that we do not know where the tipping point is or whether we are close to it. Setting a fixed cap at an inappropriately low level could lead to unnecessarily large welfare losses. Until our knowledge about climate processes and threshold effects improves we are likely better off setting a gradually increasing price on GHG emissions and providing clear market signals to firms to reduce emissions.

C. Efficiency and Political Expediency

A political realist might argue that it is inevitable that concessions will have to be made to the energy industry as part of a grand deal on U.S. carbon policy. Proponents of a cap-and-trade system argue that concessions in a cap and trade system will not bring about an efficiency loss whereas concessions in a carbon tax regime would be distortionary. Concessions in a cap and trade system would be given in the form of a free distribution of permits, which is a lump-sum transfer. The argument goes that with a carbon tax, the only way to make concessions is to exempt entire sectors or segments of sectors. This clearly would be distortionary. But nothing precludes a carbon tax from providing lump-sum transfers similar in impact to lump-sum distributions of free permits. A carbon tax, for example, could levy the tax on emissions above some threshold. The similarity between lump-sum distributions made under cap and trade systems and those made under tax systems has been pointed out by Pezzey (1992) among others.
D. Interactions with International Systems

A final argument against a U.S. carbon tax is that it is incompatible with efforts to bring the developing world into an international agreement. The argument is that we will need to use monetary transfers and technology transfer programs such as the Clean Development Mechanism (CDM) to engage the large developing countries in setting limits on GHG emissions, and that such mechanisms are only compatible with cap and trade programs, where they can be used as offsets to domestic caps.\textsuperscript{17} However, nothing about a carbon tax precludes the use of CDM-type projects as offsets. If the United States so desires it could allow certain offsets like CDM projects to be taken as credits against the carbon tax. To reduce the administrative burden for firms, the offsets could be made tradable, in which case brokers would likely emerge to serve as a clearing house for firms with carbon tax liability to purchase offsets.

On a related matter, nothing precludes the United States from employing a carbon tax while other countries rely on cap and trade systems. In the end what matters is that the international community coordinate on harmonizing carbon prices. Some countries may choose to do this through a carbon tax while others through cap and trade systems. So long as the prices are broadly in line across countries, concerns about leakage (i.e. movements of economic activity from high carbon price to low or no carbon price countries) should be minimized.\textsuperscript{18}

\textsuperscript{17} The Clean Development Mechanism was developed under the Kyoto Protocol as a way to allow GHG reducing projects in developing countries that are not subject to emissions limits to count towards the targets for countries that are subject to such limits. See Lecocq and Ambrosi (2007) for a history and analysis of CDMs.

\textsuperscript{18} Nordhaus (2007) discusses the advantages of a tax-based approach in the context of global systems. I take a more modest position here, arguing that a domestic tax-based approach can be made compatible with whatever international system evolves elsewhere.
VII. Conclusion

Carbon pricing is a necessary policy step for addressing the challenge of global climate change in the United States. One of the main objections to a carbon tax has been the uncertainty over emissions over the control period. This paper describes an approach that could be used to ensure cumulative emission caps are achieved over the control period. The REACT tax ties the change in the tax rate to progress over meeting cumulative targets. The targets could be met on an annual or less frequent basis. While this paper provides results from simulations using annual benchmarks, five year benchmarks might be more appropriate.

The revenue from the tax would be predominantly used to fund an environmental earned income tax credit tied to payroll tax collections. The combination of revenue and distributional neutrality could provide the political discipline needed to overcome obstacles to the proposal’s passage. Allowing a credit for approved sequestration and offset activities would also provide incentives to stimulate low and zero emission R&D activities that will be necessary if the United States is to make meaningful reductions in its GHG emissions.
References


Paltsev, Sergey; Reilly, John M.; Jacoby, Henry D.; Gurgel, Angelo C.; Metcalf, Gilbert E.; Sokolov, Andrei P. and Holak, Jennifer F. "Assessment of U.S. Cap-and-