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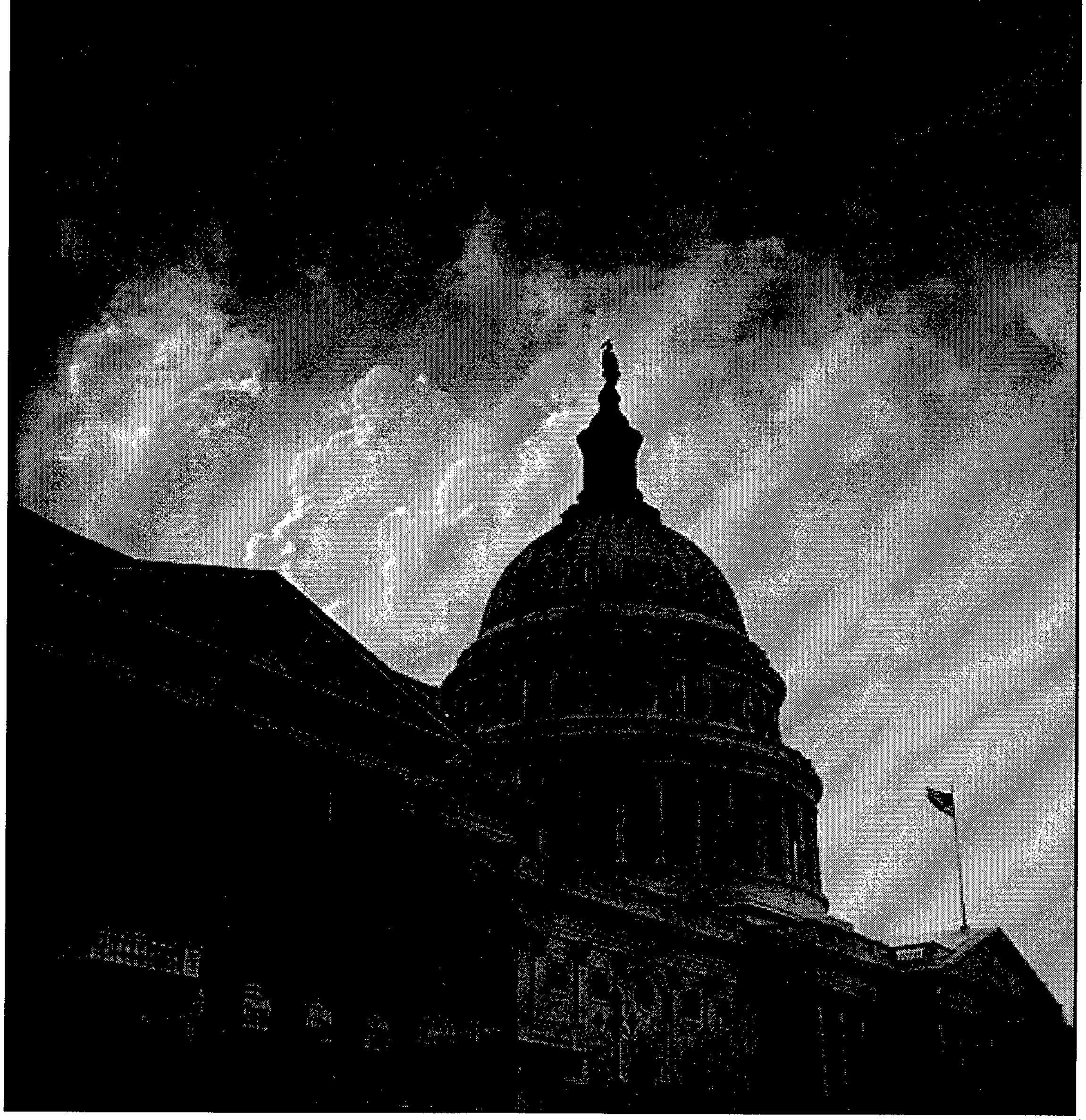
Shifting the Cost Burden of a Carbon Cap-and-Trade Program



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The Congress of the United States ■ Congressional Budget Office

Preface

Several Members of Congress and public interest groups have proposed plans to reduce U.S. emissions of carbon dioxide, which appear to be contributing to a gradual warming of the climate. Many of those proposals envision using a "cap-and-trade" program, under which the government would set a mandatory cap on total carbon emissions and would require suppliers or users of fossil fuels (which are the main source of carbon emissions) to hold the rights for each metric ton of emissions they produced. Those rights could have considerable value—possibly totaling tens of billions to hundreds of billions of dollars—depending on the design of the program.

This Congressional Budget Office (CBO) paper—prepared at the request of Senators Joseph Lieberman and John McCain—aims to increase public understanding of some of the economic effects of a carbon cap-and-trade program. It reviews the available literature about the effects of such a program on various parties (investors and workers in affected industries as well as consumers) and about the economic consequences of providing compensation to those parties.

The paper was written by Terry Dinan of CBO's Microeconomic and Financial Studies Division, which is directed by Roger Hitchner. Robert Dennis, Lisa Driskill, Arlene Holen, Robert Shackleton and Tom Woodward of CBO provided valuable comments and assistance, as did Dallas Burtraw and Karen Palmer of Resources for the Future, Lawrence Goulder of Stanford University, and Anne Smith of Charles River Associates.

Christian Spoor edited the paper, and Christine Bogusz proofread it. Angela Z. McCollough produced the initial drafts, Lenny Skutnik produced the printed copies, and Annette Kalicki prepared the electronic versions for CBO's Web site (www.cbo.gov).

Douglas Holtz-Eakin
Director

July 2003

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Summary

Several Members of Congress and public interest groups have proposed plans to reduce emissions of carbon dioxide (referred to in this paper as carbon emissions), which have generally been found to be contributing to a gradual warming of the Earth's climate. Although climate change might benefit some regions, it could ultimately cause extensive physical and economic damage in others. That damage is still uncertain, but it could include higher sea levels; wider ranges for tropical diseases; disruptions to farming, forestry, and natural ecosystems; and greater variability and extremes of regional weather. Most such damage would fall on future generations.

Many proposals to limit carbon emissions envision using a "cap-and-trade" program, under which the government would set a mandatory cap on total emissions and would require suppliers or users of fossil fuels—which are the main source of carbon emissions—to hold the rights for each metric ton of emissions they produced. After those rights (or allowances) had been distributed initially, they could be bought and sold. By employing the forces of supply and demand, such a program could minimize, although not eliminate, the cost of achieving a given cap on carbon emissions. (Cap-and-trade programs are already being used in the United States to reduce emissions of two other air pollutants: sulfur dioxide and nitrogen oxides.)

The total number of carbon allowances available would be limited by the level of the cap, which means that the allowances would acquire a scarcity value. As a result, a cap-and-trade program would transfer income from parties that ultimately paid for the allowances to parties that received their value. Depending on the design of the program, that value could total tens of billions to hundreds of billions of dollars.

Some policymakers have expressed an interest in distributing the value of carbon allowances among affected entities—such as investors, workers, or consumers—on the basis of their share of the costs of the program. For example, the Climate Stewardship Act of 2003 (S. 139) would create a cap-and-trade program for emissions of various greenhouse gases (including carbon) and direct the Secretary of Commerce to consider the distribution of costs among those entities when deciding how to allocate allowances. In addition, the Secretary would have to consider the effects of allowance-allocation decisions on economic efficiency (generally assumed to mean the overall cost to the economy).

This paper aims to increase public understanding of the distributional effects that a carbon cap-and-trade program might have on various parties, as well as the economic consequences of providing compensation to those parties. It does so by reviewing the available literature pertaining to several important questions:

- How would the costs of the policy be distributed among people in their various roles as investors, workers, and consumers?

- What portion of the allowances would policymakers need to give to affected industries to compensate shareholders for policy-induced costs (a portion referred to as the compensation ratio)?

- How much of the policy's costs would be passed on to consumers in the form of higher prices, and how would those higher prices affect households at various income levels?

- How would workers be affected by the policy?
- What share of the allowance value might be available to be used for compensation after the government covered its own costs?
- What consequences would providing compensation have for the economy?

Costs and Income Transfer Under a Carbon Cap-and-Trade Program

A cap-and-trade program for carbon emissions could impose significant costs on the economy in the form of welfare losses. Those losses would include the value of society's resources (capital, labor, and natural resources) that would be devoted to producing goods in ways that yielded lower carbon emissions. They would also include the net value of decreased production and consumption that would result from the carbon cap. Welfare losses are real costs to the economy in that they would not be recovered elsewhere in the form of higher income. Those losses would be borne by people in their roles as shareholders, consumers, and workers.

The allowances associated with a cap-and-trade program could have considerable value, depending on the level and comprehensiveness of the cap. Underlying economic forces would determine who ultimately paid for the allowances (that is, who bore the allowance costs). The government would determine who received the allowance value through its decisions about allocation. As a result, the cap-and-trade program would redistribute income from entities that ended up paying for the allowances, such as consumers or investors in energy companies, to entities that received their value.

In general, available research concludes that a large share of the welfare losses and allowance costs would be expected to fall on consumers and would be widely dispersed among households. A much smaller share would be expected to fall on investors and workers, although those costs could be significant in some sectors, such as the coal industry. (Coal is a more intensive source of carbon emissions than other fossil fuels are). Losses to industry—in the form of lower stock values—would be broadly distributed among investors, to the extent that they have diversified portfolios. Losses to workers would be more concentrated. For example, many coal workers could lose their jobs if carbon emissions were reduced significantly.

The government could use the allowance value to partly redistribute the costs of a carbon cap-and-trade program, but it could not cover those costs entirely. The reason is that the total costs of the program—including the cost of the allowances—would be greater than the allowance value. For example, if policymakers decided to sell allowances to regulated firms in an auction and use part of the resulting revenue to compensate workers who lost their jobs because of the program, there would not be enough funds available to fully compensate the entities that had to bear the costs of the allowances.

Compensation for Shareholders in Key Industries

A cap on carbon emissions would cause a reduction in the production of fossil fuels and carbon-intensive goods, such as electricity. As a result, future earnings on existing capital in those industries would fall. Several researchers have explored how much compensation would be needed to maintain profits—typically measured as maintaining equity values—in the industrial sectors most affected by a cap-and-trade program. Those sectors include "upstream" industries, such as suppliers of coal, natural gas, and petroleum, as well as key "downstream" industries, such as electricity generators.

Declines in equity values for those industries could be significant. For example, one study predicted that equity values for coal producers would fall by 50 percent if carbon emissions were reduced by 23 percent. However, researchers estimate that the large losses borne by industry could be fully offset with only a modest share of the total allowance value—generally less than 20 percent—because much of the cost of the policy would be borne by consumers in the form of higher prices. (That compensation ratio would be larger if it were measured not as a share of total allowance value but as a share of that value after accounting for the increases in government spending and declines in tax revenue that would result from the policy, as discussed below.)

Compensation for Consumers

Because much of the cost of a carbon cap-and-trade program would most likely be passed on to consumers in the form of higher prices for energy-intensive goods, understanding the distribution of costs for such a program requires examining how those higher prices would affect households at different income levels.

The price increases resulting from a carbon cap would be regressive—that is, they would place a relatively greater burden on lower-income households than on higher-income ones. Higher-income households would face larger costs in dollar amounts, but those costs would make up a smaller share of their average annual income. For example, one study estimated that the price increases resulting from a 15 percent cut in carbon emissions would cost the average household in the lowest one-fifth of the income distribution about $560 a year, or 3.3 percent of its average income. Households in the top one-fifth of the income distribution would pay an additional $1,800 a year, or 1.7 percent of their average income. (The degree of regressivity would be smaller if the estimates were based on lifetime measures of households' consumption and income rather than on annual measures.)

Households could be compensated for those price increases in numerous ways. Research shows that the revenue from an allowance auction would be sufficient to pay all households an equal lump-sum rebate that would more than fully offset the cost increases that the policy would impose on lower-income households. Alternatively, using auction revenue to cut corporate taxes would make the policy even more regressive than the initial price increases would be. Finally, giving all of the allowances to companies at no charge would be the most regressive option considered, unless the government took actions to offset that effect. Free allocations beyond those needed to offset declines in equity values would boost the income of shareholders, who are primarily in higher-income households.

Compensation for Workers and Communities

Estimates of the cost of a carbon cap-and-trade program typically exclude losses experienced by workers who would lose their jobs as a result of the program. Any policy that reduced U.S. carbon emissions would inevitably create temporary losses for workers. Those losses could be significant, particularly in the coal industry.

Concerns about fairness could prompt policymakers to offer compensation for those transitional costs. However, the research reviewed for this paper found little evidence about the possible magnitude of those costs. Whatever their size, such costs would fall heavily on a relatively small number of households—unlike declines in equity values or increases in consumer prices, which would be much more widely distributed.

What Share of Allowance Value Might Be Available for Compensation?

Initial research on industry compensation ratios for a carbon cap-and-trade program measured compensation as a share of the total potential revenue if allowances were sold in an auction. However, recent research has demonstrated that a significant share of that revenue might be needed to offset increases in government spending and declines in tax revenues caused by the program.

Using auction revenue to offset those effects could be viewed as compensating the government, but failing to do so would require the government to raise taxes if it wanted to keep its net revenues at their baseline levels (while holding spending constant). A tax increase could boost the cost of the cap-and-trade program.

A carbon trading program would affect government outlays and tax receipts in several ways. First, it would cause the government (like other consumers) to pay higher prices for carbon-intensive goods. Second, because the payments of some government programs, such as Social Security, are indexed to changes in the overall price level, higher prices could result in greater spending on those payments. Third, a cap-and-trade program for carbon emissions would lead to a decline in economic activity and a corresponding decrease in tax collections.

Researchers estimate that together, those effects could account for more than 30 percent of the total value of allowances. Thus, using some of that value to offset those effects (and thereby avoid a tax increase) would greatly reduce the amount of allowance value available to be used for compensation. Measured as a share of that net allowance value, industry compensation ratios are significantly higher than the numbers cited earlier. For example, if government effects account for 30 percent of the allowance value, compensation ratios rise by 43 percent—in other words, compensation that requires 15 percent of the total allowance value will require 21 percent of the net allowance value. (That increase in compensation ratios does not mean that the need for compensation is greater, only that compensation takes up a larger share of the available allowance value.) If policymakers opted to compensate investors in affected industries after covering the government's costs, even fewer funds would be available to compensate workers and consumers.

The Impact of Compensation on the Overall Cost of the Program

Available research indicates that providing compensation could actually raise the cost to the economy of a carbon cap. In general, paying compensation would preclude the government from using auction revenue in ways that were more economically efficient. Moreover, in some circumstances, it might exacerbate existing inefficiencies in the pricing of electricity.

First, providing compensation would have an "opportunity cost" because it would preclude the government from using auction revenue in ways that would reduce the cost to the economy of a cut in carbon emissions. Recent empirical research indicates that the overall cost of a carbon cap could be more than 30 percent lower if the government sold allowances and used the net auction revenue to reduce rates on existing taxes that discourage labor and investment—such as marginal taxes on capital, labor, and personal income—instead of using that revenue to provide compensation.

Second, compensating electricity generators by giving them free allowances could raise the cost of reducing carbon emissions. The reason is that in many regions of the country, electricity prices are set by regulators rather than by competitive forces. If generators were given allowances, regulators would probably not let them reflect the value of those allowances (that is, the amount they would receive if they sold the allowances) in the price of electricity. As a result, the increases in electricity prices that would result from free allocation would be lower than the ones that would result from an allowance auction. Those lower price increases would do less to decrease existing distortions in the pricing of electricity (where price is often less than the marginal cost of generation) and would not give consumers as much incentive to reduce their electricity use. Recent research indicates that the cost of a cap-and-trade program that covered only the electricity generating industry could be more than twice as high if generators were given allowances for free instead of being required to buy them in an auction.

Conclusions

The value of carbon allowances under a cap-and-trade program (as reflected in the amount of revenue that could be raised from auctioning the allowances) could amount to many billions of dollars. Nevertheless, if a program was established, competing demands on that allowance value would necessitate difficult policy choices. Concerns about economic efficiency would have to compete with concerns about fairness. Even if all of the allowance value was used to provide compensation, it could not cover the total losses experienced by shareholders, workers, and households.

Shifting the Cost Burden of a Carbon Cap-and-Trade Program

Research over the past few decades has shown that a variety of human activities—mainly deforestation and the burning of fossil fuels—have been adding greenhouse gases to the atmosphere and probably contributing to a gradual warming of the Earth's climate. Unless measures are taken to constrain emissions of those gases, they will continue to increase and the climate will be likely to grow warmer. Although much uncertainty remains about the effects of climate change, most assessments conclude that it could benefit some regions but ultimately cause extensive physical and economic damage in others.[1] It could raise sea levels; expand the potential range of tropical diseases; disrupt agriculture, forestry, and natural ecosystems; and increase the variability and extremes of regional weather. Given what is known about the pace of climate change, it appears that most of that damage would fall on future generations.

To reduce the likelihood of future warming, several Members of Congress and public interest groups have proposed plans to encourage or require cuts in the United States' emissions of greenhouse gases. Many of the proposals focus on the carbon dioxide that is emitted from the combustion of fossil fuels, such as coal, oil, or natural gas. Those carbon emissions make up roughly 85 percent of U.S. greenhouse-gas emissions and are the easiest type to track.[2]

1. For a discussion of the scientific consensus and economic issues related to climate change, see Congressional Budget Office, *The Economics of Climate Change: A Primer* (April 2003).

2. The total estimate of greenhouse-gas emissions used in that calculation does not account for carbon emissions from the land sector, such as from forestry and agriculture.

Many of the proposals to limit carbon emissions would create a "cap-and-trade" program, under which lawmakers would set a mandatory cap on the overall level of emissions, and suppliers or users of fossil fuels would be required to hold a right (called an allowance) for each metric ton of emissions that would result from the production or use of their products. The government could give carbon allowances to regulated companies (those required to hold allowances) at no cost, or it could sell the allowances in an auction.[3] Regardless of which allocation method was used initially, regulated firms would then be able to buy and sell allowances among themselves.[4] The government has employed cap-and-trade programs in recent years to limit several pollutants, including sulfur dioxide, which contributes to acid rain.

A cap on carbon emissions would inevitably lead to higher prices for consumer goods—primarily energy products such as gasoline, electricity, and home heating oil. Thus, it would impose costs on consumers as well as on investors and workers in the energy sector. The ultimate distributional effects of a cap-and-trade program would depend both on those cap-induced price changes and on policymakers' decisions about how to allocate emission allow-

3. Policymakers could also choose to distribute allowances directly to consumers, affected workers, or communities. That alternative is less often discussed and could entail significant transaction costs. In addition, policymakers could opt to give allowances to firms that were not required to hold them but that suffered significant losses in profits because of the policy.

4. Cap-and-trade programs could be designed to include the sequestering of carbon—for example, by planting trees, which store carbon dioxide. In that case, regulated firms could have the option of fulfilling part of their allowance requirement by paying entities (such as farmers) to sequester carbon.

ances. Because the cap would limit carbon emissions below the level that would otherwise be expected to occur (the baseline level), the allowances would have a value reflecting their scarcity. If the government decided to auction off allowances, it could use the auction revenue for a wide variety of purposes, including providing compensation to affected entities. Each method of allocating allowances would have a unique distributional effect.

In previous cap-and-trade programs for air pollutants, policymakers freely distributed virtually all of the allowances to regulated firms, thus giving those firms compensation for the additional costs that they incurred. That scenario may be less likely for a carbon cap-and-trade program because the total value of carbon allowances is expected to far outweigh the costs that regulated firms would face. Some policymakers have expressed an interest in distributing the value of carbon allowances among affected entities (including firms, workers, and consumers) on the basis of their share of the costs imposed by the cap. For example, the Climate Stewardship Act of 2003 (S. 139) would establish a cap-and-trade program for greenhouse-gas emissions (including carbon) and direct the Secretary of Commerce to consider the distributional impact on those affected entities when deciding how to allocate allowances. That legislation also asks the Secretary to consider the effects of allowance-allocation decisions on economic efficiency.

An appealing feature of cap-and-trade programs is that, if properly designed, they can reduce emissions at the lowest possible cost to society.[5] They cannot eliminate that cost entirely, however. Deciding on the appropriate level at which to cap carbon emissions would require carefully balancing the incremental costs that successive cuts in emissions would impose against the incremental benefits that would come from reducing the potential for global climate change. Measuring those costs and benefits and making that decision are beyond the scope of this analysis.

5. For more information about the role of various design features in the cost-effectiveness of a cap-and-trade program, see Congressional Budget Office, *An Evaluation of Cap-and-Trade Programs for Reducing U.S. Carbon Emissions* (June 2001) and *Reducing Gasoline Consumption: Three Policy Options* (November 2002).

Instead, this paper attempts to further public understanding of the possible distributional effects of a carbon cap-and-trade program by reviewing the available literature on that issue. In recent years, some economists have begun to examine how much compensation policymakers would need to give affected industries to offset the costs they would face from a cap on carbon emissions. Much of that research focuses on fossil-fuel suppliers and the electricity generating industry, which are expected to incur the highest costs. This paper also examines the available literature about the distributional effects that a carbon cap-and-trade program would have on consumers and workers if they did not receive compensation. Economists estimate that consumers would probably bear significant costs under such a program and that those costs would be regressive (placing a relatively greater burden on lower-income households than on higher-income households).

In addition, this paper looks at what share of allowance value might be available for compensation if the government used some of that value to offset declines in tax receipts or increases in government spending that could result from the cap on carbon emissions. Finally, the paper examines the economic consequences of compensating firms and consumers.

Costs and Income Transfer Under a Carbon Cap-and-Trade Program

A carbon cap-and-trade program could impose sizable costs on the economy. Further, because the allowances associated with the program would have considerable value, policymakers' decisions about how to allocate them could result in a significant transfer of income.

Economywide Costs: Welfare Losses

Limiting U.S. carbon emissions would reduce the welfare of U.S. residents in two ways. First, it would entail producing goods in a more costly fashion. Thus, welfare losses would include the value of society's resources (capital, labor, and natural resources) that would be devoted to producing goods in a way that yielded lower carbon emissions. Second, cutting carbon emissions would entail reducing consumption of carbon-intensive goods, such as energy products. Thus, welfare losses would also include the net value of decreased production and consumption that would result from the carbon cap. Those welfare losses are real costs to the economy in that they would not be recovered elsewhere in the form of higher income. They would be borne by people in their various roles as investors, workers, and consumers.

Decreasing carbon emissions would necessitate reducing the use of fossil fuels—particularly coal, which emits more carbon per amount of heat generated than any other fossil fuel. Firms would face higher production costs as they attempted to substitute less carbon-intensive fossil fuels (such as natural gas) for more carbon-intensive ones (such as coal) and as they moved away from using energy in their production processes. Those higher production costs would translate into welfare losses for producers in two ways. First, to the extent that companies *could not* pass the higher costs on to consumers, they would receive lower profits on the goods they sold. Second, to the extent that firms *could* increase prices—and higher prices caused consumers to buy less—firms' profits would fall because of the reduction in sales. Lower profits would lead to losses for investors and workers. In the long run, investors would adjust to those changes (for example, by leaving the industry or expanding less). But in the short run, they would experience lower returns on their existing capital, and profits would fall. Like investors, workers would also adjust in the long run, but they would experience transitional costs if decreased production caused them to become unemployed.[6]

Consumers would incur welfare losses as well. If firms were able to pass on higher production costs in the form of higher prices, consumers would have an incentive to reduce their purchases of carbon-intensive goods, such as electricity or gasoline. Their welfare losses would include the higher prices they would pay for energy products and the value of consumption they would have to forgo because of those higher prices (for example, the discomfort associated with keeping their house cooler in the winter or the loss in satisfaction that would result from canceling a vacation because of high gasoline prices).

6. If workers were reemployed in lower-paying jobs, they would incur additional losses.

Income Transfer: Allowance Costs and Allowance Value

If the government created a cap-and-trade program for carbon emissions, it would establish a new right: the right to emit one of the limited tons of carbon allowed under the cap. Those rights (the allowances) could have considerable value. Underlying economic forces—such as factors that determine the supply of and demand for different products—would determine who ultimately paid the cost of the allowances. The government would determine who received the value of the allowances through its decisions about allocation.[7] As a result, the cap-and-trade program would redistribute income from entities that ultimately bore the cost of the allowances (such as consumers or energy investors) to entities that received their value.

An example illustrates how the allocation process could transfer income. Suppose the government imposed the allowance requirement on suppliers of fossil fuel—such as petroleum refiners, natural gas processing plants, and coal mines—with each supplier required to hold an allowance for every ton of carbon that would be released when its fuel was combusted. Fossil-fuel suppliers would ultimately have to curtail production because the overall number of allowances would be limited by the level of the cap.[8] The restriction on production would make fossil fuels more scarce and drive up their market price, widening the gap between production costs and market prices. That gap would be reflected in the value of an allowance—the value of the right to sell now-scarcer fossil fuels.

If the government required fossil-fuel suppliers to purchase carbon allowances in an auction, the policy would transfer the value of the allowances from consumers (who bore the allowance costs in the form of higher fossil-fuel prices)

7. Some people argue that giving allowances away could make it difficult to raise the level of the carbon cap in the future should scientific evidence indicate that such a step was warranted. Allowance recipients might oppose increasing the cap because that would reduce the value of each allowance.

8. Technologies exist for removing carbon during the combustion process and then sequestering it, but they would become economically viable only if the allowance price rose to a few hundred dollars per ton.

to the government.[9] The ultimate distributional effect would depend on what the government did with the auction revenue. It could use that revenue (the allowance value) to directly compensate affected entities or for a variety of other purposes, such as increasing spending, decreasing taxes, or reducing the deficit.

Instead of selling allowances, the government could give them to fossil-fuel suppliers for free. In that case, fossil-fuel prices would still rise because of the need to reduce production. The difference is that fossil-fuel suppliers would benefit from higher prices on the goods they sold but would not incur allowance costs. Thus, free allocation would transfer the value of the allowances from consumers of fossil fuel to suppliers. If the value of the allowances was greater than the profits that fossil-fuel suppliers lost because of the policy, their profits would rise. Consumers would be worse off in two ways: because they would bear a large share of the allowance costs (in the form of higher prices for the fossil fuels they consumed) and because they would have to reduce their consumption of carbon-intensive goods.

The government could use the allowance value to redistribute the cost of a carbon cap-and-trade program, but it could not eliminate that cost. The reason is that the allowance value would be less than the sum of the allowance costs and the welfare losses resulting from such a program. For example, one study estimated the costs of reducing carbon emissions between 2002 and 2080 by 23 percent from the baseline level. The study estimated the welfare losses from such a reduction at $1.6 trillion and the allowance costs at $3.2 trillion (both measured as the present discounted value of costs over that period).[10] Because allowance value by definition equals allowance costs, the government at best would have $3.2 trillion of allowance value available to compensate investors, workers, and consumers for $4.8 trillion in total costs.

How Allowances Were Allocated in Previous Trading Programs and Why Carbon Might Be Different

The best-known cap-and-trade program is one designed to limit emissions of sulfur dioxide (SO_2) as a way to reduce acid rain. That program took effect in 1995 with the aim of cutting SO_2 emissions from electricity generating facilities roughly in half. The government distributed emission allowances free of charge to facilities existing at the time the regulation was enacted in a manner that was roughly proportional to their historical levels of emissions.[11] That method of distributing allowances for free on the basis of historical data is called grandfathering.

A second method of allocating allowances—called output-based allocation—will be applied in some states under a cap-and-trade program that the Environmental Protection Agency has designed to reduce emissions of nitrogen oxides (NO_x). That program—known as the NO_x SIP (State Implementation Plan) Call—takes effect this year and covers emissions from electricity generators in 19 eastern states and the District of Columbia. The SIP Call program is unique in that the federal government is establishing a budget of allowances for each state, which in turn will allocate them to its affected NO_x sources as it wishes. Some states, such as Massachusetts and Connecticut, plan to allocate a fixed quantity of emission allowances to sources in proportion to their relative share of electricity generated in a recent year. That proportion will be updated as those shares change over time. (Thus, if a generator's share of total electricity in the region increases in

9. This example assumes that prices would rise by the full amount of the allowance value. As discussed later, prices might rise by less than the full value of the allowances, which would cause producers to absorb some of the allowance costs if allowances were sold in an auction.

10. See Lawrence H. Goulder, *Mitigating the Adverse Impacts of CO2 Abatement Policies on Energy-Intensive Industries*, Discussion Paper 02-22 (Washington, D.C.: Resources for the Future, March 2002), available at www.rff.org/disc_papers/PDF_files/ 0222.pdf. Those estimates were based on the assumption that the government would use most of the allowance value to reduce marginal personal income tax rates. The total cost would be significantly higher ($5.8 trillion) if the government used the allowance value to provide direct payments to affected parties.

11. See Dallas Burtraw and others, *The Effect of Allowance Allocation on the Cost of Carbon Emission Trading*, Discussion Paper 01-30 (Washington, D.C.: Resources for the Future, August 2001), available at www.rff.org/disc_papers/PDF_files/0130.pdf.

the future, it will receive a larger number of allowances.)[12] Other states plan to grandfather allowances to affected generators.

Both of those allocation methods involve giving the vast majority of allowances to regulated entities for free.[13] Because the allowances have value (reflecting the price that a firm would receive if it sold them), such free allocation can make a cap on emissions more acceptable to the regulated firms.

As noted earlier, a third possibility for allocation is that the government could sell allowances in a revenue-raising auction. The various ways it could use that revenue (such as to boost federal spending, cut taxes, reduce the budget deficit, or compensate firms, consumers, or communities that were harmed by the policy) would have differing distributional effects. They would also have different implications for the overall cost of the carbon cap.

The question of how allowances are allocated has been important in all previous cap-and-trade programs, but it is likely to be even more important for a carbon trading program because of the magnitude of the allowance value at stake. Emission allowances in the SO_2 program are projected to have a total value of $2.7 billion in 2010.[14] Allowances in the proposed NO_x trading program are predicted to be worth about $1.7 billion per year. In contrast, a cap-and-trade program that reduced carbon emissions from the electricity sector in 2012 by only 6 percent from the projected baseline level is expected to result in an allowance value of $15 billion to $24 billion per year.[15] An economywide cap (one covering all sources of carbon emissions) could result in a much larger allowance value—perhaps more than $100 billion per year—depending on the stringency of the cap.

Besides the large potential value of carbon allowances, concerns about fairness could have a bearing on which allocation method to choose for a carbon cap-and-trade program. In general, an allocation may be more likely to be perceived as fair if it compensates entities that incur the greatest costs as a result of the policy. Freely allocating SO_2 and NO_x allowances to electricity generators could be seen as cost compensation because the magnitude of the allowance value was expected to be roughly equal to the costs that generators would incur to reduce emissions. In contrast, for modest cuts in carbon emissions from the electricity sector, the value of the allowances is expected to be at least 20 times greater than generators' costs.[16] Generators would be able to capture a significant share

12. Ibid. Another method of updating is to base changes on a generation performance standard. The government would use projections of electricity generation for a specific year along with a target level of emissions to determine a targeted emission rate. Firms with emissions below that rate would earn allowances, and firms with emissions above the rate would need to buy allowances. That form of allocating allowances has been proposed in legislation for carbon emissions from the electricity generating sector. For a discussion of that approach, see J. Alan Beamon, Tom Leckey, and Laura Martin, *Power Plant Emission Reductions Using a Generation Performance Standard* (Energy Information Administration), available at www.eia.doe.gov/oiaf/servicerpt/gps/pdf/gpsstudy.pdf.

13. About 2.8 percent of SO_2 allowances are set aside for an auction each year. The auctions help ensure that new generating facilities have a public source of allowances beyond those allocated initially to existing facilities. Moreover, the auctions helped provide price information to the allowance market in the early stages of the regulatory program. Those auctions do not redistribute allowance value because the proceeds are given back to electricity generators on the basis of their initial allocation. See Environmental Protection Agency, "Acid Rain Program Allowance Auctions Fact Sheet," available at www.epa.gov/airmarkets/auctions/factsheet.html.

14. See Dallas Burtraw and others, *The Effect on Asset Values of the Allocation of Carbon Dioxide Emission Allowances*, Discussion Paper 02-15 (Washington, D.C.: Resources for the Future, March 2002), available at www.rff.org/disc_papers/PDF_files/ 0215.pdf.

15. Ibid. That estimate assumes that the reduction is phased in between 2008 and 2012. The range for total allowance value stems from alternative assumptions about how the allowances would be allocated. Auctioning allowances would result in the lowest allowance price and thus the smallest allowance value ($15 billion), whereas a generation performance standard would result in the highest allowance price and the greatest value ($24 billion). Grandfathering would produce an allowance value between those two figures, according to the authors.

16. See Dallas Burtraw and Karen Palmer, "A Comparison of the Effects of the Distribution of Emission Allowances for Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide" (draft, Resources for the Future, Washington, D.C., May 2, 2003).

of the allowance value by raising electricity prices.[17] Thus, freely allocating all of the carbon allowances to generators would be likely to greatly overcompensate them for their share of the policy costs.

Likewise, giving all of the allowances to fossil-fuel suppliers under an "upstream" cap-and-trade program—in which suppliers of coal, natural gas, and petroleum, rather than electricity generators, were required to hold allowances—would make those firms better off. Research indicates that those suppliers could pass most of the allowance costs on to final consumers either directly or indirectly. For example, they could pass costs on to electricity generators, who in turn could pass them on to electricity users. Fossil-fuel suppliers would experience decreases in production because of those price increases (coal production would fall the most because coal emits the most carbon per amount of heat generated). However, the value of the allowances would probably be far greater than the lost profits from decreased production. Thus, freely allocating a major share of the carbon allowances to fossil-fuel suppliers could lead to much higher profits for those companies.

The question of where the cap was placed (on fossil-fuel suppliers or on "downstream" industries) could have important implications for the administrative costs of the program and for the ability of the cap to cover all of the sources of carbon emissions in the economy.[18] Regardless of where the cap was imposed, however, costs would be distributed throughout the supply chain for carbon. For example, placing the cap on electricity generators would lead to higher prices for electricity consumers, reduced demand for electricity, and reduced demand for fossil fuels, particularly coal. Likewise, placing the cap on fossil-fuel suppliers would lead to lower production of fossil fuels (particularly coal), higher prices for electricity, and reduced demand for electricity (because of higher production costs). Thus, the issue of whether—or how—to compensate fossil-fuel suppliers, downstream producers, and consumers for their costs is relevant regardless of where the cap on carbon emissions is imposed.

Compensation for Shareholders in Key Industries

A cap on carbon emissions would cause a reduction in the use of fossil fuel, especially coal, and a decrease in the production of carbon-intensive goods, such as electricity. As a result, future earnings on capital invested in those industries would be likely to fall. Investors would be able to adjust their investment strategies once the cap-and-trade program was in place (or its implementation was certain). But capital investments made before then would receive lower returns than expected.

Estimating Compensation Requirements at the Sector Level

Several researchers have explored how much compensation would be necessary to maintain profits on existing capital (typically referred to as maintaining equity values) in the industrial sectors most affected by a cap-and-trade program. In general, those analyses have assumed that compensation would occur by granting firms a perpetual allocation of a limited share of the allowances. The compensation measured in those studies would offset reduced returns on existing capital in those industries. As a result, that compensation would offset costs incurred by shareholders but not by workers (their costs are discussed in a later section of this paper).

Lans Bovenberg and Lawrence Goulder were the first to estimate the share of carbon allowances that would need to be allocated to compensate regulated entities for the lower returns on existing capital. They examined an upstream trading program that would reduce emissions by 18 percent in 2025 and would have an allowance price

17. For example, Burtraw and others found that a 6 percent reduction in carbon emissions from the electricity generating sector would increase electricity prices by 3.3 percent if allowances were grandfathered. That analysis accounts for the fact that some regions have regulated prices and that regulators would not allow generators to reflect the value of the allowances in the price of electricity in those regions. See Burtraw and others, *The Effect on Asset Values of the Allocation of Carbon Dioxide Emission Allowances*.

18. For a discussion of the relative merits of upstream and downstream caps on carbon emissions, see Congressional Budget Office, *An Evaluation of Cap-and-Trade Programs for Reducing U.S. Carbon Emissions* (June 2001).

of $25 per ton of carbon emitted.[19] They concluded that roughly 11 percent of the allowance value would need to be freely allocated to fossil-fuel suppliers to maintain equity values in those industries.[20]

Subsequent research by Bovenberg and Goulder included costs imposed on downstream industries—specifically, the electric utility, petroleum refining, and metals and machinery industries. The authors used updated data and a more stringent emission target: a decline in carbon emissions of about 23 percent over the 2002-2080 period.[21] They estimated that the present discounted value of the welfare losses from that policy would be $1.59 trillion, and the allowance value (and hence the allowance costs) would be $3.21 trillion. Of that total $4.8 trillion in costs, the authors estimated that $420 billion would be borne by investors who held stock in fossil-fuel-supplying industries and $28 billion by investors in the downstream industries listed above. Maintaining equity values in those sectors would require 14 percent of the allowance value, they concluded: 13 percent for fossil-fuel suppliers and less than 1 percent for the downstream industries *(see Table 1)*.[22] Giving the full $3.21 trillion allowance value to the regulated firms would vastly overcompensate them for their share of the policy costs.

Even though only a fairly small share of total allowance value would be needed to maintain equity values in those industries, the decline in equity values that would occur in the absence of compensation could be quite large for some of them. For example, Bovenberg and Goulder estimated that equity values in the coal industry could fall by more than 50 percent in the long run under their hypothetical cap-and-trade program. The oil and gas industry and the electric utility industry would see equity values fall by roughly 19 percent and 7 percent, respectively. Although those equity losses would be concentrated in a few industries, they would be widely distributed among investors (to the extent that shareholders have diversified portfolios).

In Bovenberg and Goulder's analyses, the significant losses borne by industry could be offset by a modest share of the total allowance value because most of the $4.8 trillion cost of the policy would be borne by consumers in the form of higher prices. Their cost estimates are based on the assumption that the government would use the remaining 86 percent of the allowance value ($2.76 trillion) to reduce marginal personal income taxes. (If that was not the case, the total cost of the policy would be higher, as discussed near the end of this paper). Thus, households—which consist of individuals who could be shareholders and payers of personal income taxes as well as consumers—would receive some compensation in the form of lower personal income taxes. However, the burden of higher prices for carbon-intensive goods would be distributed among households in a different pattern than the benefits associated with lower tax rates would be. (That difference is discussed in the next section of this paper.)

Anne Smith and others also found that compensating fossil-fuel suppliers and electricity producers would take a small share of the total allowance value.[23] Their study examined a policy that would cap annual U.S. carbon

19. See A. Lans Bovenberg and Lawrence Goulder, "Neutralizing the Adverse Industry Impacts of CO_2 Abatement Policies: What Does It Cost?" in C. Carraro and G. Metcalf, eds., *Behavioral and Distributional Effects of Environmental Policy* (Chicago: University of Chicago Press, 2001). The authors actually examined a carbon tax of $25 per ton of carbon but pointed out that it is equivalent to a trading program in which the government auctions the allowances and the resulting price is $25.

20. That number does not appear in their paper but instead comes from a personal communication to the Congressional Budget Office by Lawrence Goulder.

21. That change in emissions is the percentage change between baseline emissions and emissions under the policy in present-value terms, with the emissions stream discounted using the aftertax interest rate. See Goulder, *Mitigating the Adverse Impacts of CO2 Abatement Policies on Energy-Intensive Industries,* footnote 16 and Table 4.

22. Ibid. That analysis assumed that the price of an allowance would be $25 initially, rise by either 7 percent or 9 percent a year to $50, and then remain constant at that level. The authors do not report the $420 billion figure; it was calculated as 13 percent of the reported allowance value.

23. See Anne E. Smith, Martin T. Ross, and W. David Montgomery, *Implications of Trading Implementation Design for Equity-Efficiency Trade-offs in Carbon Permit Allocations*, working paper (Boston: Charles River Associates, December 2002).

Table 1.

Estimates of Industry Compensation Ratios Under Carbon Trading Programs, by Study

	Bovenberg and Goulder	Smith and Others	Burtraw and Others
Coverage of Cap	Economywide	Economywide	Electricity generating sector
Carbon Reduction	23 percent decrease in U.S. baseline emissions[a]	14 percent decrease in U.S. baseline emissions in 2010	6 percent decrease in baseline emissions for the electricity sector in 2012
Carbon Allowance Price	\$25 to \$50 per metric ton[b]	\$51 per metric ton	\$25 per metric ton under auction; \$38 per metric ton under grandfathering
Industries Compensated	Fossil-fuel suppliers, electricity generators, petroleum refiners, metals and machinery industries	Fossil-fuel suppliers, electricity generators	Electricity generators
Compensation Ratio[c]			
At the sector level	14 percent	6 percent	5.5 percent[d]
At the firm level	n.a.	n.a.	20.5 percent[d]

Sources: A. Lans Bovenberg and Lawrence Goulder, "Neutralizing the Adverse Industry Impacts of CO_2 Abatement Policies: What Does It Cost?" in C. Carraro and G. Metcalf, eds., *Behavioral and Distributional Effects of Environmental Policy* (Chicago: University of Chicago Press, 2001); Lawrence H. Goulder, *Mitigating the Adverse Impacts of CO2 Abatement Policies on Energy-Intensive Industries*, Discussion Paper 02-22 (Washington, D.C.: Resources for the Future, March 2002); Anne E. Smith, Martin T. Ross, and W. David Montgomery, *Implications of Trading Implementation Design for Equity-Efficiency Trade-offs in Carbon Permit Allocations*, working paper (Boston: Charles River Associates, December 2002); Dallas Burtraw and others, *The Effect of Allowance Allocation on the Cost of Carbon Emission Trading*, Discussion Paper 01-30 (Washington, D.C.: Resources for the Future, August 2001); and Dallas Burtraw and others, *The Effect on Asset Values of the Allocation of Carbon Dioxide Emission Allowances*, Discussion Paper 02-15 (Washington, D.C.: Resources for the Future, March 2002).

Note: n.a. = not available.

a. The change in the present value of emissions from 2002 to 2080, with the emissions stream discounted using the aftertax interest rate.

b. The price is \$25 per ton initially and rises by 7 percent per year until it reaches \$50 per ton.

c. The compensation ratio represents the share of the total allowance value needed to preserve equity value if compensation was made in the form of a perpetual allocation of allowances.

d. These numbers do not appear in the study but are based on conversations with the authors.

emissions at the 2000 level (1.54 billion metric tons), resulting in a 14 percent decrease in carbon emissions by 2010 and a 32 percent decrease by 2030. They estimated that compensating existing fossil-fuel suppliers and electricity generators would require 6 percent of the total allowance value—assuming that allowance allocations were perpetual. If firms were fully compensated over a limited time period, the compensation ratio would be higher, they concluded *(see Box 1)*.

The reason that estimated compensation ratios for both upstream and downstream industries in a carbon trading program are modest (less than 15 percent) is that much of the cost of the program would be passed on to the ultimate consumers of carbon-intensive goods. That would be most likely to occur under two conditions:

- If the supply of goods affected by the policy was elastic (meaning that the variable cost of production did

Box 1.

Compensating Firms Over a Limited Time Period

The estimates of compensation ratios discussed above all assume that firms would receive compensation in the form of a permanent stream of free allowances. Future payments have less value than current payments because dollars received today could be invested and thus would be worth more in the future. Economists typically use a discount rate to convert the value of future payments into present-value terms. With value measured on that basis, a firm would receive most of the value of a perpetual stream of allowance payments during the first 20 years.[1]

A study by Anne Smith and others demonstrated that the compensation ratio would be much larger in the initial years of a cap-and-trade program if firms were compensated for their losses over a shorter time period. For example, if firms were to receive all of their compensation in the first 10 years of the program, that compensation would account for 40 percent of the total allowance value, compared with only 6 percent of that value if compensation was received in the form of a perpetual stream of allowances.[2]

Shareholders might prefer to be compensated over a limited time frame because of concerns that regulators could decide to eliminate free allocations after a few years. If regulators did that, compensation would be less than anticipated and would fall short of firms' costs. Whether compensation was less than or greater than the value of firms' losses, or was provided at all, would be an important fairness issue. However, it would not be expected to change the behavior of regulated firms in ways that would raise the costs of a cap-and-trade program. Further, compensating firms over a more limited time would mean that less revenue would be available to compensate other affected entities, such as consumers, who would be expected to incur a large share of the policy costs.

1. Assuming a constant allowance value, using a 7 percent discount rate, and valuing the allowances on a continuous basis mean that 75 percent of the total allowance value of a stream of perpetual payments would be received in the first 20 years of the program.

2. See Anne E. Smith, Martin T. Ross, and W. David Montgomery, *Implications of Trading Implementation Design for Equity-Efficiency Trade-offs in Carbon Permit Allocations*, working paper (Boston: Charles River Associates, December 2002), p. 19.

not change much when the quantity of goods produced rose or fell);[24] and

- If the demand for those goods was inelastic (meaning that the amount that consumers purchased was relatively insensitive to changes in price). A good tends to have a less elastic demand when substituting another good for it is difficult. For example, the demand for electricity tends to be relatively inelastic because there are few viable substitutes for electric power. In contrast, a good that has readily available substitutes tends to have a more elastic demand. For example, the demand for a restaurant meal tends to be relatively elastic because homemade meals and prepared foods from grocery stores offer substitutes.

Producers of goods that are characterized by elastic supply and inelastic demand are most able to pass cost increases on to consumers without experiencing a reduction in profits.

24. The supply of a good tends to be elastic when immobile factors of production, such as capital, make up a fairly small share of its production costs. In that case, profits are small relative to the industry's output. Thus, declines in production because of a cap-and-trade program will result in fairly small reductions in profits and require little compensation. That point is demonstrated in both an analytical and empirical model in A. Lans Bovenberg, Lawrence H. Goulder, and Derek J. Gurney, "Efficiency Costs of Meeting Industry-Distributional Constraints Under Environmental Permits and Taxes" draft (December 2002).

Estimating Compensation Requirements at the Firm Level

The compensation estimates described above all measure losses for an entire sector, such as the electricity generating sector, rather than for individual firms. Recent research indicates that in some cases, compensation requirements could be higher than those estimates if losses were calculated at the firm level. If some firms in a sector earned larger profits as a result of the cap-and-trade program and their equity values increased, those equity gains would offset losses by other firms in the sector.[25] Thus, if equity losses were calculated for individual firms rather than for the sector, the amount of compensation required would be greater and the compensation ratio would rise.[26]

Dallas Burtraw and others have quantified that effect for a cap-and-trade program that would reduce carbon emissions from electricity generators by 6 percent in 2012. They concluded that compensating firms for policy-induced decreases in the value of existing assets at the time the policy was enacted would take 5.5 percent of the allowance value if losses were measured at the industry level (where gains offset some of the losses) but would require 20.5 percent of that value if losses were measured at the firm level.[27]

Differences in compensation ratios calculated at the firm level or the sector level depend on whether a cap-and-trade program would create winners as well as losers within a sector. Burtraw and others found a significant difference between compensation ratios at the two levels because some electricity generators with few or no carbon emissions would experience higher profits as a result of the program. In contrast, if compliance costs were uniformly distributed throughout an industry or if cost increases did not lead to price increases, the compensation ratio would be the same whether calculated at the sector level or the firm level.[28]

Compensation for Consumers

As noted above, firms would be able to pass a large share of the cost of a carbon cap-and-trade program on to final consumers in the form of higher prices if the supply of their products was elastic and the demand for those products was inelastic. Research indicates that those conditions are likely to hold true for fossil-fuel suppliers and for the electricity generating industry.[29] Thus, understanding the incidence of a carbon cap-and-trade program (that is, who bears the cost) requires examining how those

25. For example, nuclear-powered or hydroelectric generators could experience higher profits as a result of a carbon cap-and-trade program because they do not produce carbon emissions and thus would not face allowance costs, but they would benefit from higher prices for the electricity they generate.

26. Smith and others make that point but are not able to quantify it in their model.

27. Those estimates assume that the government would sell the rest of the allowances in an auction. The details of the cap-and-trade policy and the model are provided in two papers by Burtraw and others: *The Effect on Asset Values of the Allocation of Carbon Dioxide Emission Allowances* and *The Effect of Allowance Allocation on the Cost of Carbon Emission Trading*. The percentages given in the above text cannot be found in either of those papers but are based on personal communications to the Congressional Budget Office by authors Dallas Burtraw and Karen Palmer. Note that their finding that 5.5 percent of the allowance value is needed to compensate the electricity sector is not necessarily inconsistent with the estimate from Smith and others that 6 percent of the allowance value is necessary to compensate both fossil-fuel suppliers and the electricity sector. Smith and others were examining an economywide cap-and-trade program; therefore, the total value of allowances would be much larger than for a cap-and-trade program that covered only the electricity sector. Consequently, a much smaller share of that larger allowance value would be needed to compensate electricity producers under Smith's economywide analysis than under Burtraw's electricity-sector-specific analysis. Further, the impact on the electricity sector could be larger for a cap that covered only that sector than for one that covered all fossil fuels because it might prompt more substitution away from electricity.

28. As described above, whether cost increases led to price increases would depend on the elasticity of demand.

29. Besides the studies discussed above, a paper by Mark Lasky of the Congressional Budget Office surveyed and synthesized economic models used to estimate the cost of the Kyoto Protocol. That analysis indicated that higher prices for U.S. consumers would account for between 94 percent and 96 percent of the value of the allowances used, and income losses by energy producers would account for the rest. See Mark Lasky, *The Economic Costs of Reducing Emissions of Greenhouse Gases: A Survey of Economic Models*, Technical Paper 2003-3 (May 2003), available at www.cbo.gov/Tech.cfm.

higher prices would be expected to affect households at different income levels.[30]

The Congressional Budget Office (CBO) published a study in June 2000 that examined the effects on households of a cap-and-trade program to reduce carbon emissions by 15 percent.[31] That study looked at how the increases in consumer prices caused by the program would be distributed among households with different incomes. It also examined policy effects on households under alternative assumptions about how the government would allocate allowances. Unlike the previous studies discussed in this paper—which focused on the costs that firms would absorb under a cap-and-trade program but excluded consumers—the 2000 CBO study looked at how consumers would be affected by higher prices but did not consider the impact on industry. As such, it assumed that all of the cost of the program would be passed on to consumers in the form of higher prices. Thus, that study tended to overestimate the effect on consumers to the extent that industry would absorb some of the cost.

Effects of Higher Prices on Households

The 2000 CBO study assumed that the price increase for each product would be proportional to the amount of carbon emitted from the fossil fuels used in its production. Those increases would be regressive because lower-income households generally consume a larger share of their income than higher-income households do and because they spend a greater percentage of their income on energy products (such as gasoline, electricity, and fuel for heating and cooking), which are the most carbon-intensive goods.

The 2000 CBO study estimated that the price changes resulting from a 15 percent cut in carbon emissions would cost the average household in the lowest one-fifth of the income distribution (called a quintile) about $560 a year —or 3.3 percent of its average income *(see Table 2)*. Households in other quintiles would face higher costs in dollar amounts, but those costs would represent a smaller share of their average yearly income—1.7 percent in the case of the highest quintile.

Table 2.

Increase in Average Household Costs from a 15 Percent Decrease in Carbon Emissions

	Average for Income Quintile				
	Lowest	Second	Middle	Fourth	Highest
Cost Increase					
In dollars	560	730	960	1,240	1,800
As a percentage of income[a]	3.3	2.9	2.8	2.7	1.7

Source: Congressional Budget Office.

Note: The numbers in this table come from data on each quintile's cash consumption and estimates of cash income. More-complete measures of income and consumption would include in-kind items, such as employer-paid health benefits or food stamps, and thus could yield somewhat different findings. Data limitations preclude such measures, however. Consequently, these numbers should be viewed as illustrative and broadly supportive of the conclusions in this analysis rather than as exact figures.

a. The cost increases are equivalent to percentage decreases in aftertax income.

That study relied on detailed data about households' annual spending and income. Those data allowed the analysis to distribute the price increases from a carbon cap among households on the basis of their existing patterns of consumption and income. However, such an annual perspective may not accurately reflect the cost of a carbon cap over an individual's lifetime, because ratios of consumption to income vary throughout people's lives.

Viewed from a lifetime perspective, the effects of a carbon cap would probably still be regressive but less so than when measured on an annual basis. Various analyses suggest that a policy that raised the price of consumer goods would tend to be regressive if it was measured on the basis of life-

30. Providing compensation to industry over a limited period of time or calculating compensation requirements at the firm level rather than the sector level would increase the compensation ratio but would not change the extent to which consumers experienced higher prices as a result of the program.

31. Congressional Budget Office, *Who Gains and Who Pays Under Carbon-Allowance Trading? The Distributional Effects of Alternative Policy Designs* (June 2000).

time spending relative to lifetime income.[32] The reason is that lifetime consumption as a share of lifetime income —like the annual ratio—tends to fall as the level of income rises. In addition, one researcher has concluded that a group of environmental taxes (including a carbon tax) would be slightly regressive when measured on a lifetime basis.[33]

Information about the lifetime incidence of a policy can also be inferred from annual data by examining the subset of the population that is middle-aged (the point at which people tend to reach their maximum income level). Data indicate that consumption-to-income ratios would decline with increases in income for middle-aged households, but to a lesser extent than for the population as a whole. That result indicates that the price effects of a carbon cap-and-trade program would still be regressive if measured on a lifetime basis, though less so than if measured annually. Estimating the effects of a carbon cap-and-trade program on households on a lifetime basis is an important area for future research.

Effects of Alternative Allocation Policies on Households

Households could be compensated for price increases in numerous ways. The 2000 CBO study examined the distributional effects that would result if the government auctioned off allowances and used the revenue (net of increases in government expenses and reductions in tax revenue caused by the cap) to pay all households an equal lump-sum rebate or to cut corporate taxes. It found that returning all of the net auction revenue to households in the form of a lump-sum rebate would more than fully offset the burden that the policy-induced price increases would impose on lower-income households. Under that combination of allocation method and revenue use, the overall effect of the cap-and-trade program would be to increase average income for households in the lowest quintile by 1.8 percent. Households in the top quintile would see their average income decline by 0.9 percent *(see Table 3).*

The distributional effects of using auction revenue to cut corporate taxes depend on assumptions about who would ultimately benefit from such a cut. The 2000 CBO study assumed that the benefits of a decrease in corporate taxes would go to the owners of capital. Under that assumption, the cap-and-trade program would reduce the average income of households in the lowest quintile by 3.0 percent and raise the average income of households in the highest quintile by 1.5 percent.

Alternatively, some analysts assume that a cut in the marginal corporate tax rate would ultimately benefit workers. The logic behind that assumption is that such a cut would initially cause returns on capital to rise. That rise in turn would lead to an increase in investment and hence to an increase in the amount of capital (thus lowering returns back to their initial level). The higher level of capital would make labor more productive and thereby raise returns on labor (that is, wages). If the results of the 2000 CBO study were revised to reflect that alternative assumption, the effects of using net auction revenue for a corporate tax cut would still be regressive, although less so than under the previous assumption. In this scenario, the cap-and-trade program would reduce the average income of households in the lowest quintile by 2.8 percent and boost the average income of households in the highest quintile by 0.4 percent *(see Table 3).*

Finally, the 2000 CBO study estimated that giving allowances to companies at no charge could be the most regressive of all the policies considered. Since in that analysis all costs were assumed to be passed on to households, allowances that were distributed to firms for free led to increased profits and ultimately benefited shareholders,

32. See, for example, Diane Lim Rogers and Don Fullerton, *Who Bears the Lifetime Tax Burden?* (Washington, D.C.: Brookings Institution, 1993); and Paul L. Menchik and Martin David, "The Incidence of a Lifetime Consumption Tax," *National Tax Journal,* vol. 35, no. 2 (June 1992), pp. 189-203.

33. See Gilbert E. Metcalf, "A Distributional Analysis of Green Tax Reforms," *National Tax Journal,* vol. 52, no.4 (December 1999), pp. 655-681. Metcalf looked at a set of environmental taxes that included a carbon tax, a gasoline tax, an air pollution tax, and a virgin-materials tax. Of all those taxes, the one on carbon was found to be the most regressive.

Table 3.

Change in Average Aftertax Household Income Under Various Methods of Allocating Allowances and Distributing Their Value

	Average for Income Quintile				
	Lowest	Second	Middle	Fourth	Highest
Allowance Auction and Lump-Sum Rebate to Households					
Change in Dollars	310	140	-90	-370	-940
Change as a Percentage of Income[a]	1.8	0.5	-0.3	-0.8	-0.9
Allowance Auction and Cut in Corporate Taxes					
Assuming That the Tax Cut Benefits Owners of Capital					
Change in Dollars	-510	-530	-630	-790	1,510
Change as a Percentage of Income[a]	-3.0	-2.1	-1.9	-1.7	1.5
Assuming That the Tax Cut Benefits Labor					
Change in Dollars	-480	-430	-340	-160	461
Change as a Percentage of Income[a]	-2.8	-1.7	-1.0	-0.3	0.4
Free Distribution of Allowances and Cut in Corporate Taxes[b]					
Assuming That the Tax Cut Benefits Owners of Capital					
Change in Dollars	-530	-600	-740	-900	1,810
Change as a Percentage of Income[a]	-3.1	-2.4	-2.2	-1.9	1.8
Assuming That the Tax Cut Benefits Labor					
Change in Dollars	-520	-580	-680	-750	1,570
Change as a Percentage of Income[a]	-3.1	-2.3	-2.0	-1.6	1.5
Free Distribution of Allowances and Lump-Sum Rebate to Households[b]					
Change in Dollars	-340	-450	-620	-800	1,250
Change as a Percentage of Income[a]	-2.0	-1.8	-1.8	-1.7	1.2

Source: Congressional Budget Office.

Note: The numbers in this table come from data on each quintile's cash consumption and estimates of cash income. More-complete measures of income and consumption would include in-kind items, such as employer-paid health benefits or food stamps, and thus could yield somewhat different findings. Data limitatio ns preclude such measures, however. Consequently, these numbers should be viewed as illustrative and broadly supportive of the conclusions in this analysis rat her than as exact figures.

a. Measured as a percentage of aftertax income before the policy change.

b. Assumes that the government would give all of the allowances away but would regain some of their value by taxing the corporate profits that resulted f rom the free distribution. The government would then use its share of the auction value (net of policy-induced increases in government sp ending or decreases in other tax revenue) to either cut corporate taxes or provide lump-sum payments to households.

who are primarily from higher-income households.[34] (Note that the study did not distinguish between firms and households. Policies that would benefit firms would benefit households that have shareholders.) The government would regain part of the allowance value by taxing those higher profits. If the government used its share of the allowance value to decrease corporate tax rates, then the policy would be the most regressive of all the ones that CBO examined: under the assumption that the benefits of a corporate tax cut would go to owners of capital, average household income would fall by 3.1 percent for the lowest quintile and rise by 1.8 percent for the highest quintile *(see Table 3)*. The policy would be slightly less regressive under the assumption that the benefits of a corporate tax cut would go to labor. However, the free-distribution strategy would be regressive even if the government used its share of the allowance value to make lump-sum payments to households.

Available research indicates that, in reality, some of the cost of a carbon cap-and-trade program would be absorbed by firms, as described above. To the extent that costs were passed on to households, the distributional effects would be similar to those described in the 2000 CBO analysis. To the extent that firms absorbed the costs of the policy, the free-distribution scenario would be less regressive than indicated in that analysis because the free allocation would offset policy-induced costs borne by shareholders.

Compensation for Workers and Communities

Estimates of the costs of a carbon cap-and-trade program typically exclude losses incurred by workers in affected industries who would lose their jobs as a result of the program (because those estimates assume that employees who lost jobs would eventually find new ones elsewhere). Nevertheless, any policy that reduced U.S. carbon emissions would inevitably create transitional losses for workers while they were unemployed. Those losses could prove significant for some households.

Transitional losses would probably be especially large in the coal industry. The Energy Information Administration estimates that coal production would be more than 50 percent below the baseline level in 2015 if the government capped carbon emissions from the electricity sector in 2008 at 7 percent less than their 1990 level.[35] Such a significant reduction in coal production would impose a hardship on some of the nation's 71,000 coal workers, their families, and their communities.[36]

Concerns about fairness could lead to compensation for those transitional costs. However, the research reviewed for this paper yielded little evidence about the possible magnitude of such costs. Viewed from a national perspective, those costs would be concentrated on a relatively small number of households.

What Share of Allowance Value Might Be Available for Compensation?

Initial research on industry compensation ratios for carbon trading programs measured compensation as a share of the total revenue that could be raised if allowances were sold in an auction. However, some research has shown that a significant share of that auction revenue might need to go toward offsetting increases in government spending and declines in tax revenue caused by the program. Like other consumers, the government would pay more for carbon-intensive goods under a cap-and-trade program;

34. Ian Parry conducted a similar analysis for reductions in SO_2 emissions. His baseline policy assumed that emissions would be cut in half and that auction revenue would be returned to households in proportion to their income. He concluded that such a policy would be regressive, with the degree of regressivity greater when the cut in emissions was smaller. Further, regressivity increased when allowances were assumed to be given to firms for free rather than sold by the government. See Ian W.H. Parry, "Are Emissions Permits Regressive?" (preliminary draft, Resources for the Future, Washington, D.C., May 13, 2002).

35. See Energy Information Administration, *Analysis of Strategies for Reducing Multiple Emissions from Power Plants: Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide*, SR/OIAF/2000-05 (December 2000), Table 14, p. 36.

36. According to the Energy Information Administration, the average number of employees in the U.S. coal industry in 2000 was 71,522. See Energy Information Administration, *Coal Industry Annual 2000*, DOE/EIA-0584(2000), Table 40, available at www.eia.doe.gov/cneaf/coal/cia/t40p01.txt.

moreover, the economic effects of the program could reduce tax revenue in ways that are described below.

Using some of the allowance value to offset those effects could be seen as compensating the government. However, failure to do so would require the government to raise taxes if it wanted to keep net revenues at their baseline levels (while holding spending constant). A tax increase could boost the cost of the cap-and-trade program.

Smith and others estimate that an economywide cap that cut carbon emissions by 14 percent in 2010 would reduce economic activity (because, among other effects, policy-induced price increases would lower real wages and real returns on capital investments, resulting in a decline in labor and investment). That reduction in economic activity would decrease tax revenue—an effect the authors refer to as tax-base erosion. Offsetting that decrease would require the government to retain 37 percent of the potential auction revenue associated with such a cap.[37] Although tax collections would decline by only a small share (0.6 percent) in their analysis, that revenue loss would represent a large share of total auction proceeds.

Smith and others assumed that reductions in economic activity would cause proportionate declines in government tax receipts—that is, a 1 percent decline in economic activity would lead to a 1 percent decline in tax receipts.[38] However, the tax system is progressive, and the fact that parts of the individual income tax (such as the exemptions and tax brackets) are automatically indexed to changes in the price level maintains that progressivity in real terms. Consequently, the higher prices resulting from a carbon cap could lead to lower collections of individual income taxes, meaning that the percentage decline in tax collections would be greater than the percentage decline in economic activity. Terry Dinan and Diane Rogers point out that effect and estimate, on the basis of CBO data, that each 1 percent rise in the price level would produce a 0.5 percent decline in individual income tax payments.[39]

Price indexing could also lead to higher government spending under a cap-and-trade program. Payments in a number of federal programs—such as Supplemental Security Income, Social Security, and pensions for federal workers—are pegged to the price level, so higher prices could lead to increases in those payments. Moreover, as noted above, the government would pay more for the fossil fuels and other carbon-intensive goods it purchased.

Dinan and Rogers estimated that under a cap-and-trade program designed to cut carbon emissions by 15 percent, those increases in government spending and declines in tax revenue would equal 30 percent of potential auction revenue. That figure is smaller than Smith's 37 percent estimate because, even though Dinan and Rogers account for more effects on the federal budget than Smith and others do, their measure of tax-base erosion is smaller. Dinan and Rogers assume no loss in revenue from the decline in capital- and labor-market activity that might result from the policy. The reason is that the overall cost of the policy that they report includes the economic cost asso-

37. See Smith, Ross, and Montgomery, *Implications of Trading Implementation Design for Equity-Efficiency Trade-offs in Carbon Permit Allocations*. Their estimate of tax-base erosion is sensitive to the stringency of the carbon cap. The estimate rises to more than 50 percent of potential auction revenue by 2030, when their cap would reduce emissions by 32 percent.

38. Personal communication to the Congressional Budget Office by Anne Smith.

39. See Terry M. Dinan and Diane Lim Rogers, "Distributional Effects of Carbon Allowance Trading: How Government Decisions Determine Winners and Losers," *National Tax Journal*, vol. 40, no. 2 (June 2002), footnote 13. That article is a more technical version of a study by the Congressional Budget Office, *Who Gains and Who Pays Under Carbon-Allowance Trading? The Distributional Effects of Alternative Policy Designs* (June 2000).

CBO routinely accounts for an offsetting decline in government revenue that would result from new taxes imposed on businesses. Specifically, it assumes that 25 percent of the potential revenue associated with an indirect tax (one not levied on a firm's income, such as an excise tax or some fees) that was levied on businesses would be offset by a decline in other sources of government revenue. CBO made that assumption when estimating the revenue that would be generated by the Clean Power Act of 2002 (S. 556 in the 107th Congress). That bill would have required electricity generators to purchase allowances from the government for emissions of carbon dioxide, sulfur dioxide, nitrogen oxides, and mercury. CBO assumed that 25 percent of the revenue from sales of the allowances would be offset by declines in other sources of revenue. See Congressional Budget Office, *Cost Estimate for S. 556, the Clean Power Act of 2002* (November 18, 2002).

ciated with increasing existing tax rates to make up for losses in tax revenue as labor and capital supplies are reduced.[40] If they had not made that assumption, their estimate of the share of auction revenue necessary to offset changes in government spending and tax revenue would have exceeded Smith's figure of 37 percent.

Compensation ratios for industry are significantly higher if compensation is measured as a share of auction revenue net of those policy-induced reductions in tax receipts or increases in government spending. (Note that such an adjustment does not mean that the amount of compensation required is higher, only that there is less auction revenue available from which to provide it.) Smith and others estimated that the share of auction revenue needed to maintain equity values for fossil-fuel suppliers and electricity generators under their hypothetical cap would nearly double—to 11 percent from 6 percent—if measured as a share of net auction revenue rather than gross auction revenue.

The Impact of Compensation on the Overall Cost of the Program

Available research indicates that providing compensation could increase the cost that a carbon cap would impose on the economy, in two ways. First, paying compensation would entail an opportunity cost (the cost of forgoing an alternative activity) because it would preclude the government from using those funds in ways that would reduce the cost imposed on the economy. Second, if electricity generators in regulated markets received free allowances as a form of compensation, the policy-induced increase in the price of electricity would not reflect the full cost of allowances—thus failing to reduce existing distortions in the pricing of electricity and leading to less energy conservation than might otherwise occur.

The Opportunity Cost of Providing Compensation

Selling allowances in an auction instead of giving them away would provide the government with an opportunity to use the auction revenue in a way that would lower the overall cost of the cap-and-trade program—for example, by lowering taxes that discourage economic activity by discouraging labor and investment (such as marginal taxes on capital, labor, and personal income). Reductions in those taxes would give households an incentive to save, invest, or work more. That result would increase the supply of capital and labor and thus produce gains in economic efficiency (that is, lead to a higher level of economic activity), which would partly offset the economic cost of the carbon cap.[41] Using auction revenue to compensate firms, households, or workers, however, could mean forgoing those potential efficiency gains.

Some of the studies described above provide insights into the cost associated with using auction revenue for compensation instead of for cuts in existing taxes that discourage investment and labor. For example, Goulder considers a cap-and-trade program that would reduce carbon emissions by roughly 23 percent. He estimates that grandfathering all of the allowances would increase the cost of the policy by 90 percent compared with auctioning off all of the allowances and using the revenue to reduce marginal personal income taxes.[42] Grandfathering just 13 percent of the allowances (to compensate fossil-fuel suppliers for losses in their equity values) would raise the cost of the policy by 8 percent, he concludes.

Smith and others examine a policy that would cut carbon emissions by 14 percent in 2010 and estimate that grandfathering all of the allowances—as opposed to using all of their value to reduce marginal personal income taxes—

40. See Dinan and Rogers, "Distributional Effects of Carbon Allowance Trading," footnote 21.

41. Cap-and-trade programs would worsen the disincentives created by existing taxes because they would raise prices and lower real wages and returns on investments. That effect is referred to as the tax-interaction effect. Using the revenue from an allowance auction would reduce, though probably not eliminate, the tax-interaction effect. For a good survey of the literature on that effect, see A. Lans Bovenberg and Lawrence H. Goulder, "Environmental Taxation," in Alan Auerbach and Martin Feldstein, eds., *Handbook of Public Economics*, 3rd ed. (Amsterdam: Elsevier, forthcoming). Another helpful discussion can be found in Ian W.H. Parry and Wallace E. Oates, "Policy Analysis in a Second-Best World," *Journal of Policy Analysis and Management*, vol. 14, no. 4 (Fall 2000), pp. 603-613.

42. That comparison is based on the efficiency cost estimates found in Table 4 of Goulder, *Mitigating the Adverse Impacts of CO2 Abatement Policies on Energy-Intensive Industries.*

would increase the overall cost of the policy by 55 percent.[43] Further, they calculate that grandfathering 6 percent of the allowances (to compensate firms for their equity losses) would increase the cost of the policy by 9 percent.[44]

In short, using the allowance value to provide compensation instead of to lower marginal tax rates would boost the cost of a cap-and-trade program substantially. However, that opportunity cost applies only if the government would otherwise use the auction revenue in ways that would benefit the economy. A cap-and-trade program in which the government gave allowances away would not cost more than a program in which it sold allowances but used the revenue in ways that did not create efficiency gains.

Problems with Free Allocations to Regulated Utilities

Dallas Burtraw and Karen Palmer demonstrate that grandfathering allowances rather than selling them in an auction could significantly increase the cost of a carbon cap imposed on the electricity sector.[45] That result stems from the fact that electricity prices are currently set by regulators in all but about 17 states (which have committed to competitive pricing of electricity).

As explained earlier, a cap-and-trade program for the electricity sector would cause electricity prices to rise. However, in regions where prices were regulated, the grandfathering of allowances would lead to much smaller price increases than would result if allowances were auctioned. Regulators permit electricity generators to recover average costs, but since generators would receive grandfathered allowances for free, regulators would not allow the value of those allowances to be reflected in electricity prices.

Although generators would receive grandfathered allowances for free, using (or holding) those allowances would actually involve a cost because generators could otherwise sell them for some price. By not reflecting that forgone opportunity cost in the price of electricity, regulators would be understating the cost of using the allowances and thus the cost of producing electricity—in other words, the cost of the carbon emissions would not be reflected in the prices that consumers paid. As a result, consumers would have less incentive to reduce their electricity use (for example, by purchasing energy-efficient appliances) than would otherwise be the case, and the cost of achieving the carbon cap would be higher. In contrast, if generators had to buy allowances, regulators would build those costs into electricity prices and consumers would receive appropriate incentives to conserve electricity.[46]

Further, Burtraw and Palmer show that the higher electricity prices that would result from auctioning (as opposed to grandfathering) could help offset other distortions in the pricing of electricity. Currently, in most parts of the country, the price of electricity does not reflect the marginal cost of producing it. The biggest distortions exist in areas where the price is less than the marginal cost of production.[47] That gap means that people tend to use too much electricity (because the price that they pay for it is less than the cost of producing it), which imposes economic costs. Carbon policies that raise the price of electricity can help reduce that cost. In regulated areas, auctioning off allowances would do more to reduce the distortion between price and marginal cost than grand-

43. That figure is based on a personal communication to the Congressional Budget Office by Anne Smith.

44. See Smith, Ross, and Montgomery, *Implications of Trading Implementation Design for Equity-Efficiency Trade-offs in Carbon Permit Allocations*, p. 14.

45. See Burtraw and Palmer, "A Comparison of the Effects of the Distribution of Emission Allowances for Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide," p. 4. Their analysis does not account for the opportunity cost described above.

46. That would also be the result if generators faced higher prices for fossil fuels because of an upstream cap-and-trade program.

47. The share of generated electricity whose price falls short of its marginal cost is less than the share whose price exceeds its marginal cost. However, in virtually all of the cases in which price is greater than marginal cost, the difference is less than $25 per megawatt hour, whereas for cases in which price is less than marginal cost, the difference can be as much as $1,000 per megawatt hour. See Burtraw and Palmer, "A Comparison of the Effects of the Distribution of Emission Allowances for Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide," p. 15.

fathering allowances would because it would lead to bigger price increases.

Burtraw and Palmer conclude that the effect of different allocation methods on electricity prices can make a big difference in the overall cost of the cap-and-trade program. For example, they estimate that reducing carbon emissions from the electricity sector by 24 percent in 2012 would cost twice as much if allowances were given to generators than if they were sold in an auction. The percentage increase in cost would be even greater for more-modest emission reductions.[48] If auction revenue was used to offset existing marginal taxes (as described above), the difference in cost between auctioning and grandfathering allowances would be greater still.

Conclusions: Competing Goals and Hard Choices

Instituting a cap-and-trade program to reduce carbon emissions would involve creating new assets: emission allowances. Those assets could be quite valuable. How their value was allocated among people (investors, workers, and consumers) could have significant consequences, both for economic efficiency and for the distribution of losses and gains. Therefore, in deciding how to use that value, policymakers would face complicated choices between competing goals.

To prevent the cap on carbon emissions from necessitating a tax increase, the government would need to use part of the allowance value to offset increases in government spending and reductions in tax revenues caused by the program. Offsetting those effects could take a significant share of the potential revenue from selling allowances.

Policymakers would have to decide whether to use the rest of the allowance value (the net potential revenue) to lower the overall cost of the program or to provide direct compensation to affected parties. Recent research indicates that the overall cost to the economy of a carbon cap would be significantly lower if the government auctioned off the allowances and used the net auction revenue to reduce existing taxes that discourage labor and investment. Empirical studies reviewed for this paper suggest that economywide costs could be more than 30 percent lower if all of the net auction revenue was used to reduce existing marginal tax rates on capital, labor, or personal income (which is a combination of capital and labor) instead of to provide compensation.[49]

If policymakers opted to pay compensation, they would need to decide whom to compensate—consumers, shareholders in affected industries, or dislocated workers and their communities. Available research concludes that in the long run, a large share of the cost of a carbon cap is likely to be passed on to consumers in the form of higher prices for energy and other carbon-intensive goods. Those cost increases would probably impose a relatively larger burden on lower-income households than on higher-income ones.

Industry is expected to bear a much smaller share of the total cost of the program, but its costs are likely to be concentrated in certain sectors, such as the coal industry. As a result, shareholders in those sectors could experience significant declines in equity values if firms were not compensated. Such losses would be widely disbursed among investors, to the extent that they have diversified portfolios.

CBO's survey of the current literature found little information about the transitional costs that a carbon cap would impose on workers. Whatever their size, those short-term costs would fall heavily on a relatively small number of households. Costs would be particularly high

48. Ibid., Figure 3. Those results stem from the fact that some regions are regulated. Grandfathering would not raise the cost of the program if all regions set electricity prices using a competitive process.

49. That estimate assumes that 30 percent of the allowance value would be used to offset policy-induced reductions in net revenue and that the cost of the policy would be 90 percent higher if all of the allowance value was used for compensation rather than for reductions in existing taxes. The latter assumption is based on Lawrence H. Goulder, *Mitigating the Adverse Impacts of CO2 Abatement Policies on Energy-Intensive Industries*. Finally, the estimate assumes that the reduction in cost is proportional to the share of the allowance value used to reduce marginal tax rates—that is, if using all of the allowance value to reduce taxes would decrease the cost of the program by 47 percent, then using 70 percent of that value to do so would lower the cost by 33 percent.

in the coal industry because any significant cut in carbon emissions would entail a significant reduction in coal production.

Finally, if policymakers decided to compensate electricity generators by handing out allowances for free, they could inadvertently increase the cost of reducing carbon emissions. That cost increase would stem from the fact that in many regions of the country, electricity prices are set by regulators rather than by competitive forces. Generally, regulators would not allow generators to reflect the value of the allowances they received for free in the price of electricity, which means that the price would be lower under a free distribution than it would be under an auction. As a result, preexisting distortions in the pricing of electricity (where price is often less than the marginal cost of generation) would not decline as much as they would otherwise, and consumers would not have as much incentive to reduce electricity use.

In summary, although the potential value of carbon allowances under a cap-and-trade program would be large, competing demands on that value would necessitate tough choices. Concerns about economic efficiency would have to compete with concerns about fairness. To the extent that the latter prevailed, the issue of who to compensate would be important. Even if the entire allowance value was used to provide compensation, it would not be large enough to cover all of the losses experienced by shareholders, workers, and consumers.