ECONOMIC AND BUDGET ISSUE BRIEF
CBO
A series of issue summaries from the Congressional Budget Office
MARCH 15, 2005

Limiting Carbon Dioxide Emissions: Prices Versus Caps

Scientists have identified carbon dioxide—which is emitted during the combustion of fossil fuels (oil, natural gas, and coal)—as a key greenhouse gas that can affect the Earth's climate. Experts disagree about the potential damages that might result from those emissions, with some projecting modest damages and others projecting potentially abrupt and catastrophic effects. Given that range of projections, people disagree about whether anything should be done to limit emissions and if so, how much to limit them. However, one area of consensus is that any steps taken to control emissions should do so at the lowest possible cost. Two different forms of economic incentives could achieve that goal: one would reduce emissions by setting a price on them, and the other would cap the overall level of emissions. But given current information about the potential for near-term emissions to trigger abrupt and catastrophic damages, the price approach is more likely than a cap to maximize the difference between the policy's total benefits and total costs.

This brief illustrates the advantage of a price-based incentive using an example contrasting policies that would set a price for U.S. fossil fuel-related emissions of carbon dioxide with policies that would cap such emissions. The United States is the country that emits the largest amount of carbon dioxide, but to varying degrees all nations emit greenhouse gases and could potentially benefit from their control.

How Emission Prices and Emission Caps Would Work

Putting a price on carbon dioxide emissions—essentially taxing those emissions— would boost their cost, thereby encouraging firms as well as households to limit emissions (by using smaller amounts of fossil fuels or by relying on fossil fuels with relatively low carbon content) as long as the cost of doing so was below the tax or price. That price-based approach would establish an upper limit on the cost of individual emission reductions—the level of the price—but would not ensure that any particular emission target was met. That approach would balance expected benefits and actual costs provided that the price per ton was set equal to the expected benefits resulting from eliminating a ton of carbon emissions.

Cap-and-trade programs, in contrast, offer a way to set an overall limit on the level of carbon dioxide emissions while relying on economic incentives to determine where and how emission controls take place. Under such a program, policymakers would establish an overall cap on emissions but allow firms to trade rights to those emissions, called allowances. Trading would allow firms that could control their emissions most cheaply to do so in order to sell some of their allowances at a profit to firms that face higher costs to limit their emissions. Furthermore, the price increases that would result from the cap would encourage households to consume smaller amounts of fossil fuels, thus leading to lower carbon emissions. A cap-and-trade program would achieve the emission target at the lowest possible cost, but (as described below) it would not necessarily balance actual costs with the expected benefits achieved by the target.

A cap-and-trade program with a "safety valve" combines an overall cap on total emissions with a ceiling on the allowance price. Under that hybrid approach, policymakers would establish an overall cap and allow firms to trade allowances, but they would also set an upper limit on the price for allowances, referred to as the safety-valve price. If the price of allowances rose to the safety-valve price, the government would sell as many allowances as was necessary to maintain that price. Thus, if the safety valve was triggered, the actual level of emissions would exceed the cap. The cap would be met only if the price of allowances never rose above the safety-valve price.

Emission Prices Are More Efficient than Emission Caps

If policymakers had complete and accurate information on both the costs and benefits of achieving various limits on emissions, they could achieve the limit that best balanced costs and benefits using either an emission price or an emission cap. With full information, policymakers could set the price or cap to the level at which the cost of the last reduction was equal to the benefit from that reduction. However, neither the costs nor the benefits are known with certainty. For that reason, the best policymakers can do is to choose the policy instrument that is most likely to minimize the cost of making a "wrong" choice. Choosing policies that are too stringent (by setting too high a price or too tight a cap) would result in excess costs that are not justified by their benefits. Alternatively, choosing policies that are too lenient (by setting too low a price or too loose a cap) would result in forgone benefits that would have outweighed the cost of obtaining them.

Analysts generally conclude that uncertainty about the cost of controlling carbon dioxide emissions makes price instruments preferable to quantity instruments because they are much more likely to minimize the adverse consequences (excess costs or forgone benefits) of choosing the wrong level of control.[1] The price approach would motivate people to control emissions up to the point where the cost of doing so was equal to the emission price. If actual costs were less than, or greater than, anticipated, people would limit emissions more than, or less than, policymakers projected. However, emissions would be reduced up to the point at which the cost of doing so was equal to the expected benefits, provided that the emission price was set equal to the expected benefits of reducing a ton of carbon dioxide emissions. In contrast, a strict cap on emissions could result in actual costs that were far greater (or less) than expected and that therefore exceeded, or fell below, the expected benefits.

The advantages of a price-based approach stem mainly from the fact that the cost of limiting a ton of emissions is expected to rise as the limit becomes more stringent, while the expected benefit of each ton of carbon reduced is roughly constant across the range of potential emission limitations in a given year. That constancy occurs because climate effects are driven by the total amount of carbon dioxide in the atmosphere, and emissions in any given year are a small portion of that total. Further, reductions in any given year probably would fall considerably short of total baseline emissions for that year.

An Illustrative Example

The example below demonstrates the advantage of an emission price over an emission cap when the per-ton benefit of limiting current emissions is expected to be roughly constant over the range of possible reductions (see Table 1). Considerable uncertainty surrounds the benefit of limiting carbon emissions, but the example arbitrarily assumes that the value is $10 per metric ton.[2] The example shows outcomes for two domestic policies—a tax on emissions and a cap on emissions—that are designed to produce the same level of emission reductions (and thus, the same expected costs and benefits). If policymakers charged a tax of $10 per ton on carbon (based on the expectation that the benefits of eliminating a ton of carbon emissions is $10), and if the cost of limiting emissions was what they had anticipated, the $10 tax would result in 29 million fewer metric tons of carbon (mtc) in the first year of the policy and provide a net benefit of $143 million.

If, however, the cost of controlling emissions by that amount was 50 percent lower than anticipated, firms would find it advantageous to undertake additional low-cost reductions—nearly twice as many as policymakers had anticipated—in lieu of paying the tax on those emissions. As a result, actual net benefits would be $280 million, which is $137 million greater than anticipated. Similarly, if costs were 50 percent higher than anticipated, firms would limit their emissions by a smaller amount—by 19 million mtc instead of 29 million mtc. The level of net benefits also would be lower than expected—but not as low as it would have been if firms had been forced to make the full 29 million mtc cut in emissions that policymakers had expected to result from the tax. Furthermore, given that firms would limit emissions up to the point at

1. Uncertainty about the benefits of limiting emissions can lead to the wrong level of control as well. However, the adverse consequences of having chosen the wrong level of control because of underestimating or overestimating benefits are expected to be the same under both price and quantity instruments. For a more detailed discussion, see Congressional Budget Office, *Uncertainty in Analyzing Climate Change: Policy Implications* (January 2005).

2. Furthermore, the example assumes that firms would minimize their compliance costs—by equating their marginal cost of reducing emissions either to the tax or to the allowance price.

Table 1.

An Example of the Advantage of Using a Tax, Rather Than a Cap, to Reduce Carbon Emissions

		Actual Outcomes	
	Expected Outcomes	If the Cost of Reducing Emissions Was 50 Percent Lower Than Expected	If the Cost of Reducing Emissions Was 50 Percent Higher Than Expected
		Set a Tax of $10 per Ton of Carbon	
Marginal Cost (Dollars)	10	10[a]	10[b]
Emission Reduction (Millions of metric tons)	29	56	19
Net Benefit (Millions of dollars)	**143**	**280**	**96**
		Set a Cap to Reduce Carbon Emissions by 29 Million Metric Tons	
Marginal Cost (Dollars)	10	5	15
Emission Reduction (Millions of metric tons)	29	29	29
Net Benefit (Millions of dollars)	**143**	**215**	**72**
Memorandum: Percentage Increase in Net Benefit from a Tax Rather Than a Cap	n.a.	30	34

Source: Congressional Budget Office.

Notes: This example arbitrarily assumes that the benefit of reducing carbon emissions is $10 per metric ton. It examines the net benefits that would result in the first year of each policy, assuming that the policy would apply only to the United States, that the initial year would be 2010, and that the policy would have been announced 10 years earlier. The cost of firms' emission reductions (and the response to various taxes) is derived from Mark Lasky, The Economic Costs of Reducing Emissions of Greenhouse Gases: A Survey of Economic Models, CBO Technical Paper No. 2003-03 (May 2003), available at www.cbo.gov/Tech.cfm.

n.a. = not applicable.

a. The actual marginal cost of reducing 29 million metric tons of carbon (mtc) is $5, but the tax induces reductions up to 56 million mtc, at a marginal cost of $10.

b. The actual marginal cost of reducing 29 million mtc is $15, but the tax induces fewer reductions (19 million mtc instead of 29 million mtc), up to a marginal cost of $10.

which the actual cost of the last ton of carbon emissions eliminated was equal to the expected benefit (because the tax had been set equal to that expected benefit), the value of total benefits minus total costs (that is, net benefits) would be maximized, regardless of whether the actual costs were higher or lower than anticipated.

Suppose, in contrast, that policymakers set an emission cap that they believed would limit emissions by the same amount as the $10 tax—a 29 million metric ton reduction from the baseline level. The cap would allow no flexibility if actual costs turned out to be different from the anticipated costs. If the marginal cost of meeting that cap turned out to be 50 percent lower than expected, for example, then actual net benefits, at $215 million, would be greater than expected—but still significantly lower than the $280 million in net benefits from the tax, because the cap would not induce firms to undertake any additional beneficial reductions.

Likewise, if the cost of meeting the cap was higher than anticipated, firms would still be required to limit emissions by 29 million mtc, even though each cut beyond a 19 million mtc reduction (the amount induced by a $10 tax) would cost more than the benefit that it created. As a consequence of that inflexibility, the net benefits from the cap would be 34 percent lower than the net benefits from the tax.

The safety-valve approach would provide some, but not all, of the advantages of a tax. Specifically, the safety valve would protect against excess costs (and thus would provide greater net benefits than a fixed cap) in the case in which the marginal cost of meeting the cap was greater than anticipated. The safety valve would not, however, lead to more reductions than those required under the cap if the cost of emission reductions turned out to be less than anticipated. Thus, unlike the tax, the safety valve would not maximize net benefits in that case.

The less information policymakers have about the cost of meeting a particular emission cap, the greater the advantage offered by an emission price. The cost of meeting a given cap on carbon emissions is likely to be difficult to estimate for at least three reasons. First, the cost of meeting a future cap would vary significantly with the amount of growth in carbon emissions in the interim. Those emissions are difficult to predict: they are a function of numerous factors, including population trends, economic growth, and energy prices. Second, policymakers have less information about the cost of controlling emissions than do the firms that create them. Third, the cost of meeting the future cap will depend on the technologies that are developed to reduce carbon dioxide emissions and the economic consequences of adopting those technologies—neither of which can be predicted with certainty.

Is Setting a Price on Emissions Still Preferred When the Potential for Abrupt Climate Change Is Taken into Account?

Intuitively, the case for a cap on emissions would appear to be much stronger if there were evidence that temperature increases above a certain threshold would cause catastrophic damages—especially given the inertia of the climate system and the long adjustment to changes in concentrations. That possibility might seem to call for a cap on emissions to avoid crossing the threshold. But that intuition holds true only under a very restrictive set of circumstances:[3]

- There must be a trigger temperature that, if exceeded, results in a steep increase in damages;
- Policymakers must have clear information about what that trigger temperature is; and
- The threshold must be sufficiently near so that policymakers would want to virtually shut down emissions—regardless of the cost—to avoid, or delay, crossing it.

Under those circumstances, either an emission price or an emission cap (appropriately set) would probably yield very large net benefits, but the expected net benefits from using an emission cap would be greater.

If there is uncertainty about either the existence or the level of a trigger temperature—as is currently the case—the potential advantages of an emission cap decline. Under those circumstances, it is no longer clear whether, or at what level, to set a cap to avoid a catastrophic outcome. Thus, setting an upper limit on the incremental cost of reducing emissions via an emission price (even though that limit may be high) becomes relatively more important.

Similarly, a price instrument is generally superior if damages are expected to grow, but at a gradual rate of increase

3. See William A. Pizer, *Climate Change Catastrophes*, Discussion Paper 03-31 (Washington, D.C.: Resources for the Future, May 2003).

(rather than increasing very rapidly beyond a known temperature threshold). Under those circumstances, being able to control emissions precisely is less critical (because there is less concern about passing a trigger point).

Finally, a price instrument is preferred if modest emission reductions are called for. If policymakers wished to slow the increase of carbon dioxide in the atmosphere (or stabilize that level after a period of several decades), then there would be considerable leeway about when reductions occurred. Costs would be minimized by making cuts when it was least expensive to do so. A price instrument would allow for such flexibility in timing, whereas a short-term emission cap would not. Such a cap would become desirable only if extremely large cuts in current emissions were required to quickly stabilize the atmospheric stock to avoid crossing a threshold.

Related CBO Publications: In addition to the publications listed in footnote 1 and Table 1 of this brief, see *The Economics of Climate Change: A Primer* (April 2003); *An Evaluation of Cap-and-Trade Programs for Reducing U.S. Carbon Emissions* (June 2001); and *Who Gains and Who Pays Under Carbon-Allowance Trading? The Distributional Effects of Alternative Policy Designs* (June 2000).

This issue brief was prepared by Terry M. Dinan and Robert Shackleton, Jr. It and other CBO publications are available at the agency's Web site (www.cbo.gov).