National Round Table on the Environment and the Economy
Table ronde nationale sur l'environnement et l'économie

# Analysis of Options for Distributing Allowances by Auction

Domestic Greenhouse Gas Emissions Trading
Technical Paper Series

Droits d'échange d'émission nationaux des gaz à effet de serre
Série de documents techniques

# Analysis of Options for Distributing Allowances by Auction

Prepared for:

**Multistakeholder Expert Group on Domestic Emissions Trading**

**National Round Table on the Environment and the Economy**


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The National Round Table on the Environment and the Economy (NRTEE) was created to "play the role of catalyst in identifying, explaining and promoting, in all sectors of Canadian society and in all regions of Canada, principles and practices of sustainable development." Specifically, the agency identifies issues that have both environmental and economic implications, explores these implications, and attempts to identify actions that will balance economic prosperity with environmental preservation.

At the heart of the NRTEE's work is a commitment to improve the quality of economic and environmental policy development by providing decision makers with the information they need to make reasoned choices on a sustainable future for Canada. The agency seeks to carry out its mandate by:

- advising decision makers and opinion leaders on the best way to integrate environmental and economic considerations into decision making;
- actively seeking input from stakeholders with a vested interest in any particular issue and providing a neutral meeting ground where they can work to resolve issues and overcome barriers to sustainable development;
- analyzing environmental and economic facts to identify changes that will enhance sustainability in Canada; and
- using the products of research, analysis and national consultation to come to a conclusion on the state of the debate on the environment and the economy.

The NRTEE has established a process whereby stakeholders themselves define the environment/economy interface within issues, determine areas of consensus and identify the reasons for disagreement in other areas. The multistakholder approach, combined with impartiality and neutrality, are the hallmarks of the NRTEE's activities. NRTEE publications address pressing issues that have both environmental and economic implications and which have the potential for advancing sustainable development.

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# Introduction

This is one of a series of National Round Table on the Environment and the Economy (NRTEE) papers dealing with issues common to several possible designs for a domestic greenhouse gas (GHG) emissions trading system.

This paper deals with the distribution of allowances to participants in a "cap and trade" system by auction. In such a system, designated sources are required to hold allowances equal to their actual emissions. The number of allowances available is limited. The regulatory authority distributes the allowances by selling them at auction.

The main arguments for distributing allowances by auction are that:

- The allowances represent a right to use a limited public resource, namely the waste absorption capacity of the atmosphere. Proper management requires that the government obtain the highest price for the use of this public resource. A well-designed auction achieves this objective.
- An auction raises revenue that the government can use to improve the performance of the economy and to offset adverse impacts suffered by particular groups as a result of the introduction of the limit on emissions.

The main issues that arise with an auction of allowances, then, are the design of the auction and the use of the revenue generated. Although auctions are routinely used to distribute other public resources, such as treasury bills, oil and gas exploration rights and communications frequencies, they have not yet been used to distribute allowances for an emissions trading program. While an auction is part of the U.S. sulphur dioxide ($SO_2$) allowance program, it is not the basis for distributing allowances and now represents only a small share of total sales.

Topics addressed by this paper are:

- The design of the auction
- Experience with the use of auctions
- The secondary market
- Use of the auction revenue
    - Efficiency considerations
    - Equity considerations
- Rationale for transition to an auction
- Rationale for use of an auction and *gratis* distribution of allowances

Many of these topics are discussed in more detail in the paper *Tradable Carbon Allowance Auctions: How and Why to Auction*, by Peter Cramton and Suzi Kerr.[1] That paper is attached to this document and should be read in conjunction with it.

Cramton and Kerr assume that the allowance trading system is implemented for the carbon content of fossil fuels sold by oil refineries, natural gas pipelines, natural gas liquid sellers, and coal processing plants. While this is similar to one of the options for a domestic emissions trading system being analysed for the NRTEE, their conclusions relating to the use of an auction to distribute allowances apply to any cap and trade system.

Cramton and Kerr also compare an auction to a *gratis* distribution of allowances, which they assume would reflect historical emissions. Hence, they refer to *gratis* distribution of allowances as grandfathering. The NRTEE paper on *gratis* distribution of allowances, Issue 6, clearly indicates that *gratis* distribution need not, and probably should not, reflect historical emissions. Some of Cramton and Kerr's comments on grandfathering, therefore, do not apply to all *gratis* allocation rules.

1 The Cramton and Kerr paper was prepared for the Center for Clean Air Policy's Greenhouse Gas Emissions Trading Braintrust, Washington, D.C., March 1998.

# The Design of the Auction

There are many ways to conduct an auction, and there is ample evidence that the design affects the outcome. The best design for an auction varies with the nature of the item sold and the number of bidders. An auction for a unique item, such as a work of art, should be designed to elicit from each potential buyer the highest price he/she is willing to pay for the item being sold. Then selling the item to the highest bidder maximizes the revenue to the seller and maximizes satisfaction for the buyers.[2]

An auction of emissions allowances, like an auction of treasury bills, involves the sale of a large quantity of the same item, generally to multiple buyers. Either a price discriminating auction or a uniform price auction is possible in this case. In a price discriminating auction, potential buyers submit sealed bids for a specified quantity at a specified price. The bids are ranked in descending order by price, and sales occur until the available quantity has been sold. This design maximizes efficiency by getting the best price for each item sold.[3]

In a price discriminating auction buyers pay different prices for the same good purchased from the same seller on the same day. This can be interpreted as being unfair. In contrast, a uniform price auction sells all of the available allowances at the same price.[4] Potential buyers submit the quantity they wish to purchase at a given price. If the desired quantity is more than is available, the auctioneer raises the price. Potential buyers submit new bids for the quantities they wish to purchase at the higher price. This continues until the demand equals the available supply. That is the price at which allowances are sold to all bidders.

A small number of bidders, or a few bidders who purchase a large share of the available items, can reduce the price obtained in a uniform price auction and so reduce the revenue received by the government. Since there are multiple rounds of bidding, a potential buyer can "signal" other bidders (if individual bids are known) to get a lower price. In the case of an auction for greenhouse gas allowances, the number of participants would probably be relatively large (more than 25) and it is unlikely that any of them would buy a large share of the available allowances.[5]

Under these conditions, Cramton and Kerr recommend an ascending "clock" auction. The auction would be conducted by the regulatory agency responsible for the allowance trading program or an agency acting on its behalf. It would work as follows:

- The "clock" indicates the current price.
- Bidders submit the quantity of allowances they are willing to buy at the current price.
- If the total quantity exceeds the quantity of allowances available, the price is increased by a known increment.
- Bidders indicate the quantity they are willing to buy at the higher price.[6]

2 Since the item is unique, only one of the potential buyers can purchase it. If the auction design successfully elicits the highest price each buyer is willing to pay for the item, it will be sold to the buyer for whom it is most valuable, given the distribution of income.

3 An auction design that successfully elicits the highest price each buyer is willing to pay and then sells each item to each bidder at that price maximizes efficiency by allocating the items to the buyer for whom they are most valuable and maximizing the revenue from the sale of the items to the seller.

4 A uniform price auction sells all allowances at the same (market clearing) price and so does not capture the "consumer surplus" from each buyer for the seller. But it does allocate the allowances to the sources for which they have the most value. These are the sources facing the highest costs to reduce their own emissions. Given an international market for assigned amount, emissions reduction units from joint implementation projects and emissions reduction credits from clean development mechanism projects, bidders are unlikely to be willing to bid much more for allowances than the market price. Hence, the loss of revenue to the seller in a uniform price auction is minimal under these circumstances.

5 In principle, one buyer could attempt to purchase most of the allowances and then resell them to other participants at a higher price. Quarterly (or more frequent) auctions, and a secondary market linked to the global market, as discussed below, would make such a strategy unattractive.

6 Under the rules of the auction, bidders are not allowed to increase the quantity they offer to buy as the price rises.

- Bidding continues until the quantity bid is less than the quantity available.
- The allowances are then allocated at the previous price.
- Since not all bids can be satisfied at that price, allowances are pro-rated for the bidders that reduced their quantities in the last round.

The total quantity bid, but not the quantities submitted by individual bidders, is reported for each round to give bidders an indication of how quickly they are approaching the clearing price and to prevent signalling.

This format is perceived to be fair since all buyers pay the same price for their allowances, although this is not the most efficient outcome. However, if the number of participants is large enough to minimize market power, the inefficiencies are likely to be insignificant. Cramton and Kerr recommend that auctions be held quarterly to ensure a regular supply of allowances. Firms that are unsuccessful in obtaining the allowances they want at one auction can try again at later auctions or turn to the secondary market.

If allowances are to be auctioned for an emissions trading program that involves relatively few sources, a different design might be needed. For example, if the trading program included only firms that produce or import hydroflourocarbons (HFCs), a different auction design might be needed to get an efficient outcome. Combining several small trading programs, or combining small programs with a large program, is one possible way to deal with the concerns raised by having a limited number of participants.[7]

# Experience with the Use of Auctions

Although auctions are routinely used to distribute public resources, such as treasury bills, oil and gas exploration rights and communications frequencies, they have not yet been used to distribute allowances for an emissions trading program.[8] An auction is part of the U.S. $SO_2$ allowance program, but it is not the basis for distributing allowances and now represents only a small share of total sales.

## $SO_2$ Allowance Auction

The only experience with an auction for allowances is the $SO_2$ trading program for electric utilities in the United States. This auction is not used to distribute the allowances. The allowances are distributed *gratis*, and a small number are withheld for sale at auction to ensure that allowances will be available for new, small sources. The revenue is distributed to the sources whose allowances were sold.

The $SO_2$ trading program was created by Title IV of the 1990 Clean Air Act Amendments and came into effect in 1995. When fully implemented in 2000, the program will apply to all electric utility generating units with an output capacity of 25 megawatts or greater that use fossil fuels with a sulphur content greater than 0.05%.

Allowances are distributed *gratis* to generating units that existed in 1990; new units receive no allowances. During Phase I (1995-1999) the units required to participate are allocated $SO_2$ allowances on the basis

7 For example, HFC producers and importers, oil refineries, natural gas pipelines, natural gas liquid sellers, and coal processing plants could all be part of a single program with allowances denominated in $CO_2$ equivalent tonnes.

8 Communications frequencies in different urban areas are not a homogeneous commodity and the number of frequencies available in any given area is small. The issues involved in designing an efficient auction for communications frequencies are very different from those involved in the design of an auction of a uniform commodity with a large number of bidders, such as GHG emissions allowances; therefore, the experience with auctions of communications frequencies is not reported here. The treasury bill auction, like an auction of GHG emissions allowances, sells a uniform commodity. However, the number of participants in a treasury bill auction is smaller than is likely to be the case for GHG allowances. In the United States the top five primary treasury bill dealers routinely purchase over half of the issue, yet market power is not a serious concern.

of a standard emissions rate (2.5 pounds of $SO_2$ per million BTU) multiplied by the average energy input for the years 1985 through 1987.[9] In Phase II (from 2000 on) the emissions rate drops to 1.2 pounds per million BTU for all units, but it is still multiplied by the average energy input for the years 1985 through 1987. The basic allocation rule is supplemented by a number of special provisions. If necessary, all allocations are pro-rated to equal the number of allowances available for that year.

Since new units receive no allowances, independent power producers wanted assurance that allowances would be available for purchase. An auction was established for this purpose. A fraction (2.8%) of the allowances allocated to each unit is withheld and sold at auction. The revenue derived from the auction is divided among the units in proportion to the number of allowances withheld.

The auction is a sealed bid auction with bidders paying the price they bid — a price discriminating auction. The design of the auction has been criticized for providing an incentive to underbid.[10] In 1993 and 1994 the auction accounted for a substantial share of the total number of allowances traded. When Phase I began in 1995, the secondary market began to develop.[11] The quantities of allowances sold in the secondary market have grown rapidly, and auction sales have amounted to less than 5% of total trades since then. As a result, concern about the structure of the auction has diminished because it has little effect on the market.

## Bank of Canada Auction of Bonds and Treasury Bills

The Bank of Canada, in its role as the government's fiscal agent, conducts auctions of bonds and treasury bills.[12] The auctions are designed to produce the highest prices for the government while being fair and transparent for buyers. Treasury bills with terms of three, six and 12 months are auctioned on a biweekly basis. Auctions are usually held on Tuesday for delivery Thursday. To be eligible to bid, a firm must meet reporting, performance and distribution criteria. To become an eligible bidder, a firm must be an investment dealer incorporated in Canada, a bank, or a non-bank member of the Canadian Payments Association.

Approximately 30 firms are eligible to participate in the auctions. Each firm is assigned bid limits by the Bank of Canada. Any firm may bid for up to one-third of each tranche of a treasury bill auction. Bidding limits for different bonds depend on the firm's activity in the primary and secondary markets for those securities. No firm is allowed to bid for more than 25% of the total amount of bonds tendered at an auction.

The most active bidders in both bond and treasury bill markets may apply to become Bank of Canada jobbers. Jobbers are expected to bid at every treasury bill and bond auction, to consistently market treasury bills and bonds to a broad customer base, and to provide the Bank of Canada with assessments of market conditions, weekly statistical reports and audited financial statements.

9 The 263 units listed in Table A of Title IV are required to participate. Other units can choose to participate. Units that opt in receive allowances approximately equal to their historical emissions.

10 See the references to Cason 1995, Cason and Plott 1996, and Joskow, Schmalensee and Bailey 1996 in the Cramton and Kerr paper.

11 No action was required to develop the secondary market. Electric utilities can trade directly with one another, and many early transactions took this form. But by 1997 virtually all trades were arranged through brokers that specialize in emissions trading.

12 For more information, see Finance Canada, *Debt Management Report, 1997*, Finance Canada Distribution Centre, Ottawa, 1998.

## Oil and Gas Exploration Leases in Alberta

In Alberta, oil and gas development proceeds through a business arrangement between the province, as resource owner, and private companies that explore for and develop the resource. The price for the right to exploit Alberta's petroleum resources is composed of an up-front competitive bid, plus a stream of royalty payments over the life of a well. The competitive bid is based on a company's expectations of commodity price, exploitation costs, and the royalty payments associated with extraction of the resource.

Twenty-four public offerings for the disposition of Crown petroleum and natural gas rights are made each year. In 1996, 9,020 petroleum and natural gas parcels were sold involving 4.6 million hectares of land for a value of $726 million.

# The Secondary Market

If allowances are auctioned, a secondary market would also exist in Canada. Firms whose bids were unsuccessful could buy allowances in the secondary market. The allowances and credits available on the secondary market would include credits from specified domestic sources, assigned amount from international emissions trading, joint implementation reductions, clean development mechanism credits, and allowances purchased at auction and offered for resale. The secondary market would reflect global supply and demand for greenhouse gas allowances and credits.

Given that Canada's emissions are small relative to global emissions, the global market will largely determine prices in the secondary market unless international or Canadian rules restrict the ability to use, or raise the cost of using, allowances or credits from other countries.[13] If the secondary market is closely linked to the global market, the auction will be small relative to the secondary market and auction prices can be expected to reflect the global price. This is the desired outcome from an economic efficiency perspective.

The existence of a secondary market that is large relative to the auction should alleviate any concerns about strategic behaviour in the auction leading to restrictions on the supply of allowances for unsuccessful bidders. However, the auction must still be designed so that bidders are not able to buy allowances substantially below the market price.

It could be argued that the existence of a secondary market, especially one large enough to effectively determine the auction price, eliminates the need for an auction. The government could simply sell the allowances on the market. But the government will still be a relatively large seller, and the timing or quantities of its sales could affect activity in the secondary market. Holding relatively frequent auctions of allowances minimizes the impact of government sales on the secondary market.

An auction also provides a fair and transparent way for the government to sell the allowances. The procedure for determining the price and the successful buyers is fair and transparent. If, instead, the government were to sell allowances periodically on the secondary market, the process for determining the price and the successful buyers is not clear. Some buyers will on occasion purchase allowances from the government at a price lower than the market price over the next few days. Then the government is open to charges of incompetence or rewarding supporters. An auction eliminates the potential for such charges.

13 For example, supplementarity provisions for international emissions trading, joint implementation and the clean development mechanism could limit the extent to which allowances or credits from other countries could be used in Canada.

## Use of the Auction Revenue

An auction of allowances raises revenue, possibly a significant amount of revenue.[14] The economic impacts of using an auction to distribute allowances depend on how the revenue is used.

Several options for the use of auction revenue, each with its advantages and disadvantages, have been suggested, including:

- Reduce existing distortionary taxes. Any tax creates a disincentive to engage in the taxed activity. Existing taxes discourage investment, employment creation and work. Using the auction revenue to reduce such taxes can stimulate economic activity and so reduce the economic impact of the limit on greenhouse gas emissions.
- Purchase assigned amount, joint implementation credits or clean development credits from other countries. Purchasing such allowances or credits from other countries with the auction revenue means that smaller emissions reductions are needed domestically.
- Lower taxes to offset the economic burdens on individuals. The costs of limiting GHG emissions are ultimately borne by individuals. Most studies suggest the costs are proportionally larger for the lowest income groups. Auction revenue could be used to offset the economic burdens on individuals through changes to the personal income tax or goods and services tax.
- Provide adjustment assistance to the groups most adversely affected. Limiting GHG emissions will have disproportional effects on some groups, and auction revenue could be used to help them adjust. Assistance could be provided, for example, to firms, individuals and communities affected by the closure of coal mines.
- Give rebates to participating sources to reduce competitiveness impacts. Distributing the auction revenue to participants in the trading program minimizes adverse competitiveness impacts due to the limits on GHG emissions. However, the formula for distributing the revenue must give sources an incentive to reduce emissions.[15]

Clearly a decision has to be made as to how to use the revenue. That decision inevitably involves a choice among competing efficiency and equity objectives and judgments as to what is fair for different groups. The decision on how to use the revenue must therefore be a political choice.

## Reduce Existing Distortionary Taxes

Efficiency considerations favour an auction over *gratis* distribution because it raises revenue, which can be used to reduce existing distortionary taxes.[16] How the auction revenue is recycled has a significant effect on the economic impacts. Depending on conditions in the economy, the way in which the revenue is recycled can yield economic benefits that offset some or all of the cost of the emissions limitation policy.[17] Then the policy has both climate change and economic benefits — a "double dividend."

14 Cramton and Kerr (p. 2) provide an order of magnitude estimate of 10% of federal revenue and 2% of gross national product for the United States.

15 Revenues from some emissions taxes in Scandinavian countries are redistributed to the taxed sources.

16 Lawrence Goulder, Ian Parry and Dallas Burtraw ("Revenue-raising vs. Other Approaches to Environmental Protection: The Critical Significance of Pre-existing Tax Distortions," *RAND Journal of Economics*, forthcoming) show that for a given environmental goal using non-revenue raising policies is more costly than using revenue raising policies with revenue recycling. Thus, revenue raising policies with revenue recycling improve efficiency.

17 If the economy is at full employment and if all existing taxes are for social or health reasons (i.e., imposed to correct for non-environmental externalities), the possibility of an economic benefit, such as employment or income growth, does not exist. No economy meets these conditions.

Every economy has existing distortionary taxes (in the sense that they are not intended to correct for an externality or other distortion) and unemployed resources.[18] The auction revenue can be used to reduce these taxes and so increase the efficiency of the economy and hence increase employment or income. The economic effects depend on the existing tax structure and will differ depending on whether the revenues are used to reduce payroll, personal income, corporate income, investment income or expenditure taxes.[19]

The notion of a "double dividend" for policies that limit greenhouse gas emissions by using a carbon tax or auctioned allowances has created a controversy in the literature. It is important to understand that the debate is about the *attribution* of the economic benefits; there is no debate about the *existence* of these benefits.

Are the economic benefits from reducing existing distortionary taxes due to climate change policy or tax reform? Some analysts argue that since the auction generates the revenue, using the revenue to reduce existing distortionary taxes and stimulate economic growth is a valid way to reduce the cost of an emissions limitation policy. Other analysts argue that a lump sum distribution of the auction revenue should be used because it has a neutral impact on economic activity.[20] The economic benefits of reducing existing taxes are then attributed to tax reform, not the emissions limitation policy.[21] But tax reform is possible only if the government has a new source of tax revenue, such as an allowance auction, to replace the revenue lost by reducing existing taxes.

In practice, a decision to implement an allowance auction would require consideration of options for use of the revenue. Clearly, one of the options is to use the revenue to reduce existing distortionary taxes. That would stimulate economic growth and help offset (perhaps more than offset) the economic cost of the emissions limitation policy. Whether that is called climate change policy or tax reform may be important from a political perspective, but it does not change the outcome.[22]

## Purchase Allowances or Credits from Other Countries

Auction revenue could be used to purchase assigned amount, joint implementation reductions or clean development credits from other countries. Purchasing such allowances or credits from other countries with the auction revenue means that smaller emissions reductions are needed domestically.

18 If an economy had a non-distortionary tax structure and unemployed resources, and government action to reduce unemployment is constrained by lack of revenue, the auction could be used to stimulate employment and so create an economic benefit.

19 Studies for the United States suggest much larger economic benefits from reductions in taxes on capital and on employers than from reductions in corporate income, personal income or sales taxes.

20 Many studies of the economic impacts of a carbon tax (allowance auction) compare the carbon tax (allowance auction) to a baseline with no environmental policy. A fair comparison requires that the carbon tax (allowance auction) be compared to a baseline that uses other policies to achieve the same environmental goal, or that the economic cost of the carbon tax (allowance auction) be compared with the benefits of reduced climate change damage.

21 As noted by Jean-Charles Hourcade, Erik Haites and Terry Barker, "Macroeconomic Cost Assessment," Chapter 6 of J.A. Sathaye and J. Christensen, eds., *Mitigation and Adaptation Cost Assessment: Concepts, Methods and Appropriate Use,* United Nations Environment Programme, UNEP Centre, Risø, Denmark, 1998, the correct analytical approach is more complex still and is never used because of the technical and political difficulties of determining the optimal fiscal system leading to full employment.

22 The following analogy may help. Assume that the advertised price of a product is $100, but that a manufacturer's rebate of $25 is available to every purchaser. The price (assuming lump sum distribution) is $100, but the net cost of purchasing the product (reducing existing distortionary taxes) is $75. It is not possible to collect the rebate (reform existing distortionary taxes) unless the product is purchased (another source of revenue is found). One can argue that the price is $100 or $75, but the cost is $75 in either case.

Purchases of allowances or credits from other countries would use only part of the revenue raised.[23] The revenue is transferred to other countries and cannot be used to address equity issues. The revenue transferred to other countries is ultimately used to purchase Canadian goods and services.[24] The economic impacts of those purchases should be compared with use of the revenue to stimulate growth in Canada by reducing existing distortionary taxes. However, since only part of the revenue is used to purchase allowances and credits from other countries, the balance can be used to address equity and efficiency issues.

Buying assigned amount, joint implementation credits or clean development credits might make economic sense under some circumstances, but would be undesirable under other circumstances. If international trading of assigned amount, joint implementation credits and clean development credits is restricted to governments, and the international price(s) for these instruments are lower than the price in the domestic emissions trading market, such purchases would reduce the economic burden on the Canadian economy.

But if international trading is easily accessible to participants in the domestic emissions trading program and the domestic price is the same as the world price for these instruments, buying assigned amount, joint implementation credits or clean development credits makes no sense. The cost of complying with Canada's national emissions limitation commitment does not change as a result of purchasing these instruments on the international market. But using the revenue for this purpose means that it is not available to lower existing distortionary taxes and hence to benefit the Canadian economy.

## Lower Taxes to Offset the Economic Burdens on Individuals

Cramton and Kerr note that any policy to limit greenhouse gas emissions will have price effects and wealth effects. The price effects are similar regardless of the policy adopted, but the wealth effects differ.[25] Under a cap and trade system, an auction gives ownership of the right to emit GHGs to the government, while *gratis* distribution gives ownership to the recipients of the allowances, creating different wealth effects.

Although firms incur the cost of purchasing allowances, the costs are ultimately borne by consumers, employees and owners of capital. The firms that purchase allowances shift the cost to their customers, employees, suppliers, shareholders and lenders. Suppliers and customers of intermediate goods shift the cost to their customers, employees, suppliers, shareholders and lenders. Ultimately the costs are borne by individuals in their capacities as

23 If the secondary market is linked to the global market and the auction is well designed, auction prices should still be close to the global price for allowances and credits. The auction revenue will equal the world market price times the allowable emissions. Under the Kyoto Protocol allowable emissions will be 94% of 1990 emissions. The emissions trading program should cover at least half of those emissions, or more than 50% of 1990 emissions. In the absence of a national commitment, greenhouse gas emissions are likely to be 125% to 130% of 1990 emissions. Thus the reductions required are 30% to 35% of 1990 emissions. In the absence of supplementarity provisions, allowances and credits equal to this reduction could be purchased from other countries at the world price. The cost of the allowances and credits purchased (less than 35% of 1990 emissions at world prices) is less than the revenue raised (more than 50% of 1990 emissions at world prices).

24 A Canadian who buys allowances or credits from a seller in another country transfers Canadian dollars to an entity outside the country. Those Canadian dollars can only be used to buy goods and services from, or to make investments in, Canada. For the sake of simplicity, assume that the seller accepts Canadian dollars as payment for the credits or allowances. The seller can buy Canadian goods and services using the money. Or the seller can exchange the Canadian dollars for other currency. But the seller of the other currency, whether a foreigner or Canadian, then has more Canadian dollars. Those Canadian dollars can only be used to buy Canadian goods or services or to invest in Canada. Ultimately, then, purchases of allowances or credits from other countries lead to higher purchases of Canadian goods and services or more foreign investment in Canada.

25 The magnitude of the price effects varies somewhat due to differences in the efficiency of different policies.

26 Some suppliers and owners of capital may reside in other countries, so Canada's policies to limit GHG emissions can affect individuals in other countries. Conversely, the policies adopted by other countries can affect Canadians.

consumers of different products, employees of particular firms, and owners of capital.[26]

The wealth effects, and hence the impacts on owners of capital, vary for different policies. An auction of allowances assigns ownership of the right to emit greenhouse gases to the government and hence imposes a higher burden on owners of capital than a *gratis* distribution of allowances. The arguments in favour of an auction are that it is consistent with the polluter pays principle; owners of capital tend to be wealthier and so can afford the cost; and an auction captures all the value of the allowances for Canadian residents, while *gratis* distribution benefits non-resident owners of capital. Of course, an auction might also impose a higher burden on employees of those firms, but some of the auction revenue could be used to ease the adjustment for employees.

The distribution of costs across income groups due to an auction of allowances is the same as the distribution of costs due to a carbon tax. Cramton and Kerr review (pp. 14-15) empirical studies of this issue for the United States. They point out that the available studies do not reflect the effects of changes in capital value and that they assume perfectly competitive pricing, which may not be appropriate for some key industries.

Cramton and Kerr note that the studies suggest the effects will be slightly regressive — higher costs as a percentage of income for low-income groups. Auction revenue could be used to offset the economic costs to individuals, with particular attention to the adverse impact on low-income groups, through changes to the personal income tax or goods and services tax.

## Provide Adjustment Assistance to the Groups Most Adversely Affected

Limiting greenhouse gas emissions will have adverse impacts on activities that generate such emissions. Due to coal's relatively high emissions per unit of energy and the availability of substitute energy sources for many applications, coal producers and users appear to be particularly vulnerable. This is true regardless of the policies adopted to limit GHG emissions.

An auction of allowances generates revenue that could be used to facilitate adjustment by firms, individuals and communities affected by the closure of coal mines. Spending could be targeted to serve specific purposes. In contrast, *gratis* distribution of allowances to firms would allow the mining companies to determine how those resources are used.

## Give Rebates to Participating Sources to Reduce Competitiveness Impacts

Participants in the trading program required to buy allowances at auction (or on the secondary market) may be less competitive as a result. The competitiveness of other entities may also be affected through price increases and/or lower demand for energy and other products. The impact on competitiveness is very complex. It depends on the ability of participants to shift costs to their suppliers, employees, customers and sources of capital. The impact on the competitiveness of Canadian sources also depends on the policies adopted by other countries.

The competitiveness impacts of different domestic greenhouse gas emissions trading program designs is the subject of another NRTEE paper. It is tempting to suggest that adversely affected firms could be given some of the auction revenue to offset adverse competitiveness impacts. However, it would be virtually impossible to implement such a program in practice.[27] Devising rules to determine which firms were eligible for assistance and how much money they should receive would be very difficult.[28] It would also be very difficult to distribute the revenue in a manner consistent with international trade rules.[29] And revenue redistributed to participants is not available to help groups adversely affected to adjust or to stimulate economic growth.

## Rationale for Transition to an Auction

To this point an auction has been discussed as an alternative to *gratis* distribution of allowances. Another possibility is a gradual transition from *gratis* distribution to an auction. Participants at the time the trading program is launched would receive allowances *gratis* in accordance with an agreed rule. But the share of the calculated allocation received *gratis* would decline to zero over a period of five or ten years. Any allowances not distributed *gratis* would be sold at auction. Thus, at the end of the transition period all allowances would be sold at auction.

The argument for this option is that imposition of a limit on greenhouse gas emissions reduces the value of existing capital that generates emissions. *Gratis* distribution of allowances to existing sources for some period of time provides some compensation for the loss of value of this capital stock and provides transitional support to adjust to the new competitive environment. Providing such compensation conflicts with the polluter pays principle. And the auction revenue forgone is not available to offset the economic costs to individuals, to help groups adversely affected adjust, or to stimulate economic growth.

## Rationale for Use of an Auction and *Gratis* Distribution of Allowances

It is possible to use both an auction and a rule for *gratis* distribution to allocate the allowances for an emissions trading program. Participants that are not subject to international competition, such as residential and commercial buildings and motor vehicle fuels, could be sold at auction to raise revenue that can be used to reduce existing distortionary taxes. Participants subject to international competition, such as industrial sources, could receive allowances *gratis*. This would minimize the adverse competitiveness impacts on these participants.

27 A case can be made for providing temporary assistance to facilitate adjustment to production methods or product mixes with lower GHG emissions. But assistance that provides an ongoing subsidy to the existing production methods or product mix (or delays the adjustment to a less GHG-intensive production method or product mix) is inefficient. Structuring a program that achieves the former, but does not contribute to the latter is difficult.

28 The rule for distributing revenue must also be designed so that it does not have the effect of reducing the marginal cost of emissions reductions for participating firms and so lower their incentive to reduce their emissions.

29 Foreign competitors, for example, might be able to argue successfully that some forms of revenue redistribution constituted an unfair subsidy.

# Summary

An auction is a means of distributing allowances to participants in a cap and trade system. It recognizes government ownership of the waste absorption capacity of the atmosphere and obtains the highest price for the use of this public resource. An auction also raises revenue that the government can use to improve the performance of the economy and to offset adverse impacts suffered by particular groups as a result of the introduction of the limit on greenhouse gas emissions. The main issues that arise with an auction of allowances, then, are the design of the auction and the use of the revenue generated.

The auction design is important to an efficient outcome. Cramton and Kerr recommend an ascending clock auction, with quarterly auctions for an "upstream" trading program for the carbon content of fossil fuels. Such a design should be suitable for most greenhouse gas allowance trading programs, provided there are a reasonable number of participants.

The auctions would be complemented by a secondary market, where participants could buy and sell allowances. In this market they could buy and sell credits from specified domestic sources and credits or allowances from international emissions trading, joint implementation and the clean development mechanism. Unless international or Canadian rules restrict the ability to use, or raise the cost of using, allowances or credits from other countries, the secondary market will closely reflect global prices. Since the auction would be small relative to the global market, auction prices would reflect the global market price. This is the desired outcome from an economic efficiency perspective.

An auction of allowances raises revenue, possibly a significant amount of revenue. This is an argument in favour of an auction rather than *gratis* distribution. The economic impacts of using an auction to distribute allowances depend on how the revenue is used. Revenue could be used in a variety of ways to improve efficiency and/or to address equity issues. Efficiency can be improved by using the revenue to reduce existing distortionary taxes.

The costs of limiting greenhouse gas emissions, regardless of the policy used, are ultimately borne by individuals in their capacities as consumers, employees and owners of capital. In aggregate the distribution of costs is likely to be slightly regressive, but some groups will be significantly affected. Auction revenue can be used to offset some of these impacts — adjustment assistance to coal mining firms, employees and communities and changes to the personal income or goods and services tax to offset the burden on lower income groups, for example.

Clearly a decision has to be made as to how to use the revenue. That decision inevitably involves a choice among competing efficiency and equity objectives. A transition from *gratis* distribution of allowances to existing participants to an auction over five or ten years likewise involves a choice among competing efficiency and equity objectives. The decision must therefore be a political decision.

# Appendix 1

# Tradable Carbon Allowance Auctions: How and Why to Auction

Prepared for the

Center for Clean Air Policy's
Greenhouse Gas Emissions Trading Braintrust

Prepared by
Peter Cramton
Suzi Kerr

March 1998

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This paper is co-authored by Peter Cramton and Suzi Kerr. Peter Cramton is Professor of Economics at the University of Maryland, College Park, MD. Suzi Kerr is Assistant Professor, Department of Agricultural and Resource Economics, University of Maryland, College Park.

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# The Airlie Carbon Trading Papers

The Airlie Carbon Trading Papers are intended to help lay the intellectual foundation for a US greenhouse gas emissions trading system, which is a leading policy option for realizing the cost-effective greenhouse gas emission reductions needed to address global climate change. The papers are the product of a unique research, analysis and dialogue process directed by the Center for Clean Air Policy. Since November 1996, the Center has convened regular meetings of its "Greenhouse Gas Emissions Trading Braintrust," a group of high-level representatives of industry, environmental organizations, state and federal government agencies and academe.

Braintrust members and Center staff conduct research and analysis of key design and implementation questions, then bring their findings and proposals to the group for discussion. The purpose of this process is to investigate alternative design options in detail rather than to arrive at consensus on a preferred option.

Priority issues identified by the Braintrust include: definition of the instrument that would be traded, determination of who would be required to hold allowances, methods for allocating allowances, and the elements of the trading system compliance infrastructure. Braintrust members agreed to start with a focus on energy-related carbon dioxide emissions. Secondary issues identified by the Braintrust include the integration of additional greenhouse gases into the system, the incorporation of emissions reductions from forestry and land use activities and foreign countries, and the mitigation of any adverse impacts on US industry of carbon regulation.

*Why the "Airlie" Carbon Trading Papers?* The Airlie Center serves as the backdrop for the Braintrust's quarterly meetings. Situated outside the Washington, DC beltway in Warrenton, Virginia, Airlie provides an informal, congenial atmosphere that allows participants to leave their affiliations "at the door" and to build strong working relationships. These factors have been critical to the success of the Braintrust process.

The Center for Clean Air Policy wishes to express its gratitude to the Office of Policy, Planning and Evaluation at the US Environmental Protection Agency and the "Friends of the Center" for their financial support of the Center's Greenhouse Gas Emissions Trading Braintrust. The Center also gives thanks to the staff of the Airlie Center.

# About the Center for Clean Air Policy

Since its inception in 1985, the Center for Clean Air Policy has developed a strong record of designing and promoting market-based solutions to environmental problems. The Center's dialogue on acid rain in the 1980s identified many of the elements of the $SO_2$ control program that were adopted by the Bush Administration and eventually codified in the Clean Air Act Amendments of 1990. Since 1990, the Center has been active on the issue of global climate change. Center staff have participated in the Framework Convention on Climate Change negotiations and in domestic efforts to address greenhouse gases, analyzing and advocating market-based climate policies such as emissions trading and joint implementation. The Center brokered the world's first energy sector joint implementation project. The Center is also active in the areas of air quality regulation, electricity industry restructuring, and transportation and land use.

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# Executive Summary

The US is now considering the establishment of a domestic greenhouse gas (GHG) cap-and-trade system as a means of fulfilling its international emissions reductions commitments made under the Kyoto Protocol. A critical issue in designing the cap-and-trade system is the mechanism for allocating carbon allowances. Two methods have received most attention. One is auctioning the allowances, and the other is the allocation of allowances to regulated entities though the use of a formula based on historical output, energy use or emissions. The latter method is known as "grandfathering."

This paper argues that an auction is the best way to allocate allowances in a carbon cap-and-trade system. An auction of carbon allowances is the best way to achieve carbon caps set by international negotiation to limit global climate change. To minimize administrative costs, allowances would be required primarily at the level of oil refineries, natural gas pipelines, natural gas liquid sellers, and coal processing plants. To maximize liquidity in secondary markets, allowances would be fully tradable and bankable. The government would conduct quarterly auctions. A standard ascending-clock auction in which price is gradually raised until there is no excess demand would provide reliable price discovery. An auction is preferred to grandfathering (giving polluters allowances in proportion to past pollution), because it would allow reduced tax distortions, provide more flexibility in distribution of costs, provide greater incentives for innovation, and reduce the need for politically contentious arguments over the allocation of rents.

# I. Introduction

*"The vast majority of the world's climate scientists have concluded that if the countries of the world do not work together to cut the emission of greenhouse gases, then temperatures will rise and will disrupt the climate. In fact, most scientists say the process has already begun."*
President Clinton, October 22, 1997

An international agreement to address the threat of global climate change is being developed with increasing urgency. The possibility of binding domestic regulation is now a real possibility. Uncertainty still exists but the mainstream scientific consensus, represented by the Intergovernmental Panel on Climate Change, believes that the balance of evidence suggests that there is a discernible human influence on global climate (IPCC, 1996). At the Fourth Conference of the Parties to the UN Framework Convention on Climate Change in Kyoto in December 1997, a large group of developed countries agreed to restrict their carbon emissions to, on average, five percent below 1990 levels by 2008 – 2012. The United States agreed to a target of seven percent reductions (subject to ratification by the Senate).

The question at hand is how best to achieve domestically the greenhouse gas emission targets. Carbon dioxide ($CO_2$) is the major current contributor to climate change.[1] It is released whenever fossil fuels are burned and sequestered in the growth of trees. How can we reduce our consumption of fossil fuels at least cost? A primary option for the United States being considered is a tradable allowance program, following in the footsteps of the successful acid rain trading program.

1 Other greenhouse gases, such as $NO_2$ and $CH_4$ could be incorporated into the trading program at a later date. These gases raise complications in monitoring and comparability with carbon.

$CO_2$ is a uniformly mixed, accumulative pollutant. Neither the source of emissions nor their exact timing is important from an environmental standpoint.[2] Thus, allowances are ideally defined in a homogeneous way over space and time. Ideally allowances would be fully tradable internationally. We do not deal with the difficult issues of international allowance trading system design such as monitoring and enforcement, but the conclusions of this paper on auctions are consistent with an optimal domestic system operating within an international trading system. For this paper, we assume that the allowance system would regulate carbon primarily at the level of oil refineries, natural gas pipelines, natural gas liquid sellers, and coal processing plants.[3] This would create a comprehensive, administratively feasible system. Carbon emissions in all sectors of the economy would be indirectly controlled. Allowances would provide the right to a one-time emission of one ton of carbon or carbon dioxide. They could be banked indefinitely for use in later years. Trade in the secondary allowance market would be completely unrestricted. None of this is contentious.

How then to allocate the allowances? One approach would be to "grandfather" allowances to emission sources based on historical rates. This approach would have the advantage of minimizing disruption to existing economic activity, because current emission sources would be guaranteed to receive the necessary allowances to continue production. (Of course, allowances would be reduced proportionately to achieve overall reduction goals.) There are, however, two significant disadvantages to grandfathering allowances. First, it would not achieve an efficient allocation of allowances. Second, it would require developing and administering complex and politically contentious allocation rules.

There is a simple and highly efficient alternative to grandfathering. Let the government sell the allowances in periodic auctions — just as the Treasury sells debt. Auctioning would result in a more efficient allocation of allowances, provide a stronger incentive for innovation, and reduce the need for politically contentious arguments over the allocation of rents. The bonus is that the revenue from the auctions could be used to offset distortionary taxes that reduce economic efficiency. This "revenue recycling" means that emitters effectively would be buying the right to emit from the public. If the target of stabilizing emissions at 1990 levels by 2010 were implemented, 1,340 million metric tons of allowances would be issued each year (EIA 1997 Annual Energy Outlook). Current estimates of the cost of carbon regulation suggest the marginal cost of this target would be in the range $25 to $150.[4] If the marginal cost, and hence the allowance price, were $100 per metric ton, an efficient auction could raise $134 billion annually. This is approximately ten percent of federal receipts and about two percent of gross national product (GNP) in 1995.

It is important to note that if allowances were given to energy companies, consumers would still pay higher energy prices. It is the carbon cap itself that would determine the price increase. Regardless of whether the government auctioned allowances or gave them away, the same energy price would be expected. The marginal cost of controlling carbon would not be altered by grandfathering, only the initial ownership of carbon rights. The only

2 The timing of emissions does have an effect on subsequent trajectories of atmospheric concentrations, climate variables, and associated impacts. The significance of these changes is difficult to estimate. For this paper, we assume that only banking can occur — i.e., early emission reductions can free up allowances for later use. Thus, under no circumstances are emission reductions delayed.

3 The justification for this is discussed in "U.S. Greenhouse Gas Emissions Trading: Description of an Upstream Approach" by Tim Hargrave (Center for Clean Air Policy, 1998). In brief, this point of regulation achieves near comprehensive coverage of carbon, and minimizes the costs of administering the program. The paper also begins to outline the details of how carbon would be monitored in such a system.

4 Gaskins and Weyant (1993), and Nordhaus (1991).

difference would be distributional, with emitters either receiving or paying for emission allowances. The experience in cellular communications provides a vivid illustration. In the 1980s, the FCC gave away cellular licenses. The companies did not respond with lower prices. Rather, prices were high, since only two companies could operate in each market. Now the FCC auctions licenses, generating billions of dollars for the Treasury. Prices are falling as these auction winners enter the markets of those who were given licenses.

This paper presents the issues in designing a carbon allowance auction. The analysis is relevant for achieving any aggregate emissions target. In previous work on environmental auction design, researchers considered the serious design problems in the $SO_2$ auction and its effects on the operation of the auction and market (Cason 1995; Cason and Plott 1996; Joskow, Schmalensee and Bailey 1997). The arguments for auctions have not been comprehensively addressed before, although many of the individual arguments have been discussed elsewhere. In particular, papers address the advantages of revenue recycling (Parry 1995), and the effects on incentives to innovate (Milliman and Prince 1989). In the context of the Acid Rain Program, Van Dyke (1991) argued that fairness required that $SO_2$ allowances be sold rather than given out for free. No previous work has addressed the full distributional implications of allocating carbon allowances through auctions rather than some form of grandfathering.

We begin by describing how carbon allowances should be auctioned. Then we consider the alternative, grandfathering, and argue why an auction is better. We conclude that bankable, identical allowances should be auctioned on a quarterly basis using a standard, ascending-clock design. In the case of carbon we conclude that the arguments for auctions rather than grandfathering on efficiency and distributional grounds, are overwhelming.

# II. How to Auction Carbon Allowances

An auction of carbon allowances answers two questions: who, on efficiency grounds, should get the allowances, and at what prices? The best answer to these questions depends on the government's goals. Presumably a primary goal is efficiency — to put the allowances to the best possible use. A secondary goal is revenue maximization. Indeed, a government concerned with efficiency must put some weight on revenue maximization, since revenues can be used to offset distortionary taxes. Fortunately, these goals are closely aligned. An efficient auction would raise substantial revenues.

## A. What to auction

In any auction, it is crucial to define the items being auctioned. With carbon allowances this is a simple matter. Each allowance would represent one ton of carbon or carbon dioxide. To minimize regulatory transaction costs, allowances would be required of oil refineries, natural gas pipelines, natural gas liquid sellers and coal processing plants. Such an "upstream" system would be comprehensive and minimizes the number of parties that need allowances.

A basic fact from Treasury auctions is that the Treasury must pay for illiquidity. The less liquid the issue is, the greater the transaction cost. Illiquidity not only costs the seller money, but it also reduces auction efficiency. In the FCC spectrum auctions, the primary source of inefficiency stems from the exercise of market power in thin markets. Illiquidity increases the risk that some bidders may have market power in certain circumstances.

To increase liquidity in this market, all allowances would be the same after their date of issue, and allowances would be bankable; that is, an allowance issued for the year 2000 could be used in any later year. There would be no environmental loss in making allowances bankable. Current carbon emissions would be reduced to the extent that allowances were banked. Given the long life time of $CO_2$ in the atmosphere, short term voluntary banking is unlikely to have significant impacts on $CO_2$ concentrations. Allowing banking further increases liquidity in secondary markets, since all allowances are the same after their date of issue.

In addition, allowances could and should be auctioned not only for the current years but also for future issue years. Thus, some allowances for 2005 could be auctioned in 2000 even though they could not be used to offset carbon emissions until after January 1, 2005. Early auctions would facilitate the development of an active futures and options market, thus improving risk allocation.[5]

Market power should not be a concern in an auction for carbon allowances. Even in an upstream program, there would still be more than 1,700 allowance buyers. Most importantly, even the largest buyers would constitute just a tiny fraction of the market, as is seen in Table 1. This should be contrasted with the U.S. Treasury auctions where the top-five primary dealers routinely purchase over one-half of the issue. Despite this concentration, market power is not a serious problem in Treasury auctions.

It is inconceivable that any party would be successful in exercising substantial market power in the market for carbon allowances. Even the largest bidder (Peabody Holdings with 5.6 percent of the market) could gain little by understating demand. Attempts to corner the market to exclude competitors would be even more foolhardy. It would be impossible for a single firm to prevent competitors from buying allowances at auction or in an active secondary market for carbon allowances. None of the conditions that allow for market failure is present here.

**Table 1: Carbon Allowance Needs across Firms – Direct Allowance Market Players**

| Carbon User | Total Carbon produced in 1995 (million metric tons) | % of allowance market |
|---|---|---|
| **Oil Industry**[6] (175 refineries) | **436** | **31.1%** |
| Largest Oil Company (Chevron) | 31.1 | 2.3% |
| Second largest (Exxon) | 28.7 | 2.0% |
| Largest 10 oil companies | 226.7 | 16.2% |
| **Coal Industry**[7] (550 coal preparation plants) | **610** | **43.5 %** |
| Largest Coal Producer (Peabody Holdings) | 79.3 | 5.6% |
| Largest 3 companies | 158.6 | 11.2% |
| **Natural Gas Industry**[8] (150 natural gas pipeline companies and 725 natural gas processing plants) | **356** | **25.4%** |
| **Total** | **1402** | **100%** |

5 See Kerr and Toman (1998).

6 U.S. Department of Energy, Energy Information Administration (1996).

7 U.S. Department of Energy, Energy Information Administration (1997).

8 U.S. Department of Energy, Energy Information Administration.

## B. Ways to auction many identical items

There is a great deal of experience in the auctioning of many identical items. In the most basic setting, a seller is offering a fixed supply of identical items. The buyers express their willingness to buy various quantities at various price levels by submitting bids at auction. An allowance auction fits the simplest case. The government desires to sell a fixed supply of identical allowances.

As in Treasury auctions, carbon allowance auctions should be held on a regular basis, perhaps quarterly. This would be frequent enough that firms would have a good idea of their likely needs. Quarterly auctions also would reduce the cash flow problems associated with less frequent sale.

We conclude that probably the best auction form is a standard ascending-clock auction, although any of the standard auctions for multiple units would work well. To show this we discuss the characteristics of the important auction options and their advantages and disadvantages. Many different auction forms are possible. They are best divided into two basic forms: sealed-bid auctions and ascending-bid auctions.

### *Sealed-bid auctions*

In sealed-bid auctions, the bidders simultaneously submit demand schedules. The auctioneer adds these demand schedules to form the aggregate demand curve. Typically, demand schedules are required to be step functions, but piecewise linear schedules are allowed in some settings. A sample demand curve appears in Figure 1. The point at which the aggregate demand curve and the supply curve cross determines the clearing price. All demands above this clearing price are filled, those at the clearing price are rationed, and those below are rejected. The various sealed-bid auction forms differ in what each bidder pays for the amounts awarded.

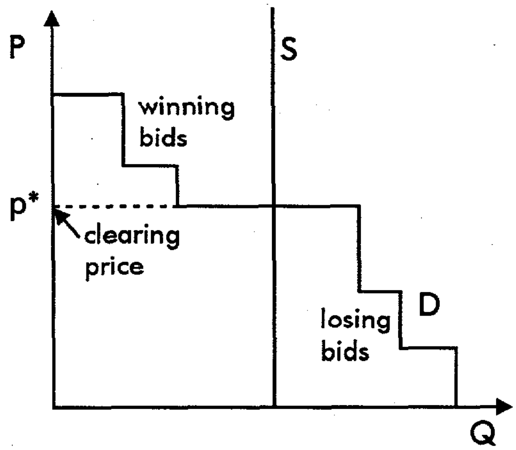
The two most common pricing methods are uniform pricing and pay-your-bid pricing. Under uniform pricing, each winner pays the clearing price p* for each allowance. With pay-your-bid pricing, each winner pays its bid. Of course, bidding behavior is quite different under the two approaches. With pay-your-bid pricing, the bidder attempts to guess where the clearing price is likely to fall and then bids slightly above it. Bids in excess of the clearing price are money left on the table. With uniform pricing, predicting the clearing price is less important, since every winner pays the clearing price regardless of how high it bids. With a uniform price, however, bidders with market power may bid below their true value in an attempt to influence the market price. Neither pricing rule is fully efficient. In both, the bidders shade their bids in complex ways. This differential shading leads to inefficiency (Ausubel and Cramton 1996).

A third pricing rule, proposed by Vickrey (1961), does yield efficiency in a private value setting.[9] With Vickrey pricing, each winner pays the opportunity cost of its winnings; that is, the extra value that would be gained if its units went to the most deserving losers. Vickrey pricing eliminates all bid shading. It is a dominant strategy to bid your true demand curve. Vickrey accomplishes truthful revelation by rewarding large bidders for bidding their full demands. Each bidder pays less for additional units won.

Comparing the sealed-bid auctions is difficult, even in the setting with private values. Vickrey is best from an efficiency standpoint. All other comparisons are ambiguous. The distinction between uniform pricing and Vickrey pricing depends on the extent of market power. When no bidder has significant market power,

9 It is unclear whether a carbon auction is best thought of as a private value or a common value auction. In a private value auction, each bidder's value does not depend on information held by others, but depends on the bidder's particular situation. In a common value auction, all bidders have the same value for the good, and each has private information about this uncertain value. Common value auctions arise when the good is purchased for resale. A carbon auction would have elements of both.

## Figure 1: Sample Demand Curve




then the outcomes are close, and uniform pricing is nearly as efficient as Vickrey pricing. Uniform pricing has the added benefit that everyone pays the same price. Uniform pricing also encourages participation by small bidders, since it is strategically simple and the small bidders benefit from the demand reduction by the large bidders. In contrast, pay-your-bid pricing exposes small bidders to strategic risk, since they may be less able to gauge where the clearing price is apt to be. Hence, among the sealed-bid auctions, a uniform-price auction probably is best for the case of carbon usage allowances.

### Ascending auctions

Ascending auctions have many advantages over sealed-bid formats. A reliable process of price discovery is a primary advantage. Both price and allocation are determined through a process of open competition. Each bidder has every opportunity to improve its bids, changing losing bids into winning bids. In the end, those willing to pay the most win the allowances. Bidders get to choose exactly how many allowances they want based on good information about price. An ascending process is especially desirable when bidders' valuations depend on information held by others. Then the bidding process reveals information, which improves the bidders' valuation estimates.

Multiple-unit ascending auctions can be conducted in two basic ways: with demand schedules or with an ascending clock.

The demand schedule approach can be thought of as a multiple-round version of the sealed-bid auctions. In each round, bidders submit a demand schedule. The schedules are aggregated to form the demand curve. The clearing price, where demand intersects supply, defines the tentative split between winning and losing bids. If this were the final round, those bids above the clearing price would be filled, those at the clearing price would be rationed, and those below the clearing price would be rejected. The process repeats until no bidder is willing to improve its bids.

To promote reliable price discovery an activity rule is needed. The activity rule prevents bidders from holding back initially and then submitting large bids after the other bidders have revealed their information. In most situations, the bidders will have (weakly) downward sloping demand curves. In this case, a simple yet powerful rule can be used without distorting behavior. The rule has three elements:

1. All bids must be entered in the initial round (that is, the total quantity that a bidder bids can only decrease).
2. Any losing bid that is not improved in the next round is permanently rejected.

3. The improvement must exceed the clearing price by at least the minimum bid increment.

This activity rule is the one-sided variant of a rule proposed by Wilson (1997) for the California Power Exchange's day-ahead electricity auction. The rule is based on the concept of revealed preference. Bidders are required to improve losing bids at the first opportunity. A failure to improve a losing bid is taken as presumptive evidence that the bidder's valuation is below the minimum bid (one increment above the prior clearing price). In this one-sided setting, prices only increase, so the unimproved bid can be permanently rejected.

The activity rule forces the bidders to bid in a way that is consistent with a downward sloping demand curve. A competitive process results, in which winning bids get topped by losing bids. The process repeats until the clearing price reaches a point where a sufficient number of bidders find it sufficiently unattractive that excess demand falls to zero. At this point there is no further pressure to improve bids and the auction ends.

Either uniform pricing or pay-your-bid pricing can be used in the final iteration. In a sealed-bid design, the distinction between uniform and pay-your-bid pricing is large. In an ascending auction, the distinction is much less important, since winning bids under pay-your-bid pricing are apt to be close to the final clearing price in equilibrium. The reason is that a bidder has little incentive to raise the bid much more than one bid increment above the clearing price. Hence, pay-your-bid pricing shares the main advantage of uniform pricing.

Pay-your-bid pricing does have an important advantage over uniform pricing in an ascending auction. With uniform pricing, the bidders can submit bid schedules that create strong incentives for the other bidders to reduce demand. In particular, they can bid in such a way that the demand curve is quite steep above the clearing price. Faced with this steep curve, it is a best response for bidders to drop their losing bids, rather than continue to bid a large quantity, which would result in much higher prices. This is similar to the problem with uniform pricing in static auctions emphasized by Wilson (1979) and Back and Zender (1993), but here the problem is magnified, since the ascending process gives the bidders the opportunity to coordinate on a low-price equilibrium. For this reason, pay-your-bid pricing should be preferred in ascending auctions.

## Ascending-clock auction

Better still is the ascending-clock auction. The clock indicates the current price. In each round, the bidders submit the quantity they are willing to buy at that price. If the total quantity bid exceeds the quantity available the clock is increased. The bidding continues until the quantity bid is less than the quantity available. The allowances are then allocated at the prior price, and are rationed for those that reduced their quantity in the last round. The activity rule in this case is simply that each bidder cannot increase its quantity as prices rise.

This design shares all the advantages of an ascending pay-your-bid auction, and has several additional advantages:

1. It is easier to implement for both seller and buyers, since a buyer only bids a single quantity in each round, rather than a schedule.
2. There is no possibility of undesirable bid signaling, since only the total quantity bid is reported.
3. It avoids the mechanism for collusion under uniform pricing, yet yields a single market-clearing price.
4. Rapid convergence is guaranteed, since the price increases by one bid increment with each round of bidding.

A difficulty with all the ascending-bid approaches described above is that they are inefficient. In each case, bidders shade their bids in order to keep the price down. Large bidders tend to shade more than small bidders, since a particular price effect has a bigger impact on profits for a large bidder. This differential shading leads to an inefficient outcome. Large bidders win too little and small bidders win too much.

Ausubel (1996) proposes an alternative ascending-clock auction that achieves efficiency. In the Ausubel auction, items are awarded when they are "clinched" and the price paid is the amount on the clock at the time of clinching. An item is clinched when it becomes mathematically impossible for the bidder not to win the item (that is, excess demand would fall to zero before the bidder could reduce its demand to zero). This pricing rule implements Vickrey pricing in an ascending format. Efficiency is restored without losing the advantages of an ascending-bid format.

However, in this setting where market power is apt to be slight, the inefficiencies from a standard ascending-clock auction are likely to be insignificant. Hence, the equity and simplicity of having everyone pay the same price may be worth a modest inefficiency. In years past, conducting an ascending auction for carbon allowances would have been difficult, because of the costs of getting all the bidders together at the same time and place. However, communication advances have now made it easy to implement an ascending auction of this scale over the Internet.

### C. Desirable auction form for carbon allowances

We conclude that bankable and identical carbon allowances should be auctioned on a quarterly basis using a standard ascending-clock design. If it is viewed that an ascending auction is infeasible, then we prefer a sealed-bid uniform-price auction. Both the auction market and the secondary market should be open to all.

A carbon allowance auction would be the simplest of all multiple-unit auctions. The items auctioned would be identical and there would be an absence of market power. The banking of allowances would further increase the liquidity of the allowances. As such, there would be no impediments to creating a fully efficient carbon allowance auction. Indeed, auctions in much more complex and challenging settings have worked extremely well. Examples include the FCC spectrum auctions (Cramton 1997) and recent experiments with the day-ahead auction of electricity (Wilson 1997, Plott 1997).

Secondary markets for allowances likely would be highly efficient as well. These markets would complement an efficient auction, allowing firms to make adjustments to their allowance inventory on an as-needed basis.

## III. Why Auction Rather than Grandfathering?

Instead of auctioning, the government could give the allowances away to the regulated entities. This alternative is known as "grandfathering." The government could allocate allowances on the basis of past usage, on some measure of output, or based on more political considerations necessary to win support for enabling legislation. The traditional view is that grandfathering, while inefficient, is chosen because it provides greater political control over the distributional effects of regulation (Stavins 1997). We argue that auctioning is superior to any of these methods, because it allows reduced tax distortions, provides greater incentives for innovation, provides more flexibility in distribution of costs, and reduces the need for politically contentious arguments over the allocation of rents. We recognize that this does not mean auctions will be chosen. We argue however that these arguments may be more compelling in the case of carbon than they have been in $SO_2$ and other programs, and therefore may outweigh the political economy problems.

## A. Efficient revenue raising

Auction revenue can replace distortionary taxes. Distortionary taxation creates a deadweight loss by inserting a wedge between marginal cost and price. Any efficient form of carbon regulation must make carbon scarce, thereby raising the marginal cost of using carbon. The rise in marginal cost implies a real cost of carbon regulation equivalent to the deadweight loss from distortionary taxation (see Figure 2). This real welfare cost corresponds to loss of output estimated to be on the order of 0.8 percent of GDP which would have been $60 billion in 1995 (Repetto and Austin 1997). At the same time, the regulation of carbon would create scarcity rents on the order of $134 billion. In a grandfathered system, these rents would go to those who received the allowances. In an auction system, the rents would be collected as revenue by the government. This revenue could be used to cut labor, payroll, capital, or consumption taxes or to reduce the deficit, all of which would create efficiency gains. Some could be used to further equity goals as discussed below.

Ballard, Shoven and Whalley (1985) estimate that each additional $1.00 of government revenue, raised through distortionary taxation, costs society $1.30. If we could gain revenue with no additional distortion, by auctioning rather than grandfathering, we could achieve significant efficiency gains. The revenue raised in the auction could be used to cut taxes and reduce the deficit. One concern commonly expressed by private sector actors is that government would not use the revenue well. While this may be true, with revenue of around $134 billion annually Congress would be forced to use the revenue in transparent and hence probably more socially beneficial ways. If the auction raised $134 billion annually, compensating tax cuts could increase GNP by up to $40 billion.

The "double dividend" argument is that not only are environmental goals achieved in a tax or tradable allowance system, but the tax system is also made more efficient through revenue recycling so that the overall cost of the policy is negative. Because of interactions with existing taxes, however, the carbon regulation could have higher costs than are immediately apparent (Bovenberg and Goulder 1996). For example, if the carbon regulation reduced the return to labor, it would exacerbate the existing distortion from the labor tax. These tax interactions would occur regardless of the form of regulation. Research strongly suggests that US carbon regulation would not generate a double dividend. The numbers above are consistent with this. Nevertheless, even if there is no double dividend from raising revenue through environmental regulation, it is always more efficient to auction. Parry, Williams, Burtraw and Goulder (1997) estimate that, if the emissions reductions are less than 23 percent, grandfathering allowances, and hence losing the value of revenue recycling, would double the cost of regulation relative to an auction system.

One criticism of the efficient revenue raising argument is that government spending is not exogenous. Raising revenue through auctions thus might not lead to equivalent tax cuts. Preliminary work by Becker and Mulligan (1997) suggests that more efficient tax systems are associated with larger governments. If this were the case, the efficiency gain from auction revenue would depend on the actual size of the tax cuts and what was done with the additional government spending.

## B. Dynamic efficiency

The choice of auctions over grandfathering has dynamic advantages. Innovation reduces costs. This is always advantageous to firms. Innovation, however, also reduces scarcity rents. Industry incentives to innovate are even greater with auctions than grandfathering because, when allowances are auctioned, innovators benefit from the innovation-induced fall in allowance prices (Milliman and Prince 1989). In a grandfathered system these rents belong to the industry so there is no gain from reducing them.[10] Another dynamic advantage is that auctions guarantee liquidity and thus ensure the availability of allowances to new entrants and small traders.

Some people argue that firms are liquidity-constrained and that this limits innovation and adoption of new technology. This may be a reasonable argument for households buying new refrigerators, but is not reasonable for the likely recipients of grandfathered allowances such as large energy companies and manufacturers. A tax cut would more effectively provide resources to liquidity-constrained households and small firms.

## C. Distributional effects of auctions

In studying the distributional effects we break them into two parts, the effects which arise through changes in prices and returns to factors, and the wealth effects of changing ownership of a resource. Ownership is being transferred from the commons to either the taxpayer, under auctions, or the recipients of grandfathered allowances. The price effects, which are the most complex effects, are the same regardless of the form of carbon regulation. In particular, they are unaffected by whether allowances are auctioned or grandfathered. The aggregate distributional effects depend on the sum of price and wealth effects.

Three aspects of the distribution of costs of carbon regulation are important because of concerns about equity, political feasibility or both. The extent to which "the polluter pays" is important for equity reasons, and from the point of view of environmental groups.[11] The way that costs are distributed across the income distribution, and the effects on particularly vulnerable groups, have clear equity impacts. The costs borne by specific interest groups are critical for political feasibility.

### *Theory of cost incidence*

Three groups ultimately bear costs: consumers, workers and capital owners, especially current owners of physical capital. Consumers suffer loss of consumer surplus, workers suffer a fall in income, and capital owners suffer a fall in the value of their capital. Who bears costs does not depend on the legal form of the regulation, only on its effects on prices.

At every point in the economy, economic actors can pass changes in price due to carbon regulation forward to buyers, and backward to suppliers of factors of inputs.[12] When a domestic carbon allowance system is instituted, carbon becomes scarce and the cost (inclusive of the allowance) of domestic fuels containing carbon rises. If this rise in cost does not lead to an equivalent rise in wholesale price, the owners of the fuel sources lose.[13] The change in wholesale price depends on the relative elasticities of supply and derived demand. The elasticity of domestic supply depends partly on fossil fuel producers' access to international markets. The long run supply elasticity will be higher than the short run, because producers can alter exploration and development behavior. The elasticity of demand for fuel from producer depends partly on all the possible ways that downstream producers and consumers can reduce their use of specific fuels through fuel switching, increased fuel efficiency and changes in consumption. The cost incidence also depends on the industrial structure (Atkinson and Stiglitz 1980). In a monopoly, if supply is inelastic, producers will tend

10 In fact the incentive to innovate depends not on whether allowances are auctioned or grandfathered, but on who owns the allowances at the time of innovation. If allowances are auctioned many years in advance, the incentives are identical under auctions and grandfathering (Kerr and Toman, 1998).

11 In the case of carbon, "polluter pays" may be inappropriately judgmental in tone. However the logical replacement "user pays" has the same equity implications.

12 Prices of substitutes and complements to factors, inputs and outputs will also be affected through cross elasticities. Some factors and consumers may benefit from rising returns or falling prices.

13 As with a tax on land rent (Feldstein (1977)), not all the tax is borne by fossil fuel reserve owners even though in the short run they can do nothing to change their behavior.

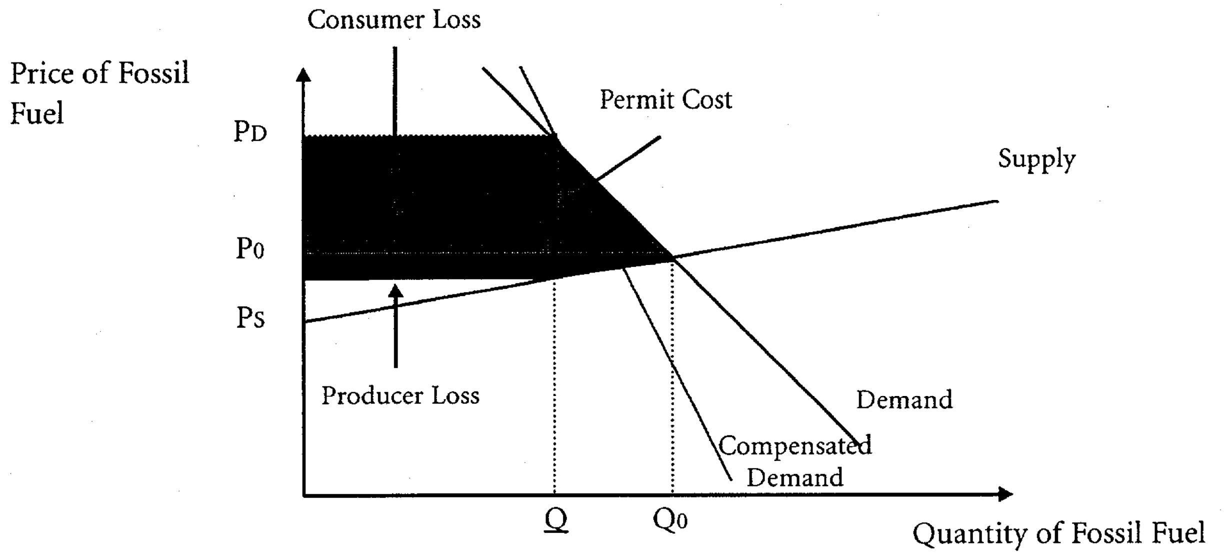
to bear the cost. If supply is elastic, the price rise will depend on the shape of the supply curve, the price could rise by more than the tax leading to a negative incidence on producers.[14]

In the same way that producers pass part of the cost forward with an increase in fuel prices, some can be passed backward through reductions in factor returns, to factors used in fossil fuel production, such as coal miners' labor. The effect on coal miners' wages depends on the elasticity of demand for coal miners, and their elasticity of labor supply to mining. In the short run at least, coal miners may be geographically and occupationally immobile, so may face significant wage reductions and unemployment.

We can identify similar effects throughout the economy. As each producer faces a cost increase they pass some on to their demanders, as increased prices, and some back to their workers. In general, part of the cost increase can also be passed backward to owners of capital. If capital is specific to a particular industry, its supply is inelastic in the short run. The return to its use will fall, leading to a fall in its value. Coal fired electric utilities, gas pipelines, and industrial boilers are examples of immobile capital, which will fall in value. The current owners of these assets will face losses. Ultimately the price changes reach the final consumer of fossil fuel or any good produced using fossil fuel. How much of the cost consumers bear depends on the elasticity of demand for fuels and goods containing carbon, relative to the elasticity of supply. In the short run, consumer demand for fuel may be relatively inelastic, because they can only respond by reducing usage. In the longer run, they can invest in new heating systems, cars, houses, and appliances that allow them to switch fuels and increase energy efficiency.

Figure 2 illustrates the losses to consumers and producers (passed on to factors). This figure assumes only one fossil fuel, and that it is sold directly from producers to the ultimate consumers. Q is the carbon cap translated into a fossil fuel cap. The figure shows how as the fossil fuel is restricted the price buyers pay rises to clear the market, and the price supply receives falls. The allowance price is the difference between these prices. In this illustration the buyer has inelastic demand and hence bears most of the price rise. The social cost is the sum of the loss of consumer and producer surplus. Consumer surplus is measured as the area under the compensated demand curve to

**Figure 2: Fossil Fuel Price and Quantity Effects from Carbon Regulation**




14 MR = p(1-1/hD) where hD is the price elasticity of demand. With a constant elasticity demand curve, and tax = t , MR = MC+t so dp/d t = (1/(1-1/hD)) which is greater than one for a monopolist.

reflect the amount consumers would be willing to pay to have the price lowered to its original level. We could draw similar figures for specific labor markets, specific intermediate product markets and physical capital markets.

In summary, the relative changes in prices (including wages and dividends) in response to the regulation, depend on relative elasticities of supply and demand for crude fossil fuels, specific types of capital and labor, and consumer goods. The overall cost to the economy of a given carbon target will fall with higher elasticities. The costs to specific individuals depend on these price changes, their ownership of different types of physical and human capital, and their consumption patterns.

## *Empirical evidence on the incidence of carbon regulation*

A variety of empirical studies shed light on the incidence of carbon regulation. All current models assume that the tax is fully passed through to consumers. Thus they implicitly assume perfectly elastic supply of factors, or equivalently full factor mobility. Poterba (1990) considers the relative expenditure shares directly devoted to energy across the expenditure distribution. Casler and Rafiqui (1993) use a similar methodology for direct expenditures. They also use an input-output framework to estimate indirect incidence through the purchase of goods produced using energy. Dowlatabadi, Kopp and Tschang (1994) consider only direct effects but allow for partial equilibrium responses to energy prices. Jorgenson, Slesnick and Wilcoxen (1992) use a general equilibrium model to consider the lifetime incidence of carbon taxes through all possible channels.

The different models have several consistent qualitative results. All agree that the impact of the tax will be relatively, but not dramatically, regressive.[15] The indirect effects tend to reduce the regressivity. Consumer incidence varies significantly by region. The Midwest bears the highest costs; the Pacific states bear the lowest. Other results are less clear. Casler and Rafiqui find that rural households are harder hit, and the young less affected. Jorgenson et al. find the opposite. Jorgenson et al. find that large households are more affected.

None of these models can say anything about loss of capital income and therefore loss of capital value. To do this a model needs to identify the elasticity of capital in specific industries and the owners of capital. The models currently can say nothing about the effects of carbon regulation on labor markets. Also the models all assume perfectly competitive pricing, which may not be appropriate in some of the key industries.

The regional effects on employment and consumption may exacerbate each other to create short-run macroeconomic effects on local economies, particularly in the East South Central region. The wide dispersion of owners and the high mobility of financial capital imply that the regional effects on capital value are unlikely to have local macroeconomic effects.

Identifying the cost distribution is a non-trivial exercise. It seems likely that costs will be slightly regressive across consumers, will reduce the income of shareholders in parts of the energy sector (especially coal producers and users), and will have impacts on immobile workers in the coal sector. Clearly more research is needed to clarify these relative effects on individuals.

## *Distributional effects under auctions and grandfathering*

Prior to compensation, an auction system would distribute costs in the same way as a grandfathered system. Both systems would lead to a distribution of costs that was determined by general equilibrium cost incidence, factor endowments and consumption

15 As Poterba (1990) points out, for consumers in the lowest expenditure quintiles who are receiving transfers, an automatic partial compensation mechanism exists through the indexation of transfers. This compensation is not captured in measures of regressivity.

patterns. The underlying distribution would be broadly consistent with polluter pays. Those heavily dependent on fossil fuels for capital or wage income, or in their consumption patterns, would bear more costs. Groups that responded significantly and rapidly to the pressure to reduce fossil fuel use would be rewarded by lower shares of costs. The ultimate distribution of costs would vary between the options depending on how the auction revenue was used — who would benefit and how much efficiency was increased — and to whom the allowances were grandfathered.

The government could use auction revenue to reduce tax distortions and thus reduce costs throughout the economy. It could be used to reduce labor or consumption taxes, benefiting all taxpayers. Payroll taxes could be cut or personal exemptions increased, benefiting the poor and middle classes. The deficit could be reduced, providing benefits to current borrowers and future generations. Auction revenue could be used to directly compensate afflicted workers, and provide transition assistance to help them change industries or locations. It could be used to cut the capital gains tax and hence benefit capital owners. It could provide assistance to afflicted communities and regions during their transition to a less fossil fuel-dependent economy. Only the political process and the normal constraints on redistribution would limit the flexibility of compensation under auctions.

In contrast, grandfathering allowances would not yield efficiency benefits so total costs would be higher. It would redistribute wealth only to those who directly received allowances. If the government were to grant allowances to coal companies, electric utilities, and other large emitters, it would yield no benefits for workers in those industries, local economies or consumer prices. Grandfathering could compensate some current owners of specific capital if allowance allocations were carefully targeted. These owners, however, could be adequately and more efficiently compensated, if such compensation were thought necessary, through targeted tax breaks. It would be theoretically possible to grandfather the allowances to a wide range of workers, consumers and capital owners, but this would be a cumbersome way to achieve a less efficient result than a tax-cut auction.

Equity could be better achieved under auctions. Cost bearing would be widely spread, and, in the long run, all costs would be borne by consumers. Therefore compensation should also be more widely spread. Auctions could provide more flexibility than grandfathering in compensation. In addition, poorer people tend to be workers and consumers more than they are shareholders, so they would be unlikely to benefit from grandfathering. These arguments were also true for the Acid Rain program, where grandfathering was chosen, but as Joskow and Schmalensee (1997) point out, the effects were attenuated because the recipients of allowances were electric utilities subject to rate regulation. Utilities were expected to pass on the scarcity rents as lower electricity prices. In contrast, the energy sector does not generally face economic regulation, so prices would not reflect rents.

# IV. The Politics of Auctions and Grandfathering

## A. Grandfathering

If allowances were grandfathered, interest groups would fight bitterly for a share of annual rents. This fight would lead to direct costs during the design of the policy. Groups would invest in lawyers, government lobbying, and public relations campaigns. Government officials would spend enormous amounts of time preparing and analyzing options and in negotiations. This would lead to high administrative costs and probably considerable delays in implementation. Problems of this nature in the allocation of the telecommunications spectrum ultimately led to industry support for the recent FCC auctions.

In addition, the enormous rents would mean that interest groups would continue to seek changes in the allocation over time. Firms might end up putting as much effort into rent capture as into finding efficient ways to reduce carbon usage. Investments might be delayed in the hope that high observed marginal costs would lead to more generous allowance allocations as compensation. The increased complexity of the program, which grandfathering would tend to create, might lead some groups to seek exemptions, or bonus allowances in particular circumstances. In the $SO_2$ case the negotiation process was costly and lengthy and the ultimate allocation formula reflects many special interests and exemptions (Joskow and Schmalensee 1997). Additional allowances were allocated to reward behavior such as investment in scrubbers.

## B. Auctioning

In contrast, the main political economy problem with auctions is that potentially regulated entities would have a strong incentive to support grandfathering and oppose auctions in order to obtain a portion of the available rents. Because industry perspectives will be important in passing climate change regulations, these incentives could greatly influence the structure of the regulatory approach. This is particularly true because potentially regulated industries usually have much more concentrated interests than consumers, workers and indirectly affected sectors.

The only example of auctioned rights in the US is the recent spectrum auctions. In the spectrum auctions the politics may have been altered by the enormous cost to the industry from delays suffered while spectrum rights were fought over. Auctions also had efficiency advantages for the industry because of the extremely complex problem faced when allocating heterogeneous allowances with highly interdependent values. The design of the Spectrum Auction reflected this difficulty. In addition, in a fast growing industry, many powerful players were non-incumbents who were unlikely to receive grandfathered allowances. This may also be true in the electricity sector in the wake of deregulation.

In the case of carbon allowances, the energy industry is already beginning to lobby for some form of grandfathering. The more efficient and equitable outcome of auctions will only be achieved if it becomes clear how the true costs will be spread, and if other affected groups are mobilized to protect their interests. Carbon is different from previous environmental regulations because of its potential scale and the pervasiveness of energy use. The scale will make the distribution of rents more transparent. Powerful players in non-energy sectors may well find it worthwhile to engage in this debate.

Transparency, however, can also have a down side for auctions. The auction price would be publicly visible, and large amounts of money would be transferred between the private and public sectors. This would affect perceptions of the distribution of costs. It might hinder the passing of the carbon regulation as a whole. It would raise opposition from those who were skeptical that the program would be revenue neutral, with tax cuts completely offsetting the auction revenue.

# V. Conclusion

We have addressed one key question concerning how best to meet carbon targets set in international negotiations. Assuming that the choice of domestic regulation will be a tradable allowance market, we outlined and argued for a tax-cut auction of the allowances.

Scarce allowances could be allocated through auctions or grandfathering. It is in the interest of current emitters to argue for grandfathering — allocating allowances based on past energy use or emissions. Such a system would pass on all scarcity rents to the regulated entities. This would represent a huge windfall gain to these entities.

A much better approach would be for the government to auction allowances on a regular basis. An auction would get the allowances to those who most need them, complementing the secondary market. Most importantly, in an auction the government would keep the scarcity rents rather than private entities. Auction revenues could be applied to reduce distortionary taxes, thereby providing an efficiency benefit. The equity benefit would be that tax cuts would spread the scarcity rents broadly across society, more closely reflecting the distribution of costs.

Designing a carbon allowance auction would be especially simple. $CO_2$ is a uniformly mixed, accumulative pollutant. Neither the source nor timing of emissions is important. Hence, carbon allowances could be auctioned as a homogeneous and bankable good. Even in an upstream system, which minimizes administrative costs by requiring allowances where monitoring is easiest, market power would not be an issue. The largest firm now has only a 5.6 percent market share. Firms with less than a one percent share of the energy industry would hold the vast majority of allowances.

In this setting, we recommend a standard ascending-clock auction. The auction would begin at a low price. With each round, the bidders would be asked what quantity they demanded at the price posted on the auction clock. If there were excess demand, the price would be increased. This process would continue until the excess demand fell to zero. The bidders would then receive their quantity bid at the final price. This auction would generate a uniform price for carbon allowances. All bidders would get their demands at the market price. A secondary market would allow the sale and purchase of allowances as circumstances change. This design would assure a highly efficient allocation of the allowances.

We have proposed a tax-cut auction for carbon allowances. In the carbon case, the allowance design would be simple, and the costs are very high and dispersed throughout the economy. These factors make the design of an auction simple. Auctions are feasible and efficient. The normative case for auctioned carbon allowances is strong. Given that the forces of supply and demand, rather than who is legally liable to meet the regulation, determine costs, the government has neither an efficiency nor an equity reason to give scarcity rents to industry. The best way to control climate change is to minimize the costs and distribute the rents fairly with a tax-cut auction.

# VI. References


Ausubel, Lawrence M. (1996), "An Efficient Ascending-Bid Auction for Multiple Objects," Working Paper, University of Maryland.

Ausubel, Lawrence M. and Peter C. Cramton (1996), "Demand Reduction and Inefficiency in Multiple-unit Auctions," Working Paper No. 96-07, University of Maryland.

Atkinson A. and J. Stiglitz (1980), *Lectures in Public Economics* (New York: McGraw Hill) pp. 206-217.

Back, Kerry and Jaime F. Zender (1993), "Auctions of Divisible Goods: On the Rationale for the Treasury Experiment," *Review of Financial Studies*, 6, 733-764.

Ballard, Charles L., John B. Shoven, and John Whalley (1985), "General Equilibrium Computations of the Marginal Welfare Costs of Taxes in the United States," *American Economic Review*, 75, 128-138.

Becker, Gary S. and Casey B. Mulligan (1997), "Efficient Taxes, Efficient Spending, and Big Government," Draft, University of Chicago.

Bovenberg and Goulder, 1996. "Optimal environmental taxation in the presence of other taxes: general equilibrium analysis," *American Economic Review*, September.

Casler, Stephen D. and Aisha Rafiqui (1993), "Evaluating Fuel Tax Equity: Direct and Indirect Distributional Effects," *National Tax Journal* 46(2), 197-205.

Cason, Timothy N. (1995), "An Experimental Investigation of the Seller Incentives in EPA's Emission Trading Auction," *American Economic Review*, 85, 905-922.

Cason, Timothy N. and Charles R. Plott (1996), "EPA's New Emissions Trading Mechanism: A Laboratory Evaluation," *Journal of Environmental Economics and Management*, 30, 133-160.

Cline, William (1991), *The Economics of Global Warming* (Institute of International Economics: Washington, DC).

Clinton, President (October 22, 1997), "Remarks by the President on Global Climate Change," *National Geographic Society*, Washington, DC.

Cramton, Peter (1997), "The FCC Spectrum Auctions: An Early Assessment," *Journal of Economics and Management Strategy*, 6:3, 431-495.

Dowlatabadi, Kopp and Tschang (1994), "Distributional and Environmental Consequences of Taxes on Energy," Resources for the Future Discussion Paper 94-19, March.

Feldstein, Martin (1977), "The Surprising Incidence of a Tax on Pure Rent: A New Answer to an Old Question," *Journal of Political Economy* pp. 349-360.

Gaskins, D. W. and J. P. Weyant (1993), "Model Comparisons of the Costs of Reducing $CO_2$ Emissions" *American Economic Review* (AEA papers and Proceedings), Vol. 83 (2), pp. 318-323.

Hargrave, Tim (1998), "U.S. Greenhouse Gas Emissions Trading: Description of an Upstream Approach," Center for Clean Air Policy, Airlie Carbon Trading Papers, March.

IPCC (Intergovernmental Panel on Climate Change) (1996), *The Science of Climate Change*, Vol. 1 of *Climate Change 1995: IPCC Second Assessment Report* (Cambridge University Press, Cambridge).

Jorgenson, Dale W., Daniel T. Slesnick and Peter J. Wilcoxen (1992), "Carbon Taxes and Economic Welfare," Brookings Papers: Microeconomics.

Jorgenson, Dale W. and Peter J. Wilcoxen (1992), "Reducing U.S. Carbon Dioxide Emissions: The Cost of Different Goals," in *Advances in the Economics of Energy and Natural Resources*, ed. By John R. Moroney, vol. 7 (JAI Press: Greenwich, Connecticut).

Joskow, Paul L. and Richard Schmalensee (1997), "The Political Economy of Market-Based Environmental Policy: The U.S. Acid Rain Program," *Journal of Law and Economics*, forthcoming.

Joskow, Paul L., Richard Schmalensee, and Elizabeth M. Bailey (1996), "Auction Design and the Market for Sulfur Dioxide Emissions," Working Paper, MIT-CEEPR 96-007WP.

Kerr, Suzi and Michael Toman (1998), "Uncertainty, Renegotiation, and the Design of a Carbon Trading Program," Draft paper, University of Maryland, College Park.

Manne, Alan S. and Richard G. Richels (1992), *Buying greenhouse insurance: The economic costs of $CO_2$ emission limits* (MIT Press: Cambridge, Massachusetts).

Milliman Scott R. and Raymond Prince (1989), "Firm Incentives to Promote Technological Change in Pollution Control," *Journal of Environmental Economics and Management* 17, 247-265.

Noll, Roger G. (1989), "Economic Perspectives on the Politics of Regulation," in *Handbook of Industrial Organization*, Volume II, ed. R. Schmalensee and R. D. Willig (Amsterdam: Elsevier) 1234-1287.

Nordhaus, William D. (1991), "The Cost of Slowing Climate Change: A Survey," *The Energy Journal*, 12(1).

Nordhaus, William D. (1994), *Managing the Global Commons: The Economics of Climate Change* (MIT Press: Cambridge, Massachusetts).

Parry, Ian W. (1995), "Pollution Taxes and Revenue Recycling," *Journal of Environmental Economics and Management*, 29:3, S64-77.

Parry, Ian W. H., Robertson C. Williams, Dallas Burtraw and Lawrence H. Goulder (1997), "The Cost Effectiveness of Alternative Instruments for Environmental Protection in a Second-Best Setting," Paper presented at NBER Summer Institute Workshop on Public Policy and the Environment, Cambridge, Massachusetts, August.

Plott, Charles R. (1997), "Experimental Tests of the Power Exchange Mechanism," Report to the California Trust for Power Industry Restructuring, March 10.

Poterba, James (1990), "Is the Gasoline Tax Regressive?" MIT Working Paper 586, Nov.

Poterba, James (1991), "Tax Policy to Combat Global Warming: On Designing a Carbon Tax," in eds. Rudiger Dornbusch and James Poterba, *Global Warming: Economic Policy Responses* (MIT Press, Cambridge, Massachusetts).

Repetto, Robert and Duncan Austin (1997), *The Costs of Climate Protection: A Guide for the Perplexed* (World Resources Institute: Washington, DC).

Stavins, Robert N. (1997), "What Can We Learn from the Grand Policy Experiment?: Positive and Normative Lessons from $SO_2$ Allowance Trading," *Journal of Economic Perspectives*, forthcoming.

U.S. Department of Energy, Energy Information Administration (1996), *Petroleum Supply Annual.*

U.S. Department of Energy, Energy Information Administration (1997), "Coal Production Industry Profile," Unpublished Report.

U.S. Department of Energy, Energy Information Administration, "Oil and Gas Production Industry Profile," Unpublished Report.

Van Dyke, Brennan (1991), "Emissions Trading to Reduce Acid Deposition," *Yale Law Journal*, 100: 2707-2726.

Vickrey, William (1961), "Counterspeculation, Auctions, and Competitive Sealed Tenders," *Journal of Finance*, 16, 8-37.

Wilson, Robert (1979), "Auction of Shares," *Quarterly Journal of Economics*, 94, 675-689.

Wilson, Robert (1997), "Activity Rules for the Power Exchange," Report to the California Trust for Power Industry Restructuring, March 14.

Wilson, Robert (1997), "Activity Rules for the Power Exchange: Experimental Testing," Report to the California Trust for Power Industry Restructuring, March 3.