DISCUSSION PAPER

June 2006 ■ RFF DP 06-28

Simple Rules for Targeting CO_2 Allowance Allocations to Compensate Firms

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RESOURCES FOR THE FUTURE

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Abstract

Policies to cap emissions of carbon dioxide (CO_2), such as the recently announced agreement among seven northeastern states, are expected to have important effects on the electricity industry and on the market value of firms that own electricity generation assets. The economics literature finds large efficiency advantages for initial distribution of tradable emissions allowances through an auction so as to direct revenues to tax relief or other public investments. However, an auction raises the costs for the regulated firms. This paper identifies rules for an initial distribution that satisfy a compensation goal for firms that is achieved through free distribution of a portion of the allowances, while maximizing the value of allowances that can be directed to public purposes. The paper employs a detailed simulation model to calculate numerical results for the market value of generation assets under the CO_2 cap-and-trade program in the northeastern United States.

Key Words: emissions trading, allowance allocations, electricity, air pollution, auction, grandfathering, output-based allocation, cost-effectiveness, greenhouse gases, climate change, global warming, carbon dioxide, asset value

JEL Classification Numbers: Q2, Q25, Q4, L94

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1. Introduction

One reason that global warming is a tremendously complex problem is that policies to mitigate its effects necessarily will involve the actions of millions of actors. In some cases, policies would impose high costs on severely affected parties. A frequently cited principle of public policy is that government should “do no direct harm” (Schultze 1977); that is, public policy needs to respond to the direct harm that may be concentrated on severely affected parties. Compensation can take a variety of forms. One form is the time delay between announcement of a public policy and its implementation, which provides for the realization of economic value from previous investments while giving investors the opportunity to realign their decisions going forward. Years that have transpired between the announcement of policy goals and the implementation of policy provide such opportunity. Within a cap-and-trade program, another fundamental form of compensation is in the initial distribution of emissions allowances, because the free distribution of emissions allowances conveys substantial economic value to recipients.

In this paper, we examine the claim for compensation from electricity producers and consumers that are affected directly by the regional proposal in the northeastern United States known as the Regional Greenhouse Gas Initiative (RGGI). The RGGI represents the first mandatory policy requiring reduction of emissions of greenhouse gases in the United States. Secondly, we investigate ways to deliver compensation to electricity producers through free allocation of emissions allowances, while simultaneously attempting to minimize the amount of compensation that would be received undeservedly. To the extent that the compensation target can be achieved at minimum cost, this leaves more revenue (in the form of valuable emissions

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* Palmer and Burtraw are Senior Fellows and Kahn is a Research Assistant at Resources for the Future. David Evans provided excellent technical support. The authors appreciate comments from Brian McLean and Wallace Oates on an earlier version of the paper. This research was funded by grants from the Energy Foundation, the Packard Foundation, and the New York Community Trust. Model capability for this project was developed under EPA National Center for Environmental Research (NCER) STAR Program, EPA Grant R828628.

allowances) that can be directed toward other complementary public policy goals such as improving efficiency or compensating other parties.

The burden of the cost of emissions reductions, as well as the cost of paying for the use of emissions allowances, forms the basis for stakeholder claims for compensation. In addition, the regional approach could put electricity producers within the region at a competitive disadvantage with respect to competing generators operating outside the region. In order to gain acceptance of such a regional policy, policymakers will need to find a way to compensate firms for some or all of their increased costs.

Emissions allowances represent an enormous economic value that arises due to the value placed on emissions within a cap-and-trade system, and the initial distribution of emissions allowances to electricity generators represents a significant potential source of compensation. However, others, including residential, commercial, and industrial electricity consumers and fuel suppliers, also face the prospect of losses under a greenhouse gas cap-and-trade policy. Free allocation of emissions allowances to generators diverts revenues that otherwise could be dedicated to general tax relief, which offers tremendous efficiency gains and forms broad-based compensation for the diffuse effects of the policy on households. It also diverts revenues from other purposes, such as research initiatives or efficiency programs linked to climate policy. Policymakers need to be cognizant of likely impacts on all affected parties and they may want to limit and narrowly target free distribution of emissions allowances in order to be better able to address the broader set of efficiency and compensation goals.

One approach that could address a mix of efficiency and compensation goals would be to combine free initial distribution to electricity generators with an auction. Indeed, under an allowance auction several firms, including but not limited to those that rely heavily on nuclear and other non-emitting generating technologies, will actually realize profits in excess of those received in the absence of a CO_2 cap-and-trade policy. The value of the emissions allowances in the regional program that we model is at least four times the cost to producers of mitigating CO_2 emissions. Thus, ideally only a portion of the allowances need to be given away for free to compensate adversely affected generators, which would leave the remainder to be auctioned.

As a point of departure, we calculate the change in market value of existing generation assets were the policy to take effect immediately without warning. We find the policy has an important effect on facilities outside the RGGI region, which typically gain value due to the change in the regional wholesale power price. Taking changes outside the RGGI region into account, the industry is fully compensated for the costs of the policy under an auction through the change in electricity prices and increased revenues paid by consumers. From this industry-wide perspective, we find regulators could reserve 100 percent of the emissions allowances for auction and dedicate the revenues to compensate consumers or to other purposes.

However, changes at the industry level mask the effects on individual firms, some of which gain value and some of which lose value, and the effect on individual firms may play an important role in the policy dialogue. A key to maximizing the value of allowances that can be directed to other public purposes is to find ways to tailor compensation to firms' known losses. We find that if information about the future profitability of the firm with and without the cap-and-trade regulation were available to the regulator and if the regulator were willing to act on this information, then the amount of compensation that would be required to achieve a given compensation target can be reduced dramatically. One mechanism through which the regulator might be able to entice firms to reveal their true costs is through a process analogous to stranded cost recovery proceedings, albeit one that performs very differently from the historical experience.

A crucial question is whether the regulator can successfully use a revelation strategy to identify the winners and deny them compensation and thereby limit and target the free allocation of emissions allowances to firms that lose value. If this were possible, we find that it would be sufficient to limit free allocation to 34 percent of the allowances in order to maintain fully the market value of all firms generating electricity in the RGGI region, while allowing many firms to gain substantial value. The remaining 66 percent of the emissions allowances could be auctioned or otherwise directed toward other compensation goals or public purposes.

In the alternative, the regulator might not be able to identify the gains and losses of individual firms. To address this possibility, we investigate decision rules that are simple to understand, simple to execute, and that make use of information that is generally available to state regulators. The decision rules that we envision would condition the initial distribution of emissions allowances to incumbent generators on variations of historic measures that, for the most part, have been used in previous cap-and-trade programs. These measures involve a formula for allocation based on historic generation at the facility level, with variations including different formulas for different fuels and for different gas-fired generating technologies and mechanisms to account for the portion of a firm's generation that is nonemitting. We formulate a mathematical problem with the objective of finding an approach to allocation that provides the maximum amount of revenue available for public purposes subject to the constraint that a specific compensation target is achieved for the electricity industry. In these cases, it appears that the regulator would need to freely distribute about 77 percent of the allowances in order to maintain at least a break-even value for all firms while also enabling, in this case, a substantial increase in value at many firms and for the industry as a whole. The regulator could auction the remaining 23 percent of the emissions allowances. It is noteworthy that this value is proximate to the requirement in the memorandum of understanding in the RGGI region that stipulates that states should reserve for public purposes (equivalent to an auction) at least 25 percent of the emissions allowances.[1]

Finally, we relax the assumption that the policy is announced and implemented without warning in order to consider a more realistic delay between adoption and implementation of the policy. The time between announcement and implementation delays the cost of compliance and gives firms an opportunity to depreciate existing capital and to adjust their investment strategies. Moreover, we consider the appropriate goal for compensation. Some would argue that investors should assume responsibility for risks stemming from changes in policy or market conditions, especially since in many cases firms are poised to capitalize on these changes. One might argue, for instance, that firms deserve less than full compensation for disadvantageous investments made since earlier dates when global warming emerged onto the policy agenda. We illustrate how the allocation rules we calculate can be adjusted linearly to reflect the effects of policy delay or to achieve whatever level of compensation is the goal of regulators.

2. The Design of Cap-and-Trade Policy

The RGGI is as an effort by nine Northeast and mid-Atlantic states to develop a regional, mandatory, market-based cap-and-trade program to reduce greenhouse gas emissions. The effort was initiated formally in April 2003 when Gov. George Pataki of New York sent letters to governors of the Northeast and mid-Atlantic states. Each of the nine participating states (Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont) assigned staff to a working group to develop a memorandum of understanding and a model rule by the end of 2005. On December 20, 2005, seven of the original nine states (excluding Massachusetts and Rhode Island) announced an agreement on a memorandum of understanding to implement the RGGI program. A draft model rule was released for comment in March 2006. In April, legislation was signed by the governor of

[1] As a part of the RGGI memorandum of understanding, the seven participating states agreed to set aside a minimum of 25 percent of their state allocation to fund a number of potential public purposes, including mitigating impacts on electricity ratepayers (RGGI 2005).

Maryland to bring the state into the program. Initially, the program will address carbon dioxide (CO_2) emissions from the electric power sector. If successful, the program could serve as a model for a national cap-and-trade program for GHG emissions.

Several approaches to the initial distribution of emissions allowances have been considered in other regulatory contexts and in analyses of the RGGI program (Burtraw et al. 2005, 2006). One is to distribute allowances on the basis of **historic** measures of electricity generation; this approach is often called grandfathering because it distributes allowances without charge to incumbents in the industry. Another approach is to regularly **update** the calculation underlying the allowance distribution based on current- or recent-year data. Like distribution based on historic data, an updating approach distributes allowances free of charge and also could distribute them according to various measures, such as the share of electricity generation or heat input (a measure related to fuel use and CO_2 emissions) at a facility. The primary alternative to these free distribution approaches is the sale of allowances through an **auction**, directly or indirectly (e.g., allowances may be sold by the government or distributed for free to third parties such as energy consumers or their trustees, which then sell allowances through an auction).

Burtraw et al. (2002) and Bovenberg and Goulder (2001) find that, in the case of nationwide CO_2 regulation, the free allocation of emissions allowances can dramatically overcompensate the electricity industry in the aggregate, although different parts of the industry are affected very differently. Analysis of the CO_2 emissions trading system in Europe that began in 2005 has reached a similar conclusion (Sijm et al. 2005; UK House of Commons 2005). In RGGI, earlier work (Burtraw et al. 2005, 2006) suggests that giving away 100 percent of the allowances for free to emitting generators based on historic output (or other measures) will more than compensate generators for the costs of the program. Using a simple model with fixed capacity and fixed demand in the RGGI program, the Center for Energy, Economic & Environmental Policy (2005) finds that all three approaches to allocation—historic, updating, and auction—would lead to increased profitability for the electricity sector as a whole in RGGI relative to no policy, with the historic approach resulting in the greatest increase in profits.

Using the same detailed simulation model we use in this paper, with endogenous investment and price-responsive demand, Burtraw, Palmer, and Kahn (2006) analyze a regional CO_2 cap-and-trade policy that generates roughly twice the emissions reductions as the proposed RGGI policy. Also, unlike the RGGI policy, the policy that is modeled is announced in 2008 and implemented immediately, albeit with a phased-in reduction in emissions over time. They find that the industry as a whole sees a substantial increase in value when emissions allowances are distributed for free under a historic approach. Furthermore, under any approach, the value of the industry will be greater when the analysis includes the effect of the policy on the value of generation assets located outside the RGGI region.

The changes in the value of generation assets are illustrated in Figure 1, which depicts the effects of an auction approach to allocation on the 23 largest generating firms that sell electricity within the RGGI region. A number of firms profit and some experience important losses in the value of generation assets owned inside the RGGI region. Nearly all firms show an increase in the value of the generation assets they own outside the region, and some of these increases are sizeable. Taking the unified assets of the firms inside and outside the RGGI region into account, almost half of the 23 largest firms increase in value even when they purchase emissions allowances in an auction. Therefore, limiting free allocation so as to compensate only losing firms provides the opportunity to compensate other affected parties, including consumers.

Another compelling reason to limit free allocation of emissions allowances is efficiency. Many economists and other analysts suggest that auctioning provides a source of revenue that may have economy-wide efficiency benefits if it is used to reduce taxes, with potentially dramatic efficiency advantages compared to free distribution (Bovenberg and de Mooij 1994; Parry 1995; Bovenberg and Goulder 1996; Goulder et al. 1999; Parry et al. 1999; Smith et al. 2002). Moreover, an auction has a dramatic efficiency advantage in regions of the country where electricity prices differ substantially from marginal costs due to cost-of-service regulation because the auction approach tends to reduce the difference between price and marginal cost in this case (Parry 2005; Burtraw et al. 2001, 2002; Beamon et al. 2001).

In addition to its implications for how allowance allocation affects efficiency, how electricity prices are set also is a key issue that determines how well firms will fare under an emissions trading program (Burtraw et al. 2001). In the RGGI region, electricity markets are deregulated, and retail prices are based on marginal costs rather than regulated average cost of service. In this case, there is little difference to electricity price between auction and historic approaches to distributing allowances because investment and compliance behavior are expected to be nearly identical. The difference is that in one case, the revenues (allowance value) go to government; in the other, they go to industry. An updating approach leads to lower electricity prices than an auction or historic approach and therefore it is expected to have greater social costs because it does not provide the same incentive through higher prices for consumers to improve the efficiency of energy use.

3. Overview of the Model

Our analysis is based on a detailed national electricity market simulation model developed at Resources for the Future. The scenarios employ specific assumptions about the potential design of a regional CO_2 policy in the original nine-state RGGI region, including Massachusetts and Rhode Island, and not including Maryland. These assumptions are not intended to mirror precisely the specific proposals under development or to anticipate the policy outcome of RGGI. Our annual CO_2 emissions target is calculated as a 20 percent decline from 2008 baseline emissions levels in the nine-state RGGI region to be phased in on a linear basis between 2008 and 2025, which is about twice the stringency of the agreement in the memorandum of understanding among the seven states announced in December 2005.[2] The simulation model predicts how our representation of a regional greenhouse gas cap-and-trade system in the RGGI region would affect generation and investment by type of technology and electricity price and demand in the region. The results also predict effects on electricity trade with neighboring regions and effects on electricity producers and consumers outside the region.

As a point of departure, we assume that allowances are sold through auction at a market-clearing price. Our central question is how to compensate shareholders in firms in a manner that is sufficient to maintain a specified market value through free allocation of a portion of the allowances, while preserving as much value as possible in the auction.

The effect of the policy on the value of generation assets varies significantly across types of generators and is a reflection of the change in revenues and costs. The model accounts for the change in revenues that depends on the change in electricity price, which is determined by the change in the cost at the marginal generation facility. It also depends on the change in quantity produced at a particular facility, which in turn depends on both the change in the relative costs of generation among different facilities and also on the changes in demand that occur in response to the change in electricity price. The costs of coal and natural gas also change in response to the change in the use of these fuels. Also important to asset value is the value of the allocation of emissions allowances, including both the new allocation of CO_2 emissions allowances and the change in the value of the allocation for other programs such as the SO_2 and NO_x emissions allowance trading programs. The change in market value for each facility is the present

[2] We do not include endogenous banking of CO_2 emissions allowances, but instead assume that annual emissions caps decline linearly over the simulation horizon. The agreement is available on the RGGI web site at http://www.rggi.org/ (accessed April 26, 2006).

discounted value of the changes in net revenue over the period 2008–2030 measured in 1999 dollars. The generating assets planned and built through 2005 are assigned to firms using information on plant ownership as of January 1, 2004. The value of new facilities that the model predicts will be built after 2005 is not assigned to the incumbent firms.

To find the net present discounted value of the allowance pool we calculate the present discounted value of the predicted CO_2 permit price in each future year and multiply by the number of allowances allocated in that year to obtain the present discounted value of the allowances in each year. Summing over the time period of 2008–2030 yields the net present value of the entire allowance pool to be allocated over the forecast horizon. Dividing this by the total number of allowances under the RGGI cap over the entire time period yields a weighted average of the present discounted value of one allowance in the RGGI program.

4. Compensation When Regulators Have Complete Information

We model individual facilities to calculate the effects of the policy. However, typically investors do not own individual facilities. Instead, investors own portfolios of facilities organized either at the industry level through mutual funds and institutional investments or by holdings of stocks and bonds of a specific firm. We begin by modeling a policy that is announced and implemented without warning. In section 4.1, we consider the case when regulators seek to compensate on an industry-wide basis. In section 4.2, we consider the case when regulators have, or can elicit, full information about the expected financial impacts of the trading system on individual firms. Subsequently, in section 5, we consider the case when regulators seek to compensate individual firms and they have imperfect information about the performance of firms. In section 6, we consider the delay between announcement and implementation of the policy.

4.1 Compensation at the Industry Level

Inside the RGGI region the change in electricity price in 2020 is expected to be about $3.30/MWh or 3.3 percent above the baseline. To consider effects outside the RGGI region, we focus on the eastern United States, an area that includes much of the Ohio Valley and mid-

Atlantic region.[3] In the eastern U.S. area outside the RGGI region, average electricity price rises by $0.19/MWh or 0.3 percent. Even after taking into account the small reduction in electricity demand that would result, as captured in the simulation model, the increase in price provides a sizeable new source of revenue to electricity generators. The industry realizes new costs from mitigating carbon emissions and, in the case of an auction, from the purchase of emissions allowances. Accounting for changes inside and outside the region, we find that even with an auction at the industry level the increase in revenue is greater than the increase in costs. That is, if the industry is viewed as whole we find no claim for compensation through free allocation of emissions allowances. This result is recorded in the upper left cell of Table 1. If the increase in the value of assets at some facilities were used to offset the decrease in value at other facilities and the effects inside and outside the RGGI region were taken into account, then the industry as a whole would require no allocation in order to preserve its market value. If one views the principals who are directly affected by the emissions trading system as shareholders in mutual funds that may be invested in electricity stocks generally, then one might claim there is no need for compensation because investors actually benefit in the aggregate from the emissions trading program.

As evident from Table 2, however, consumers are worse off under the program because of the increase in electricity price. The difference between historic and auction approaches in the table stem strictly from slight differences in stranded cost recovery from industry deregulation.

The lower left cell of Table 1 indicates that if one limits attention to the assets located inside the RGGI region, then the number of allowances needed to compensate the industry would constitute 29 percent of the total value of emissions allowances. However, in this case the industry would realize gains outside the RGGI region. We estimate those gains—the net increase in the market value of the industry in the eastern United States but outside the RGGI—to be $1.27 Billion (1999$).

[3] Outside the nine-state RGGI region, we focus on the eastern United States, which we define to include the states of Indiana, Michigan, Ohio, Kentucky, West Virginia, Pennsylvania, Maryland, the District of Columbia. These are the states that trade electricity with states in the RGGI region and, also, the states where generating firms that operate in RGGI tend to own assets outside of RGGI.

4.2 Compensation of Firms

If a regulator can identify the performance of individual firms under the trading program, one can imagine the regulator might seek to compensate firms through an individualized allocation of emissions allowances in order to achieve a precise compensation goal. One way the regulator may obtain such detailed information is by solving a simulation model. Another way the regulator may obtain information is by establishing a rebuttable presumption against compensation and inviting firms to appeal through the demonstration of harm, again presumably through the use of simulation modeling. These approaches would resemble the stranded cost recovery proceedings that accompanied the restructuring of the electricity sector in many states in the late 1990s, when regulators relied on simulation models to estimate the potential change in the value of generating assets due to restructuring.[4]

In the restructuring process, the modeling exercise led to contentious disputes between utilities and regulatory staffs (and consumer representatives) concerning the validity of simulation models, including key data input assumptions and calculation procedures. In the absence of case settlements, state commissions were required to adjudicate these very technical modeling issues. In the present case, similar disagreements can be expected. If energy efficiency or taxpayer advocates anticipate receiving a share of the emissions allowance revenue, they may become more directly involved in the regulatory proceedings than occurred previously in the case of stranded costs. Further, if a fixed number of allowances were to be awarded to industry, it is possible that one would see the emergence of firms monitoring other firms and their respective claims for compensation. One way to imagine that the regulator could gain information about the expected performance of firms is a mechanism that enticed firms to reveal their own estimates.

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[4] In the proceedings, regulators and utilities used three methods to estimate the potential change in value of generating assets due to restructuring (Kahal 2006). One was the measure of the change in the discounted value of revenues due to anticipated changes in prices as a result of restructuring. A second and conceptually similar method calculated the year-by-year revenues and costs of the generating assets in a deregulated market over the assumed remaining lives of the assets. The net present value (discounted cash flow) of this stream of profits was assumed to be the market valuation. The difference between the market valuation and the net book value of the assets (i.e., the value under regulation) measured the gain or loss from deregulation.

In the later stages of restructuring, the comparable transaction approach became widely used. This much simpler method involved compiling a database on generation plant sales (usually associated with utility divestitures) and then, through the use of expert judgment, identification of comparable generation assets that had been sold and sales prices announced. In many cases, this method produced much higher post-restructuring asset valuations than those produced by simulation models, perhaps because asset buyers were willing to pay premium prices to enter newly deregulated markets quickly.

Policymakers could declare a default allocation rule that promises limited compensation to all firms, but then invite firms that are not happy with their allocation to justify a higher allocation within a structured process in which these firms bring information into a common, open-source simulation-modeling framework.

In any event, we imagine that for the firms to credibly appeal for compensation, it would likely involve simulation modeling on their part. In this section, we assume the results of modeling are available to the regulator who seeks to target the allocation of emissions allowances in order to achieve a compensation goal.

The second column of Table 1 reports results when the regulator's goal is to compensate every adversely affected firm and when regulators can identify the winners under the trading system—for example, firms that operate a large portfolio of nonemitting generation—and can exclude these firms from compensation. The upper right cell accounts for the unified assets of firms throughout the eastern United States. We find that 34 percent of the value of emissions allowances is required to fully compensate all losing firms in this case. The remaining two-thirds of the allowances could be assigned to public purpose. Again, in this case the overall market value of the industry would increase relative to the baseline because many firms that are winners would retain their gain in value and the allocation ensures that no firms would lose value. We estimate the net increase in the market value of the industry in the eastern United States under the RGGI carbon policy, including the compensation of 34 percent of emissions allowance value, to be $1.48 billion.

The lower right cell considers only changes in the value of the firm's generating assets inside the RGGI region. In this case, 53 percent of the value of emissions allowances would be needed to fully compensate these firms. Again, in this case the overall performance of the industry also would be better than break-even because there would be many winners. However, in this case the limited focus on the regional perspective creates more winners because many firms, including some firms that are losers within RGGI, would be winners outside of RGGI and the gain in value outside of RGGI would not be counted on to offset the loss inside RGGI. This approach would lead the industry in the eastern United States to gain $2.2 billion in market value, which includes the value of 53 percent of emissions allowances.

5. Compensation When Regulators Have Incomplete Information

In practice, the regulator may not have information about the financial performance of firms and may not be able or willing to gain this information through the regulatory process.

Nonetheless, in this case the regulator has information based on readily observable characteristics of firm portfolios of generating capacity and historic generation that can be used to differentiate among firms. For instance, the most obvious distinction is the type of fuel used by various facilities.

5.1 The Mathematical Problem

We assume the regulator is motivated to minimize the amount of free allocation in order to achieve a compensation target. To do so, the regulator uses simple rules based on observable characteristics of the facilities owned by the firm. The mathematical problem is to find allocation rules that maximize the amount of allowances that would be leftover for auction while achieving 100 percent compensation through free allocation for firms suffering losses under the auction. Formally, the problem is to identify allocation rates r_j , defined as allowances per MWh of 1999 generation by fuel type j, where j refers to coal, gas, oil, that minimizes the value of the allowances that are allocated for free:

$$\min_{r_C, r_G, r_O} P^* \left[\sum_{f=1}^{F} r_C C_f + r_G G_f + r_O O_f \right] \text{ such that } \forall f \in F: P^* \left[r_C C_f + r_G G_f + r_O O_f \right] \geq \theta (V_f^{BL} - V_f^A)$$

where P^* is the discounted weighted average allowance price (\$/ton CO_2) and F is the set of firms {f} operating in RGGI. C_f, G_f and O_f denote 1999 generation (MWh) with coal, gas, and oil, respectively. V^A_f is the net present value of firm f under an auction, and V^{BL}_f is its net present value in the baseline – that is the absence of the policy. All values are reported in 1999 dollars.

The parameter θ presumably can vary between zero and one ($0 < \theta < 1$) and represents the portion of market value in the absence of the program to be maintained through compensation. For instance, if $\theta = 1$, then the solution will provide 100 percent compensation to the most disadvantaged firm, implying that other firms and the industry as a whole would gain value.

There are about 100 firms operating in the RGGI region that are included in the analysis. Under this approach to defining compensation rules, usually there is one firm that just breaks even for each fuel category and thereby determines the allocation rule. These break-even firms typically are small firms with an idiosyncratic, unbalanced portfolio of assets. To achieve full compensation, these firms require a very high rate of allowances per MWh of generation in 1999, which leads to massive overcompensation of the other firms that also receive allowances at the same rate. Thus, these three firms (one for each fuel type) are deemed outliers and removed from the analysis and the allocation rules by fuel type are recalculated for the remaining firms. The recalculated number of allowances required for compensation is divided by the total number of allowances under the RGGI cap over the period 2008–2030 to obtain the percentage of the allowance pool that must be given away.

The rules we identify are differentiated by fuel type so that, for example, gas-and coal-fired generators receive a different amount of allowances per MWh of historic generation. There is regulatory precedent for differentiating allowance allocation by fuel type; for example, in the Environmental Protection Agency's Clean Air Interstate Rule, where NO_x allowances are allocated to coal-fired generators at the rate of one times the total number of NO_x allowances divided by the fuel-adjusted total average annual heat input (BTU) between 1999 and 2002. Gas-fired generators receive allowances at a rate that is 40 percent of the coal-fired rate (per BTU of total historic heat input) and oil-fired generators receive allowances at 60 percent of the coal-fired rate.

In addition to differentiating by fuel type, we explore other variations on the allocation rule, including differentiating by type of natural gas technology (turbine, steam, and combined cycle) and including an adjustment to the allocation rule based on the nonemitting share of the firm's generation. Other variations include the exclusion of small- or medium-sized firms from direct compensation instead applying a generic historic allocation approach for these firms.

5.2 Accounting for Fuel and Technology Characteristics

The goal of the mathematical programming problem is to allocate allowances in a way that will achieve the compensation goal while minimizing the number of allowances that have to be given away for free. As reported in the first row of Table 3, if the regulator only differentiates the allocation to individual facilities based on fuel, nearly 100 percent of the allowances must be given away for free in order to compensate the most adversely affected firms, even when accounting for gains outside the region. To achieve this target requires coal generation to be compensated at a rate of 27.7 allowances per MWh of generation in 1999, oil generation at 9.2 allowances per MWh, and natural gas generation at 11.2 allowances per MWh. To put these numbers in perspective, firms would be compensated at a rate of 17.9 allowances per MWh of 1999 generation under the historic allocation where all fossil generation was treated the same.

The driving factor in this result is the presence of small firms that have an unbalanced portfolio of generation assets. Even after we eliminate one firm as an outlier for each of the three fuel types, we still find additional small firms that require a very large allocation in order to avoid a decrease in their market value. Under this policy, all firms are made whole (their value under the policy is greater than or equal to their baseline value), so most gain value and the overall value of the industry in the eastern United States increases by $3.9 billion.

The second row in Table 3 assumes that the regulator also can differentiate among natural gas technologies, treating combustion turbines, steam, and combined cycle as classes of facilities deserving different allocation rules. This differentiation has little effect on the allocation necessary for compensation.

Another alternative is to account more completely for the portion of historic generation that comes from nonemitting sources. Heretofore, we assumed that nonemitting sources do not qualify for an allocation. However, we expect that firms that own nonemitting generation realize an increase in value from those assets and hence are unlikely to need as much compensation as firms that have a less balanced portfolio. By adjusting the allocation based on the portion of the portfolio that is nonemitting, we find we reduce the overcompensation that accrues to many firms. The third row of Table 3 combines the allocation to firms by fuel type with an adjustment in proportion with their share of generation in the region that is nonemitting. This adjustment is fairly potent and reduces the percentage of the allowances to be given away for free to 85 percent.

The fourth row combines all three adjustments for fuel type, gas technology, and the share of generation that is nonemitting. We find that 84 percent of the allowances need to be given away for free in order to maintain the value of the disadvantaged firms. All the other firms in the region are winners, and the industry gains $3.29 billion in value.

When the regulator accounts for the change in the value of assets within the RGGI region only, the results are similar, but in this case firms are slightly better off. For example, the last row in Table 3 indicates that if the regulator accounts for fuel type, type of gas technology, and adjusts for nonemitting generation, then to maintain the value of the disadvantaged firms requires that only 77 percent of the allowances be given away for free. The percent is less when considering changes only within the RGGI region in this case. Although electricity price goes up outside the RGGI region and firms benefit from increased power sales into RGGI, we also find that changes in payments for capacity reserve as well as changes in the price of natural gas can lead to negative effects on specific facilities outside RGGI. Several of these facilities are elements of the portfolios of the small firms that set the allocation rules for individual fuel types.

5.3 Accounting for Firm Size

As noted, the firms that are driving the performance of the allocation rules typically are small- and medium-sized firms. The compensation rule singles out firms that have imbalanced portfolios, and consequently, any formula based on their historic generation leads to overcompensation for the large firms that typically have a more balanced portfolio.

Table 4 reports performance when small firms are excluded from the identification of fuel-specific allocation rules. Instead, we assume these firms are directly compensated with generic historic allocation. Small firms are identified as those with less than 500,000 MWh of generation inside the RGGI region in 1999. With a historic approach to allocation, these small firms realize a gain in market value.

The first row indicates that excluding small firms and using fuel-specific rules still requires 90 percent of the allowances to be allocated for free. The second row extends the generic historic allocation method to all medium-sized firms—those with more than 500,000 but less than one million MWh of generation in RGGI in 1999. There remain 23 large firms identified as those with generation of more than one million MWh in RGGI in 1999. In this case, using only a fuel-specific allocation rule requires that 79 percent of the allowances be given away for free.

The third row of Table 4 combines all of the features of Table 3: adjustment for fuel type, gas technology, and for the portion of nonemitting generation. The resulting share of allowances needed for compensation is 77 percent. We find that 87 percent of the firms are winners under this policy. We find the same solution when considering only the change in the value of assets located within the RGGI region. The sixth row of Table 4 indicates that the percentage of allowances that must be given away also is 77 percent. In the aggregate, we find that within the eastern United States, the industry gains $1.72 billion in market value.

Finally, in sensitivity analysis we consider what would happen if the regulator could identify firms that are winners under the auction and exclude them from further compensation. We consider the case in which the regulator uses a generic historic approach to allocation for small- and medium-size firms and applies the other rules for the large firms. Accounting for changes in the eastern United States outside the RGGI region, the regulator would need to give away 58 percent of the emissions allowances. In so doing, the regulator still would be creating new winners while compensating the most disadvantaged firms.

6. The Level of Compensation

We have maintained a 100 percent compensation goal for the most disadvantaged firms as a yardstick for comparing the different approaches to the distribution of allowances. Let us denote the share of the value of allowances that must be given away for free to achieve this goal as *S*. In reality, the regulator may decide on a goal that differs from 100 percent compensation. The estimates we provide can be adjusted in a linear way for any goal. For a compensation target less than 100 percent—that is, for $\theta < 1$—the value of allowances necessary to achieve that goal is $\theta \cdot S$.

Several factors influence the compensation goal (θ). Hochman (1974) argues that individual behavior presumes the permanence of preexisting rules and dealing equitably with those who suffer windfall losses may be crucial to preserving a belief in the fairness of social rules and institutions. On the other hand, investors in a competitive market are expected to anticipate uncertainties and factor them into account. Some policy changes have a positive effect and some have a negative effect on investments, and some observers argue that society is better off in the absence of compensation.[5] For the most part, investors retain the payoff when gains exceed expectations, although sometimes regulators or legislators intervene to prevent taking of profits, as in recent decisions in Maryland and elsewhere to allow consumers to phase in adjustments in electricity rates when rate caps that survive from industry restructuring will be lifted. Fairness and efficiency may be served by a symmetric process in which the regulator relieves the firm of some but not all responsibility for changes in policy that impose large loss in value. Inevitably, the final outcome will be shaped as much by political necessity as by compensation principles, but information about those principles can help inform the policy dialogue.[6]

In the RGGI example, the emergence of climate policy may have been anticipated years ago—perhaps with the signing of the Kyoto Protocol or at some other point in time at which changes in policy could have been anticipated. The time between when a policy is announced and when it is implemented gives firms that are to be regulated time to adjust their investment

[5] For example, Polinsky (1972) suggests that a single policy should be viewed as part of a larger social agenda in which government pursues many policies to improve the welfare of society generally.

[6] A "public choice" view is that appropriate compensation is discovered in a political market place, with bartering commencing in the form of political negotiations (Buchanan 1973). Compensation serves a practical purpose by this rationale, affecting a political buy-out of groups opposing changes in social policy (Tullock 1978).

plans so as to avoid new investments that would be particularly disadvantaged under the forthcoming policy and to make investments that will perform better under the policy. To the extent that the loss in economic value stems from investments made between the announcement and implementation of the policy, this advance warning diminishes the claim for harm. In the RGGI region, most investments since the early 1990s were in natural gas generation technologies, some of which gain value and some of which lose value due to the policy.

A second aspect to delay is that it may allow for the realization of economic value from investments that predate the policy. As a consequence, the lost economic value will be less than if the policy is implemented in the same year it is announced because for the intervening years the owner will continue to incur revenues and costs equivalent to those in the baseline. Therefore, the need for compensation will be less if implementation occurs sometime after the adoption of the policy. However, delay does not directly affect the compensation target (as a share of harm that is to be compensated) or the share of allowance value necessary to achieve that target.

To illustrate these points, we assume that the value of existing assets going forward is constant in every year *t* in the baseline (v^{BL}), and also constant at a reduced value under the auction policy (v^{A}). If the policy is adopted and implemented in the same year, the loss in value (*L*) is:

$$L = \sum_{t=0}^{\infty} \partial^t \left(v^{\mathrm{BL}} - v^{\mathrm{A}} \right) = \left(\frac{1}{1-\partial} \right) \left(v^{\mathrm{BL}} - v^{\mathrm{A}} \right).$$

Assume the discount factor is $\partial = 0.92$ corresponding to a discount rate 0.08. Then the instantaneous loss in the value of existing assets from the implementation of the policy is $(12.5)\left(v^{\mathrm{BL}} - v^{\mathrm{A}} \right)$. If implementation is delayed by five years after the adoption of the policy then the loss in value due to the policy is:

$$L = \sum_{t=5}^{\infty} \partial^t \left(v^{\mathrm{BL}} - v^{\mathrm{A}} \right) = (8.24) \left(v^{\mathrm{BL}} - v^{\mathrm{A}} \right).$$

The delay in implementation reduces the financial magnitude of harm by more than one-third. However, delay also reduces the present value of allowances measured at the time when the policy is adopted. Consequently, the portion of allowance value (*S*) required for full compensation is unchanged.

7. Conclusion

A regional program to cap greenhouse gas emissions from electricity generators like the recently adopted RGGI program in the Northeast can be expected to have important effects on the market value of firms that own electricity generation assets. This paper explores rules for the initial distribution of emissions allowances that preserve all or some portion of the value of the firms, while maximizing the amount of allowances that can be allocated to other public purposes.

We calculate decision rules under a scenario in which the policy is announced and implemented in the same year. We find that if the regulator has full information about the profitability of firms or is able to execute a revelation strategy to encourage firms to reveal information, and if the regulator sets a compensation target of maintaining 100 percent of the market value of all firms, then about two-thirds of the value of emissions allowances can be made available for public purposes and the most adversely affected firms can be fully compensated. Many firms would be winners under this policy. If the regulator has to execute a decision rule with less information, then about one-quarter of the value of emissions allowances can be available for public purposes, while fully compensating the most adversely affected firm. In both cases, while the most adversely affected firm is made whole, many firms enjoy an increase in value relative to the baseline.

An important source of compensation is the time that intervenes between the announcement of the policy and its implementation. The RGGI process began in 2003 and culminated in a memorandum of understanding in 2005. The program is planned to begin in 2009. The delay in implementation provides time for investors to realize the value of previous commitments. As an example, we find that with a discount rate of 8 percent, a five-year delay between adoption and implementation of the program implies that the financial harm to companies is reduced by one-third. However, the present value of emissions allowances also is reduced, so the portion of allowance value that is required to achieve a compensation goal is unchanged. Finally, we find that if the regulator decides that maintenance of the value of the firm at less than 100 percent is adequate, then the calculated allocation rules can be adjusted in a straightforward and linear manner.

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Tables and Figures

Table 1. Percent of Allocation Required to Achieve 100% Compensation Target When Regulator Can Identify Firms That Are Winners and Provide Exact Compensation to Losers

	Compensation of Industry	Targeted Compensation of Firms That Lose Value
Eastern United States[a]	< 0%	34%
RGGI Region Only	29%	53%

[a]The eastern United States includes Indiana, Kentucky, Michigan, Ohio, West Virginia, Pennsylvania, the District of Columbia, Maryland, and the 9 RGGI states.

Table 2. Overview for Allocation Cases, 2025[a]

RGGI region (nine states)	Baseline	Historic	Auction
Average electricity price (1999$/MWh)	$103.4	$107.1	$107.2
TOTAL generation (billion kWh)	393	348	348
Coal	73	48	48
Gas	130	115	116
Nuclear	107	108	108
Renewable	34	40	40
TOTAL new capacity[b] (GW)	28	31	31
Gas	23	24	24
Renewable	5	6	6
CO_2 price (1999$/ton)	n/a	$18.1	$18.3
Emissions			
CO_2 (million tons)	147	100	99
NO_x (thousand tons)	118	70	70
SO_2 (thousand tons)	193	101	107
Mercury (tons)	1.2	0.8	0.8

[a] The modeled scenario does not match any specific proposal that is part of RGGI.

[b] Numbers may not sum because of rounding.

Table 3. Allocation Using Fuel-Specific Rules to Fully Compensate the All Firms[a]

Differentiate among Gas Technologies	Adjust for Nonemitting Generation	Percent of Allocation Required to Achieve 100% Compensation Target
Eastern United States		
		99%
Yes		**98%**
	Yes	**85%**
Yes	**Yes**	**84%**
RGGI Region Only		
		98%
Yes		**89%**
	Yes	**84%**
Yes	**Yes**	**77%**

[a] Fuel-specific rules include elimination of one outlier for each fuel type.

Table 4. Allocation Using Fuel-Specific Rules to Fully Compensate All Medium and Large Firms; Historic Allocation to Small Firms

Historic Allocation Also to Medium Firms	Differentiate among Gas Technologies	Adjust for Nonemitting Generation	Percent of Allocation Required to Achieve 100% Compensation Target
Eastern United States			
			92%
Yes			**79%**
Yes	**Yes**	**Yes**	**77%**
RGGI Region Only			
			90%
Yes			**82%**
Yes	**Yes**	**Yes**	**77%**

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Figure 1. Change in Market Value for the 23 Largest Firms in the RGGI Region under an Auction