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Managing Costs in a U.S. Greenhouse Gas Trading Program

A Workshop Summary

Marika Tatsutani and William A. Pizer

1616 P St. NW
Washington, DC 20036
202-328-5000 www.rff.org

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Managing Costs in a U.S. Greenhouse Gas Trading Program: A Workshop Summary

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Abstract

Cost containment has emerged as a major point of contention in the current congressional debate about designing a cap-and-trade program to limit future U.S. greenhouse gas (GHG) emissions. This paper reviews basic concepts and policy options for cost management, drawing on a March 2008 workshop sponsored by Resources for the Future (RFF), the National Commission on Energy Policy, and Duke University's Nicholas Institute for Environmental Policy Solutions. The different sources and temporal dimensions of cost uncertainty are explored, along with possible mechanisms for addressing short- and long-term cost concerns, including banking and borrowing, emissions offsets, a price cap (or safety valve), quantity-limited allowance reserve, and the concept of an oversight entity for GHG allowance markets modeled on the Federal Reserve. Recognizing that the inherent trade-off between environmental certainty and cost certainty has no perfect solution, the paper nonetheless concludes that numerous options exist for striking a reasonable and politically viable balance between these two objectives. In the effort to forge consensus around a particular set of options, it will be important for policymakers to strive to fit the remedy to the problem they are trying to solve and to preserve the underlying integrity of the overall program in terms of its long-term ability to sustain meaningful market incentives for low-carbon technologies.

Key Words: cost containment, greenhouse gases, cap-and-trade, safety valve, allowance reserve, uncertainty, banking and borrowing, offsets, price volatility, carbon Fed

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I. Introduction

With the U.S. Congress likely to act on climate change legislation within the next few years, debate over the details of a workable proposal for limiting U.S. greenhouse gas (GHG) emissions has sharpened. Cost containment has emerged as a major point of contention, forcing policymakers to weigh the need for environmental certainty—in terms of confidence in future emissions reductions—against the need for safeguards to protect the U.S. economy in the event of high costs. This paper is intended as a kind of primer on the subject of cost containment: its aim is to provide policymakers and interested stakeholders with a basic understanding of issues and options relevant to the current debate. It draws heavily on materials and discussion points from a workshop on cost containment sponsored by Resources for the Future (RFF), the National Commission on Energy Policy, and Duke University's Nicholas Institute for Environmental Policy Solutions. The workshop, which was held in Washington DC in March 2008, featured presentations from senior RFF researchers and invited speakers with expertise in economics, financial markets, and environmental regulation. Further information from the workshop, including access to speaker presentations and materials is available at: http://www.rff.org/Events/Pages/Cost_Containment_USGHG.aspx

This report is organized as follows: Section II provides general context and reviews why cost concerns have always been important in the U.S. climate-policy debate. Section III discusses cost uncertainty and its drivers in the specific context of a cap-and-trade program for reducing GHG emissions. Section IV describes the most prominent cost-management approaches that have emerged in the context of recent legislative proposals. Section V identifies a number of additional considerations for policymakers in devising solutions to the problem of cost uncertainty. Section VI concludes with a summary of key insights and general principles that are likely to be useful in the search for cost-containment solutions that can win support from a broad array of stakeholders.

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[*] Marika Tatsutani, Energy and Environment Consulting, mtatsutani@gmail.com; William A. Pizer, Senior Fellow, Resources for the Future.

II. Cost as a Central Issue in the U.S. Climate-Policy Debate

At its core, opposition to the adoption of a mandatory policy for reducing GHG emissions in the United States has always been driven by concerns about cost. That is because, under any mandatory policy, a cost would be attached to emissions that have heretofore been released to the atmosphere "for free."[1] As a result, any regulatory policy to limit emissions will necessarily result in higher prices for activities that emit carbon dioxide and other GHGs. In the context of the U.S. economy this means higher prices for carbon-emitting fossil fuels and for all the goods and services that rely, somewhere up the chain of production, on the use of those fuels. A price signal is essential for the simple reason that without it, no financial incentive exists to avoid emissions. The more stringent the regulatory program—that is, the deeper the emissions reductions it seeks to achieve—the larger the price signal. This might be desirable, for obvious reasons, from the standpoint of addressing the environmental problem and providing strong inducements to develop new, low-carbon technologies. But it would also mean higher energy prices and larger costs to the U.S. economy.[2]

For many stakeholders, these costs—and their potential impact on consumers and U.S. industry—are a significant source of concern. A fundamental issue then, becomes the trade-off between doing more to protect the environment and the higher cost of meeting a more aggressive emissions-reduction target.

If it were possible to know with certainty the future cost of achieving a given level of GHG abatement, the current political debate—which typically pits those who argue for vigorous action on environmental grounds against those who worry that limiting emissions will impose unacceptable costs on the economy—would be considerably less fraught. As it is, however, substantial uncertainty exists about the long-term cost of reducing U.S. GHG emissions. On the one hand, opportunities for reducing emissions exist throughout the economy—they are as diverse and numerous as the vast array of activities and devices that give rise to GHG emissions in the first place. But even where the technical potential and engineering costs for achieving

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[1] In the parlance of economic theory, the point of regulation is to internalize—that is, reflect in market prices—a currently unrecognized "externality." The externality or unrecognized cost in this case is the cost of environmental damage associated with each ton of GHG emissions.

[2] It bears acknowledging here that there is a school of thought among some proponents of aggressive climate policy action that the technological transformations induced by attaching a price to carbon will lead to an overall decline in production costs with net benefits, over time, to the economy as a whole. This, however, is a minority view that is not widely shared by mainstream economists.

reductions are (theoretically at least) relatively well understood—an example might be the opportunity to replace a given type of appliance with a more efficient model—uncertainty often exists about the true cost of capturing reductions in light of real-world barriers and market constraints. In addition, many of the low-carbon technologies that might be required to sustain major GHG reductions in the future—such as renewable energy technologies, new nuclear technologies, and carbon capture and sequestration—either have not been deployed yet on a commercial basis or face potentially significant but highly uncertain barriers to large-scale expansion.[3]

In short, the primary driver of long-term costs for reducing future GHG emissions—technology innovation—also happens to be impossible to predict accurately, particularly when the forecast horizon extends beyond a decade or so. Compounding the difficulty, other factors—often equally difficult to anticipate with confidence—can also be expected to have a large impact on future costs (examples might include population growth, regulatory conditions, international developments, and behavioral changes, to list just a few). Finally, uncertainty also exists about the short-term behavior of GHG allowance markets. Year-to-year or even month-to-month fluctuations in supply and demand could lead to sharp swings in the price of allowances. Liquidity constraints and other unexpected short-term contingencies could produce price spikes and temporary shortages—potentially generating adverse ripple effects throughout the economy. A regulatory program that produced excessive market volatility—in which, for example, allowance prices might be low one month and much higher the next—would not be economically efficient, would make it difficult to plan low-carbon investments cost-effectively, and could erode political support for the policy. Thus, the cost issue has multiple temporal dimensions—a nuance that is sometimes lost in the current legislative debate.

In fact, as scientific understanding of global warming has improved and as uncertainty about the nature of the problem itself has diminished, cost concerns have moved very much to the center of the policy discussion—in the United States and elsewhere. Indeed, the first sentence of a headline story on climate policy that appeared in The Wall Street Journal on January 23, 2007 declared: "*The global warming debate is shifting from science to economics.*"[4] The

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[3] Even if, for example, policymakers could establish with reasonable certainty the cost of building a new nuclear plant or large wind farm ten or twenty years from now, considerable uncertainty would still exist about the cost and difficulty of siting such a facility, or of securing the necessary financing.

[4] Wall Street Journal, "In climate controversy, industry cedes ground" by Jeffrey Ball, January 23, 2007, Section A; Column 3; Pg. 1, 55.

potential intractability of these concerns—especially given the wildly divergent conclusions that can be drawn from different cost analyses conducted to date—is now prompting stakeholders and policymakers to focus in detail on options for addressing cost uncertainty in the context of a cap-and-trade program for GHG emissions. At this juncture, it seems increasingly clear that finding consensus around an appropriate response to cost concerns will be essential to advancing meaningful climate legislation in the U.S. Congress within the next few years.

III. Managing Cost Uncertainty in the Context of a GHG Cap-and-Trade Program

In the United States, a cap-and-trade program is widely viewed as the most likely choice for regulating GHG emissions at the national level. Under such a program, regulated entities would be required to submit permits or allowances for each ton of GHG emissions for which they are responsible. Individual firms would be free to buy and sell permits or allowances, but overall emissions would be limited by the total quantity of permits or allowances issued (the emissions cap). The costs associated with meeting the cap would be reflected in future allowance prices, but they could not be precisely known when the program is launched—that is, policymakers may have estimates of what these costs will be, based on technology assessments and economic modeling analyses, but they cannot be sure in advance. This is in contrast to a policy approach that seeks to limit emissions by taxing them—in that case, costs are certain and known from the outset, but policymakers cannot be sure what level of emissions reductions will be achieved by a given level of tax.[5]

It is worth pointing out that the choice of a cap-and-trade regime itself constitutes one response to the cost concerns commonly raised in relation to GHG mitigation. The economic arguments for emissions trading—especially in cases where emissions sources are diverse and

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[5] The observation that regulating on the basis of price (as in an emissions tax) versus regulating on the basis of quantity (as in a program that sets a specific limit or “cap” on emissions) will produce different outcomes where uncertainty exists about costs was first articulated by Weitzman in 1974 (Weitzman, M.L., 1974. Prices vs. Quantities, *The Review of Economic Studies*, Vol. 41, No. 4, pp. 477-491). Economists such as Newell and Pizer have subsequently argued that price regulation makes more sense in the case of pollutants like carbon dioxide, where significant uncertainties exist about costs and impacts, where impacts depend on cumulative emissions, and where there is no single, identifiable quantity threshold above which impacts become intolerable (Newell, R.G. and W.A. Pizer, 2003. Regulating stock externalities under uncertainty, *Journal of Environmental Economics and Management*, vol. 45, p. 416-432). For a variety of reasons, however, the current political environment in the United States appears to favor quantity-based regulation for GHG emissions (i.e. a cap-and-trade program rather than a carbon tax).

impacts are independent of geographic location—have been explored in detail elsewhere.[6] Briefly, a cap-and-trade approach—because it relies on market incentives to drive all emissions sources to implement the lowest-cost reductions first—can achieve results at substantially lower cost than a traditional regulatory program that stipulates specific control requirements for different entities. This was certainly the case in the Acid Rain program, which has produced significant sulfur dioxide reductions at costs that are much lower than either industry or regulators predicted in the early 1990s, when the program was introduced (see Figure 1). A market-based policy has the further advantage of providing transparency about the cost of emissions abatement. The price of allowances in a cap-and-trade program reveals information about costs that might be hidden under a command-and-control policy where information about the cost to individual entities for complying with a given policy would be privately held.

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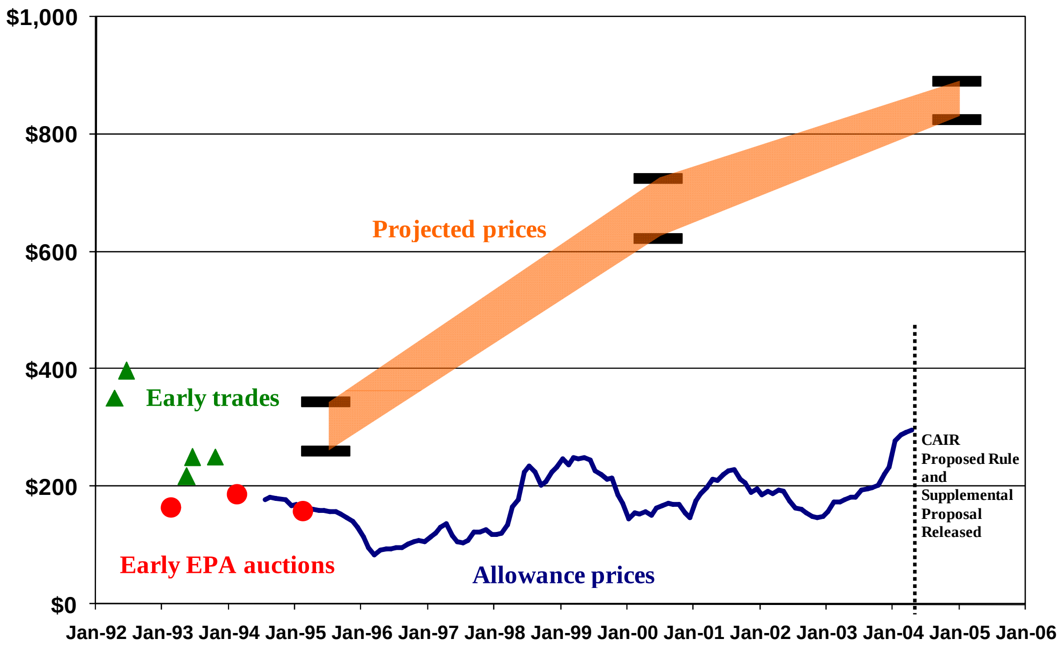
[6] See for example: Kopp, R.J. and W.A. Pizer, eds., 2007. *Assessing U.S. Climate Policy Options*. Resources for the Future: Washington, DC, available at http://www.rff.org/cpfreport

Figure 1. Expected vs. Actual SO_2 Allowance Prices in the U.S. Acid Rain Program



Source: Graph provided by Dallas Burtraw, Resources for the Future. Projected SO_2 prices are from: *Comparison of the Economic Impacts of the Acid Rain Provisions of the Senate Bill (S.1630) and the House Bill (S.1630)* (sic), Prepared for the U.S. Environmental Protection Agency by ICF Resources, July 1990. Data on actual prices from early in the SO_2 allowance market were obtained from Figure 7.1 of: *Markets for Clean Air: The U.S. Acid Rain Program*, A.D. Ellerman, P.L. Joskow, R. Schmalensee, J.P. Montero, and E.M. Bailey. Cambridge University Press, New York, NY. 2000, 362 pp. CAIR is the Clean Air Interstate Rule, which revised the rules of the Acid Rain Program and thus shifted the trajectory of SO_2 allowance prices.

Even taking a cap-and-trade regulatory structure and a defined set of emissions goals as the starting point, however, significant cost uncertainties remain. Table 1 compares results obtained using two different economic models and a range of different input assumptions to assess the likely costs of a single prominent legislative proposal, America’s Climate Security Act of 2007 (S. 2191). This bill, which was introduced in Congress in November 2007 by Senators Lieberman and Warner, would establish a cap-and-trade program designed to reduce U.S. GHG emissions 33 percent below 2005 levels by 2030 and 70 percent below 2005 levels by 2050. The results shown in Table 1 suggest a high degree of uncertainty, with estimated allowance prices in 2030 ranging from a low of $24 per ton of carbon dioxide-equivalent emissions (tCO_2e) to a high of $160/$tCO_2e$. Some of this variation can be traced to different assumptions about specific design features of the policy being analyzed. For example, whether and to what extent a U.S. program allows for the use of offset credits—that is, credits for emissions reductions achieved in sectors or from sources that are not directly regulated under the program, including some potentially low-cost reductions from forestry projects or other activities undertaken overseas—has a potentially very large impact on expected costs. (The subject of offsets is one to which we return later in this report.) The inclusion of offsets, by itself, accounts for the seven-fold difference in estimated 2030 allowance prices (from $24 to $160 per ton, according to one model) noted above.

Table 1. Estimated GHG Allowance Prices from U.S. EPA Economic Analysis of S. 2191 (Prices in 2005 $/tCO$_2$e)

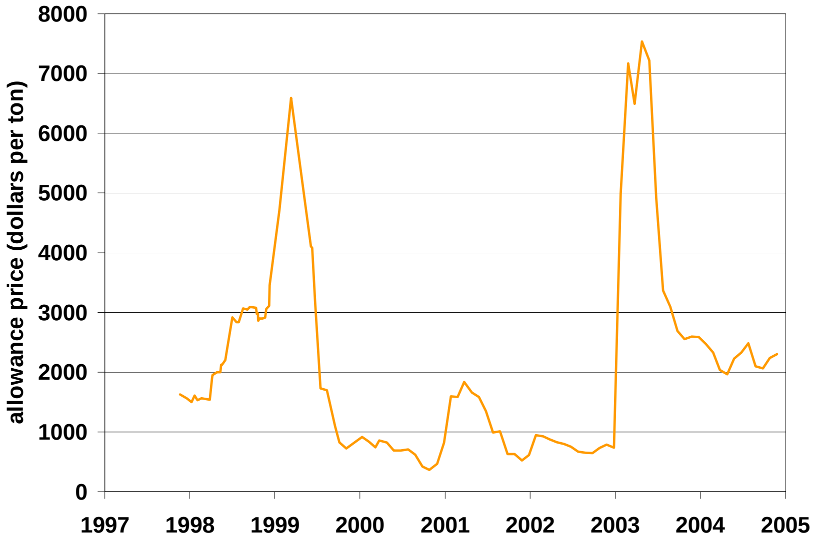
Scenario/ Model[*]	YEAR							
	2015	2020	2025	2030	2035	2040	2045	2050
1. S. 2191								
ADAGE	$29	$37	$48	$61	$77	$98	$125	$159
IGEM	$40	$51	$65	$83	$106	$135	$173	$220
2. S. 2191 w/ Low International Action								
ADAGE	$27	$35	$44	$56	$72	$92	$117	$149
IGEM	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3. S.2191 w/ Unlimited Offsets								
ADAGE	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
IGEM	$11	$15	$19	$24	$30	$39	$50	$63
4. S. 2191 w/ No Offsets								
ADAGE	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
IGEM	$77	$98	$126	$160	$205	$261	$333	$425
5. S.2191 Constrained Nuclear and Biomass								
ADAGE	$39	$49	$63	$80	$101	$129	$164	$208
IGEM	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6. S.2191 Constrained Nuclear & Biomass, and Carbon Capture and Storage (CCS)								
ADAGE	$55	$69	$88	$112	$142	$181	$229	$290
IGEM	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Source: Environmental Protection Agency, *EPA Analysis of the Lieberman-Warner Climate Security Act of 2008*, March 2008. U.S. EPA: Washington, DC, available at http://www.epa.gov/climatechange/downloads/s2191_EPA_Analysis.pdf

[*] Note that ADAGE and IGEM refer to two economywide computable general equilibrium models that have been used to model economic impacts under a future U.S. GHG cap-and-trade program. ADAGE stands for Applied Dynamic Analysis of the Global Economy; IGEM refers to Intertemporal General Equilibrium Model. More information about these models and about the assumptions modeled in different scenarios is available at http://www.epa.gov/climatechange/economics/economicanalyses.html.

Carbon prices at the high end of the cost ranges shown in Table 1 could have very different implications for the nation's economy and energy systems than carbon prices at the low end. Moreover, it is important to stress that the estimates shown in Table 1 illustrate a range of *expected* cost outcomes under a defined set of assumptions. Even if political consensus can be reached about what constitutes an acceptable level or range of expected cost, the possibility always exists that actual costs will deviate from expectations—in either direction. This is true for both long-term costs (as already noted, actual costs under the Acid Rain program proved an order of magnitude lower than expected when that program was adopted); it is also true for short-term prices, which may be subject to very sharp fluctuations. Figure 2, which shows historic allowance prices under an existing cap-and-trade program for emissions of nitrogen oxides (NOx), illustrates the potential for short-term price volatility under an emissions trading regime.

Figure 2. Price of Current-Vintage NOx Allowances in Ozone Transport Commission (OTC) Region



Source: Presentation by Brian C. Murray, Nicholas Institute for Environmental Policy Solutions, Duke University at March 19, 2008 RFF Cost Containment Workshop. See *http://www.rff.org/Events/Documents/USGHG-Murray.pdf*.

The issue of cost uncertainty is thus more complex than participants in the current legislative debate may appreciate at the outset. This means that it will be important, in designing potential policy responses, for policymakers to establish some clarity about the problems they are trying to solve. Is the concern that expected regulatory costs are too high? Or is the concern primarily that actual costs could turn out to be much different than expected costs? What mechanisms are available for managing short-term price uncertainty—including the potential for extreme price volatility—and how do they differ from mechanisms that can address long-term price uncertainty? The next section of this report reviews the most prominent cost management options now under discussion as Congress grapples with various climate bills. Before exploring how each of these options might address cost concerns, however, it is helpful to distinguish between different forms of cost uncertainty and to identify some of the factors that are likely to influence GHG allowance (or permit) prices over the short and long term. Specifically, future allowance prices are subject to at least four kinds of uncertainty:

- Short-term demand uncertainty because of fluctuating emissions. Baseline GHG emissions can be expected to vary naturally from year to year by a few percent, owing to changes in weather, economic activity, and energy supply.

- Short-term supply uncertainty because of fluctuating availability of offset credits. The volume and price of available offsets may vary because of changes in implementing regulations, competing demand from other programs, supply constraints in originating countries/sectors, or estimation errors and natural variation.

- Long-term demand uncertainty because of unpredictable economic or technological developments. Over longer periods of time, costs can deviate from expectations because either (or both) economic growth or technological innovation does not proceed as expected.

- Long-term supply uncertainty because of unpredictable regulatory developments. In programs with banking, expectations about future compliance costs can drive current market prices; if market participants expect allowances to be valuable in the future because of tighter regulations, they will want to purchase any undervalued, current allowances for later use, thereby driving up current prices.

In addition to the general types of uncertainty noted above, uncertainty also exists about short- and long-term costs to individual sectors or sources. This type of cost uncertainty is not addressed in this report, which generally focuses on cost management options that are program-wide (and thus not targeted to particular sectors). It bears noting, however, that policy options are available to address the potential for disproportionate cost impacts. In particular, allowance allocation and targeted technology investments provide appropriate opportunities for addressing concerns related to the *distribution* of cost burdens (as opposed to concerns about the overall magnitude of the cost burden).

IV. Policy Options for Addressing Concerns about Program Cost

A variety of options have been proposed for addressing cost uncertainty, some of which are better suited to addressing some types of uncertainty than others. This section describes the most prominent options featured in legislative and other proposals to date (see also Table 2). We begin with two options that are primarily useful for addressing long-term cost uncertainty.

1. Program targets and timetables

If long-term abatement costs prove much different than expected, one obvious remedy is to change program targets and timetables. This option is arguably inherent (in the sense that Congress could always pass new legislation), but it could also be explicitly facilitated by building in periodic program reviews and opportunities for Congress, the president, and/or some regulatory agency (such as the U.S. Environmental Protection Agency) to make program adjustments. The chief drawback of relying on program changes as a mechanism for addressing cost concern is the political difficulty (and sometimes long timeframe) often associated with modifying any major regulatory program.[7] Moreover, the prospect that emissions targets might change in the future will itself affect expectations and could undermine regulatory certainty. If firms expect a loosening of the emissions cap in the future, this will tend to undercut incentives to invest in low-carbon technologies; conversely, an expectation that the cap will tighten could strengthen investment incentives.

2. Technology investments

Given that technology innovation is likely to be the primary driver of long-term program costs, technology investments—potentially funded by allowance or permit sales under a cap-and-trade regime—could be seen as another response to long-term cost concerns; indeed, most legislative proposals to date have included provisions to increase public investment in technology research and development. While there is generally wide support for such investments as an essential part of any comprehensive long-term climate policy, however, technology incentives are likely to offer only weak to moderate reassurance to stakeholders concerned about the potential for high cost and adverse economic impacts. This is simply

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[7] It is worth pointing out here that program adjustments could go either way in terms of loosening versus tightening curbs on GHG emissions. In discussions about cost containment, the focus is often on options for relaxing program requirements, but in principle, regulatory requirements could also be made more stringent if abatement costs prove lower than expected.

because the impact of public R&D investments and deployment incentives on future technology costs is difficult to predict, especially given that the scale and scope of investment at issue in the climate context is unlike any associated with past regulatory programs.

Both of the above options have generally been included, implicitly or explicitly, in recent legislative proposals. Neither of them, however, is well-suited to addressing concerns about short-term cost uncertainty. We turn now to a number of cost-management mechanisms that are primarily suited to managing unexpected, short-term cost risks. It is this issue of short-term cost management—arguably more than a concern about long-term costs—that is currently generating vigorous debate on Capitol Hill.

3. Offsets

Many recent legislative proposals make some provision for recognizing offset credits as an alternative compliance option. Typically, such credits would be awarded for verifiable GHG reductions achieved in sectors or from sources not otherwise covered by the cap-and-trade program (for example, soil and forest carbon sequestration, capturing fugitive methane emissions, etc.) as well as for qualified projects in other countries. Based on the widely-held assumption that substantial, low-cost forest-carbon and other “off-sector” mitigation opportunities exist—in the United States and especially overseas—the inclusion of offsets can significantly reduce expected program costs. (As already noted, this point is well-illustrated by the cost estimates shown in Table 1.) Offsets can also provide a mechanism, however, for addressing short-term, unexpected cost risks. In the event of an allowance shortage or price spike, a temporary increase in the available supply of offsets could help to moderate upward price pressures and relieve liquidity constraints. In theory, at least, an increase could be achieved by simply modifying or removing constraints on the use of offsets, relaxing project verification requirements, and/or expanding the types of projects eligible to receive credit.[8]

In concept, offsets have support from many environmental groups (as a means of creating incentives to take advantage of important GHG mitigation opportunities) and from industry (as a means for reducing compliance costs). As with banking and borrowing, however, there are also concerns. A first is that excessive reliance on offsets for compliance purposes may risk overall

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[8] In practice, the efficacy of such mechanisms would depend on a ready and ample supply of offsets to be tapped. As discussed later in this section, experience with the Clean Development Mechanism (CDM) program to date suggests that verification and accreditation hurdles could slow the availability of offsets, especially as a rigorous but efficient structure for administering an offsets program is still being developed.

program integrity with respect to the achievement of intended environmental objectives if offset projects are not subject to a rigorous verification process. Unfortunately, setting up and administering such a process presents considerable practical challenges. The primary existing program for international GHG reduction projects, for example, is the Clean Development Mechanism (CDM) created under the Kyoto Protocol—that program currently has a large backlog of projects that have yet to go through the validation and registration process.[9]

A related concern is that an emissions market awash in low-cost, low-quality offset credits would drive down allowance prices and reduce financial incentives for investing in domestic reductions and needed, new low-carbon technologies. Finally, the inclusion of offsets itself exposes U.S. emissions markets to a new set of uncertainties. Thus, for example, a change in forest policy in another country could, if it affects the global supply of offsets, indirectly drive up U.S. allowance prices. Likewise, increased competition for international offsets as a result of more stringent climate policies in other nations could have the same effect.

An obvious response to the concerns that exist about offsets is simply to place some constraints on the use of this mechanism. In fact, many of the GHG cap-and-trade bills introduced in Congress of late propose to do just that by, for example, limiting the quantity of offsets that can be used in a given compliance period and limiting the types of projects that may qualify for offset credits.

4. Inter-temporal flexibility (banking and borrowing)

Allowing firms to bank and borrow emissions permits across compliance periods can go a long way toward addressing short-term cost concerns and reducing the potential for excessive price volatility in GHG emissions markets. The argument for including this kind of flexibility is strengthened by the observation that the environmental impact of concern in this case—global climate change—is not especially sensitive to emissions levels on a year-to-year basis. Rather, climate impacts depend on cumulative emissions over longer periods of time. Thus, most legislative proposals to date have allowed for some inter-temporal flexibility, either (or both) in the form of banking and borrowing across compliance period or in the form of multi-year compliance periods.

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[9] The CDM program has also been criticized for allowing participants to inflate claimed GHG reductions and for creating conditions in which project operators are often overpaid for their efforts.

Inter-temporal flexibility can substantially reduce the potential for short-term price spikes and help ensure that allowance markets maintain the liquidity needed to function efficiently. Indeed, the economics literature suggests that this mechanism by itself—along with the financial instruments (or derivatives) that would likely spring from banking and borrowing, such as futures and options—might be adequate to address most short-term price risks.[10] In practice, however, evidence from past cap-and-trade programs suggests that some potential for high prices and/or short-term price volatility can persist because of institutional or regulatory constraints and other realities (for example, the existence of default risk, the possibility that firms may not always operate rationally or with adequate foresight, etc.).

Over the longer run, banking and borrowing can help to reduce expected costs—by giving firms flexibility to manage their compliance obligations more cost-effectively[11]—but it affords little protection against unexpected long term costs, especially if one assumes that the cumulative emissions reduction requirement over the course of the program remains firm. Finally there is the risk that excessive borrowing from future compliance periods could undermine long-term program integrity and depress short-term allowance prices to the point where insufficient incentives exist for developing and deploying low-carbon technologies. The resulting lag in technology investment could result in increased costs down the line when increased reductions are needed to repay the allowance "debt" accumulated in the early years of program implementation. For these reasons, most proposals to date have imposed constraints on banking and borrowing, such as limits on the use of borrowed allowances in any given compliance period and/or interest requirements or other penalties.

5. Safety valve

While enhancing regulatory flexibility via banking and borrowing and offsets can certainly be expected to allay cost concerns, neither offers cost certainty or short-circuits the debate about whose cost estimates are more likely to be correct. Some recent proposals have therefore gone further in imposing an explicit limit on future program costs in the form of a so-called "safety valve." The concept is straightforward: as part of the design of the program, the government agrees to sell an unlimited quantity of additional permits, on demand, at a pre-

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[10] See, for example, Jacoby, H.D. and A.D. Ellerman, 2004. The safety valve and climate policy, *Energy Policy,* vol. 32(4), pp. 481-491.

[11] For example, inter-temporal flexibility might allow a firm to defer the retirement of a carbon-intensive capital asset (like a coal-fired power plant) until closer to the end of its natural life, thereby reducing overall cost.

determined price. Any time allowance prices rise above the safety valve threshold, firms will buy additional allowances from the government rather than spend more to obtain allowances from other sellers. The safety valve price, which can be configured to rise in a predictable way over time, effectively establishes a short- and long-term cap on the price of permits or allowances—in practice it means that if costs rise above a defined threshold, U.S. GHG emissions will be governed by a price rather than a quantity constraint and emissions will rise above the program cap.[12]

By providing absolute certainty about maximum cost, a price cap obviously goes farthest in reassuring stakeholders with concerns about the impacts of GHG regulation on the nation's economy and industrial competitiveness. It also has the advantage of providing more planning certainty for industries—such as electric utilities—that are in the business of making long-lived capital investments. Other stakeholders, however, are strongly opposed to the safety-valve option. Their central objection is that, by trading cost certainty for emissions certainty, a cost cap provides too little assurance that long-term environmental objectives will be met:[13] if mitigation costs exceed the safety valve level, the emissions target will not be achieved—ever. A perhaps more subtle, but also compelling objection concerns the prospect that a price cap will dampen incentives to invest in technology innovation—especially if the cap is not paired with a floor (or lower limit) on permit or allowance prices.[14] Without at least some potential for high permit prices—and commensurately high returns on low-carbon investments—this argument goes, entrepreneurs may not commit to the kinds of untested, break-through technologies that will likely be needed to achieve significant further GHG reductions after the first decade or two of program implementation. Obviously both concerns—about achieving targeted reductions and about providing sufficient long-term technology incentives—can be alleviated to an extent by setting the price cap at a high level (and/or allowing it to escalate steeply): if the safety-valve

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[12] In other words, including an unrestricted safety valve means that, above a certain price, GHG regulation—in effect—defaults to an emissions tax rather than an emissions cap.

[13] Some stakeholders strongly object to this trade-off, pointing to the growing body of scientific evidence that suggests substantial global emissions reductions are needed by mid-century to avert some of the worst consequences of warming.

[14] Although interest in cost-containment mechanisms has generally been motivated by concern about the potential for price spikes, proponents of a "symmetric" safety valve—that is, including a lower as well as upper limit on costs—point out that allowance prices have more often fallen *below* expectations in past cap-and-trade programs. Analysis by RFF researchers suggests that compared to a one-sided safety valve (which only caps costs at the high end), a symmetric valve produces greater emissions-reduction benefits and improves overall welfare. We return to this point in Section V of this document.

price is set significantly higher than expected costs it is less likely to be invoked. On the other hand, a very high price cap will also afford less protection against the adverse economic consequences it is intended to prevent.

Of the three options described so far—banking and borrowing, offsets, and safety valve or price cap—none fully resolves or avoids the inherent tension between cost and emissions certainty. As a result, policymakers and stakeholders have continued to debate combinations and variants of all of these options, and to explore additional or alternative mechanisms for balancing environmental and economic concerns. In general, these mechanisms combine some features of the options discussed above and are targeted primarily at managing unexpected, short-term cost fluctuations and other market problems (like price spikes, liquidity constraints, and others).

6. Quantity-limited allowance “reserve”

Like the idea of a carbon market board (see below), this concept is relatively recent but seems likely to appeal to a number of stakeholders. Essentially, the idea would be to create a pool of allowances—in addition to and separate from the current-year emissions budget—that could be drawn upon to temporarily expand supply if certain (adverse) market conditions are met. To assure the integrity of long-term emissions targets, the allowances in the reserve could be drawn or “borrowed” from future-year budgets. This would have the effect of reducing the emissions cap in later years, effectively shifting part of the compliance burden from the present into the future when, presumably, additional low-carbon energy technologies are likely to be available.[15] It has been suggested, for example, that simply deducting a small fraction (on the order of 10 percent or less) of allowances from emissions budgets from 2030 to 2050 would generate a sufficiently large reserve—in excess of a year’s worth of emissions—to respond to short-term price and volatility concerns. The reserve could be further augmented by allowances that remain unsold if the government auctions allowances with a price floor.

While preliminary analyses suggest that a quantity-limited allowance reserve could be designed to provide nearly as much price protection as a simple safety valve, especially in the early years of program implementation, this mechanism does not provide the same planning certainty as a safety valve. If demand for reserve allowances outstrips supply, prices could still

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[15] Use of this mechanism might be particularly appropriate and effective if allowance prices are higher than expected because low-carbon technologies, while on the horizon, are being deployed more slowly than originally anticipated. If low-carbon alternatives fail to emerge at all, on the other hand, shifting compliance burdens into the future will not solve the cost problem in the long run.

rise above whatever threshold level is intended to trigger the use of this mechanism. That likelihood will in turn depend on a combination of program parameters (including the size of the reserve and any annual limit on the use of reserve allowances).

Nevertheless, the allowance reserve concept has a number of advantages compared to other cost-containment options and could provide the basis for striking a reasonable balance between certainty about cost and about emissions. First, unlike a simple safety valve, it maintains greater certainty about cumulative emissions over the course of the program (in other words, it doesn't threaten to "break" the cap). Second, it is transparent and could be designed to function in a predictable way (for example, through a supplemental auction of allowances with a higher reserve price). Finally, demand for reserve allowances could function as a kind of gauge of program performance. If there is little demand for reserve allowances, this would indicate that the economy is adjusting to GHG constraints and experiencing mitigation costs that are in line with expectations. If there is high demand for reserve allowances, on the other hand, and the reserve begins to run low, this could point to market problems and higher-than-expected mitigation costs.

7. Other automatically triggered program adjustments

Other automatic adjustments or rule changes (besides a quantity-limited allowance reserve) could be used to respond to certain price or volatility conditions in the context of a cap-and-trade program for GHG emissions. Examples of such adjustments could include making additional offsets available or relaxing constraints on the use of borrowed allowances. Proponents of these approaches emphasize that, unlike the safety-valve concept noted earlier, these mechanisms do not violate the longer-term emissions cap. Moreover, in contrast to program designs that allow for very broad use of offsets or borrowing regardless of market conditions, triggered mechanisms do not risk overly *low* prices. Automatically triggered mechanisms have potential downsides, however. One is that the triggered response is not necessarily scaled to a particular supply-demand imbalance: as a result there is no way to know whether the mechanism will dampen prices too much or have little effect at all. If a triggered mechanism causes prices to crash it could exacerbate market volatility, creating an oscillating cycle in which prices spike, the mechanism triggers, prices crash, the mechanism resets, and prices quickly rise again. Additional instability is possible if market participants, anticipating that an adjustment will be triggered, try to delay purchasing allowances in the expectation that prices will soon fall.

8. Carbon market board

This concept, while relatively new, has stimulated considerable interest since it was introduced in S. 2191 (the “Lieberman-Warner” legislation discussed previously). That bill proposes to establish a “Carbon Market Efficiency Board”—often described as an entity analogous to the Federal Reserve Board—to oversee GHG allowance markets. Like the Fed, a carbon market board would have discretionary authority to intervene, within limits, to ensure the smooth functioning of GHG allowance markets and, like the Fed, it would be set up as an independent agency, separate from Congress and the administration, so as to be at least somewhat insulated from short-term political pressures. Beyond this fairly simple analogy, however, the specifics of a carbon board remain largely undefined. This leaves numerous important and potentially difficult policy, legal, institutional, and resource questions to be answered: How should a “Carbon Fed” be structured? What principles or policy objectives should guide its interventions? What form would those interventions take and how much discretion would the new entity have in deciding when and how to act? Why not simply assign the authorities and responsibilities envisioned for this new entity to an existing agency within the current government structure?[16] These and many other details—from the term limits of board members to the process for selecting them; from staffing and resource needs to legal and institutional issues—would need to be decided to actually implement the carbon board concept.

For the moment it is worth pointing out that the Carbon Market Efficiency Board idea is different in nature from the other cost-containment mechanisms discussed in this paper. It represents an institutional means for responding to cost concerns in the future—quite likely using some combination of the already discussed options—rather than a cost-containment mechanism *per se*. As such, it may allow policymakers to defer the challenge of defining such mechanisms. Indeed, part of the appeal of this concept is precisely that a new institution could respond to new information, in real time, in a way that policymakers—operating under conditions of uncertainty when they set out to design a regulatory program—cannot. At the same time, however, it is important to recognize that the inclusion of such a board by itself does not represent a decision about how to balance uncertainty about emissions and costs. Uncertainty and lack of

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[16] For example, it has been suggested that one of the many functions of such a board could include program-relevant data collection and analysis. Quite likely, however, this information-gathering role could also be served by an existing institution, including potentially the implementing regulatory agency.

transparency about how such a board will operate can create its own problems, especially in the early years of program implementation when it would be unrealistic to expect any new entity to possess the institutional credibility, expertise, and established track record of the Fed.[17] The question remains how large a role this entity would play and how quickly it could be in a position to play that role.

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[17] In fact, it seems germane to point out that the Fed itself took decades to develop the status and authority it now enjoys. It was not widely viewed as a successful institution in the early years of its history.

Table 2. Cost-Containment Options

	Type of Cost Risk Addressed	Emissions Certainty	Cost Certainty	Pros	Cons
Revise Program Targets & Timetables	long-term expected	n/a	n/a	responds to new information	low predictability; can be difficult for Congress to act
Technology Incentives & Investments	long-term expected	n/a	n/a	can be adjusted over time to respond to new information or opportunities	low predictability; public expenditures may not be effectively directed or used
Banking & Borrowing	short-term unexpected	high (assuming credible payback requirements)	unclear	firms have discretion to apply this tool, subject to limitations; also preserves integrity of long-term emissions cap	firms may not act rationally or with adequate foresight; could promote hoarding behavior; could undermine long-term cap
Offsets	long-term expected and short-term expected	depends on rigorousness of program criteria	n/a	opens the door to potentially substantial GHG mitigation opportunities and provides a mechanism for funding tech transfer	difficult to ensure that reductions are real, permanent, verifiable, and additional; supply and demand influenced by other countries' policies
Safety Valve or Price Cap	long-term unexpected and short-term unexpected	low	high	provides absolute certainty about maximum price; facilitates planning; simple to administer, predictable, and transparent	creates uncertainty about final emissions; may dampen technology incentives, especially without symmetric price floor
Quantity-Limited Allowance Reserve	short-term unexpected	high	medium	provides some of the benefits of a simple safety valve, but preserves integrity of ultimate cap	does not provide absolute price certainty
Triggered Mechanisms	short-term unexpected	depends on mechanism triggered	unclear	provides additional flexibility when costs are high without risking possibility that indiscriminate use of the mechanism will lead to excessively low prices	ambiguous consequences and may create additional volatility in the market
Carbon Market Board	governance structure, not cost-containment mechanism per se	n/a	n/a	flexible & discretionary; can respond to new information	raises numerous implementation questions; will take time to set up and gain institutional authority/expertise

V. Further Considerations in Selecting a Cost-Management Approach

The pros and cons of the different cost-management approaches discussed in the previous section are summarized in Table 2. Clearly, parties to the current debate have many complex issues to consider. Therefore it will be important to begin with a clear understanding of which problem (or problems) policymakers are trying to solve. It will also be important to recognize that the need for different forms of cost management is likely to change as GHG markets mature. Well-defined approaches that provide a high degree of predictability and transparency in the short run may be appropriate and necessary to address unexpected, near-term cost concerns in the early years of program implementation, while other mechanisms that provide for more flexibility or discretion to adapt to future conditions may be appropriate in later phases of program implementation.

The cost debate is difficult to navigate precisely because there are no perfect solutions: there is no regulatory approach that can provide absolute certainty with respect to both cost and emissions. The chief drivers of future cost—technology, the economy, and regulation—are not only inherently uncertain, they become increasingly difficult to predict as the time horizon of concern extends to multiple decades. Policymakers have, at best, indirect influence over the first two of these drivers; they have perhaps more control—at least in the near term—over regulatory expectations. The importance of confidence in the long-term integrity of the overall program, in particular, is difficult to overstate. GHG markets will not be able to function efficiently or with the benefit of effective risk-management tools if participants lack confidence that regulatory commitments will be upheld in the future.

Credibility is also critical if the cap-and-trade program is to succeed in generating meaningful incentives for investment in low-carbon technologies. In fact, most current legislative proposals—by gradually increasing the stringency of program targets—attempt to create a steadily escalating price trajectory such that firms will make long-term investments knowing that the ability to avoid GHG emissions will become more and more valuable over time. This approach makes sense for many reasons: a gradual transition to lower emission caps and higher allowance prices will help to minimize overall costs because it gives firms the opportunity to develop and adopt lower-carbon technologies in ways that avoid price shocks and abrupt, costly adjustments. An expectation of rising allowance prices can, however, also create incentives to hold or “bank” allowances now based on their future value, thereby causing current prices to rise. In effect, this dynamic could shift a portion of the costs associated with later phases of program implementation closer to the present, potentially reanimating some of the same cost concerns that might have led policymakers to design a program with initially low (but subsequently rising) prices in the first place.

Allowance *borrowing*, by contrast, has the opposite effect: that is, it tends to dampen near-term price effects by shifting costs from the present to the future (costs will be higher in the future because borrowed allowances will have to be deducted from future-year budgets to keep the overall program whole). Thus, while borrowing provides an effective means of limiting price increases in the short run—indeed, with relatively unrestricted banking, it becomes almost impossible for the market to generate significant price spikes—it also creates its own risks to program integrity. Specifically, the concern would be that excessive reliance on borrowed allowances or permits would create a "debt" (in terms of offsetting reductions in future emissions budgets) that would prove politically unsupportable in later phases of program implementation. Put another way, shifting costs from the present to the future could create irresistible political pressure to adjust emissions budgets in subsequent years, even if doing so means abandoning the initial emissions-reduction objective. In sum, cost-containment mechanisms must be carefully designed with these temporal effects and political and program risks in mind.

Finally, while much of the climate-policy debate has focused on the concern that costs will be too high, policymakers should also consider the possibility that allowance prices could turn out to be significantly *lower* than expected. This potential is illustrated by actual experience in both the U.S. Acid Rain program and the European Union's GHG Emissions Trading Scheme; in the former case, compliance costs simply proved much lower than expected and in the latter case, the absence of banking meant that a temporarily excessive supply of allowances drove the price to zero. Sustained low prices would suggest that additional emissions reductions could be achieved at or below the cost originally contemplated in the design of the program. They might also give rise to a concern that resulting financial incentives are inadequate to stimulate the development of new technologies that will be necessary as part of an effective long-term strategy for combating global climate change.

At least two remedies are available to address sustained low prices. The first is to change program targets and timetables so as to accelerate required emissions reductions. Most of the targets outlined in current legislative proposals take care of this by driving toward significant long-term emissions reductions. A second, complementary element is to allow relatively unrestricted banking: this will have the effect of dramatically reducing the possibility of low prices in the short term if everyone realizes that more significant reductions will be required in the future. A third option is to establish a minimum price for allowances. This is most easily accomplished if the government auctions a substantial share of the allowance pool. In that case, the government can stipulate a minimum price for all bids such that no allowances are sold below that price. This would effectively restrict the supply of allowances available at a given time and raise prices. Unsold allowances could be taken out of circulation permanently (thereby effectively lowering the cap and increasing the cumulative environmental benefits achieved by the program) or directed to an allowance reserve for use in future compliance periods when prices might rise too high. Importantly, an allowance price floor could help ensure that technology programs and other societal investments that receive support under a cap-and-trade program (for example, adaptation efforts) would be assured adequate funding flows in the future. In fact, some have argued that the combination of a price cap and price floor *improves* overall societal welfare relative to either (1) a program that includes a price cap only or (2) a program that imposes no cost constraints at all.[18]

VI. Conclusion

Developing consensus around a suitable approach for managing cost risks in the context of a cap-and-trade program for U.S. GHG emissions will undoubtedly entail balancing a variety of different and sometimes competing concerns and policy objectives. The current debate—while still far from settled—has already yielded a number of important insights and general principles that are likely to be useful in the search for cost-containment solutions that can win support from a broad array of stakeholders:

- Regulatory credibility and environmental integrity are essential to the success of any long-term incentive program.
- Cost-containment mechanisms should be carefully tailored to suit the problems they are intended to address, whether it is expected cost, short-term uncertainty, or longer-term uncertainty (and to avoid creating new problems wherever possible).
- Cost risks have a temporal dimension. Appropriate remedies for managing risk associated with expected, long-term costs are likely to be different from the remedies best suited to managing short-term, unexpected cost risks
- Predictability and transparency are valuable, especially in the early years of program implementation. Over time, it may be appropriate to place greater emphasis on flexibility and on the ability to respond to new information, with a consequent lack of certainty (in the present) about the exact nature of future prices and emission levels.

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[18] This result depends, of course, on the assumption that funds generated by the sale of allowances under a cap-and-trade program are directed to productive societal investments.

- Emissions certainty and cost certainty exist on two ends of a continuum. Policies that increase one type of certainty inevitably reduce the other. Hybrid options—such as a quantity-limited allowance reserve—can be designed to operate at various places along the continuum. For example, they can be designed to protect against short-term cost risks but without the absolute cost certainty of a safety valve.
- To effectively drive the development and deployment of low-carbon technologies, meaningful financial incentives must be sustained over a long period of time. Mechanisms intended to address cost concerns should be designed with this underlying policy objective in mind.