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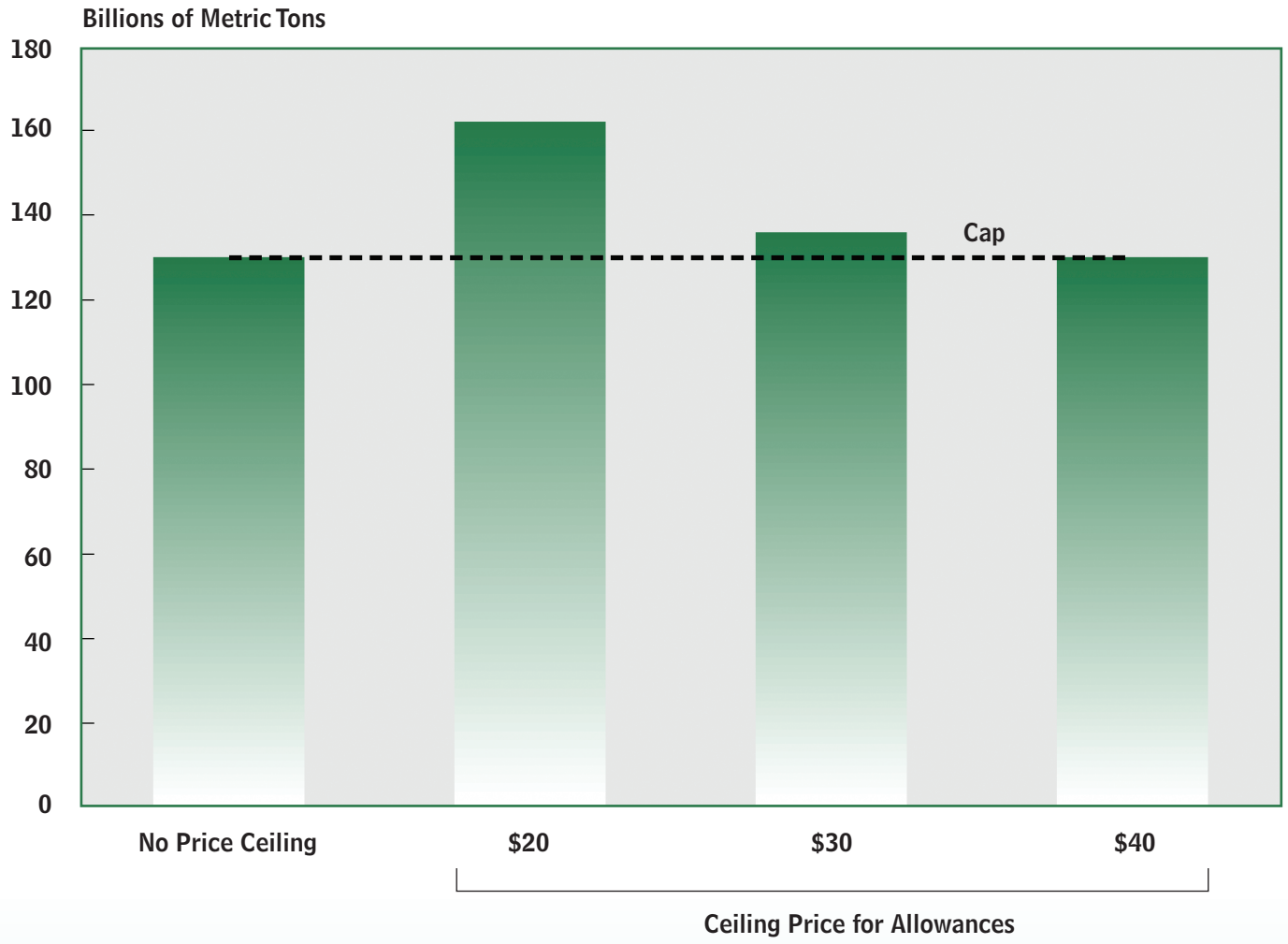
Managing Allowance Prices in a Cap-and-Trade Program



Greenhouse Gas Emissions with a Price Ceiling as One Option for Managing Allowance Prices

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Preface

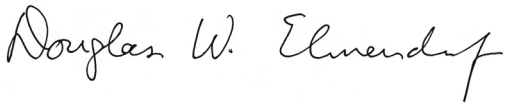
Scientists generally conclude that rising concentrations of greenhouse gases are warming the Earth's climate. Concern about the damage that might result has led policymakers and analysts to consider policies designed to restrict emissions of those gases. One type of policy, a cap-and-trade program, could minimize the cost of achieving a limit, or cap, on emissions by allowing market forces to determine where, how, and to some extent when the cuts in emissions necessary to achieve the cap would be made. (Other options include taxes on emissions and regulatory standards to reduce emissions, or a combination of the various approaches.) A cap-and-trade program would establish increasingly stringent annual limits on greenhouse gas emissions over the course of several decades. The government would distribute rights to emit such gases (allowances) by either selling them, possibly in an auction, or giving them away. Firms would be allowed to trade the allowances after they had been distributed and to shift them over time to some degree by "banking" unused allowances for future use or by "borrowing" allowances allocated to future years.

The price of allowances would rise to the level necessary to ensure that the limit on cumulative emissions over the life of the policy (implied by the annual caps) was met. That price level would depend crucially on a variety of factors, including the growth of the economy and the development of new technologies to reduce emissions. Because policymakers cannot know in advance how high or low prices will be in any given year, they might consider adding features to the design of a cap-and-trade program that would limit the range of potential allowance prices.

This Congressional Budget Office (CBO) study—prepared at the request of the Chairman of the Senate Committee on Energy and Natural Resources—examines the potential effects of features that would help manage allowance prices, and thus the cost of complying with a cap-and-trade program, by altering the number of allowances available to firms at various prices. In keeping with CBO's mandate to provide objective, impartial analysis, the report contains no recommendations.

The study was written by Terry Dinan of CBO's Microeconomic Studies Division under the guidance of Joseph Kile and David Moore. Deborah Lucas, Damien Moore, Robert Shackleton, and Andrew Stocking, all of CBO, provided comments, as did Harrison Fell of Resources for the Future, Gilbert Metcalf of Tufts University, and Adele Morris of the Brookings Institution. (The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.)

Leah Mazade edited the study, and John Skeen proofread it. Jeanine Rees prepared the report for publication, and Maureen Costantino designed the cover. Monte Ruffin printed the initial copies, Linda Schimmel coordinated the print distribution, and Simone Thomas prepared the electronic version for CBO's Web site (www.cbo.gov).



Douglas W. Elmendorf
Director

November 2010

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Summary

The accumulation of greenhouse gases in the atmosphere—particularly carbon dioxide released as a result of deforestation and the use of fossil fuels—could create costly changes in regional climates throughout the world. Concern about the damage from such changes has led policymakers and analysts to consider policies designed to reduce emissions of those gases.

Many proposals have focused on cap-and-trade programs, which would limit the number of tons of greenhouse gases emitted into the atmosphere over several decades from certain sectors of the U.S. economy. Under such a program, lawmakers would set gradually tightening annual caps on greenhouse gas emissions that together would imply a cumulative limit over the duration of the policy. Rights to emit the gases, referred to as allowances, would then be distributed to businesses or other entities, such as state governments, in amounts that corresponded to those limits. (One allowance would permit one ton of emissions.) The government could distribute the allowances by either selling them, possibly in an auction, or giving them away. Once the allowances were distributed, they could be bought and sold in the secondary market for them that would develop.

Firms subject to the caps—for example, firms that emitted large quantities of greenhouse gases or that produced or imported fossil fuels that released emissions when burned—would be required to submit allowances to the agency charged with implementing the program. Under most proposed programs, firms could shift their use of allowances from one year to another by "banking" unused allowances for the future or, to a more limited degree, by "borrowing" allowances from future allocations. That trading and flexibility in timing would allow firms to undertake emissions reductions where, how, and to some extent when it was least costly for them to do so.

In choosing the level of the annual caps on emissions, policymakers would be making decisions complicated by uncertainty about the damage that might result from greenhouse gas emissions, and thus the benefits to be gained from reducing them, and about the costs of such reductions. Those costs would increase what firms spent in producing goods and services and would be borne by households in the form of higher prices. In establishing a program's annual limits on emissions, policymakers ideally would have reliable information about the allowance prices that would be associated with the various caps they might consider. Those prices would reflect the cost of the most expensive reduction in emissions made to comply with the program at a given point in time. But projections of allowance prices are inherently uncertain. Once a cap-and-trade program was in place, actual prices would vary on the basis of current conditions, such as the weather and the economy, and firms' expectations about factors affecting their compliance costs over the duration of the policy.

In fact, prices in the allowance market would be continually changing and could reach levels that were much higher or lower than policymakers had anticipated. Changes in prices that were caused by new information could help ensure that the caps on emissions were met at the least possible cost. Higher allowance prices, for example, would encourage firms to invest more in emissions-reducing equipment in the near term as a way to curtail their longer-term costs for meeting the caps. However, unexpectedly high (or low) allowance prices would make the cost of meeting the caps much higher (or lower) than policymakers had expected, which could alter the trade-off between costs and benefits that policymakers had anticipated when they selected the caps.

Concerns about unexpectedly high or low allowance prices have led to proposals to place upper or lower limits on those prices. The Congressional Budget Office (CBO) has examined the possible effects of several features that would change the number of allowances available to firms

at various prices and in so doing help limit the range of allowance prices.

CBO's Findings

CBO examined the effects on allowance prices and greenhouse gas emissions of three mechanisms that would help prevent allowance prices from reaching unexpected highs and lows: a *price ceiling,* which would be implemented by offering an unlimited number of allowances for sale at a given price, thereby placing an upper bound on allowance prices; an *allowance reserve,* in which a limited number of additional allowances would be offered to firms at or above a given price, thereby curtailing but not eliminating price increases beyond that level; and a *price floor,* which would be implemented by decreasing the number of allowances available at a given time to maintain a lower bound on prices.

An upper bound on allowance prices could prevent the policy's costs to the economy from being unacceptably high, but it could also cause emissions to exceed the cumulative cap because the bound would be sustained by adding allowances to the program. The effects of a lower bound would depend on whether firms could bank allowances. If banking was not permitted, a lower bound could motivate firms to make additional cuts in emissions over the duration of the policy beyond those that would otherwise be required by the cap. If banking was permitted, firms would probably not make such additional cuts.

A Price Ceiling

Policymakers could set an upper limit, or ceiling, on allowance prices by allowing firms to buy an unlimited number of allowances, in addition to those created under the cap, at a specified "ceiling price." Such a policy would have the following consequences:

- It would provide an upper limit on allowance prices but not on emissions.
- The higher the ceiling price was set above the projected path of allowance prices, the less likely it would be that firms would buy additional allowances and if they did buy them, the fewer they would buy. As a result, a higher ceiling would generally lead to fewer additional emissions than would arise under a lower ceiling.
- Provided that firms were able to shift allowances from one year to another—that is, bank and borrow them—a ceiling could dampen the price of allowances, even when the market price was below the ceiling price. Such price dampening, which would be most likely when the market price of allowances was near the ceiling price, would occur because firms would attach a lower value to an allowance today to reflect the fact that its price in the future could not rise above the ceiling price.
- If the ceiling lowered allowance prices, it would diminish firms' incentives to invest in equipment that reduced emissions and in efforts to develop new lower-cost emissions-reducing technologies. That decrease in investment would lower firms' spending for emissions reductions in the near term but could increase it in the future, when firms' compliance costs rose.

An Allowance Reserve

Alternatively, policymakers could offer to sell firms a limited number of "reserve" allowances at or above a given price, referred to here as an "access price." Such a reserve would have the following effects:

- It would impose an upper limit on emissions—which might be different from the cap—but would not set an upper limit on the price of allowances.
- The environmental and economic consequences of using the allowances in the reserve would depend on whether the reserve increased or decreased the number of allowances that would otherwise be permitted under the cap.
  - A reserve created by *supplementing the number of allowances supplied under the cap* would allow a limited loosening of the cap when costs were high. A supplemental-allowance reserve would tend to increase emissions and lower allowance prices relative to a policy with the same cap but no reserve. All else being equal, the larger the reserve and the lower the access price for releasing the allowances it contained, the more likely that the reserve would dampen allowance prices and allow emissions to exceed the cap.
  - A reserve created by *withholding allowances that would otherwise be distributed under the cap* could increase firms' compliance costs but allow fewer emissions than those under a program with the same cap but no reserve. All else being equal, the

larger the reserve and the higher the access price, the more likely that the reserve would increase prices and curb emissions to a greater extent than would a similar program without a reserve.

- The effect of a reserve on emissions and allowance prices might be greater but would be less certain if regulators could restock the reserve by using offset credits, which reflect reductions in domestic or overseas emissions that would not otherwise be subject to the cap. Under such an approach, regulators would purchase the credits, then retire them and add a corresponding number of allowances to the reserve. Allowing regulators to restock the reserve in that way could lower firms' costs for compliance because the number of reserve allowances would rise. However, that reliance might also prompt questions about the credibility of the cap: Regulators could find it challenging to verify that offset credits represented actual reductions relative to projected emissions in the absence of the cap-and-trade program.

- If the federal government used auctions to sell the reserve allowances it created, it would capture their full value. Alternatively, if the reserve allowances were distributed by offering firms options to purchase them at a fixed price, the government and firms would share the allowances' value.

A Price Floor

Another approach, a price floor, would set a lower limit on the price of all traded allowances. With a "hard" price floor, the simplest form of such an approach, the government would be required to purchase an unlimited number of allowances at a predetermined price. Broadly speaking, including a price floor in a cap-and-trade program would tend to boost allowance prices in the near term but would probably not result in fewer emissions over the duration of the policy if firms were permitted to bank allowances. CBO's analysis also indicates the following:

- The further below the projected path of allowance prices that the floor price was set, the less likely it would be that the floor would become binding—that is, prevent any further decline in prices.

- At the time that it was binding, a price floor would increase firms' compliance costs, relative to a policy with the same cap and no price floor, because it would require firms to reduce emissions more than they otherwise would.

- To the extent that a price floor increased the price of allowances, it would strengthen firms' incentives to invest in emissions-reducing capital equipment and to develop new lower-cost technologies for reducing emissions. Those investments would boost firms' spending in the near term but decrease their compliance costs (and lower allowance prices) in the future.

- If firms could shift allowances from one period to another, a price floor would probably not result in cumulative emissions over the life of the policy (typically several decades) that were less than the amount permitted under the policy's cap. Instead, a floor would shift reductions forward in time.

- Policymakers could try to set a lower limit on the price of allowances by establishing a minimum bid price for the allowances sold in a government-run auction. But that bid price would establish a floor for prices in the secondary market only if the demand for allowances was great enough that firms would want to buy at least some of the allowances being auctioned.

Unintended Consequences of Managing Allowance Prices

Actual experience in managing allowance prices through the approaches that CBO examined is quite limited, which could make it harder to anticipate the effects of such features if they were included in a cap-and-trade program for greenhouse gas emissions. For example, a hard price floor might turn out to be very costly to implement. Also, some analysts are concerned that a price ceiling or an allowance reserve could result in allowances being added to the program under circumstances—including firms' attempts to manipulate allowance prices through those features—that in the end might not be justified by actual compliance costs. A further consideration is that the mere presence of a price ceiling or a price floor might cause allowance prices to gravitate toward those levels. Moreover, allowing firms to buy an unlimited number of allowances at a ceiling price could complicate possible efforts to tighten the annual caps in the future: Firms could bank allowances during the time that the price ceiling was in effect and then use those allowances to exceed the tighter caps established for future periods.

Managing Allowance Prices in a Cap-and-Trade Program

Over the past several decades, growing quantities of greenhouse gases—produced in large part by human activities—have been accumulating in the atmosphere. Most experts expect that those accumulated gases will result in a variety of environmental changes over time, including a gradual warming of the global climate, extensive changes in regional weather patterns, and significant shifts in the chemistry of the oceans.[1] Emissions of carbon dioxide—the result mainly of fossil fuel consumption and deforestation—are a particularly large source of greenhouse gases; in the United States, carbon dioxide accounts for roughly 80 percent of all greenhouse gases emitted annually.[2]

In the light of growing concern about the prospect of global climate change, lawmakers have considered policies to reduce greenhouse gases and thus limit the extent of such change and the harm that could result from it. Because reductions in emissions would impose costs on the U.S. economy, policymakers have sought approaches that would curb emissions in the most cost-effective way possible.[3] The range of available options includes conventional command-and-control approaches (such as setting standards for vehicles, buildings, machinery, equipment, and appliances) and market-based approaches (such as imposing taxes on emissions or establishing cap-and-trade programs).[4] Market-based approaches give firms and households much more latitude to determine the most cost-effective means of reducing emissions to a specified level. As a result, experts generally conclude that market-based approaches would accomplish that goal at a significantly lower cost than would conventional standards-based methods.

This Congressional Budget Office (CBO) study focuses on one of those market-based approaches that has been considered by the Congress—cap-and-trade programs. Under such programs, the government would set annual limits on emissions—the "cap" part of the program—that would gradually tighten over several decades. It would then distribute allowances, which are essentially rights to emit specific amounts of greenhouse gases, to private-sector firms and other entities. The number of allowances issued would reflect the emissions permitted by the annual caps, measured in metric tons of carbon dioxide equivalent.[5] Firms that were subject to the caps—for example, firms that emitted large quantities of greenhouse gases or that produced or imported fossil fuels that generate emissions when burned—would have to submit one allowance for each ton of emissions they generated to the agency charged with implementing the program,

1. See Congressional Budget Office, *Potential Impacts of Climate Change in the United States* (May 2009).

2. Other greenhouse gases are methane, nitrous oxide, and several man-made gases containing fluorine and chlorine.

3. For additional information, see Congressional Budget Office, *The Costs of Reducing Greenhouse-Gas Emissions*, Issue Brief (November 23, 2009), and *Policy Options for Reducing CO_2 Emissions* (February 2008).

4. Some proposed programs would combine those approaches. For additional discussion, see Congressional Budget Office, *How Regulatory Standards Can Affect a Cap-and Trade Program for Greenhouse Gases*, Issue Brief (September 16, 2009).

5. Greenhouse gas emissions differ in the amount of global warming that they cause. Carbon dioxide equivalent indicates the amount of carbon dioxide that would have the same global warming potential as a particular greenhouse gas when measured over a specified period (generally 100 years).

such as the Environmental Protection Agency.[6] The government would distribute the allowances by selling them, giving them away, or using some combination of the two approaches.

Once the allowances were distributed, firms would be able to "trade" them, buying and selling them in a secondary market in which firms that required fewer allowances—because they could reduce their emissions relatively inexpensively—could sell their allowances to firms that had greater difficulty and costs in reducing theirs. In addition, under most proposed programs, firms could shift their use of allowances from one year to another by "banking" unused allowances for the future or, to a more limited degree, by "borrowing" allowances from future allocations. That trading and flexibility over time would allow firms to undertake emissions reductions where, how, and to some extent when it was least costly for them to do so. The firms that would need either to submit allowances or reduce their emissions to comply with the program would generally pass those compliance costs on to their customers. Thus, the prices of goods and services throughout the economy would eventually increase on the basis of the emissions associated with their production and consumption.

The price of allowances would reflect the "marginal" cost of the reductions made at any point in time to comply with the program—that is, the cost of the last metric ton of emissions to be reduced after all lower-cost options had been exhausted. Under a program that did not permit allowances to be shifted over time, firms' emissions-reducing efforts at any given point would depend on the cap for that particular year. Under a program that allowed for such shifting, firms' efforts would depend on the cumulative cap implied by the sum of the annual caps and on the relative cost of reducing emissions at different times. The price of allowances would be higher or lower depending on the chosen level of the cumulative cap; on the amount of emissions that would have occurred in the absence of the program, referred to as "baseline emissions"; and on the technologies available for reducing emissions. Baseline emissions, in turn, would depend on such factors as the level of economic activity, fluctuations in energy markets, and the weather—for example, an exceptionally hot summer would increase the demand for energy and make meeting a cap more expensive.

Factors such as baseline emissions and future technologies, which would help determine the price of allowances and thus firms' compliance costs, cannot be known with certainty when a cap-and-trade program is being designed. Consequently, the actual prices that would prevail once the program was in place might be quite different from projections of allowance prices provided by analysts before the program had begun. That intrinsic uncertainty about the price of allowances and the corresponding uncertainty about the cost of the program to businesses and, ultimately, consumers have led some policymakers to express interest in including features in a program's design to manage allowance prices—in particular, by altering the supply of allowances available to firms at various prices.

This study examines the effect that three such features—price ceilings, allowance reserves, and price floors—would be likely to have on long-term trends in emissions, the price of allowances, and firms' incentives to invest in emissions-reducing technologies. The study also addresses some of the unintended consequences that efforts to limit prices could entail. Features that set upper or lower limits on allowance prices could affect the degree of price fluctuation that occurred within those limits; however, an examination of that fluctuation is beyond the scope of this analysis.

An Overview of Cap-and-Trade Programs and Allowance Prices

Policymakers have used cap-and-trade programs to reduce several pollutants in the United States. Since 1995, for example, a federal cap-and-trade program has been operating to reduce sulfur dioxide emissions from coal-fired power plants (sulfur dioxide is a major

6. For example, many programs that have been proposed would impose a cap on large "downstream" emitters of greenhouse gases involved in the generation of electricity (such as electric utilities and large industrial emissions generators) and on "upstream" suppliers of petroleum and natural gas not used in generating electricity. (Those suppliers would be required to submit allowances on the basis of the emissions that would ultimately be released when their product was burned.) Such a system would cover more than 80 percent of all greenhouse gas emissions from the burning of fossil fuels while limiting the number of entities that would need to comply with the cap.

contributor to acid rain).[7] And since January 2009, a state-level cap-and-trade program has been reducing emissions of carbon dioxide from large power plants in 10 states in the Northeast and in the mid-Atlantic region.[8] In addition, the European Union has implemented a cap-and-trade program for greenhouse gases, the Emissions Trading System (formerly known as the Emissions Trading Scheme).

Flexibility in Reducing Emissions

In a cap-and-trade program, flexibility about where and how reductions in emissions could occur comes through the trading of allowances. Many cap-and-trade proposals would increase that flexibility by allowing regulated firms to submit "offset credits" in lieu of allowances for some of their emissions. Those credits would be created when entities (within the United States or in other countries) whose emissions would not otherwise be subject to the caps reduced those emissions in approved ways. For example, regulators might issue domestic offset credits for the carbon dioxide that would remain sequestered in the soil—rather than be released into the atmosphere—if farmers in the United States tilled the soil less when planting their crops. Similarly, they might issue international offset credits for the carbon dioxide that would remain sequestered in trees if countries agreed to limit the deforestation taking place within their borders.

Banking and borrowing provisions in a cap-and-trade program could offer firms flexibility in timing the emissions reductions they must undertake, freeing them from the obligation to reduce their emissions by just the amount necessary to meet each year's annual cap. Typically, under such provisions, a firm could bank unused allowances from a year when its compliance costs were relatively low and then use them in a relatively high-cost future year.[9] Similarly, firms could borrow allowances from future years to use when the prices of allowances were unusually high. Most cap-and-trade proposals would allow firms to bank an unlimited number of allowances but would restrict the amount of firms' borrowing.[10]

Allowing firms to bank and borrow allowances would enable them to reduce their emissions at the most cost-effective time. The costs that a firm would incur in complying with a program's specific annual caps could vary from year to year for a number of reasons—for example, severe weather in winter could increase the use of fossil fuels, and thus the amount of greenhouse gas emissions, to provide heating or cooling for households and businesses; the level of economic activity could be higher or lower than average, affecting energy use from year to year; or new technologies for reducing emissions could either become available or their commercial use could be delayed.

Permitting businesses to decide where, how, and when to reduce emissions would probably not lessen the benefits of limiting emissions of greenhouse gases. Such gases are global pollutants: A ton of emissions from any point on the globe has the same effect on the atmospheric concentration of the gases and thus causes the same amount of damage. Therefore, shifting efforts to reduce emissions from one firm to another to minimize the costs would result in the same benefits. In addition, climate change depends on the gases' buildup in the atmosphere over decades, not on the amounts emitted in a given year. So shifting efforts to reduce emissions from one year to another would probably not alter the policy's benefits,

7. Acid rain is precipitation containing harmful amounts of sulfuric and nitric acids formed primarily from sulfur dioxide and nitrogen oxides released into the atmosphere when fossil fuels are burned. It can be wet precipitation (rain, snow, or fog) or dry precipitation (absorbed gaseous and particulate matter, aerosol particles, or dust). For more information, see the discussion at www.epa.gov/acidrain.

8. Cap-and-trade programs were also used in the United States to phase out the use of leaded gasoline in the 1980s and the use of ozone-depleting chemicals (such as chlorofluorocarbons) under the Montreal Protocol (see www.epa.gov/ozone/intpol), and to reduce sulfur dioxide and nitrogen oxide emissions from sources in the Los Angeles area via the RECLAIM program (see www.aqmd.gov/reclaim/reclaim.html).

9. For a detailed description of various options for providing flexibility in timing, see Congressional Budget Office, *Policy Options for Reducing CO_2 Emissions*.

10. For example, under the American Clean Energy and Security Act of 2009 (H.R. 2454), which was passed by the House of Representatives, a firm could meet no more than 15 percent of its compliance obligation in any given year by submitting borrowed allowances. In addition, firms would not be able to borrow allowances from their allotment more than five years ahead. Under H.R. 2454, borrowed allowances would permit a firm to emit only a fraction of the greenhouse gases that would have been permitted had the allowances been used in the year for which they were issued: For example, an allowance permitting 1 ton of emissions in 2017 would permit only 0.84 tons of emissions if it was submitted to comply with the cap in 2015.

provided that the reduction in cumulative emissions was the same over the duration of the policy.

Allowance Prices

The price of allowances under a cap-and-trade program would be determined by many factors whose values would be revealed over time. As a result, the actual prices that prevailed once the program was in place could be quite different from projections of allowance prices made by analysts prior to the start of a program.

Factors Affecting Allowance Prices. The annual caps, baseline emissions, and technologies that firms had available for staying within the caps would all play an important role in determining the price of allowances. All else being equal, more-stringent caps would lead firms to deploy more-expensive emissions-reducing technologies: Businesses would use the lowest-cost methods first and move on to higher-cost approaches as needed for compliance. Consequently, more-stringent caps would lead to higher prices for allowances.

Typically, cap-and-trade programs set looser annual caps in the initial years of a program and tighter caps in later years. But if a program also included provisions that allowed firms to bank their current-year allowances for use later as well as borrow allowances from a future year's allotment, the price of an allowance at any point in time would depend less on the cap in place that year than on the *cumulative* limit on emissions over the entire policy period—that is, the sum of the annual caps. When firms are allowed to transfer allowances over time, they seek to minimize their total compliance costs over the duration of the policy by reducing emissions more when the cost of doing so is relatively low and less when the cost is high. Under such conditions, the price of an allowance at a certain time—in economic terms, the marginal cost of reductions made at that time—reflects not only the current cost of cutting emissions but also what firms expect future compliance costs to be.

Because allowances in a cap-and-trade program could be bought and sold, they would be financial assets. Entities (including firms that were subject to the caps as well as other firms that might want to trade allowances) would wish to buy or sell them depending on whether future allowance prices were expected to be higher or lower than today's prices. For example, the price of an allowance would be lower today and the effort that firms put into reducing emissions less if businesses and investors expected emissions-free nuclear energy to be cheap and widely accepted in the future. In that case, the current holders of allowances would expect future prices to be relatively low, and firms would tend to defer reducing their emissions. If, however, new information indicated that nuclear power was unlikely to be widely available—for example, if an accident occurred at an existing nuclear plant—the price of allowances could take a sharp jump because firms would no longer expect to minimize their compliance costs by waiting to reduce their emissions. In those circumstances, firms that held allowances could expect to sell them at a higher price in the future—reflecting the higher future compliance costs—so they would demand a higher price for them today. As a result, the allowances' anticipated price path would shift upward; that is, both the current price of allowances and expectations about prices in the future would rise.

Moreover, active trading would result in the constant updating of those expectations. In some cases, new information could lead to large shifts in prices, which could produce sizable changes in firms' compliance costs. However, those shifts could also motivate firms to undertake actions that would minimize their total costs for complying with the cumulative cap over the life of the program. For example, an increase in the current price of allowances, reflecting expectations of higher prices in the future, would motivate firms to invest more in developing new lower-cost technologies for reducing emissions and to spend more on emissions-reducing capital equipment in the near term in order to cut their compliance costs in the future.

Although information about current and future conditions affecting the cost of meeting a cap would help determine the *level* of allowance prices at a given time, other market conditions would determine the *rate* at which prices rose over time.[11] Because allowances are financial assets, firms would bank and borrow them up to the point at which the return they expected to receive on them from increases in their price equaled the return they

11. Estimates of the growth in allowance prices over time are strongly affected by different assumptions about how firms that are subject to a cap would take advantage of banking opportunities. See Congressional Budget Office, *The Costs of Reducing Greenhouse-Gas Emissions*; and Congressional Research Service, *Climate Change: Costs and Benefits of the Cap-and-Trade Provisions of H.R. 2454*, CRS Report for Congress R40809 (September 14, 2009).

Figure 1.

The Daily Price of Selected Allowances Under the European Union's Emissions Trading System

(Nominal dollars)

Sources: Congressional Budget Office based on data from IHS Cambridge Energy Research Associates.

Note: Data are plotted daily from April 19, 2005, through August 2, 2010. They reflect the average daily closing price of December futures contracts for allowances that are eligible for compliance in phase II (covering 2008 to 2012) of the European Union's Emissions Trading System, a multinational cap-and-trade program to reduce carbon dioxide emissions from large businesses. (A December futures contract for allowances is an agreement to exchange a fixed number of allowances in December of the specified year at an agreed-upon price.)

could receive on a comparable investment—that is, one carrying a similar risk of loss. For example, if a firm judged that the price of an allowance would rise faster than the rate of return on that comparable investment, it would want to bank more rather than fewer allowances. That tendency would slow the rate at which allowance prices rose: It would increase the demand for and thus the price of allowances in the current year and then increase their supply and decrease their price in the future, when the banked allowances were sold or used. Consequently, the price of allowances would be expected to increase at roughly the same pace as the rate of return on comparable investments.

Allowance prices in a U.S. cap-and-trade program would also be affected by events outside the United States. For example, if other countries implemented cap-and-trade programs and allowed their firms to comply with a cap by purchasing international offset credits, fewer credits would be available to U.S. companies, and their price would go up. Constraints on the ability of U.S. firms to comply with emissions limits by using low-cost offset credits would result in higher allowance prices in a domestic cap-and-trade program.

The Variability of Allowance Prices. Prices would undoubtedly fluctuate as conditions changed and as new information about factors affecting compliance costs—such as technological developments—became available. It is difficult to extrapolate from the allowance price paths of existing domestic and international cap-and-trade programs to an economywide program for greenhouse gas emissions in the United States. Nevertheless, it is revealing that existing programs, such as the European Union's Emissions Trading System, have experienced continually changing prices (see Figure 1).

Ups and downs in allowance prices may stem from transitory factors as well as from changing expectations about factors affecting long-run costs, including the possibility of alterations in the stringency of a program's caps. (For example, in the case of the U.S. Acid Rain Program, a spike in allowance prices in 2005 was due at least in part to the fact that policymakers were considering tightening the caps.) A U.S. cap-and-trade program for greenhouse gases could see substantial fluctuations in the price of allowances, particularly in the program's early years, because firms would be uncertain about the operation of the allowance market and would not as yet have had a

chance to build up a bank of allowances (if the program allowed it).

Rationales for Managing Allowance Prices

The price of allowances under a cap-and-trade program could be much higher or lower than policymakers had anticipated when they decided how stringent to make the caps. As a result, the costs that firms would face in complying with the caps could exceed those that policymakers had considered acceptable when they chose those limits—a decision that entailed trade-offs between anticipated costs and benefits.

Prices that were higher than anticipated would impose larger costs on firms that had to comply with the policy as well as on U.S. households, which would pay higher prices for the goods and services they purchased. In addition, higher allowance prices could lead to greater-than-expected reductions in profits and employment in emissions-intensive industries whose products faced foreign competition—especially competition from firms in countries without limits on emissions. If the policy's substantially larger costs in those circumstances exceeded what policymakers had originally considered acceptable, given their view of the benefits of reducing emissions, the caps would end up being more stringent than lawmakers would have chosen if more accurate cost information had been available.

In contrast, allowance prices that were lower than anticipated, particularly in the early years of a program, could fail to motivate firms in the near term to invest in equipment or new lower-cost technologies for reducing emissions. That lack of investment would in turn increase firms' costs for complying with limits on emissions in the future. Moreover, if the costs of complying with the policy were substantially less than policymakers had anticipated when they designed the policy, those unexpectedly low costs might make them wish they had chosen tighter caps, which would be more expensive to meet but might be justified by their benefits.

Managing Allowance Prices with a Price Ceiling, an Allowance Reserve, or a Price Floor

Most of the recent legislative proposals for cap-and-trade programs have included features to manage allowance prices (see Box 1). CBO examined the effects of three of those mechanisms on prices and emissions: a *price ceiling,* which would be implemented by adding an unlimited number of allowances at a given price to the initial supply; an *allowance reserve,* in which a limited number of additional allowances would be offered for sale to firms at or above a given price; and a *price floor,* which would be implemented by decreasing the number of available allowances at a given time to maintain a lower bound on prices. In part, those features are attempts to manage allowance prices—and in turn firms' compliance costs—when actual prices vary from the projections made prior to a program's start.

In its analysis, CBO used a simplified cap-and-trade system as a basis for assessing the effects of alternative price management features. That illustrative program is similar to some proposed systems but does not reflect the full details of any of them. Specifically, the hypothetical program used for this analysis would:

- Cap cumulative greenhouse gases from large emitters throughout the United States over the 2012–2050 period, reducing their emissions from a baseline level of 245 billion metric tons to 130 billion metric tons,
- Allocate allowances to firms through an auction or at no charge,
- Permit firms to borrow a limited number of allowances for current use and bank an unlimited number for future use, and
- Allow firms to purchase up to 1.5 billion domestic or international offset credits annually instead of reducing their emissions or using allowances for that part of their compliance obligation.

Under a program with those features and using available information and current estimates about the many factors that would affect allowance prices, CBO estimated that the nominal price of allowances in 2012 would be $17. It also estimated that prices would increase through 2050 at a real (inflation-adjusted) annual rate of 5.6 percent, the rate of return firms might expect to receive on an investment with a similar risk of loss.

Taking that simplified cap-and-trade program as a starting point, CBO examined the effects that various designs of a price ceiling or an allowance reserve might have if the price of the allowances necessary to comply with the

Box 1.

Recent Legislative Approaches to Managing Allowance Prices

Several recent proposals have included features that would help manage allowance prices in a cap-and-trade program by altering the supply of allowances available at various prices.

- The Low Carbon Economy Act of 2007 (S. 1766) and the Carbon Limits and Energy for America's Renewal, or CLEAR, Act of 2009 (S. 2877) would allow firms to purchase an unlimited number of additional allowances at a predetermined price (called a "Technology Accelerator Payment" under the Low Carbon Economy Act and a "safety valve" price under the CLEAR Act) that would rise over time and serve as a ceiling on prices. In addition, the CLEAR Act would establish a price floor to prevent allowances from being purchased below a given price in the auctions held by the government to sell the allowances. Further, those allowances that consequently were withheld from the overall supply available under the cap would not be offered to firms in subsequent auctions. The Low Carbon Economy Act did not include a price floor.

- America's Climate Security Act of 2007 (S. 2191) would have established a "Carbon Market Efficiency Board" that could, among other things, have increased the total number of allowances available in a particular year by reallocating allowances from future years to the present. However, the board would not have been permitted to increase the number of allowances available over the entire policy period. S. 2191 did not include a price floor.

- The American Clean Energy and Security Act of 2009 (H.R. 2454), the Clean Energy Jobs and American Power Act (S. 1733), and the American Power Act of 2010 (APA) would each create, at the onset of the policy, a reserve of allowances taken from future allocations. H.R. 2454 and S. 1733 would permit firms to purchase allowances from the reserve at or above a specified minimum price. In contrast, APA would permit firms to purchase a limited number of allowances from the reserve each year at a fixed price; the number they could purchase would depend on their emissions. Under all three bills, allowances that were not purchased from the reserve while the policy was in effect would go unused, and regulators could replenish the reserve by purchasing offset credits (issued for reductions in greenhouse gases made outside sectors of the economy that were covered by the cap). H.R. 2454 and S. 1733 would require regulators to replenish the reserve with international offset credits; APA would allow them to use domestic offset credits if international credits were not available. All three bills would establish a price floor by withholding allowances that the government would have auctioned had their price not fallen below a given amount. Those allowances would then be placed in the reserve.

program's cap was twice as high as had been initially projected.[12] In that high-price example, the price of allowances would begin at $34 rather than at $17 and rise at a real annual rate of 5.6 percent. In addition, CBO considered the effects that a price floor might have if allowance prices were lower than anticipated.

A Price Ceiling

A price ceiling would set an upper limit on the price of allowances in a cap-and-trade program. Policymakers could establish a ceiling by requiring the government to offer to sell an unlimited number of additional allowances at a predetermined price that would typically increase each year. Because firms would always have the option of purchasing allowances at that price, the ceiling

12. Specifically, for its high-price example, CBO assumed that emissions would be 20 percent higher than in the base case, that only 1.25 billion offset credits would ultimately be available to firms, and that the reduction in emissions caused by a 10 percent increase in the price of allowances would be 20 percent less than in the base case.

would set an upper bound on the cost per metric ton of reducing emissions and on the price at which allowances would trade. If firms could cut their emissions at a cost that was less than the ceiling price, they would choose to do so; if the cost for cutting their emissions was greater than the ceiling price, firms would choose to purchase additional allowances from the government at the ceiling price.

In choosing the ceiling price, policymakers would have to balance the goals of not exceeding the cap on emissions and limiting firms' costs for complying with the cap. A lower ceiling price would offer firms greater protection from higher-than-anticipated costs, which in turn would lower the program's overall cost to the economy. But the lower price would also increase the likelihood that emissions would exceed the cap, because policymakers could not know at the time they designed the policy how many additional emissions the ceiling would allow.

Policymakers could reduce the likelihood that the price ceiling provision would be triggered (causing firms to buy additional allowances and emissions to exceed the cap) by setting the ceiling price well above the annual prices projected for allowances when the program was established.[13] For example, if the actual price of allowances in 2012 was $34—and not $17, as initially projected for CBO's hypothetical program—and policymakers had set the ceiling price for that year at $40, firms would generally choose not to purchase any additional allowances (see the far-right column in Figure 2). In that case, the price of allowances and the number of emissions would be the same as they would have been under a program with the same cap but no price ceiling (see the far-left column in Figure 2).

Alternatively, if policymakers had set the initial ceiling price at $20 or $30, firms would probably purchase additional allowances from the government at the ceiling price. All else being equal, firms would wish to purchase more additional allowances at a ceiling price of $20 than at a ceiling price of $30 (see the middle two columns in Figure 2). CBO estimated that under the parameters of its high-price example, a ceiling price of $20 (rising in subsequent years at a real annual rate of 5.6 percent) would result in the issuance of 32 billion additional allowances and therefore 32 billion additional tons of emissions—25 percent more than would have been emitted in the absence of the price ceiling—over the lifetime of the program. In contrast, an initial ceiling price of $30 would lead to the issuance of 6 billion additional allowances, for a 5 percent increase in emissions.

By curbing increases but not decreases in the future price of allowances, a price ceiling could also dampen current prices even if it was not currently binding. In general, the value that firms attached to an allowance—that is, its market price—would depend on the price at which they expected to be able to sell it in the future: The higher firms expected future prices to be, the more they would pay for an allowance today. Thus, firms would be willing to pay less for an allowance today if they knew that the price ceiling would curb any *increase* in the future price that could result from, say, an extraordinarily hot summer but not any *decrease* in price that could result from an extraordinarily mild one. That price dampening would be most likely when the market price of allowances was near the ceiling price.[14]

Any lowering of allowance prices would be likely to weaken firms' incentives, relative to a cap-and-trade program with the same cap and no price ceiling, to develop new technologies for reducing emissions. Prices could be lower than would otherwise be the case either because the ceiling became binding or because the ceiling dampened prices as the market price approached the ceiling. The expectation of lower allowance prices stemming from the price ceiling would reduce the profits anticipated from developing such technologies, which in turn would tend to curtail investment in them.

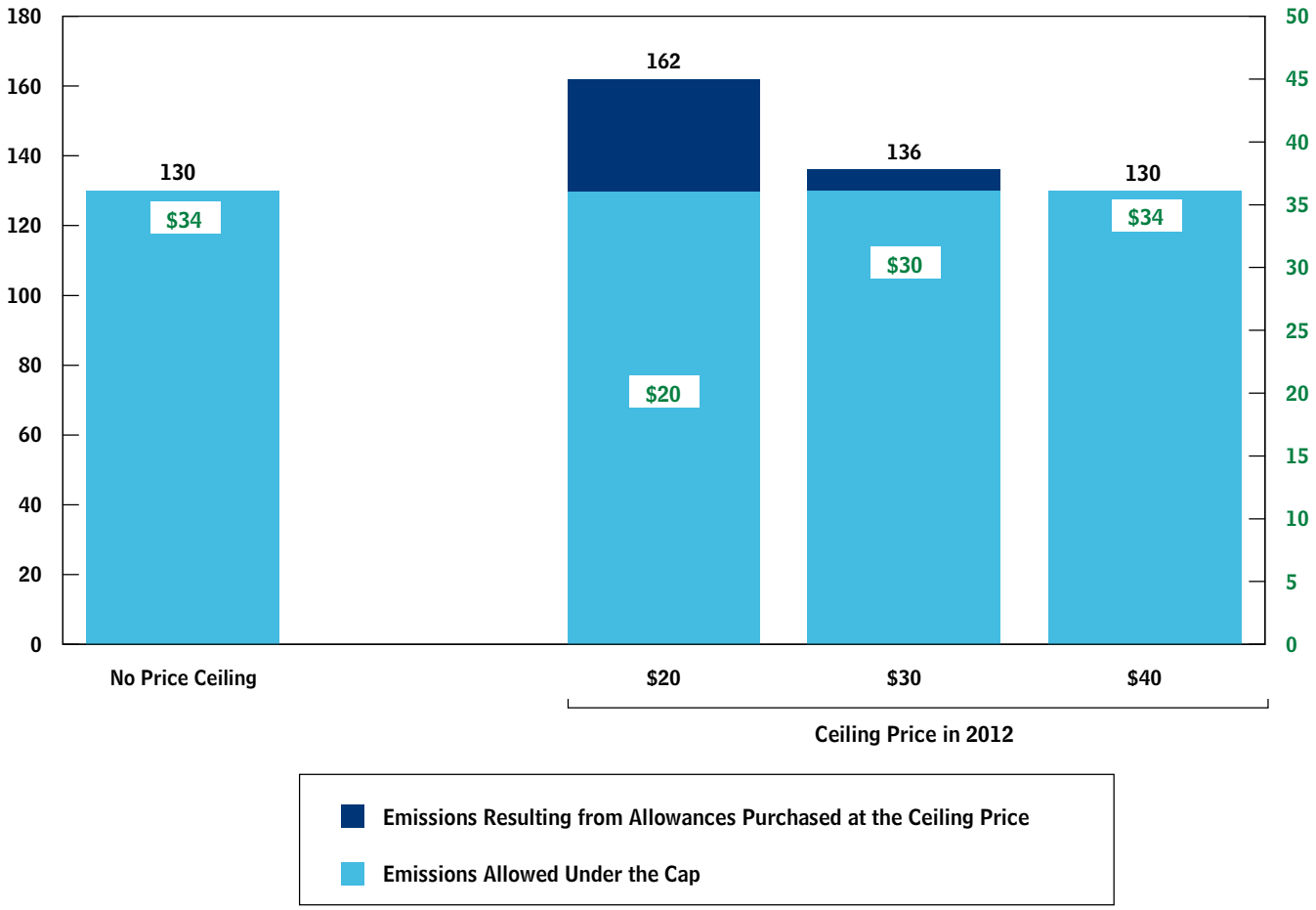
However, firms' incentives to develop new technologies could also be weakened by uncertainty about the future of the policy, which could be affected by the presence or absence of a price ceiling. With no limit in place, the price of allowances might rise so high that pressures would build to loosen the cap on emissions or repeal the policy, which would lead to a subsequent drop in prices.

13. For example, Robert Stavins ("A Meaningful U.S. Cap-and-Trade System to Address Climate Change," *Harvard Environmental Law Review,* vol. 32, no. 2, 2008, pp. 293–371) suggests that the ceiling should be set at the highest amount that society is willing to bear to achieve reductions. Such a ceiling would prevent reductions in emissions that were unexpectedly—and unacceptably—costly to achieve.

14. For a related discussion, see Dallas Burtraw, Karen Palmer, and Danny Kahn, *A Symmetric Safety Valve*, RFF DP 09-06 (Washington, D.C.: Resources for the Future, February 2009).

Figure 2.

Greenhouse Gas Emissions and Allowance Prices Under Various Price Ceilings in a Cap-and-Trade Program



Source: Congressional Budget Office.

Note: Each bar in the chart except the one farthest to the left corresponds to a different price ceiling in 2012; for this analysis, ceiling prices were assumed to grow at a real (inflation-adjusted) annual rate of 5.6 percent. The height of a bar shows the amount of emissions over the 2012–2050 period under that price ceiling, and the box within each bar shows CBO's estimate of the market price of allowances in 2012. That price was also assumed to grow at a real annual rate of 5.6 percent.

The existence of a ceiling, by contrast, could make firms more certain that the cap would be sustained, which would maintain their expectations about prices as well as their incentives to invest in low-carbon and energy-efficient technologies.

An Allowance Reserve

Policymakers could curb rather than eliminate increases (beyond a given level) in the price of allowances by providing a "reserve" of additional allowances that firms could draw on. The reserve would contain a set number of allowances; thus, unlike a program with a price ceiling, a program with a reserve would impose a fixed limit on emissions over the life of the program. Potential methods for distributing the allowances held in a reserve would include auctioning them at or above a specified minimum price or giving each firm required to comply with the program the option of purchasing a limited number of allowances at a fixed price.

Establishing the Reserve. A cap-and-trade program with a reserve would establish a limit on emissions, but that

Table 1.

Allowance Prices and Emissions Under a Cap-and-Trade Program with an Allowance Reserve Relative to a Program with the Same Cap but No Reserve

Source of Reserve Allowances	Prices		Emissions	
	Reserve Is Used	Reserve Is Not Used	Reserve Is Used	Reserve Is Not Used
Supplemental to the Cap	Lower	Same	Higher	Same
Withheld from the Cap	Same	Higher	Same	Lower

Source: Congressional Budget Office.

limit could exceed the program's cumulative cap. The manner in which the reserve was stocked—either by boosting the number of available allowances above the number specified by the cap or by setting aside, or "withholding," a portion of the allowances that the cap already included—would determine whether the use of the allowances would cause emissions to exceed the cap.

- Using allowances purchased from a reserve that added to those already counted under a cap—called here a supplemental-allowance reserve—would permit emissions to exceed the cap, thus allowing greater environmental damage; that approach would also lower allowance prices compared with the prices that would result with the same cap in place but no reserve (see Table 1).

- Using allowances purchased from what is referred to here as a withheld-allowance reserve would not cause emissions to exceed the cap. If firms did *not* purchase allowances from such a reserve—for example, because the market price for allowances remained below the minimum price at which firms could bid on the reserve's allowances—the establishment of the reserve would increase firms' compliance costs and the price of allowances because it would effectively remove allowances from the system. However, relative to a program with the same cap but no reserve, a policy that included a withheld-allowance reserve would tend to reduce emissions, further lessening damage to the environment.

Despite the two approaches' differing implications for allowance prices and emissions *relative to programs with no reserve*, policymakers could design a program so that either approach would result in the same allowance prices and the same emissions. For example:

- Policymakers could set the cap on cumulative emissions over the policy's duration at 130 billion metric tons and allow regulators to issue 15 billion additional (supplemental) allowances. If firms used all of those additional allowances, emissions would rise to 145 billion metric tons and exceed the cap, but the costs of complying with the program would be lower than would otherwise be the case—because the additional allowances would help lower allowance prices. Using none of the reserve allowances would result in 130 billion metric tons of emissions.

- Alternatively, policymakers could limit cumulative emissions over the course of the policy to 145 billion metric tons and withhold 15 billion allowances—place them in a reserve at the outset of the program. Using the full reserve would result in 145 billion metric tons of emissions, but the cap would not be exceeded. Using none of the reserve allowances would result in 130 billion metric tons of emissions, an amount well below the cap; however, that reduction would be more costly to achieve than if all of the allowances—representing the full 145 billion tons of emissions—had been distributed.

The final outcomes of both approaches for the environment and the economy would be the same, even though the implications for meeting the cap would be different: The first approach would have a lower initial cap that could be exceeded, whereas the second approach would involve a higher initial cap that could not be exceeded.[15]

15. Among the legislative proposals described in Box 1 on page 7, those that feature a reserve—H.R. 2454, S. 1733, and the American Power Act of 2010—define the cap as including the allowances that are placed in the reserve.

Distributing Reserve Allowances. Of the two potential methods that CBO examined for distributing the allowances—auctioning them at or above a specified minimum price (referred to here as the reserve "access" price) or giving each firm required to comply with the cap-and-trade program the option of purchasing a limited number of allowances at a fixed price—neither would set an upper limit on the market price of allowances. Depending on conditions in the market, the price of allowances could be either higher or lower than the access price at which firms could bid on the reserve allowances or the fixed price at which they could purchase a limited number of them.

The market price of allowances and the broad economic costs of the program would generally be the same regardless of the method chosen for distributing the reserve allowances: Those price and cost outcomes would reflect the total supply of allowances available over the course of the policy, including those in the reserve. (As discussed later, that conclusion would not hold if the reserve allowances were distributed in a manner that weakened firms' incentives to reduce their emissions.) However, in contrast to the method's effect on prices and economic costs, the way policymakers chose to distribute the reserve allowances would determine which entities—the government or various private firms—could garner the reserve allowances' value. Selling them in an auction or giving firms the option to purchase them at a fixed price would lead to different outcomes.

Selling the reserve allowances in an auction would allow the federal government to reap their full market value. Lawmakers could specify a minimum price that firms had to pay for the allowances—for example, firms could purchase allowances only at or above a price of $30. That minimum price would not necessarily be the price that firms would actually pay for the allowances when they first got them from the government or the price at which the allowances would trade in the secondary market. If the number of allowances that firms wanted to purchase at the access price exceeded the number of allowances available from the reserve, the auction price of the reserve allowances would increase until the number of allowances that firms wanted to buy at the auction price was equal to the number of available reserve allowances.

In contrast, distributing reserve allowances by offering firms options to purchase them at a fixed price would mean that the government and firms would share the allowances' value. Under that distribution method, firms that received the options could profit from them by selling the allowances in the secondary market at a higher price. Policymakers would determine which firms could receive those profits when they decided how to distribute the options.

Yet another consideration in choosing a distribution method is how it might distort firms' decisions about how much to reduce their emissions. Firms would have less of an incentive to reduce emissions if the reductions decreased the number of allowance-purchasing options they received. To keep that from happening, policymakers would have to use a strategy that was not tied to firms' emissions under the program. For example, lawmakers could base the number of options that each firm received on the firm's emissions during a year well before the time of the program's design. Under that kind of policy, firms would not have an incentive to increase their emissions in order to receive more allowances.

Restocking the Reserve. Policymakers could expand the reserve by directing regulators to replenish it over time, which would allow more allowances to be sold from the reserve than the number initially placed in it. For example, policymakers could specify that 2 billion allowances be placed in the reserve. But provided that the reserve could be replenished, regulators could eventually sell substantially more than 2 billion allowances from it over the course of the policy.

To date, cap-and-trade proposals that allow restocking would direct the government to replenish the reserve as follows: Regulators would purchase offset credits with the revenue raised by selling the reserve allowances, increase the number of allowances in the reserve according to the number of credits purchased, and then retire the credits.[16] Restocking the reserve in that manner would make the reserve's ultimate size uncertain because the amount of restocking that occurred would depend on the availability of the credits. If credits proved scarce, regulators might be unable to sell the full number of allowances from the reserve that legislators had authorized them to sell.

16. That approach was included in the provisions of H.R. 2454, S. 1733, and the American Power Act of 2010 (APA). Under H.R. 2454, the number of allowances that regulators could sell over the course of the program would exceed the number originally placed in the reserve by 12 billion, or roughly 9 percent of the total cap. Under S. 1733, that excess would be 30 billion, or roughly 23 percent of the total cap; under APA, it would be 17 billion, or roughly 12 percent of the cap.

Directing regulators to purchase offset credits for restocking would be most likely to lower firms' compliance costs and, as a result, reduce the price of allowances (because more would be available) if one of the following conditions applied:

- A large supply of low-cost offset credits was available, but firms purchased only some of them because of constraints on the number they could submit to comply with the cap; or
- Regulators could purchase offset credits from a pool that individual firms did not have access to—for example, a pool of credits that did not meet the standards applied to credits purchased by firms for compliance purposes.

Under other conditions, the use of offset credits for restocking a reserve would probably not lower firms' compliance costs and the price of allowances. For example, if offset credits were costly for both firms and regulators to obtain, regulators might be able to purchase only a few credits with the revenue from selling the reserve allowances.[17] Further, if regulators were trying to purchase offset credits from the same limited supply that private firms were attempting to access, then regulators' purchases could drive up the prices of the credits for those firms.

If regulators could restock the reserve by purchasing offset credits that would not otherwise be purchased by firms needing to comply with the cap, the fraction of the cap that represented the use of offsets would increase. That would then boost the extent to which compliance with the cap relied on reductions in emissions that were made outside the capped sector of the economy and that might be more difficult to verify than reductions from sources whose emissions were subject to the cap.[18] Some observers are concerned that such increased reliance on offsets could undermine the program's environmental goals and lessen the credibility of the cap.[19]

17. See Harrison Fell and others, *Soft and Hard Price Collars in a Cap-and-Trade System: A Comparative Analysis*, RFF DP 10-27 (Washington, D.C.: Resources for the Future, April 2010).

Illustrative Example of the Effects of a Reserve. CBO used its high-cost scenario to estimate the effects that reserves of varying sizes and differing access prices would have on emissions and allowance prices. Under that scenario, the initial price of allowances (with no reserve) would be $34 rather than $17, the projected price in CBO's base-case program, and the cost of complying with an emissions cap of 130 billion metric tons over a four-decade period would be roughly twice as great as policymakers had anticipated at the time they established the cap.

All else being equal, the higher the access price that would permit firms to purchase the reserve allowances, the smaller would be the likelihood that they would make such purchases. For example, if the access price for a supplemental-allowance reserve was $40 in 2012 (rising in subsequent years at a real annual rate of 5.6 percent), firms would not demand any reserve allowances because the price at which they could buy them would exceed the $34 market price (see Figure 3). In contrast, if the initial access price was either $20 or $30, firms would bid at the reserve auction and purchase enough allowances to clear the market—that is, they would bid the price up to the point where the demand for allowances at that price was equal to their supply. If a supplemental-allowance reserve held 5 billion allowances and they were all made available, the expected price of allowances in 2012 would drop to $31—but the added reserve allowances would also allow total emissions of 135 billion metric tons over the 2012–2050 period (versus 130 billion tons under a program with no reserve). The access price would be neither a price ceiling nor a price floor: The market price of allowances could be higher than the access price, as would be the case for the reserve with a $20 or $30 access price, or the market price could be lower, which would be the

18. For example, under H.R. 2454, if firms submitted the maximum number of offset credits allowed and if restocking enabled firms to purchase the full number of reserve allowances that regulators were permitted to sell each year, up to 74 percent of the reductions in emissions that the act would require could be achieved, in CBO's estimation, through reductions made by sources not covered by the cap-and-trade program.

19. For a discussion of the potential cost savings and challenges associated with using offset credits, see Congressional Budget Office, *The Use of Offsets to Reduce Greenhouse Gases,* Issue Brief (August 3, 2009).

Figure 3.

Greenhouse Gas Emissions and Allowance Prices Under Various Designs of a Supplemental-Allowance Reserve in a Cap-and-Trade Program

Source: Congressional Budget Office.

Notes: A supplemental-allowance reserve would increase the number of allowances available under the cap. Firms would have the option of purchasing the reserve allowances at or above a specified minimum price—referred to here as the reserve "access" price—that would be determined by law.

Each bar in the chart except the one farthest to the left corresponds to a unique combination of allowance reserve size and access price in 2012; for this analysis, access prices were assumed to grow at a real (inflation-adjusted) annual rate of 5.6 percent. The height of a bar shows the amount of emissions over the 2012–2050 period under that combination, and the box within each bar shows CBO's estimate of the market price of allowances in 2012. That price was also assumed to grow at a real annual rate of 5.6 percent.

case with the same sized reserve but an access price of $40.

Increasing the size of the reserve, all else being equal, would lessen the likelihood that the market price would exceed the access price, but it would also permit more emissions. For example, if the supplemental-allowance reserve was increased from 5 billion to 15 billion allowances and firms could purchase reserve allowances at or above an initial access price of $20, they would find it cost-effective to purchase all of those allowances.[20] The additional 10 billion allowances from the larger reserve would further dampen the price of allowances—in 2012, it would be $5 lower ($26 rather than $31, as under a 5billion-allowance reserve)—but emissions over the life of the policy would increase by 10 billion metric tons. Total emissions from 2012 through 2050 would be 145 billion metric tons if that larger reserve was in place, compared with 135 billion metric tons with the smaller reserve.

By adding to the supply of allowances, a supplemental-allowance reserve would tend to push down prices even when the market price was below the access price. Like a price ceiling, the reserve would dampen increases but not decreases in allowance prices, and that asymmetry would result in a downward adjustment in expected prices. Once the reserve was (or was expected to be) depleted, actual prices would be somewhat lower than they would have been in the absence of the reserve; however, no further price dampening would occur because firms would have incorporated the entire supply of reserve allowances into their expectations about prices and no additional reserve allowances would be available.

Creating a reserve by withholding allowances from the supply already designated under the cap would yield a different outcome: It would tend to increase the allowances' expected prices and lower expected emissions relative to a policy with the same cap but no reserve. In CBO's high-cost scenario, for example, creating a reserve of 5 billion allowances by withholding those allowances (rather than adding 5 billion to the number of allowances corresponding to the cap) would increase the price of allowances in 2012 from $34 to $38 and reduce emissions under the program from 130 billion to 125 billion metric tons if the access price was set at $40 (rising in subsequent years at a real annual rate of 5.6 percent; see Figure 4). In that instance, firms would not find it cost-effective to purchase any of the reserve allowances. Alternatively, if the initial access price was $20 or $30 and the allowance price in 2012 was $34, firms would consider it cost-effective to purchase all of the reserve allowances. Under those lower access prices, allowance prices and emissions would be the same as they would have been if none of the 130 billion allowances created with the cap had been withheld for a reserve.

All else being equal, if policymakers increased the size of a reserve composed of withheld allowances, the allowances' expected price would tend to increase, because firms would have fewer allowances available to them below the access price. For example, if the cap was 130 billion metric tons and the size of the reserve increased to 15 billion allowances, firms would have access to only 115 billion allowances at less than the access price; consequently, they would be willing to pay a higher price to acquire the reserve allowances. In the example here, firms would purchase 7 billion of the 15 billion reserve allowances if the initial access price was set at $40, CBO estimates.

A Price Floor

If policymakers were concerned that allowance prices might turn out to be lower than anticipated, thus diminishing firms' incentives to reduce emissions, they might choose to establish a floor—that is, a lower bound—on allowance prices. A floor, which could be implemented on its own or in conjunction with a price ceiling or an allowance reserve, could take two possible forms. Policymakers could establish a *hard price floor* for the market price of allowances by agreeing to purchase them from firms at a predetermined price. Those purchased allowances would then be effectively removed from the supply represented by the cap. Alternatively, the government could attempt to establish a lower bound on prices by selling some or all of the allowances created by the cap in an auction and withholding allowances from that auction

20. Firms that expected the reserve to be exhausted would have an incentive to purchase allowances at the access price and either use them in the current period or bank them for future use. Firms would also have an incentive to purchase as many of the reserve allowances as were available if they expected the price of allowances to rise above the access price in the future and the reserve to be rapidly depleted. Such purchases would be a natural consequence of the limited number of allowances in the reserve, the initial supply of allowances, and the expected demand for allowances in the future. See Stephen Salant, "The Vulnerability of Price Stabilization Schemes to Speculative Attack," *Journal of Political Economy,* vol. 91, no. 1 (February 1983), pp. 1–38.

Figure 4.

Greenhouse Gas Emissions and Allowance Prices Under Various Designs of a Withheld-Allowance Reserve in a Cap-and-Trade Program

Source: Congressional Budget Office.

Notes: A withheld-allowance reserve would decrease the number of allowances available under the program if the reserve was not used. Firms would have the option of purchasing the reserve allowances at or above a specified minimum price—referred to here as the reserve "access" price—that would be determined by law.

Each bar in the chart except the one farthest to the left corresponds to a unique combination of allowance reserve size and access price in 2012; for this analysis, access prices were assumed to grow at a real (inflation-adjusted) annual rate of 5.6 percent. The height of a bar shows the amount of emissions over the 2012–2050 period under that combination, and the box within each bar shows CBO's estimate of the market price of allowances in 2012. That price was also assumed to grow at a real annual rate of 5.6 percent.

if the price fell below a certain amount—that is, below a *minimum bid price*.

When allowance prices under a cap-and-trade program were lower than policymakers had anticipated in establishing the program, the presence or absence of a price floor could affect the incentives firms would have to reduce emissions and the actions they would undertake. If a binding price floor was in effect, it would boost allowance prices, causing firms to reduce emissions more than would otherwise be the case and providing a greater incentive for firms to invest in emissions-reducing capital equipment. But if the program permitted banking, a binding price floor in one period would probably not lead to greater reductions in emissions over the duration of the policy: The floor would tend to just shift those reductions forward in time. Whether the price floor came

into play would depend on the costs firms faced in complying with the cap and the floor price itself. The more costly that reductions in emissions were—that is, the higher the market price of allowances—and the lower the floor price, the less likely it would be that conditions would warrant the floor's taking effect.

Unless otherwise noted, the discussion that follows uses the term "price floor" to cover a hard price floor and a minimum bid price, both of which CBO assumed would rise over time. A further assumption is that the minimum bid price would effectively establish a lower bound on the price of allowances. (Circumstances in which a minimum bid price would not serve as an effective lower bound on the price of allowances sold in the market are discussed at the end of this section.) The effects of both limits are assessed relative to the outcomes of a program with the same cap but no floor.

Effects on Prices. If a price floor took effect, the price of allowances would be higher than would otherwise be the case during the time that the floor was binding. Moreover, even when the market price of allowances was higher than the floor price, a floor would tend to increase the market price and slow the pace at which that price rose over time.

Both of those effects stem from a price floor's tendency to strengthen the incentives firms have to bank allowances. CBO assumed that under a program with no price floor—that is, one in which the price of an allowance could fall to zero—firms would be willing to bank allowances only if they expected to receive a return on them of at least 5.6 percent. Thus, without a price floor, a firm would be willing to purchase an allowance, say, at $10, bank it, and sell it the next year only if the firm expected the price of allowances in that next year to be at least $10.56, or 5.6 percent more. But the price of allowances would be uncertain, so the presence of the price floor would generally reduce the risk of loss associated with banking allowances by guaranteeing firms a certain minimum return from selling what they had banked. For example, if a firm bought an allowance at a floor price of $10 and the floor price was scheduled to increase at an annual rate of 3 percent, the firm would not run the risk of having to sell it for less than $10.30 the next year.

Because the price floor would reduce the risk of banking allowances, it would in turn increase the demand for allowances and thus their price. Moreover, a floor would lead firms to require a lower rate of return on banked allowances (because of less risk), which would slow the pace of increases in allowance prices. The faster the pace at which the price floor rose, the more that it would boost the demand for allowances in the current period—because firms could bank them and sell them at a higher guaranteed minimum price in a future period—and thus the more it would drive up the current price of allowances. The tendency of a floor to boost near-term prices would be lessened if the government made the allowances that were removed from the market (in establishing the price floor) available to firms in the future.[21]

In the near term, a price floor would increase firms' costs for complying with the cap because it would lead to higher allowance prices. However, those higher prices would also increase firms' incentives to install emissions-reducing capital equipment and develop new technologies for reducing emissions, both of which would tend to lower compliance costs in the future. A floor would have the opposite effect of a price ceiling or an allowance reserve in that regard: Whereas a ceiling or reserve would tend to lower near-term prices and reduce incentives to invest in new technologies, a floor would tend to raise near-term prices and boost incentives.

Effects on Emissions. If a program permitted firms to bank allowances, the triggering of a price floor would probably not reduce the number of allowances that firms purchased—and the amount of greenhouse gases they emitted—over the course of the policy. A floor would cause firms to undertake more emissions reductions (compared with the results from the same policy with no price floor) in a year in which the floor was binding. However, because a floor would decrease the risk associated with banking, it would increase firms' incentives to bank allowances for future use or sale. If firms chose to acquire allowances at the floor price and bank them, the additional reductions in emissions when the floor was in effect would be offset by a corresponding increase in emissions when firms submitted the banked allowances for compliance in future years.

21. H.R. 2454, S. 1733, and the American Power Act of 2010—but not the Carbon Limits and Energy for America's Renewal, or CLEAR, Act of 2009—would make allowances that were not sold in the government-run auctions available to firms in future periods by adding them to the reserve that each of those proposals includes.

The likelihood that firms would engage in such behavior would be substantial because allowances purchased at the floor price would be relatively safe investments: Firms would know that they could sell them in the future at tomorrow's floor price (which generally would rise over time), but they would also know that if the market price rose above the floor price, they could sell them at an even higher price. Firms would have an incentive to bank any allowances they purchased at the floor price unless they did not expect the government to maintain the price floor in the future (see the discussion below) or unless the market price was below the floor price during the program's final compliance period. In the latter case, firms would sell allowances to the government at the floor price if a hard price floor was in effect or decline to purchase allowances below the floor price in any government-run auctions held in that final period.

In contrast, if firms did not have the option of banking allowances, the triggering of a price floor would lead to fewer emissions over the duration of the policy. The floor would boost the price of allowances, which would cause firms to undertake more emissions reductions—more, that is, up to the point at which the marginal cost of achieving them was equal to the floor price. However, the additional reductions undertaken when the floor was in effect could not then be used to permit more emissions in future compliance periods.

Implementing an Effective Price Floor. The government would be more certain of setting an effective floor for the market price of allowances if it agreed to buy them at a given price—establishing a hard price floor—than if it withheld allowances from the government-run auction when bids fell below that price. In particular, the latter approach would be ineffective if conditions in the allowance market caused firms to choose not to purchase any allowances from the government when the auction's minimum bid price was in effect.[22] For example, the government could not maintain a price floor if it sold only 10 percent of the supply of allowances in its auctions and the market price for the remaining 90 percent was less than the minimum bid price in those auctions.

The credibility and effectiveness of a hard price floor would depend on the strength of the government's commitment to purchase allowances—those that firms had banked, for example—at the floor price. The government could face a substantial financial obligation if market conditions caused firms to decide to sell large quantities of banked allowances to the government at the floor price. Moreover, if firms anticipated that the government at some point would be unable or unwilling to support the price floor, they would tend to sell their allowances sooner than they otherwise would.

The Potential for Unintended Consequences from Managing Allowance Prices

Setting upper or lower limits on allowance prices would reduce some of the uncertainties associated with a cap-and-trade program but could also have unintended consequences. Existing cap-and-trade programs in the United States and the European Union do not include price ceilings or allowance reserves, so they can provide no evidence about how those approaches might work in practice. One program, the Regional Greenhouse Gas Initiative (RGGI), has a price floor but only a brief history from which to extrapolate: The initiative began capping greenhouse gas emissions from large electricity generators in January 2009. The program features a minimum bid price of $1.86 on allowances auctioned on behalf of RGGI; however, none of the allowances that firms can use for complying with the program's cap in the current year have sold at the minimum bid price in any of the eight quarterly auctions for which data are available. (In one auction, though, they sold for just 2 cents above the minimum bid price.) Future-vintage allowances, which can be bought now but used for compliance only in future years, sold at the minimum bid price in three of the eight auctions.

Some efforts by governments to control prices in other areas of their economies have failed or led to unintended results. One example was an attempt in 1992 by the United Kingdom to control prices of another sort—namely, to prevent the value of the pound from falling below a targeted level. That undertaking failed because the government ultimately found it too costly to do what was needed to succeed—buy up pounds to decrease the supply. That experience could be relevant to setting a price floor for allowances, depending on the method that was used to establish the floor. If the government implemented such a limit by agreeing to purchase allowances at

22. The minimum-bid approach is used in H.R. 2454, S. 1733, the American Power Act of 2010, and the Carbon Limits and Energy for America's Renewal, or CLEAR, Act of 2009.

a given price, market conditions might cause many firms to take up that offer, at a substantial cost to the government, which might conclude that maintaining the floor price was too costly.[23] In contrast, if the government attempted to establish a floor for the price of allowances in the secondary market by setting a minimum bid price on the allowances it auctioned, no federal expenditures would be required to maintain the floor. However, that price would serve as a floor in the market only if demand for allowances was sufficiently strong that firms wanted to buy at least some of those that the government was selling in its auctions.

In addition to potential difficulties in maintaining an allowance price floor, other unintended effects of attempts to manage prices could include the following:

- If expectations about future compliance costs caused the price of allowances to increase—and caused additional allowances to be introduced into the program via the price ceiling or allowance reserve—the additional allowances (and the additional emissions they represented) would become a permanent part of the program, even if those expectations were not borne out.

- In some circumstances, a small number of firms could seek to use a price ceiling or an allowance reserve to manipulate the price of allowances. For example, the firms might purchase large quantities of the additional allowances available at a ceiling price (if the program had a price ceiling) or an access price (if it had a reserve), even when the market price of allowances—and thus the marginal cost of complying with the program—were below those levels. The availability of those additional allowances would then loosen the cap and cause allowance prices to fall. That small group of firms could profit from such a strategy under a limited set of circumstances—in particular, if they had very large compliance obligations and if, in general, firms used relatively short planning horizons in deciding whether to bank or borrow allowances.[24] Under those circumstances, additional allowances would be released through the price ceiling or the allowance reserve—even though the marginal cost of complying with the program had remained below the level that policymakers had designated as justifying a loosening of the cap.

- The presence of an allowance price ceiling or price floor could cause market prices to gravitate toward those bounds. For example, experiments using simulated markets found evidence that when price floors and ceilings were present, the responses of study participants tended to migrate toward them as if those boundaries provided significant information about the market value of products.[25]

- The method by which policymakers chose to add allowances to or subtract them from the cap could create uncertainty about the future supply of allowances, which in turn could affect prices and the degree to which they fluctuated. Those outcomes would be most likely if the rules for altering the supply of allowances were not clearly established at the onset of the program but were instead left to the discretion of regulators. By creating considerable uncertainty, that kind of approach could decrease the allowances' value and cause their prices to fluctuate on the basis of speculation about regulators' decisions.

Some analysts have focused on another consideration—that a price ceiling could complicate possible efforts to tighten the annual caps in the later years of a policy.[26] Firms that considered more stringent caps a possibility would have an incentive to purchase large numbers of allowances at the ceiling price, bank them, and use them once the caps were tightened and compliance costs were

23. If the floor's credibility came into question, firms might then seek to sell large quantities of allowances to the government at the floor price. See Salant, "The Vulnerability of Price Stabilization Schemes to Speculative Attack."

24. See Andrew Stocking, *Unanticipated Consequences of Price Controls: An Application to Allowance Markets*, Congressional Budget Office Working Paper 2010-06 (September 2010).

25. See Mark Isaac and Charles Plott, "Price Controls and the Behavior of Auction Markets: An Experimental Examination," *American Economic Review,* vol. 71, no. 3 (June 1981); and Vernon Smith and Arlington Williams, "On Nonbinding Price Controls in a Competitive Market," *American Economic Review,* vol. 71, no. 3 (June 1981).

26. See Brian C. Murray, Richard G. Newell, and William A. Pizer, "Balancing Cost and Emissions Certainty: An Allowance Reserve for Cap-and-Trade," *Review of Environmental Economics and Policy,* vol. 3, no. 1 (2009), pp. 84–103.

higher. That strategy would undercut the objective of such tightening and enable firms to produce emissions in excess of any newly tightened caps. Policymakers could attempt to adjust for that behavior by taking the additional banked allowances into account in their changes to the caps; however, those adjustments could in turn prompt even more banking.

Preventing firms from banking the allowances they purchased at the ceiling price might seem to be a logical solution to that problem. But firms could use those allowances to comply in the current year and bank other allowances for use in the future. Policymakers might be able to tighten the caps in a way that would compensate for that kind of behavior, although they could find it difficult to estimate how many allowances firms might purchase in those circumstances.[27]

Restricting the number of additional allowances firms could purchase, as an allowance reserve would do, would make it harder for firms to purchase additional allowances to avoid making higher-cost reductions in emissions once caps were tightened. And smaller reserves—or annual limits on the number of allowances that firms could purchase from a reserve in any given year—would provide more protection against such behavior than would larger reserves or reserves with no limits on purchases. However, those measures would also do less to reduce uncertainty about prices.

Because the operation of a cap-and-trade program would depend on many future decisions about its design, the possible unintended consequences discussed here are by no means an exhaustive list of those that might result from a price ceiling, an allowance reserve, or a price floor. At the same time, those mechanisms could help prevent the costs of a cap-and-trade program from being much higher or lower than policymakers had envisioned. The potential for unintended consequences would also accompany other approaches to curbing emissions or other ways of implementing a cap-and-trade program.

27. In contrast, a tax on greenhouse gas emissions would provide an upper limit on the marginal cost of emissions reductions; provide firms with a stable, predictable price on emissions; and allow policymakers to increase the stringency of the program whenever it was desirable (by increasing the tax). Such a policy would not, however, guarantee a given level of emissions: Lawmakers would need to adjust the tax rate to motivate fewer (or allow more) emissions. For a discussion of a proposal for a tax that would be adjusted on the basis of a legislative formula, see Gilbert Metcalf, "Cost Containment in Climate Change Policy: Alternative Approaches to Mitigating Price Volatility," *University of Virginia Tax Review,* vol. 29, no. 2 (2009).