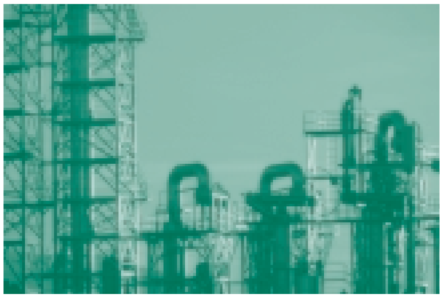
United States Environmental Protection Agency

Tools of the Trade





A Guide to Designing and Operating a Cap and Trade Program for Pollution Control

Tools of the Trade:

A Guide To Designing and Operating a Cap and Trade Program For Pollution Control

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Table of Contents

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1

Introduction

Introduction

To ensure a cleaner, healthier environment, governments are increasingly using market-based pollution control approaches, such as emission trading, to reduce harmful emissions. The theory of emission trading and the potential benefits of market-based incentives relative to more traditional environmental policy approaches are well established in economic and policy literature. Until recently, however, practical applications of emission trading programs have been relatively limited. In 1990, the United States enacted legislation to implement a comprehensive national sulfur dioxide (SO_2) program using a form of emissions trading called "cap and trade." The U.S. SO_2 cap and trade program has proven to be highly effective from both an environmental and an economic standpoint. The success of this program and others that followed has spurred interest from policymakers, regulating authorities, and business and environmental organizations. Today, emission trading mechanisms are increasingly considered and used worldwide for the cost-effective management of national, regional, and global environmental problems, including acid rain, ground-level ozone, and climate change.

Purpose

This guidebook is intended as a reference for policymakers and regulators considering cap and trade as a policy tool to control pollution. It is intended to be sufficiently generic to apply to various pollutants and environmental concerns; however, it emphasizes cap and trade to control emissions produced from stationary source combustion. In the United States, SO_2 and NOx are controlled with cap and trade programs. These programs provide many illustrative examples that are described within this text.

Structure

This guidebook is organized as follows:

- The introduction explains the policy tool known as cap and trade.
- Chapter 2 provides guidance on how to determine if cap and trade is the right solution for a particular problem and describes how it varies from other policy options, including other forms of emission trading.

- Chapter 3 explains the process for developing a cap and trade program.
- Chapter 4 explains how to implement and operate a cap and trade program.
- Chapter 5 discusses how to assess the results of a cap and trade program and communicate them to the public.
- Glossary of Terms and Acronyms contains definitions of the terms and abbreviations used throughout this guidebook.
- References contains a list of articles and papers cited in this guidebook.
- The Appendices contain additional technical and reference information.

Specific examples are provided throughout the text. These examples draw on the experience from cap and trade programs, including the U.S. SO_2 Allowance Trading Program (also known as the Acid Rain Program), the Regional Clean Air Incentives Market (RECLAIM) in Southern California, the Ozone Transport Commission (OTC) Regional NOx Trading Program in the Northeastern United States, and the United Kingdom's emission trading program for carbon dioxide (CO_2). These examples were selected to illustrate various aspects of cap and trade and are not intended to endorse controls on a specific pollutant.

Cap and Trade

Cap and trade is a market-based policy tool for environmental protection. A cap and trade program establishes an aggregate emission cap that specifies the maximum quantity of emissions authorized from sources included in the program. The regulating authority of a cap and trade program creates individual authorizations ("allowances") to emit a specific quantity (e.g., 1 ton) of a pollutant. The total number of allowances equals the level of the cap. To be in compliance, each emission source must surrender allowances equal to its actual emissions. It may buy or sell (trade) them with other emissions sources or market participants. Each emission source can design its own compliance strategy – emission reductions and allowance purchases or sales – to minimize its compliance cost. And it can adjust its compliance strategy in response to changes in technology or market conditions without requiring government review and approval.

How a Cap and Trade Program Works

1. The regulating authority sets a cap on total mass emissions for a group of sources for a fixed compliance period (e.g., 1 year).
2. The regulating authority divides the cap into allowances, each representing an authorization to emit a specific quantity of pollutant (e.g., 1 ton of SO_2).
3. The regulating authority distributes allowances.
4. For the compliance period, each source measures and reports all of its emissions.
5. At the end of the compliance period, each source must surrender allowances to cover the quantity of the pollutant it emitted.

If a source does not hold sufficient allowances to cover its emissions, the regulating authority imposes penalties.

Environmental Certainty

Cap and trade programs offer a number of advantages over more traditional approaches to environmental regulation. First and foremost, cap and trade programs can provide a greater level of environmental certainty than other environmental policy options. The cap, which is set by policymakers, the regulating authority, or another governing body, represents a maximum amount of allowable emissions that sources can emit. Penalties that exceed the costs of compliance and consistent, effective enforcement deter sources from emitting beyond the cap level. In contrast, traditional policy approaches such as command-and-control regulation generally do not establish absolute limits on allowable emissions but rather rely on emission rates that can allow emissions to rise as utilization rises.

With cap and trade programs, even new emission sources may not increase the limits on emissions. The regulating authority may require new entrants to purchase or receive allocated allowances from the total allowable emissions set by the cap (see Chapter 3 for a description of different ways that new entrants may be treated). Thus, the emissions target is maintained and the price of an allowance can adjust to reflect the increased demand for allowances.

A cap and trade program may also encourage sources to pursue earlier reductions of emissions than would have otherwise occurred, which can result in the earlier achievement of environmental and human health benefits. This is a result of two primary drivers: first, the cap and associated allowance market creates a monetary value for allowances, providing sources with a tangible incentive to decrease emissions. Second, a cap and trade program can incorporate the flexibility of banking (see Chapter 4) to provide sources with an additional incentive to reduce emissions earlier than required. Banking allows sources to carry over unused allowances for use in a later compliance period when there might be more restrictive requirements or higher expected costs to reduce emissions. Essentially, banking gives sources some flexibility in the timing of emission reductions (i.e., temporal flexibility). This is in addition to flexibility given to sources in the location at which they make emission reductions (i.e., spatial flexibility).

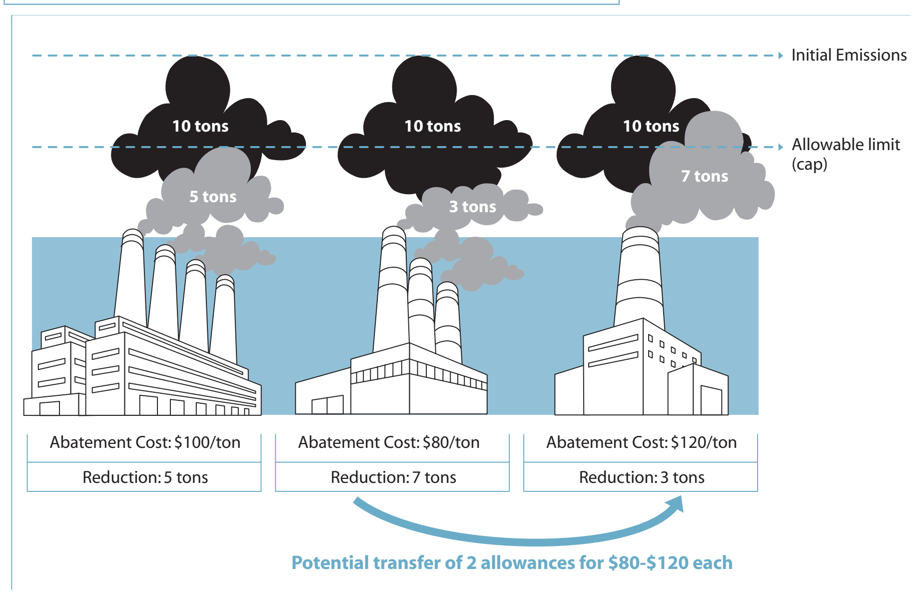
Another environmental advantage of cap and trade is improved accountability. Participating sources must fully account for every ton of emissions by following protocols to ensure completeness, accuracy, and consistency of emission measurement. This system contrasts with most environmental programs that base compliance on periodic inspections and assumptions that equipment is functioning and the source is in compliance between inspections.

Accurate measurement of emissions and timely reporting are critical to the success of a cap and trade program and the integrity of the cap. After emissions data and allowance transaction information are reported, the regulating authority can provide detailed or summary information to the public (e.g., on the Internet). This transparency, or access to information, can provide confidence in the effectiveness of the program.

Minimizing Control Costs

In addition to the environmental benefits of adopting a cap and trade program, significant economic benefits also support the use of such a mechanism. Cap and trade programs provide sources with flexibility in how they achieve their emission target, which is uncommon under traditional environmental policy approaches. The cap establishes the emission level for emission sources; the sources, however, are provided with the flexibility of choosing how they want to abate their emissions. Each source can choose to invest in abatement equipment or energy efficiency measures, to switch to fuel sources with no or reduced emissions, or to shutdown or reduce output from higher emitting sources. The regulating authority does not need to approve each source's compliance choices because the cap, accompanied by emission measurement and reporting requirements, enable the regulating authority to focus on assessing compliance results (i.e., ensuring that each source has at least one allowance for each unit of pollution emitted). Cap and trade programs also allow sources to trade allowances, providing an additional option for complying with the emissions target. Sources that have high marginal abatement costs (i.e., the cost of reducing the next unit of emissions) can purchase additional allowances from sources that have low marginal abatement costs. In this way, both buyers and sellers of allowances can benefit. Sources with low costs can reduce their emissions below their allowance holdings and earn revenues from selling their excess allowances – a reward for better environmental performance. Sources with high costs can purchase additional allowances at a price that is lower than the cost to reduce a unit of pollution at their facility (see Figure 1). This outcome is consistent with the "polluter pays" principle.

Figure 1. **Cost Minimization With Trading**



A well designed cap and trade program can also provide continuous incentives for innovation in emission abatement. Because of the value attached to allowances. The value creates an economic incentive to invest in research and development for emission abatement options that can further reduce the costs of attaining compliance.

Finally, the cost-minimizing feature of cap and trade has long-term environmental benefits. Driving down the cost of reducing a unit of pollution means that policymakers and regulating authorities can set targets that reduce more pollution at the same cost to society. This system makes it economically and politically feasible to achieve greater environmental improvement.

Is Cap and Trade the Right Tool?

Introduction

Cap and trade can be an effective tool to address air pollution. However, it is not appropriate in all situations or for all environmental problems. Policymakers should consider a number of important issues before deciding whether cap and trade is appropriate. Prior to developing a cap and trade program, policymakers and other experts should determine whether the nature of the environmental problem, as well as the institutional capacity and political situation, is conducive to the successful establishment of such a program (Benkovic and Kruger, 2001).

This section begins with a brief discussion of some of the general issues that must be assessed for any type of emission reduction program. Next, the section examines whether cap and trade can address a particular environmental problem. Finally, it compares cap and trade to other types of policies including different forms of emission trading.

General Assessment Issues

Before making a decision about an emission reduction program, policymakers should assess a number of science, technology, and other issues. For example, regardless of the type of program chosen, policymakers must understand the nature of the environmental or health problem of concern, the pathways of exposure, the location and magnitude of the sources that contribute to the problem, and the emission reductions necessary to address the problem. Similarly, policymakers should have answers to technical and economic questions such as the cost, availability, and performance of control technologies. Although a full discussion of these questions is beyond the scope of this manual, Appendix B summarizes how some of these questions were addressed under the U.S. SO_2 Allowance Trading Program.

Once policymakers have a thorough understanding of these issues and questions, they can determine whether cap and trade is an appropriate tool to address the problem. The following sections outline some of the key considerations used to determine whether cap and trade will be an effective program for a particular situation.

Is Flexibility Appropriate?

Cap and trade is premised on the notion that regulators do not need to direct the type or location of specific emission reductions within a region. Instead, these programs set an overall target and let "the market" determine where to make the most cost-effective reductions. In some cases, however, it does matter where an emission reduction is made. For example, some toxic emissions may have primarily local health impacts in the area immediately surrounding a facility. Allowing such a facility to buy allowances from other similar facilities in the area may not fully address the risks caused by its emissions. It may make a situation worse by causing a "hotspot" if the cap does not require sufficient reductions to minimize or prevent local impacts. In such a case, it may be necessary, from a public health standpoint, to impose source-specific controls and limit the flexibility inherent in an emission trading program.

In general, the more a pollutant is uniformly dispersed over a larger geographic area, the more appropriate it is for the use of cap and trade.

Even when the location of emissions does matter, cap and trade may be effective if the environmental goal can be met through emission reductions in a general region. For example, a cap and trade program can reduce total loadings of a pollutant into the atmosphere, particularly if these pollutants are emitted by many sources and transported over a large geographic region. This was the case in the United States with the SO_2 Allowance Trading Program, which is intended to reduce acid deposition in the Eastern United States and Canada. Similarly, cap and trade programs can address ambient air quality problems by reducing background levels of pollution that contribute to adverse air quality. For example, if there are prevailing winds, it may be necessary to include emission sources upwind of the polluted area that could prevent downwind areas from meeting their ambient air quality standards. The NOx cap and trade programs in the Northeastern United States were designed to reduce long-range transport of NOx emissions that lead to the formation of ground-level ozone.

Before designing cap and trade programs to address emissions that are not uniformly mixed, it is necessary to conduct an assessment of the possibility of hotspots. Chapter 3 contains a discussion about ways to assess the potential for hotspots and how to develop policies to avoid them if necessary. In such cases regulating authorities may need to limit emissions at specific sources or limit trading to ensure that the program does not create hotspots and that it achieves the environmental objectives. It should be noted, however, that if a program requires too many trading restrictions to avoid hotspots, a more conventional regulatory approach to address the problem might be preferable.

Do Sources Have Different Control Costs?

Cap and trade programs make the most sense when emission sources have different costs for reducing emissions (Newell and Stavins, 1997). These cost differences may result from the age of the facilities, availability of technology, location, fuel use, and other factors. In the U.S. SO_2 Allowance Trading Program, there was considerable diversity in emission reduction costs because of differences in the age of power plants and the proximity to low sulfur coal supplies (Stavins, 1998). Where costs are different, there is "room for a deal," because sources with high marginal abatement costs have an incentive to buy allowances from sources with low marginal abatement costs. Conversely, if affected sources tend to be relatively homogenous, their marginal abatement costs may be approximately equal and there is little incentive for trading. In this case, a cap and trade program is not likely to yield a significantly more cost-effective outcome than more traditional types of regulation. Table 1 is a compilation of SO_2 marginal control costs for sources in Taiyuan, China. The data were used to assess the feasibility of using cap and trade to reduce SO_2 emissions. This type of analysis is critical to determining the merits of using cap and trade as a policy instrument.

Are There Sufficient Sources?

In general, cap and trade programs should include enough sources to create an active market for allowances. If there are too few sources, there may be few opportunities for trading. In addition, even if there are cost-effective trading opportunities in a program with few sources, a market with few transactions could make potential sellers reluctant to part with their excess allowances. These potential sellers could be concerned that if business conditions change and they need more allowances in the future, they will have difficulty purchasing them. They may instead hoard excess allowances even though it might not appear to

Table 1: Cost-Effectiveness of SO_2 Control Measures in Taiyuan, China

Control	Source	Cost/ton (US$)
Treat post-combustion gas	Taiyuan District Heating	$60
Flue gas desulfurization (FGD)	Eastern Mountain Power Plant	$80
Lower sulfur coal (~1.3%)	Taiyuan #1 and #2 Power Plants, Taiyuan Iron & Steel	$100
FGD (simplified)	Taiyuan #1 Power Plant	* $240
Limestone fuel additive	Coal Gasification Plant	$130

* In addition to unspecified costs paid through a grant from the government of Japan.

Source: RFF, 2001

be in their economic interest to do so. Additionally, with fewer sources, there may be a concern that larger sources may exert market power and withhold allowances from the market to drive up prices of allowances.

There is a tradeoff, however, in that the more numerous the sources, the more complex and costly the cap and trade program may be to establish and operate. For example, a cap and trade program for vehicles could be administratively costly if there was a need to measure and report emissions and enforce compliance at the vehicle level.[1] Technological advances, however, are making it possible to cost-effectively expand participation in cap and trade programs (e.g., computerized data tracking systems, improved emission measurement technology (Kruger, et al., 2000)).

Is there Adequate Authority?

Another important question government officials must consider is whether the relevant government entity has sufficient jurisdiction over the geographic area where they would implement the cap and trade program. In many countries, regional or local authorities are responsible for implementing environmental programs. Often, they must follow national policies but are given considerable autonomy in implementation.[2] To the extent that the region of a cap and trade program covers more than one jurisdiction, the authorities should maintain some consistency in key design elements of the program. To ensure that the allowances are consistent and fungible across jurisdictions, cap and trade programs require common design elements, including standards for determining applicability, emissions measurement and reporting, recordkeeping, enforcement, and penalties for non-compliance (Kinner, 2002). Thus, program designers should answer the following questions:

- Will provinces and municipalities be responsive to directives, such as monitoring requirements, imposed by the national government or would they cooperate to form a collective effort to develop such requirements?
- Does the central government, or coalition of local governments, have the capacity to enforce compliance provisions and penalties throughout the entire trading region?

Other design elements, such as allocation methodologies for assigning the initial distribution for allowances, might be left to the provinces or municipalities since the allocation methods have little environmental impact.[3]

Are there Adequate Political and Market Institutions?

For the trading component of a cap and trade program to work, a country must have some of the same institutions and incentives in place as those required for any type of market to function. These include:

1 Other environmental policy tools, or alternatively, the compliance obligation and allowance allocation at the vehicle manufacturer, fuel refiner or distributor level, may be more appropriate in this case.

2 For example, China's provincial Environmental Protection Boards have the main responsibility for running air quality and other environmental programs. Similarly, in Slovakia there are 79 local districts that implement environmental and other programs.

3 Allowing different provinces or municipalities to have different allocation schemes may have distributional economic impacts, such as favoring firms within an industrial sector in one region of a country over another. This result could have economic efficiency effects if product markets are not perfectly competitive.

- A developed system of private contracts and property rights (see Chapter 3 for discussion of property rights issues associated with emission trading).
- A private sector that makes business decisions based on the desire to lower costs and raise profits.
- A government culture that will allow private businesses to make decisions about "how" to achieve objectives with a minimum of intervention.

As with all environmental programs, a cap and trade program requires adequate enforcement to ensure that emission objectives are met. In addition, for an allowance market to develop, market participants must be confident that sources will measure and report emissions correctly, the regulating authority will verify compliance, and, if there is non-compliance, the regulating authority will assess sufficient financial penalties. Thus, cap and trade programs will have greatest success in countries where rule of law is respected and enforcement is consistent, impartial, transparent, and independent of political considerations (EDf and RSHE, 2000). In addition, once regulations are implemented, they should be changed only through transparent and fair procedures. Participants should clearly understand from the beginning how the program works and how regulating authorities will measure and enforce compliance. Interest in a trading program will diminish significantly if firms believe that rules are unfair, arbitrary, or unpredictable.

Even if a country does not yet have all of the attributes described above, it may still be beneficial to develop the infrastructure necessary for a cap and trade program in advance of more comprehensive economic changes (Ellerman, 2002). As centrally planned economies make the transition to become more market oriented, they may also transform their environmental programs to become more efficient. Even if conditions are not yet ripe for trading, the structure of a cap and trade program may improve environmental performance. In particular, the emphasis on careful mass-based emission measurement and accounting may improve environmental accountability of sources. For example, recent experiments in Slovakia (CCAP, 2001) and Chile (Montero, et al., 2000) have indicated that the allocation process associated with cap and trade has served as an incentive for more complete and accurate emission inventories.

Are Measurement Capabilities Sufficiently Accurate and Consistent?

In considering whether cap and trade is an appropriate tool to address an environmental problem, policymakers should consider whether sources covered by the program can measure emissions with sufficient accuracy and consistency to support the cap and trade policy tool. (For a discussion of emission measurement priorities and issues for a cap and trade program, see Chapter 3.)

Unlike many types of environmental regulation where regulating authorities judge compliance by adherence to detailed technology or process specifications, cap and trade programs require a purely performance-based test for compliance. Ultimately, measured emissions dictate how many allowances a source must surrender at the end of the compliance period. Thus, the measured emissions dictate how many extra allowances a source may be able to sell or how many additional allowances a source may need to buy. If one source uses a less accurate emission measurement method than another, and consequently underestimates its actual emissions, it could surrender fewer allowances than necessary to offset its emissions. If this scenario occurred, the emission goal (or cap) would not be met. In addition, facilities with opportunities to reduce emissions beyond required levels would lose some of the economic incentive, because the underreporting sources need fewer allowances for compliance and will therefore either increase the supply or decrease demand for allowances.

Comparison of Cap and Trade and Other Policy Options

A number of different policy tools can be used to address environmental concerns. These include:

- Economic-incentive approaches, such as environmental taxes and emission trading.
- Command-and-control approaches, such as technology mandates or emissions rate standards.
- Non-regulatory approaches, such as voluntary agreements and eco-labeling.

Ultimately, the policymaker's objective should be to achieve the optimal level of pollution control to adequately protect human health and the environment at a minimum cost to society.

Market-Based Approaches vs. Command-and-Control Regulation

For many air pollution problems, command-and-control (or direct regulation) may be the best course. For example, where regulating authorities can identify a specific facility as the source of a public health problem, limiting its emissions may be the simplest and most effective solution. Also, in the transportation sector where fuel characteristics can have a direct impact on the effectiveness of engine technology, it may be best to directly specify fuel parameters, such as sulfur content, to permit firms to design engines in the most cost-effective way to reduce harmful emissions of particulates or other pollutants such as NOx, hydrocarbons, and carbon monoxide.

Command-and-control regulations often work best when:

- Emission reduction experience is limited and expertise is concentrated among regulators.
- Solutions are clear or there are few options for reducing emissions.
- Monitoring total mass emissions is not feasible.
- Emissions have serious local health impacts, and trading might make such hotspots worse.
- Emissions are toxic, and the desired emissions level might be zero.

With command-and-control, the regulating authority typically establishes a requirement to install a specific type of emission reduction technology. Although sources may achieve a certain level of emissions per unit of heat input or product output using the technology, increased utilization and new emissions sources can threaten the ability to achieve and maintain an emissions target. Older sources that have been exempted or "grandfathered" from strict emissions controls might also threaten the ability to achieve and maintain an emission target. This threat can affect the ability to achieve an environmental and/or human health goal.

For some environmental problems, however, specific requirements may cost more than flexible policy approaches and inhibit innovation. These types of environmental problems may work well for a transitional application of incentive-based approaches or economic instruments, such as taxes or a cap and trade program. Such programs may be preferred to encourage more economically efficient solutions. If properly designed, economic incentives can harness market forces to work toward environmental improvement. By internalizing pollution control costs they can make pollution reduction in the economic interest of the firm and promote innovation.

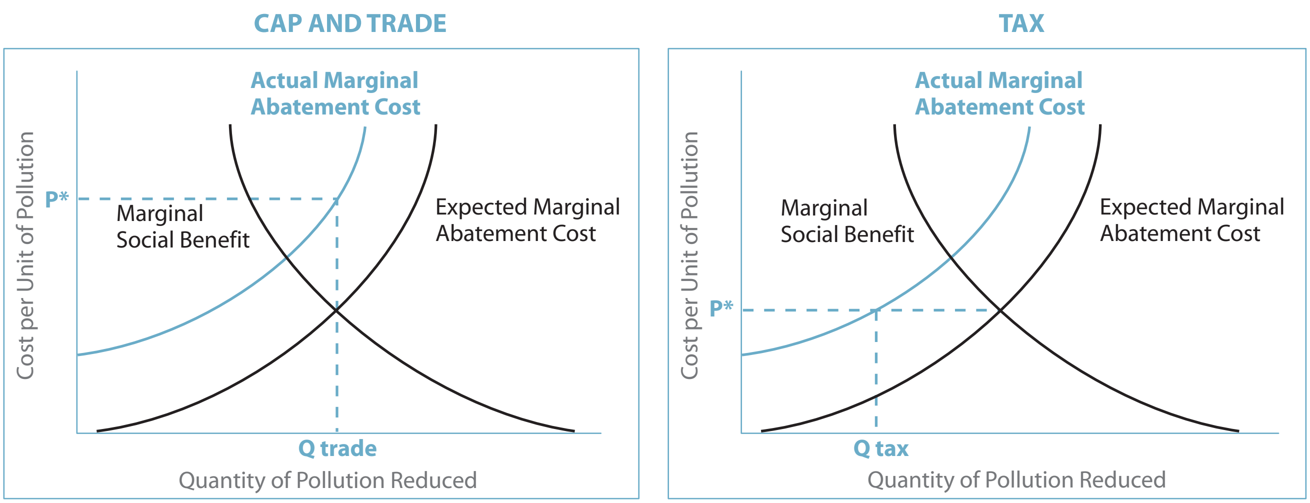
It is also possible and, in some instances, beneficial to use a hybrid approach where command-and-control policies are implemented side-by-side with a cap and trade program. Command-and-control policies, if not overly restrictive, can establish a backstop or safety net to adequately protect human health and the environment (see Chapter 3).[4]

Cap and Trade vs. Environmental Taxes

Environmental taxes are another significant market-based instrument for reducing pollution. The major difference between cap and trade and environmental taxes is that cap and trade imposes an absolute restriction on the quantity of emissions allowed (i.e., the cap) and allows the price of emissions to adjust to the marginal abatement cost (i.e., the cost of controlling a unit of emissions). An environmental tax sets a price for a ton of emissions and allows the quantity of emissions

[4] For a discussion of integrating cap and trade with other instruments, see Schreifels, 2000 and Ellerman, 2002.

Figure 2. **Economically Efficient Control of Pollution**



Theoretically, environmental taxes or cap and trade will provide the same level of environmental protection. However, if policymakers have incomplete or imperfect information about costs and benefits, researchers create new control technologies, or unforeseen developments arise, cap and trade provides certainty that the level of emissions will not increase beyond the emission cap. However, there are no assurances about the cost of the program. An environmental tax does not provide certainty about emissions, but it does establish a limit on the cost of the program to ensure that the price of emitting a unit of pollution does not exceed the tax level. In the second graph, the actual marginal abatement cost is higher than expected leading to fewer emission reductions (i.e., higher emissions) for the tax program. If the actual marginal abatement cost were lower than anticipated, the emission reductions for the environmental tax program would be greater than for the cap and trade program (and costs would be higher.)

to adjust to the level at which marginal abatement cost is equal to the level of the tax (See Figure 2).

Environmental Certainty

There is extensive discussion in economics literature about the relative merits of cap and trade and environmental taxes.[5] In situations where greater environmental certainty is needed, cap and trade programs are preferable because the cap sets an emission goal that sources must meet. With taxes, the regulating authority must establish a tax per unit of emissions. However, due to imperfect information (e.g., regarding marginal abatement costs and price sensitivities) and technological changes, setting the tax at the level required to attain the emission target becomes difficult and uncertain.[6] Moreover, under a regime of environmental taxes, new entrants into the polluting activity will lead to increased emissions. With cap and trade, regulating authorities can require new entrants to purchase allowances directly from the market or the regulating authority can provide allowances from set-asides that are within the cap. Thus, the emission goal can be maintained.

Price Certainty

In situations where price certainty is needed, tax programs are preferable because the tax per unit of emissions limits the cost to firms. For example, where the costs of achieving a level of emission reductions are uncertain, policymakers may decide to set an emissions tax rather than taking a chance that an allowance price will rise to a level that is economically or politically unsustainable. [7]

[5] For a discussion of the economic considerations for choosing between taxes versus emissions trading, see Baumol and Oates, 1988.

[6] A recent study of environmental taxes in Europe showed that these programs have failed to achieve the expected level of emission reductions (OECD, 2001).

[7] A third type of economic instrument is essentially a hybrid of a tax and a cap and trade program. This mechanism, sometimes known as a "safety valve" or a "price cap" is a cap and trade program with a maximum price per ton. If the market price per ton rises above the maximum price, regulated sources can buy additional tons at the maximum price. In such a situation, the emission cap is exceeded, but the price per ton does not rise above the maximum level (Pizer, 1997).

Administrative Costs

Administrative costs are similar for both environmental taxes and cap and trade. Each approach requires sources to keep records of fuel consumption or emissions and to report this information to the regulating authority. The regulating authority's administrative costs include processing this information, reviewing it for completeness and accuracy, and recording it. The regulating authority could also conduct detailed audits of selected submissions.

With both instruments the regulating authority must decide the rigor of emission measurement and reporting requirements. For example, Sweden's NOx tax and the U.S. SO_2 Allowance Trading Program require the use of continuous emission monitors (Blackman and Harrington, 1999). Similarly, the regulatory authority's review of data can be more or less rigorous depending on the level of review necessary. Under the U.S. SO_2 Allowance Trading Program, emission data review is rigorous. Although it is highly automated, more than 75 percent of staff resources at the federal and state level are associated with the measurement, processing, and tracking of emissions data (see Chapter 4 for a more detailed discussion of administrative costs).

Under a cap and trade program, a small amount of additional resources are necessary to process allowance transfers and reconcile emissions and allowances at the end of a compliance period. A tax program will require resources to collect and manage tax receipts. Some fiscal institutions, however, may already have the resources in place to collect and manage receipts from other tax schemes.

Political Considerations

Some regions have a history of implementing environmental tax programs. In these regions environmental taxes may be easier to implement because they are already understood and accepted and much of the infrastructure may already exist. In other regions, there may be political reasons to opt for a cap and trade program. Emission sources may prefer a system in which allowances are allocated without charge rather than a system of environmental taxes in which a source has to pay for emissions. The initial allocation of allowances reflects a transfer to sources of an asset that is scarce and therefore has economic value. Recognizing this, sources are often more supportive of this market-based incentive program than they are of environmental taxes. In some circumstances, policymakers might use both policies, environmental taxes and cap and trade.[8] A low tax can generate revenue for the regulating authority while still offering emission sources the benefits of a cap and trade program. Alternatively, the regulating authority could generate revenue with a cap and trade program by distributing some or all allowances through an auction.

Other Forms of Emission Trading

This section examines two additional forms of emission trading – project-based trading and rate-based trading – and compares them to the cap and trade approach in terms of potential to limit total emissions, ability to achieve cost minimization, administrative overhead, and transaction costs.

Cap and Trade vs. Project-Based Trading

Potential to Limit Total Emissions

Project-based trading, otherwise known as credit trading or offset trading, is generally not used as a standalone program. It can be used to offer emission sources the flexibility to seek lower cost emission offsets from sectors outside a regulatory program. Historically in the United States, these types of credits or offsets have been used to meet rate-based emissions limits for conventional pollutants. More recently, there has been considerable international interest in using project-based trading as a complement to cap and trade to meet voluntary or mandatory greenhouse gas emission targets.

Emission offsets, or credits, are typically calculated by comparing actual emissions against a baseline. The baseline is an estimate of what emissions would be in a hypothetical situation (e.g., if the project had not been created). Determining the baseline is often the biggest challenge with project-based trading. Designing effective protocols to verify offsets is difficult because it requires making a determination about whether the emission reductions from an offset project would have occurred anyway. This type of test is known as "additionality." If emission reductions from a project are not "additional," there is a risk that these reductions could dilute an emissions goal and lead to

[8] For a discussion of integrating cap and trade and environmental taxes, see Ellerman, 2002.

increased emissions compared to a case in which no offsets are allowed.

A similar concern in some situations is "paper credits." These are created when a source uses its legal allowable level of emissions (e.g., its maximum potential to emit) as its baseline rather than what emissions would have been in the absence of the project. These paper credits are the difference between what a source is allowed to emit and what a source actually emits. These credits increase allowable emissions without generating any real emission reductions.[9]

Two issues must be addressed for project-based trading–the effect on total emissions from "non-additional" offsets and "leakage," which is an increase in emissions or decrease in sequestration caused by the project but not accounted for in the emission baseline for that project activity.[10] The underlying concept is that a particular project can produce offsetting effects that fully or partially negate the benefits of the project. For example, a project that protects a forest tract slated for deforestation may simply accelerate logging of the next most suitable location.

Projects that temporarily sequester emissions (e.g., forestry projects that sequester carbon dioxide) also raise issues of "permanence." If the emission reductions from the project are used to offset other emissions, and the project subsequently releases the sequestered emissions, not only is the environmental benefit lost, but the credits may allow emissions to increase.

Cost Minimization

As with cap and trade, project-based trading can reduce the economic costs of achieving an emission goal by adding flexibility for sources to develop appropriate compliance strategies. For example, a polluting facility may invest in an offsite emission abatement project to earn emission reduction credits. If approved, these credits may be used to offset emissions from the facility.

Administrative Involvement and Transaction Costs

A key difference between cap and trade and project-based trading is the way that emission reductions are verified and the implications for administrative involvement. A cap and trade program requires preliminary analysis to establish an emission cap for regulated sources. Depending on the method of allowance distribution (see Chapter 3), additional work may be required to allocate emission allowances to the regulated sources. Due to the emission cap and measurement requirements, there is no need for the regulating authority to review each emission reduction activity or to calculate an emission baseline for each activity. Instead, each regulated source measures and reports its total emissions, and the regulating authority focuses on ensuring emissions are measured accurately and an allowance is turned in for each unit of emissions.

In contrast, project-based trading often requires that project participants develop a project specific emission baseline for review by the regulating authority or other authorized experts.[11] Review of such baselines can be contentious and resource intensive because it is extremely difficult to define with certainty what would have happened in the absence of a project.

To reduce administrative and transaction costs and address additionality concerns, the regulating authority may establish multi-project baselines. Multi-project baselines use performance standards or benchmarks for a type of project. If the project results in emission rates lower than the standard, the project automatically receives credit equal to the difference between the baseline and the actual emissions (Sathaye, et al., 2001). Standardizing baseline methodologies in advance can significantly reduce administrative costs and reduce the subjectivity inherent in the review of a project baseline. They may not, however, always be a perfect test for whether emissions are below the levels that would have occurred otherwise. Also, multi-project baselines may be difficult to develop for some types of projects.

Project-based trading can reduce the costs of attaining an emission goal, but the administrative and transaction costs per unit of emission reduction are often higher than cap and trade programs; there is greater uncertainty and risk associated with an offset than an allowance (e.g., due to baseline, permanence, and leakage issues); and extensive involvement and oversight by the regulating authority are required to ensure environmental integrity. These transaction

[9] Paper credits can also affect rate-based trading programs.

[10] Leakage can also occur in cap and trade programs that do not include all sources contributing to the environmental problem. Sources in the program may shift production to other sources not participating in the program, thereby negating some of the emission reductions.

[11] Adequate safeguards for using an outside expert for verification include: sufficient direction and oversight from the regulating authority; accreditation of competency; and protection from conflicts of interest.

complexities vary depending upon project type. Project-based trading can be an effective way to introduce some sectors to market-based incentive programs. In addition, it can be effective for sectors in which it is easier to measure an emission reduction (e.g., the quantity of gas captured from a landfill methane recovery project) than total mass emissions.

Cap and Trade vs. Rate-Based Trading

Under a rate-based trading approach, the regulating authority determines a performance standard (e.g., an amount of emissions allowed per unit of output) for a sector (e.g., tons of a pollutant per kWh of electricity generated). Sources with emission rates below the performance standard can earn credits[12], whereas sources with emission rates above the standard must obtain credits for their excess emissions to remain in compliance.

Sources with low cost opportunities to improve their emissions rate have an incentive to operate at rates below the performance standard. They can then sell the resulting credits to sources that have higher costs to attain the performance standard. Rate-based trading programs have been used in the United States to phase out lead in gasoline and control mobile source emissions.

One consideration when evaluating rate-based trading is that if the activity level increases at a rate faster than the emission rate declines, sources can earn credits while total emissions increase.

Potential to Limit Total Emissions

Perhaps the most important measure of a regulatory approach is whether it can produce the desired environmental improvement. Emission caps set the total emission level, in effect, constructing a program from the environmental goal back to the sources. In contrast, rate-based trading attempts to establish an emission rate standard for each source that will, in aggregate, produce the desired environmental improvement. However, under a rate-based program, emissions and the pollution load on the environment can increase if sources increase their utilization or if new sources are built.

This situation raises a distinction between cap and trade programs and rate-based programs regarding industrial growth. Both types of programs accommodate growth. The responsibility for addressing growth, however, falls upon the sources in a cap and trade program while it falls on the regulating authority in a rate-based program. More specifically, under a cap, sources must determine how to operate new facilities or increase utilization of existing facilities and still comply with the emission cap. This approach encourages industry to innovate and find lower-cost approaches to reducing emissions. In the U.S. SO_2 Allowance Trading Program electricity production and economic growth increased while SO_2 emissions decreased significantly (see Figure 3). In a rate-based program, as with an environmental tax program, the regulating authority must periodically impose new rate standards to achieve and maintain an emission target and prevent (or correct for) additional emissions that may result from increased production. This cycle of revising regulatory programs can create a less certain regulatory environment for sources to conduct compliance and business planning.

Cost Minimization

As with cap and trade, the fact that sources can trade their credits under the rate-based approach implies that the performance standard could be achieved at a lower economic cost. This is because sources with high marginal abatement costs will choose to purchase credits from firms with lower marginal abatement costs.

Administrative Involvement and Transaction Costs

Under a rate-based system, the regulating authority converts each source's emission rate and activity level to credits. Because the regulating authority must collect activity level data, the data requirements may be greater for rate-based trading. Such data may also include commercially sensitive data that could be difficult to obtain. This information, however, may be useful for other types of trading programs as well. The regulating authority can use the information to verify measured emissions.

Like cap and trade, rate-based approaches do not necessarily require that the regulating authority approve each trade (in contrast to the project-based trading described earlier). Because some additional steps for government approval may be required, the level of administrative involvement and costs could be

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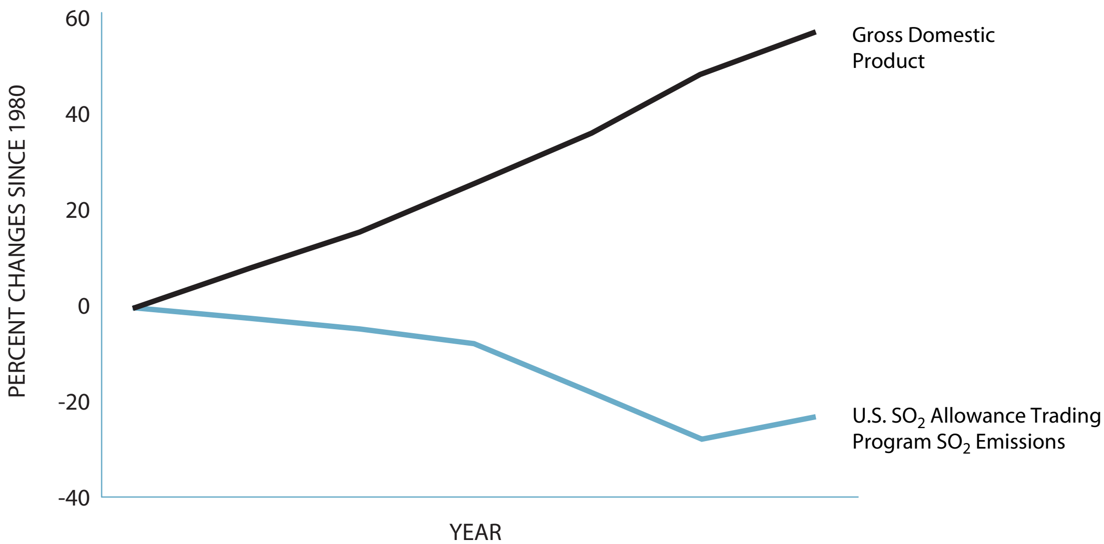
[12] For electric power sources, the credits earned would be equal to the difference between the performance standard and the source's emission rate multiplied by the source's current heat input or generation.

Figure 3. **Decoupling Economic Growth and Environmental Protection**



the same or slightly greater than those of a cap and trade program.

Summary of Other Forms of Emission Trading

Each of the three forms of emission trading is appropriate in certain situations. When achieving and maintaining an absolute emission goal is important, a cap and trade program can provide more certainty about total emissions. Administrative and transaction costs for cap and trade programs are often lower than for project-based trading, which is burdened by higher uncertainty and risk and the need for extensive regulating authority involvement.

Project-based trading programs have historically evolved from the introduction of limited flexibility in traditional command-and-control programs. Because project-based programs usually do not require net emission reductions, they are not effective as standalone programs. However, a well designed project-based trading program may complement a command-and-control program that establishes emission or concentration limits. It may also complement a cap and trade program in sectors for which accurate emission measurement of entities or activities may not be as well developed.

Rate-based trading can be an effective way to promote efficiency if circumstances do not require an absolute cap on emissions. The administrative and transaction costs for rate-based trading programs are likely to be the same or similar to cap and trade. (See Table 2 for a summary of the forms of emission trading.)

Table 2: Three Forms of Emissions Trading Compared

	Limit Total Emissions	Cost Minimization	Administrative & Transaction Costs
Cap and Trade	High	Yes	Low
Project-based Trading	Low to Medium	Yes	High
Rate-based Trading	Medium	Yes	Low to Medium

Early Emissions Trading in the United States

Cap and trade in the United States evolved to improve upon earlier experiences that were expensive, resource-intensive and burdened with subjective review procedures, which resulted in limited environmental benefits. The U.S. EPA and state-level environmental agencies have used several different forms of emission trading with varying degrees of environmental and economic effectiveness. Although many of the early achievements were modest, the early efforts in emission trading are important because they provided a foundation and valuable practical experience for the development of more effective emission trading programs (e.g., the U.S. SO_2 Allowance Trading Program).

Offset Program

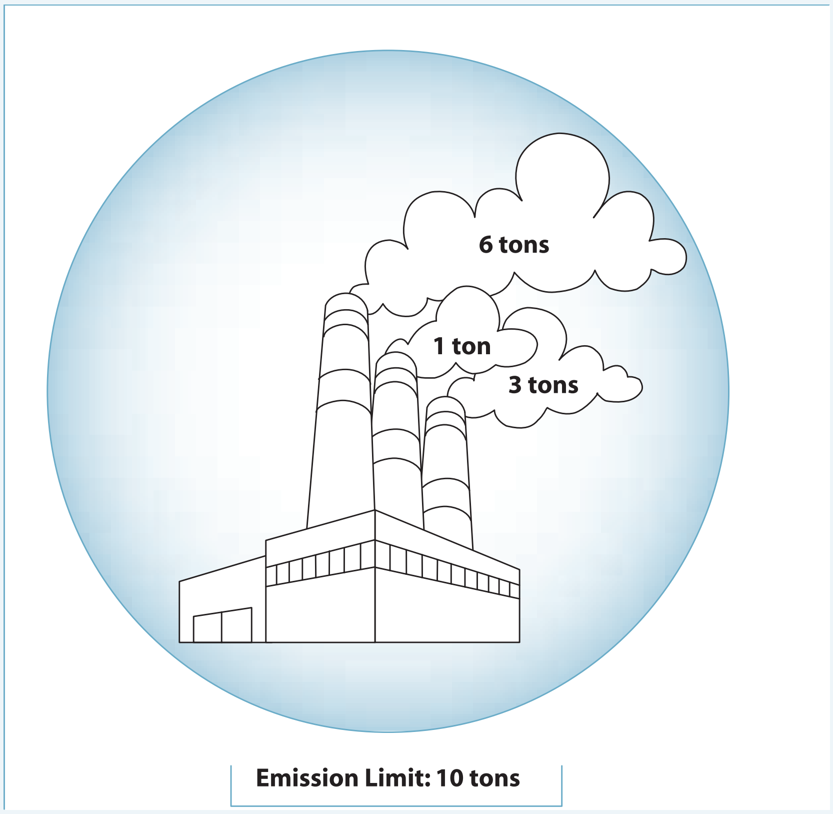
EPA first applied the concept of marketable emission permits in the mid-1970s as a means for new sources of emissions to locate in areas with poor air quality without causing additional air quality problems. New sources and existing sources that wanted to expand their facilities were required to "offset" their emissions by acquiring emission reductions from other sources. In this program, offsets are generated when a source reduces actual emissions below their permitted level and applies to a state agency for certification of the reduction. For a source to receive an offset, the state must determine that the reduction is: (1) surplus in the sense of not being required by current regulations; (2) enforceable; (3) permanent; and (4) quantifiable. Offsets are normally denominated by the quantity of pollutant in tons released over 1 year (tons/year). The most common method of generating offsets is closing the source or reducing its output. However, sources can also earn offsets by modifying production processes or installing pollution control equipment.

Bubble Policy

The bubble policy is another approach that served as a foundation for later trading policies. Established in 1979, the bubble policy allowed sources to meet emission limits by applying a single aggregate emission limit to multiple sources within a facility rather than applying individual control equipment or emission rate requirements at each emission source. The term "bubble" is used to invoke an image of a bubble over a facility (such as a refinery or a steel mill) with several emission sources. A facility or group of facilities can aggregate emissions and use a mix of controls that is different from those mandated by regulations, as long as total emissions within the bubble are equal to or less than the cumulative limit for all sources within the bubble (see Figure 4).

By design, bubbles are intended to be neutral in terms of environmental

Figure 4. **Bubble Policy**



impact. However, bubble proposals must undergo individual review and approval, which, over the years, has been streamlined but is still rather burdensome. Consequently, the bubble provision has been used in less than 100 cases in the United States over the last 20 years.

Evaluation of Early Emissions Trading Activities

Several factors limited the appeal of these early trading approaches. The trading mechanisms were meant to modify or enhance existing air pollution control programs that did not themselves address total emissions. Therefore, the trading mechanisms were not effective at controlling overall emission growth. To ensure that air quality did not deteriorate, expensive air quality modeling was often required before regulators accepted proposed trades. Deposits to emission banks (credits generated for some later, yet-to-be-determined use) were typically "taxed" by the air quality management authority to meet state air quality requirements or to generate a surplus that the area could use, for instance, to attract new firms. Offset ratios (i.e., requiring more than 1 ton of emission reductions to offset 1 new ton of emissions) used to counter some of the uncertainties from a trade further depressed credit value. Finally, the administrative oversight to protect against the creation of "paper credits" and "anyway tons" turned out to be resource-intensive.

In a 2001 study on project-based trading systems, the Environmental Law Institute (ELI) concluded that such programs in the United States "have generally failed to generate considerable trades and retrospective reviews have tended to blame their shortcomings on high transaction costs, uncertainty and risk in obtaining needed government approvals, as well as lack of clear legal authority and clearly specified objectives" (ELI, 2001).

3

Developing a Cap and Trade Program

Introduction

Prior to implementing a cap and trade program, policymakers should examine various design options, decide which features to employ, and ensure that there is adequate legal authority. Key decisions include determining which sources to include in the program (i.e., applicability), the level of the emission reduction or limitation (i.e., cap), and the timing when reductions will be required. In addition, policymakers should determine requirements for measuring and reporting emissions, methods of distributing allowances, rules governing allowance use, compliance and enforcement provisions, and provisions for integrating cap and trade with existing policies. Before design work can proceed, it is critical to have information on the potentially affected sources, such as their emissions, utilization, and control options. All of these issues are discussed in this chapter.

Guiding Principles

Several overarching principles can guide the development of a cap and trade program. Adhering to these principles—simplicity, accountability, transparency, predictability, and consistency—can promote environmental compliance and efficient markets.

Simplicity

Simplicity is an important goal when designing an effective cap and trade program. Program operation for both emission sources and regulating authorities can be less costly and time-consuming if the rules are not overly complex or burdensome. Markets function better when the rules are simple and easily understood by all participants. Moreover, the environment is more likely to be protected when rules are clear and easily enforced. In contrast, complexity often requires more decisions, debate, and information collection. This situation, in turn, can create uncertainty and unnecessary burden that may lead to delays, opportunities foregone, and ultimately higher costs. In some countries, complexity may also make it more likely that there will be litigation over contentious issues.

Another aspect of simplicity that will increase the economic effectiveness of a cap and trade program is the fungibility of allowances (i.e., an allowance is a standardized unit of trade that is interchangeable with other allowances). Fungibility is highly desirable to minimize transaction costs in the program and to maximize the efficiency of the cap and trade program to lower costs. Simplicity is enhanced by avoiding the creation of different categories of allowances with different attributes, unless it is absolutely necessary to maintain the environmental integrity of the system. For example, discounting the use of certain types of allowances based on their geographic origin or on their ability to be banked complicates transactions and reduces the cost effectiveness of allowance trading and may not have significant environmental benefits.

More broadly, the principle of simplicity can be applied to all elements of the program, including:

- Applicability thresholds (determining which facilities are affected)
- Allocation formulas
- Trading rules and/or restrictions
- Measurement options and rules
- Reporting requirements
- Penalty assessment

Accountability

A cap and trade program must create a framework of oversight and enforcement that will hold participants accountable for their emissions and ensure compliance with the program's requirements. The basis of accountability is the accurate measurement and verification of emissions and the rigorous and consistent enforcement of penalties for fraud or noncompliance. The regulating authority can facilitate accountability through clear and simple rules.

Transparency

Transparency refers to the full and open disclosure of relevant public and private decisions, such as establishing the rules and regulations for a trading program and determining if an emission source is in compliance. Transparency is important to a well-functioning cap and trade program, both in terms of its design and its operation. Transparency of the design process can promote public acceptance and confidence in the cap and trade program.

Information transparency is also important to the effective operation of an emission trading program. Providing public access to source-level emission and allowance data promotes confidence in the program and provides an additional level of scrutiny to verify enforcement and encourage compliance. In some jurisdictions these data are classified as confidential and may require legal changes to make them publicly available.

Advances in information technology and the Internet have made it possible to provide interested parties with timely and useful information about emissions, allowances, and program results.

Predictability and Consistency

Predictability and consistency in the design and application of program rules are important principles for an effective cap and trade program. They help create the right circumstances to encourage innovation and lower costs. With a cap and trade program, emission sources have an incentive to find better and lower-cost opportunities to reduce emissions. This incentive depends upon long-term, predictable, and consistent rules that affect the economic value of emission reductions. This arrangement does not mean, however, that rules cannot change in response to new information. Rather, it means that the framework must include the possibility for change and a clear explanation of the process for changing the rules.

Establishing Legal Authority

As discussed earlier, there must be legal authority to establish a cap and trade program. Although policymakers can include many components in authorizing legislation, the basic components are listed below. Several of these components are discussed in more detail in this chapter and Chapter 4.

- **Setting the mass-based emission cap:** If the cap is not set directly by policymakers, the regulating authority must have authority to limit the total quantity of pollution from the relevant sector(s) by establishing a cap on emissions.
- **Implementation dates:** Sources must comply with the emission caps starting in a particular compliance period.
- **Sources covered:** A complete control program must define which sectors are subject to program requirements and, within each sector, which emission sources are affected. For example, the scope of an electric generating sector cap and trade program could include all electric generating units or only electric generating units above a certain generation capacity.
- **Distributing tradable allowances:** Traditional air quality permits authorize a certain amount of

emissions and are non-transferable. Policymakers establishing a cap and trade program must provide for tradable permits, specifically that appropriate increments (e.g., allowances) are tradable among participants in the program. The regulating authority can allocate these authorizations, or allowances, to emit in a variety of ways, or auction them to the highest bidders. Policymakers should also explicitly state which regulating authority is responsible for issuing and distributing the allowances.

- **Banking:** Policymakers might allow sources to use allowances issued in one period for compliance in subsequent periods. This arrangement is called banking.
- **Trading procedures:** A cap and trade program needs consistent rules for conducting allowance transfers, as well as a system for tracking allowances. Policymakers should explicitly state which regulating authority is responsible for developing and enforcing trading procedures.
- **Emission monitoring and reporting:** Accurate, comprehensive emission data are a cornerstone of a credible and effective cap and trade program. The regulating authority must have the authority to require standardized methodologies for emission measurement, collect emissions data to determine compliance, and publicize emission and allowance data to provide transparency and promote confidence in the program.
- **Compliance:** Each affected emission source is required to hold at least one allowance in their account for each unit of emissions during the compliance period. Cap and trade programs must include provisions that authorize the regulating authority to reconcile the emissions of each source with the number of allowances they hold to determine compliance.
- **Establishing and enforcing penalties for non-compliance:** The regulating authority must have the authority to impose and enforce sufficient penalties on emission sources that do not comply with the rules of the program.

Legislation to provide legal authority can range from a few broad sentences to many detailed pages. The legislation may provide only general language authorizing the use of emission trading or it may explicitly state the rules and guidelines for a cap and trade program.

In addition to establishing this new authority, a cap and trade program may require appropriate amendments to a country's existing legislation. For example, fundamental legal issues (e.g., existing technology standards or taxes) may hinder the development of a cap and trade program if not properly addressed. Most countries will already have some regulations that are related to environmental performance. If existing regulations (or economic incentives) are simply in place to collect revenues for the government (e.g., environmental taxes set well below the marginal abatement cost), then a cap and trade program can likely be added. If there are technology standards, it may be necessary to make certain adjustments in existing legislation (e.g., replacing the technology standards with caps of equal or greater stringency, or allowing firms to opt out of them in favor of participating in the cap and trade program). For further discussion on cap and trade and potential conflicts in the existing legal structure, see Chapter 4.

Creating an Emission Inventory

An important step in the development process for a cap and trade program is the creation of an adequate source-level emission inventory. The types of data and appropriate level of detail for the emission inventory will depend upon the intended use of the data. The emission inventory is likely to be useful in analyzing and making the following design decisions:

- **Program applicability:** The regulating authority may use inventory data to make decisions about which sectors to include, where to apply the obligation to hold allowances (e.g., at the fuel distributor or the emission source), and what thresholds should be set to determine if a source is affected by or exempted from the program (e.g., production capacity).
- **Allowance allocations:** The regulating authority may use inventory data to analyze the effects of different allocation options on emission sources and to decide on a method for distributing allowances.
- **Aggregate cap:** The regulating authority will need the inventory data for the affected emission sources to analyze the potential costs and benefits of different emission caps, as well as to

assess the performance of the program once implemented. In some cases, the emission inventory is used to project future emissions, either using a sophisticated computer model or using simple assumptions about projected emission growth.

Minimum data requirements for the emission inventory include: (1) individual emission source characteristics (e.g., size, location, name-plate capacity, process type, boiler type, fuel type); and (2) emission levels for individual sources based on output, fuel use, and/or emission data. These data requirements will vary depending upon: (a) the types of sources to be regulated under the cap and trade program; (b) the pollutant; (c) the choice of allowance distribution method; and (d) the method for setting the overall cap.

Inventory Level of Detail

For cap and trade programs that require emission sources to hold allowances, sources can be inventoried at five different levels of detail: (1) the company level[13]; (2) the plant level, which denotes a plant or facility that could contain several emitting activities; (3) the point/stack level, where emissions exit to the ambient air from stacks, vents, or other points; (4) the process/segment level, representing the unit operations of specific source categories (e.g., a single boiler that burns both coal and gas would count as two segments); and (5) the unit level (e.g., each individual boiler)[14].

Although a full comparison of the different options is beyond the scope of this guidebook, the most significant factors in making this decision are:

- **Program design considerations:** The level of detail needed for the emission inventory is often determined by program design considerations. For example, if the program applicability threshold is based on the size of a combustion unit, then an inventory created at the plant level will not provide sufficient detail; additional information at the unit level will be necessary. Similarly, allowance allocation formulas may require a certain level of inventory data.
- **Cost of data collection and availability of data:** Some options may make it easier to collect necessary data. For example, fuel purchase records may be kept only at the plant level rather than for each individual unit. Although data can be apportioned when necessary, it may be more cost effective to collect data at more aggregated levels of detail, such as the plant level.
- **Completeness:** Inventorying emissions at the unit level avoids many of the complications that may arise with other inventory levels (e.g., complex configurations of production units and stacks) and provides the most detailed information about the emission sources. However, this arrangement requires more data that may be more difficult to compile.
- **Measurement Method:** It is important to consider whether the data gathered for the program development stage will need to match the level used to assess compliance once the program is in place. If so, the regulating authority should evaluate issues related to emission measurement for the various levels of detail. For example, if in-stack measurement such as continuous emission monitors (CEMs) is used for compliance with the program, a stack-level inventory would be an advantage because it would include all of the emissions from each stack. However, for alternative measurement methods (e.g., fuel-based mass balance approaches), using stack level data for compliance might complicate emission measurement, particularly if several units share fuel supplies but exhaust through different stacks.

Program Design Elements

In developing a cap and trade program, the regulating authority should consider a number of design elements. Each design decision affects other aspects of the program. Although these elements are discussed in a specific order, the interrelationships between all the design elements should be considered together when making program decisions.

[13] Measuring emissions at the company level is very complicated and is not recommended for cap and trade programs. Issues such as partial ownership, mergers, and sales all effect the ability to accurately attribute emissions to a specific company.

[14] In many cases, unit level may correspond to point/stack level, but it is possible for a unit to exhaust to multiple stacks or for multiple units to share a single stack.

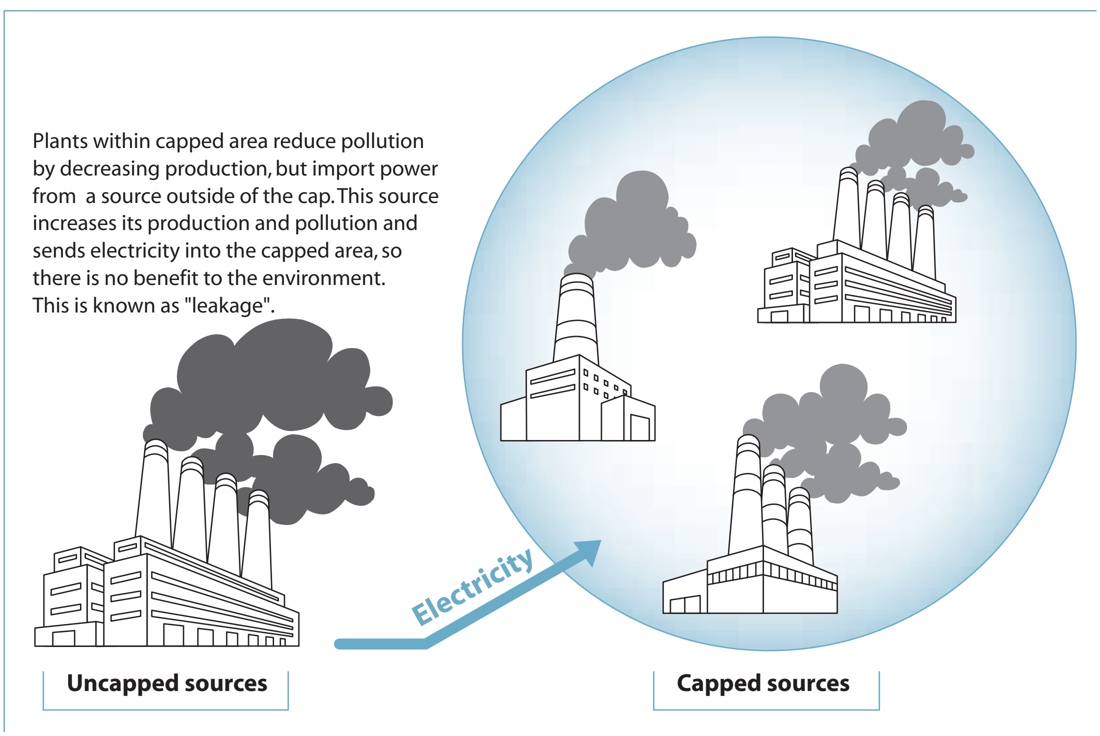
Applicability

After deciding that cap and trade is the preferred approach to reducing the emissions of a particular pollutant, policymakers must determine which emission sources to include in the cap and trade program. Ideally, all sources, sectors, and emissions would be included for full coverage and maximum environmental effectiveness and economic efficiency. However, measurement capabilities and costs, available control options, administrative burdens, political considerations, and other constraints may limit participation to a subset of emission sources.

When determining the applicability of a cap and trade program, there are several important considerations:

- **Contribution to emissions:** Included sources should represent a substantial portion of emissions in order to appropriately address the environmental issue of concern. To determine whether to include sources or sectors in a program, the regulating authority should perform an analysis using the existing emission inventory (as discussed in the previous section), as well as an analysis of how future growth will change the existing emission patterns. In this analysis, it is important for the regulating authority to acknowledge and, if necessary, address emission sources that they cannot feasibly include, but that could receive shifts in production from emission sources constrained by the cap. Such shifts of production from affected sources to other non-affected sources ("leakage") could undermine the environmental benefits of the cap (See Figure 5). Maximizing the coverage of emissions in a cap and trade program can optimize both the environmental effectiveness and the economic efficiency of the program. Conversely, the environmental effectiveness of a cap and trade program is diminished if a large percentage of emissions are outside the cap. Although the regulating authority can implement other policies for emissions outside the cap, the level of these emissions is not guaranteed. Also, because sources outside the cap do not benefit from the economic efficiency of the trading program, the policies to control their emissions may be relatively more costly.
- **Availability of cost-effective control options:** Some sources included in the program should have a range of cost-effective abatement options to ensure the ability to achieve the reduction goal. Variation in abatement costs promotes competition among control options, stimulates innovative technologies, and helps lower compliance costs.
- **Ability to measure emissions:** As discussed further in this chapter, sources that participate in a cap and trade program must have the ability to account for their emissions accurately and consistently. Alternatively, a regulating authority may involve independent parties to measure

Figure 5. **Leakage**



and report emissions. If independent parties are involved, the regulating authority should have oversight, certification, and review procedures in place to promote accountability. Because each allowance has economic value, it is important to ensure that emissions (and thus allowances used) are quantified accurately and consistently.

- **Number and size of sources:** The number and size of sources participating in the cap and trade program may affect the regulating authority's ability to manage the program. The regulating authority must balance the desire to maximize the coverage of the program to increase the environmental effectiveness and efficiency against the ability to operate the program and enforce compliance. If sources responsible for a significant portion of the total emissions are not included in the program, the program may be less environmentally effective and less economically efficient. In addition, excluding some significant sources within an industrial sector can cause sources to shift activity to those sources outside the cap, thereby reducing the environmental effectiveness of the program. It might not, however, be necessary to include all small sources. Excluding some small sources may help keep the total number of sources to a level that is manageable for the administration of the program.
- **Simplicity:** It is important to avoid overly complex applicability criteria. Complex criteria make it more difficult and costly for sources and for the regulating authority to determine which sources the program covers. Complex criteria also increase the likelihood of loopholes that allow significant sources in the same industrial sector to avoid inclusion in the program. To this end, the threshold(s) for determining source applicability should be based on source characteristics that remain constant, such as capacity or potential to emit, rather than characteristics that could vary from year to year, such as mass emissions or fuel use. This will ease administration of the program, provide greater certainty to sources, and avoid frequent changes in an individual source's applicability status.
- **Equity:** The regulating authority should give careful consideration to the economic competitiveness of businesses and the effect on markets that could result from including or excluding certain industries from a trading system. Fairness relative to emission reduction potential is another consideration for the regulating authority.

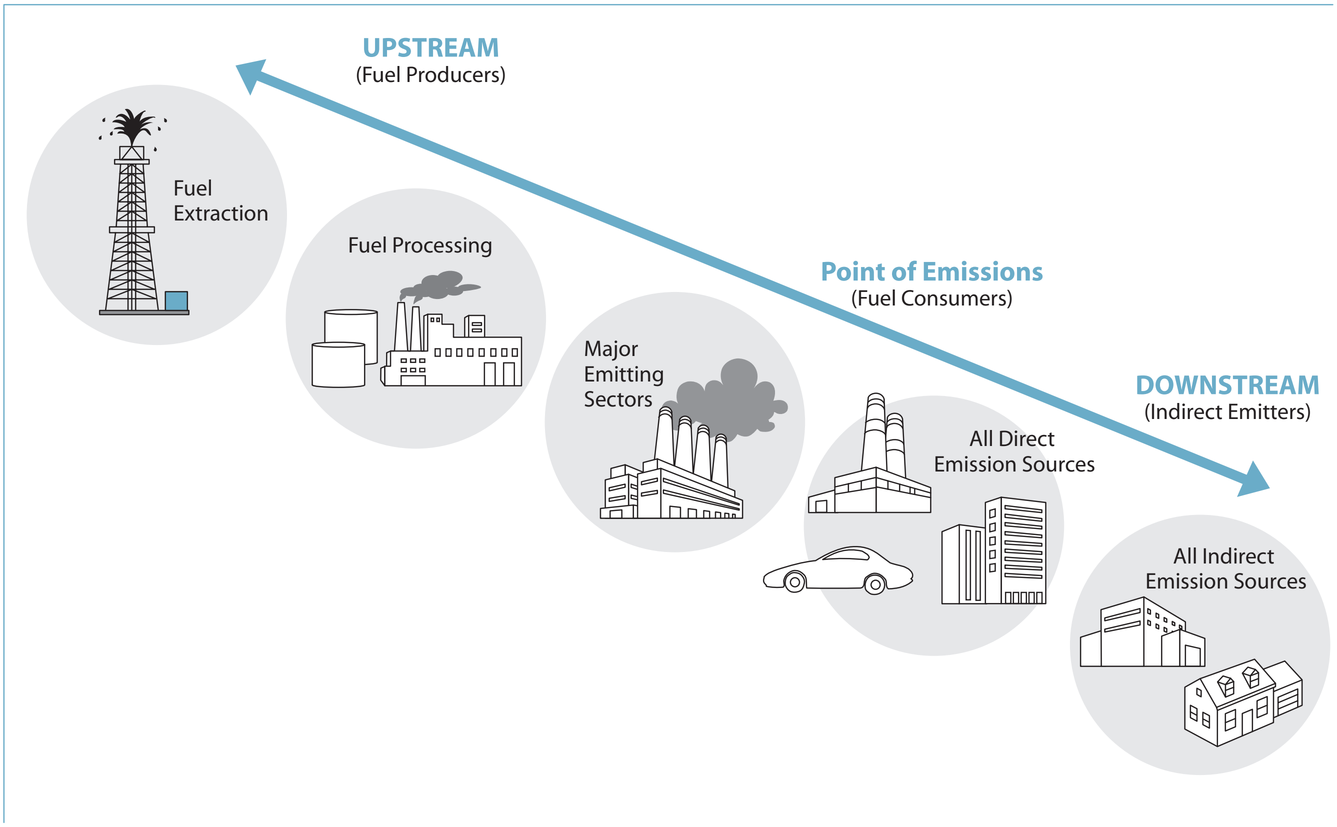
Point of Obligation

Closely related to the questions of which sources and sectors are covered in a cap and trade program is the question of where there is an obligation to hold allowances (See Figure 6). There is a growing literature discussing how this would apply to emissions that can be capped at several different points in an economy, including:

- **Point of emissions (Direct emitters)[15]:** A point of emission program focuses on direct emission sources (e.g., electricity generators and large industrial sources) where the pollutant(s) are released to the atmosphere. This approach works well if the production or combustion process affects emissions (e.g., NOx from industrial boilers) or there are available end-of-pipe controls (e.g., SO_2 from electricity generators). The U.S. cap and trade programs obligate emission sources to hold allowances equal to their total mass emissions.
- **Upstream (Potential emitters):** An upstream program focuses on any point prior to the emission source (e.g., fuel producers and processors such as coal mines or oil refineries). An upstream program does not have a direct cap on emissions. Rather, the cap is set on the emission potential inherent in the fuel. The restriction at the fuels level restrains supply and can cause fuel prices to increase relative to alternatives. This "price signal" encourages fuel consumers to reduce demand for the fuel, either by finding more cost-effective alternatives or creating new technologies that use the fuel more efficiently. In this way, it operates much like a pollution tax, but has the benefit of a cap on total emission potential (CCAP, 1998; Kopp, et al, 1999).
- **Hybrid:** A hybrid approach could be used to cap some entities upstream and some entities at the point of emissions. For example, large emitters such as electricity generators might be capped at the point of emissions, while emissions from transportation might be capped upstream (CCAP, 2000, ELI, 1997).

[15] In U.S. literature, this is often referred to as "downstream," while obligations at any point after the emission source (e.g., commercial electricity consumers) are referred to as "indirect."

Figure 6. **Point of Obligation**



Analysts often compare upstream and point of emission approaches on several key program parameters:

- In most countries, an upstream system could capture the highest percentage of potential emissions. Upstream can be particularly effective when emissions are closely related to the fuel characteristics or end-of-pipe controls are not readily available. In addition, an upstream approach may better address sectors in which there are numerous small energy users with direct emissions. Advocates of the upstream approach also argue that it is economically efficient because it would spread the efficiencies of cap and trade across a larger segment of the economy.
- Most economists argue that upstream and point of emission approaches create identical incentives for reducing emissions from affected sources' energy use because energy consumers face higher costs from using fuels with greater emission potential in both cases (Kopp, et al., 1999). For example, under an upstream system, an electricity generator would face higher fuel prices if fuel producers were required to hold allowances. These higher fuel prices would encourage the generator to improve efficiency or switch to lower-emitting fuels in the same manner that the generator would be motivated to reduce emissions if it was required to hold allowances. However, a few analysts have argued that a point of emission approach provides a more direct signal to reduce emissions, because the target is the emission source. According to this view, an upstream system, which relies solely on price signals, may not provide sufficient incentive to find new technologies that reduce emissions per unit of fuel or sequester emissions. In particular, an upstream system provides little incentive for emission sources to develop and employ post-combustion control technologies since this behavior would not be directly rewarded (CCAP, 1998). On the other hand, although it creates additional complexity, policy-

makers can create incentives for post-combustion controls by awarding credits to downstream emission sources that reduce or sequester emissions.

- An upstream system may include fewer sources, which would generally lower the administrative burden of a program. Although this is an important consideration, recent advances in the use of information technologies to manage cap and trade programs have allowed regulating authorities to handle greater numbers of emission sources without being overburdened (Kruger, et al., 2000).

Some analysts argue that a hybrid system may be an acceptable compromise. These analysts contend that such a design would be desirable because it would provide similar coverage of emissions to an upstream system, while allowing the program design to focus on the types of emission sources that have been successfully included in past cap and trade programs (Mazurek, 2002). Potential downsides to such an approach include a larger number of sources than an upstream program and added complexity from the need to avoid double counting emissions at both upstream and point of emissions sources. For example, policymakers may include natural gas-fired electric generators (point of emissions) and natural gas distributors (upstream) in a hybrid cap and trade program. The regulating authority would have to deduct fuel used by the included electric generators from the amount of natural gas distributed by upstream sources to ensure that emissions are not counted by both sectors.

Opt-ins

Some sectors may not meet the above criteria for inclusion in the cap and trade program but have individual sources that can meet the criteria. In such cases, it may be desirable to allow these sources to voluntarily "opt-in" to (participate in) the program. These sources receive an allowance allocation and are subject to the same requirements as sources under the cap. Theoretically, these sources will have cost-effective emission reduction opportunities that warrant the expense of meeting the monitoring and other requirements associated with the cap and trade program. If policymakers allow opt-ins, sources that choose to opt-in should be subject to all the terms of the program. It is imperative that any sources opting in employ a measurement protocol that is equivalent in consistency and accuracy to the methods used by the affected sources. This ensures that the reductions achieved are real, verifiable, and comparably valued.

Although voluntary opt-in provisions may reduce costs to affected sources, they raise some of the same issues associated with project-based credits discussed in Chapter 2. Sources may decide to opt-in and take advantage of allowance allocations that are above what their emissions would have been if they were not participating in the cap and trade program. In some cases, they may opt-in and then take measures to reduce emissions that would have occurred anyway, regardless of participation in the program. Unless the regulating authority can make an allowance allocation at a level that equals "business as usual," extra allowances will be introduced into the system and will undermine the environmental effectiveness of the cap and trade program. Research on the U.S. SO_2 Allowance Trading Program has shown that many of the sources that voluntarily joined the program under opt-in provisions[16] were spurred by overly generous allowance allocation formulas. Opt-ins using these provisions achieved very few additional emission reductions (Ellerman, et al., 2000).

Setting the Level of the Cap

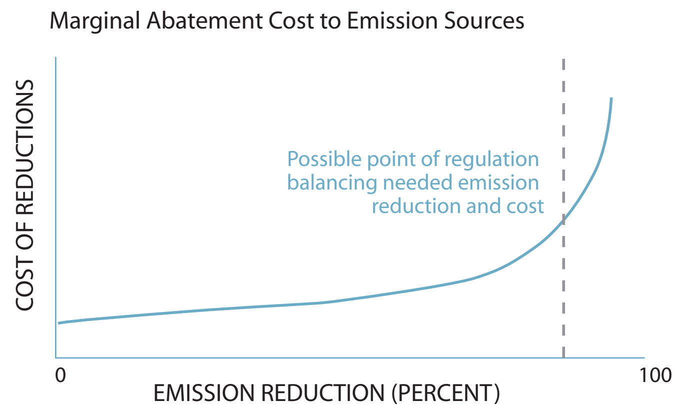
Setting the level of the emission cap is one of the most important decisions for policymakers and the regulating authority. In theory, the most economically efficient level for the emission cap is where marginal abatement costs are equal to marginal benefits from the reduced emissions (see Appendix A for further discussion). However, this level is often difficult to determine due to uncertain information. More generally, the cap should be set at a level that is expected to address the environmental and health problems of concern at an acceptable cost.

As with other types of policies to reduce emissions, it is desirable to use atmospheric and ecological or health effects models to assess the impacts of different levels of emission reductions. Models range from those that describe links between one receptor area and one source, to others that describe complex regional-scale relationships. Models also can project a wide variety of

[16] There were three provisions in the SO_2 trading program that encouraged voluntary entry into the program. The Substitution and Compensating Generation provisions were used to bring Phase II units into the program during Phase I. The Industrial Opt-in provision was used to bring industrial boilers and small generating units into the program.

impacts throughout the region. Some models address changes over short time periods, such as episodes, while others focus on longer time periods, and some attempt to do both. Usually, models focus on one part of the overall assessment and should be linked to produce a truly integrated assessment. Emission models develop emission data for input into air quality models. The output of the air quality models is then translated into impacts using a variety of models characterizing human health and ecological welfare and other effects. Ultimately, selection of the best model framework or best set of models depends on the question being asked. (USEPA, 2001)

Figure 7. **Knee of Marginal Abatement Cost Curve**



In practice, policymakers will determine the cap by considering a combination of science, economics, and political feasibility. One approach that policymakers sometimes use to determine the aggregate emission cap is finding the “knee in the cost curve” (i.e., the point before costs per unit of emission reduction begins to rise rapidly (see Figure 7)). Policymakers may also want to ensure that costs are within an acceptable range. To estimate costs and benefits, policymakers may use economic modeling to depict optimal control decisions.

The decision of when to implement the cap is integral to the decision on the level of the cap. Policymakers may need to weigh the pros and cons of opting for a tighter cap with a later implementation date versus a less aggressive cap with an earlier implementation date. For example, it may not be feasible to set the cap at the optimal level for the initial stage of implementation. However, rather than delay implementation until a later date when the optimal level may be more achievable, it may be advantageous to begin the program as soon as possible to encourage advances in control technology and influence investment decisions. Under such a scenario, policymakers may establish a cap that declines over time to ultimately achieve the environmental goal. This is one of the advantages of allowing emission sources to bank excess allowances. It encourages early reductions, advances control technologies, and reduces the economic effect of the declining cap. For predictability, it is important that policymakers or the regulating authority define the decline in allowances in advance to provide sources sufficient time to adjust to new cap levels.

The level of the cap will also depend on applicability decisions about which sources and sectors to include in the program. In the case where policymakers establish a national emission goal and develop a cap and trade program in conjunction with other regulatory tools, they must determine what portion of the goal should come from sources in the cap and trade program (the cap) and what portion from other sectors and sources. Ideally, a cap and trade program should include as many sectors as possible to maximize the cost savings from trading between sources with different marginal abatement costs. If it is not possible to include certain sectors under the cap and trade program, then alternative policy instruments may be used to reduce emissions in sectors outside the cap. Where possible, however, these instruments should be used to reduce emissions to levels where marginal abatement costs in the uncapped sector(s) are roughly equivalent to the marginal abatement costs in the sector(s) participating in the cap and trade program.

Length of Compliance Period

The length of the compliance period should be linked to the environmental problem and reflect operational considerations. If the environmental problem is continuous and long-term, as in the case of acid rain or climate change, the compliance periods should be continuous, covering all months of the year. If the problem is seasonal, as is the case with ground-level ozone in the Eastern United States, then the compliance period may be seasonal, such as the five-month compliance period each year used in the Ozone

Transport Region (the District of Columbia and 12 states in the Northeastern United States).

The decision of whether to assess compliance quarterly, annually, or less frequently should also take into account the administrative burden imposed. A short compliance period puts a larger administrative burden on both the regulating authority and emission sources but allows for swifter action to correct a case of noncompliance. A longer compliance period allows more flexibility for the sources to achieve compliance and reduces the administrative burden for the regulating authority. By lengthening the period between compliance assessments, however, cases of noncompliance can persist for longer periods of time, possibly increasing the difficulty of correcting those problems. Most cap and trade programs determine compliance on an annual basis.

Quantifying Emissions from Sources in the Program

One of the most important features of a cap and trade program is that sources measure total mass emissions (as opposed to emission rate or concentration) as accurately and consistently as possible. Because the emission measurements are the "gold standard" underlying the traded allowances, it is important that a ton of emissions at one source is equal to a ton of emissions at any other source. This creates a level playing field for participants in the program and a strong foundation upon which a market can operate.

The emissions monitoring priorities for a cap and trade program differ from other types of environmental regulations (see Table 3 for emission monitoring priorities of different types of programs). In considering potential emission measurement regimes for a cap and trade program, the following monitoring objectives may be useful as a guide:

- **Consistency:** The regulating authority should create clear and consistent protocols for sources to determine emissions. This means employment of standard procedures and the use of sound engineering practices. This arrangement can be particularly challenging if the cap and trade program includes sources from a variety of industrial sectors.
- **Accuracy:** For a cap and trade program, accurate measurement is more important than consistency over time. Policymakers should consider enhancements to measurement methods or using different methods if better approaches are available and practical. The monitoring program can also be designed to include performance standards that reward sources that achieve better accuracy than required. For example, for less accurate approaches, sources should use more conservative estimation methods that are not biased toward underestimating emissions. Ultimately, it is most important to avoid systematic underestimation of emissions.

Table 3: Emissions Monitoring Priorities

Purpose	Priorities
Cap and Trade	• Complete and consistent accounting of total mass emissions • Accurate and consistent measurement among sources • Conservative emission estimates (not underestimated)
Command-and-Control	• Accounting of emission rate or technology installation
Project-based Trading	• Reasonably accurate estimate of baseline (what emissions would have occurred in the absence of the project) • Accurate accounting of emission rate and activity level
Research Inventory	• Best available emission data, regardless of consistency among sources or sectors • Consistent emission measurement methodologies over time

Considerations in Choosing a Measurement Approach

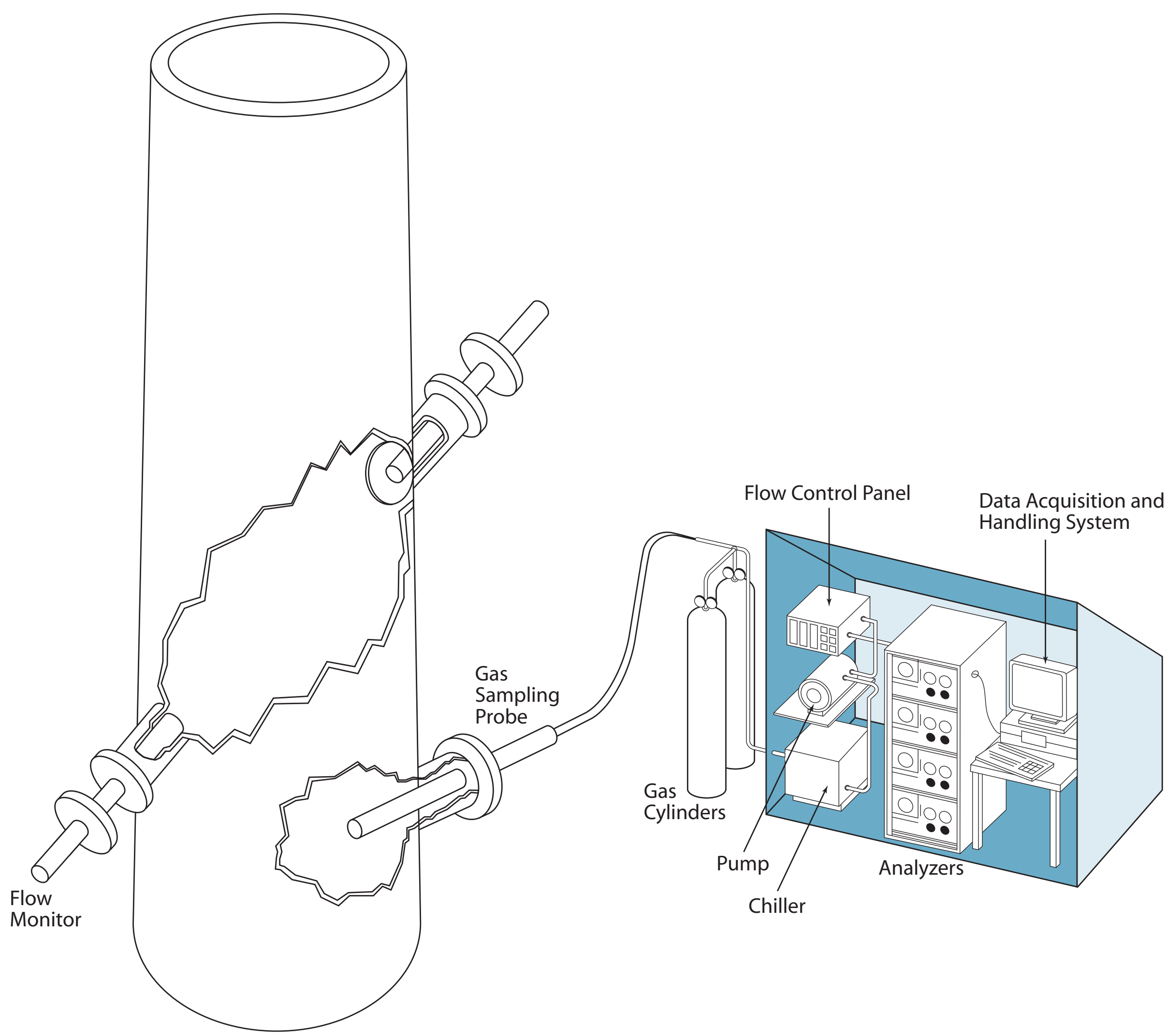
Pollutant

The pollutant to be measured, the conditions under which it is created, and the mode in which the emissions enter the atmosphere will affect the types of emission measurement techniques available. For example, measurement issues related to emissions of SO_2, NO_x, and CO_2 from stationary source combustion will vary because emissions of SO_2 and CO_2 are directly linked to the combusted fuel, while emissions of NO_x also depend on the combustion conditions. Therefore,

Typical Emissions Measurement Under the U.S. SO_2 Allowance Trading Program

In most cases, emission sources must continuously measure and record hourly emission concentrations of SO_2, NOx , and CO_2, as well as flow of exhaust gases with a continuous emission monitoring system (CEMS) (see Figure 8). EPA has established provisions for initial equipment certification procedures, periodic quality assurance and quality control procedures, record keeping and reporting, and procedures for filling in missing data periods. Where possible, incentives are provided to improve and maintain the quality of the monitoring. For example, units must periodically undertake relative accuracy tests on their CEMS (which involves comparing the monitored emissions from the CEMS to monitored emissions from an independent or reference measure of emissions); if the CEMS receives a superior accuracy result, the frequency of future testing is reduced and the firm saves money. For a full discussion of monitoring performance standards and incentives for improving accuracy through quality assurance requirements, see Saile, 1995.

Figure 8. **A Continuous Emission Monitoring (CEM) System**



an appropriate measurement method for CO_2, such as mass balance based on carbon content in the fuel will not be appropriate for NOx . Instead, accurate measurements of NOx emissions from stationary source combustion must be taken from exhaust gases.

How Emissions Enter the Atmosphere

How emissions enter the atmosphere can limit the choice of methodology. For example, continuously measuring actual emissions is an option only if emissions are vented through a stack or other contained area where measurement equipment can be located. In contrast, measuring fugitive emissions (i.e., emissions that escape directly into the atmosphere in a diffuse manner) may depend on estimation techniques based on inputs and defaults.

Emissions Abatement Options

The abatement options available for sources to reduce their emissions are also a factor in the choice of measurement method. It is important that the measurement method be able to accurately capture the reductions made. For example, measurement methodologies based on fuel inputs (e.g., mass balance) may be appropriate for sources that reduce emissions by switching or conserving fuels, but it would be much less appropriate for sources that use reduction technologies such as combustion modification or post-combustion control. In choosing a standard measurement approach, it is important to allow sources full flexibility of compliance/mitigation options. It is also important to consider potential technological innovations in mitigation approaches. Thus, it is useful to choose a method that can measure the reductions achieved through various reduction strategies or to specify multiple measurement options, some of which may be allowed only for certain mitigation options.

Point of Obligation

The point of obligation will influence where and how emissions, or their proxy, are measured. Similarly, measurement constraints will influence where and how the emissions are regulated. If the regulation is directed at upstream sources, such as fuel suppliers, it is not appropriate to measure combustion emissions using an in-stack monitor at the power plant where the fuel is burned. Instead, the fuel supplier's compliance with the cap and trade program should be judged based on the amount and characteristic of each type of fuel sold, and the monitoring method would focus on determining the total amount of each type of fuel sold.

Frequency of Measurement

Although a cap and trade program requires a complete accounting of each unit of emissions, the minimum frequency of measuring emissions or the parameters used in calculating the quantity that is emitted will need to be determined (e.g., continuous emission monitoring, periodic monitoring, or the use of emission factors). The nature of the problem to be solved, the potential variability of the measured parameters, and the length of the compliance period will influence the appropriate frequency. For a cap and trade program aimed at solving a problem caused by a total accumulation of emissions in the atmosphere, such as acid rain, the frequency will be dictated by the ability to capture variations in emissions and contribute to an accurate estimate of total emissions. For an episodic problem, such as ground-level ozone, more importance will be placed on the frequency of measurement because aggregation of emission measurements must be at frequent enough intervals to investigate individual episodes. Furthermore, greater frequency of measurement is warranted when emissions, or the parameters used to calculate emissions, have the potential for high variability (e.g., for units that use fuels with varying characteristics or for units in which emissions can be affected by the way the unit or control devices on the unit are operated). Both the U.S. SO_2 Allowance Trading Program and the OTC Regional NOx Trading Program in the Northeastern United States (which is aimed at addressing episodic ground-level ozone) require reporting of hourly emissions which are the average of at least four measurements taken each hour.

Frequency of Reporting

In addition to deciding upon the frequency of measurement, the regulating authority should consider how often to receive the data. The RECLAIM emission trading program in California uses computers to get the source measurement data reported to the regulating authority in real time. The U.S. SO_2 Allowance Trading Program, which requires sources to record hourly data, requires sources to compile and send emission reports to EPA on a quarterly basis even though compliance is determined on an annual basis. Factors to consider when setting the frequency of reporting include: allowing enough staff time to review the data (e.g., not waiting until the end of the year to

> ### Measuring Small, Clean Units in the U.S. SO_2 Allowance Trading Program
>
> The U.S. SO_2 Allowance Trading Program allows sources that operate very infrequently or are very small to use conservative estimations of emissions rather than install more expensive CEMS. The program provides limited alternatives for smaller emission sources, at which the cost of more accurate measurement is high relative to the emissions. These alternatives are designed to ensure that emissions are never underestimated. The program also allows large units that burn pipeline-quality natural gas to use fuel metering and default emissions rates to measure SO_2 emissions because the characteristics of pipeline-quality natural gas are very consistent and the resulting SO_2 emissions are very low.

review all data at once); giving time to sources to correct any errors found during review; and providing timely, reviewed data summaries to the public.

Cost and Feasibility

Within a cap and trade program, there may be sources that emit small quantities of emissions because they are small, clean, or operated infrequently. Alternative and less costly methodologies may be appropriate for such sources due to the high cost of the standard methodology. It is important to the integrity of the trading system to ensure that less accurate methodologies are conservative in nature (i.e., the methods overestimate rather than underestimate emissions), as well as to keep the number of sources treated in this fashion relatively small. It is also important to keep in mind that the cost of accurate emission monitoring should be considered in light of the cost savings afforded by the cap and trade approach over traditional approaches to environmental protection. The added cost of accurate measurement may be a small percentage of the savings achieved by implementing a cap and trade program versus another form of regulation, and the resulting accuracy and confidence in the emission data may be well worth the expense (Ellerman, et al., 2000).

Quality Assurance and Quality Control (QA/QC)

Simply requiring the most accurate emission measurement methodology will not ensure an effective trading system. Effective implementation is critical. It is essential that the measurement techniques are standardized, commonly applied to program participants, implemented properly, and validated for individual applications. In addition, regardless of what measurement systems are used to quantify emissions, it is imperative that any system be subject to a well-defined and continuous quality assurance and quality control (QA/QC) program. These QA/QC programs should be based on national or international standards (e.g., International Standards Organization) and must be documented with records that can be audited.

Missing Data Substitution

It is essential to account for each unit of emissions from a source because cap and trade programs assess compliance by comparing the total emissions and the total number of allowances held. In real-life situations, however, monitored data may be unavailable because monitoring equipment occasionally functions improperly or is being tested or maintained. Therefore, there is a need for rules to provide a standard methodology for substituting for missing data periods.

This standard methodology should provide incentives for regulated sources to keep records in good order, to keep measurement equipment well maintained, and to have procedures that ensure that faulty

> ### Quality Assurance Under the U.S. SO_2 Allowance Trading Program
>
> The U.S. SO_2 Allowance Trading Program requires sources to test each continuous emissions monitor (CEM) system in its installed location. The CEM is tested at least annually against an independent reference method prior to certifying the CEM for use. The independent reference method consists of inserting a calibrated probe into the exhaust stack and running a sample of exhaust gas through a calibrated analyzer to compare the reading with the installed CEM. A bias test determines if there is any systematic bias in the CEM readings relative to the reference method. If the CEM systematically underestimates emissions, the operator may either fix the monitor and retest it or calculate a bias adjustment factor (based on differences between the CEM reading and the reference method) that is applied to all reported data.

Missing Data Substitution for the U.S. SO_2 Allowance Trading Program

Under the U.S. SO_2 Allowance Trading Program, if a measurement device (e.g., continuous emission monitoring system or fuel flow meter) is not operating properly or if fuel sample analysis is not available for a particular hour, then the rules require that a substitute value be calculated by the source. The rules dictate the use of a substitute data algorithm—specified in the regulations—which represents a graduated response. Whether the substitute value is calculated as an average value or a conservative value depends on the percentage of time that the monitoring system has been able to produce and report a quality-assured value, as well as on the length of time that the data is missing. The substitute data calculation varies from a) the average of the hour before and the hour after the missing data period—for missing data periods of short duration; to b) a very conservative maximum potential value for long or frequent missing data periods.

equipment will be replaced or repaired in a timely fashion. To accomplish this most simply, the rules could require a very conservative substitute value (e.g., a value that would result in the maximum potential emissions) to be used for any hours of missing data. Another option, which is more complex, would be to consider the frequency and length of the missing data periods in determining a substitute value. This way, an average or slightly conservative value is used for short and infrequent periods of missing data and a very conservative value is used for long or frequent missing data periods.

Allowance Distribution

The distribution of allowances may be one of the most difficult issues for policymakers when developing a cap and trade program. Distribution decisions have economic, equity, and political ramifications.[17] Cap and trade programs create a valuable asset for those who own or control the authorizations to emit. If emission sources receive allowances through a no-cost allocation, they capture the gains from these valuable assets. Under an auction, the government captures the value of these assets in the form of increased revenues. Some analysts have argued that the revenues from allowance auctions can have economy-wide efficiency or equity benefits if they are distributed in certain ways (e.g., used to reduce distortionary taxes or distributed in lump sums to households or other groups.)[18]

Different types of allocation formulas can create "winners" and "losers" among sources participating in a cap and trade program. It is important to note, however, that the method for distributing allowances will not affect the environmental integrity of the program if the program is properly enforced.

The first major step in the allowance distribution process is to decide whether the allowances will be allocated at no cost to the emission sources (usually based on some form of operating data), sold by the regulating authority through an auction or a direct sale, or distributed by some combination of these systems. To date, existing cap and trade programs have allocated allowances at no cost to sources.

Whatever allowance distribution method is selected, policymakers can include set-asides or pools of allowances from within the cap. Existing cap and trade programs utilize set-asides to provide allowances for new sources or to provide an incentive or compensation for certain types of behavior (e.g., early reductions, energy efficiency measures, or renewable energy generation). This section explains the incentives and decisions associated with allocations, auctions, and direct sales.

Allocations

If policymakers decide that allowances will be allocated free of charge, many different methods can be used to distribute the allowances. The regulating authority will need to consider the following issues:

- **Data foundation:** In general terms, there are three different aspects of a unit's operation that may be measured and used (individually or in combination with performance standards) as a basis for allocating allowances: mass emissions, fuel (or heat) input, and production output (e.g.,

[17] For a more detailed discussion of the equity, economic, and political ramifications of different distribution schemes, see Burtraw, et al., 2001 and Ellerman, et al., 2000.

[18] For a more detailed discussion of the equity, economic, and political ramifications of different allowance distribution schemes, see Burtraw, et al., 2001; Ellerman, et al., 2000; and Dinan and Rogers, 2002.

The U.S. Experience with Allocations

The U.S. SO_2 Allowance Trading Program uses a combination of historic level of activity (heat input in million British thermal units (mmBtu) and an emissions standard, 1.2 pounds of SO_2/mmBtu), as the primary basis of a permanent allocation. This ensures that the plants with the highest emission rates will be encouraged to reduce the most, while plants that already reduced emissions will need to do less (or nothing). The RECLAIM program also uses a combination of past activity levels and an emission standard for initial allocations. In both programs, total allocations are ratcheted down to match the program cap. Further, in both programs, new units must purchase allowances for compliance. In the case of the U.S. SO_2 Allowance Trading Program, units may purchase these allowances in the marketplace or directly from the government in the government-operated auction.

Regional NOx trading programs in the Northeastern United States utilize an updating input- or output-based allocation scheme (the methodology varies from state to state). The treatment of new sources in the OTC Regional NOx Trading Program will also vary by state, but states generally include a set-aside account to provide allowances for the addition of new sources (McLean, 2002).

quantity of electricity produced). The measures of input and output will vary by sector, but any of these processes could be used as a basis for the allocation of allowances. Policymakers should consider the character and quality of existing data (e.g., it may be difficult to base allocations on historic output if multiple sectors with different products are included in the cap and trade program) and the behavior they want to reward (e.g., allocations based on historic emissions benefit the largest and least-efficient emitters, whereas allocations based on historic input or output benefit those that used the most fuel or produced the most product). Additionally, allocations could be based on the above information in conjunction with a performance standard, control measures, or existing control technology requirements, again depending upon the resources available and the desired effect.

- **Reference period:** The reference period for allocations could be historic, current, or even projected. Though an important decision in any allocation scheme, the relative importance of the reference period decision increases with the length of the allocation, as further explained below. Allocations using historic reference periods are attractive to firms that typically have been big emitters, or in the case of input or output approaches, near their maximum capacity in the past (whether they have subsequently reduced these activities or not) because they are guaranteed a relatively large allocation under the new cap and trade regime. Using the average of several years' data can smooth out possible irregularities (e.g., extreme weather conditions, plant shutdowns for maintenance).

  An important issue to consider when determining the reference period is how the choice will affect sources that implemented emission reduction measures prior to the start of the cap and trade program. For example, if the allowances are allocated based on historic emission levels, choosing a recent year for the reference period will penalize those sources that voluntarily reduced emissions early. If emission sources predict that such a choice may be made in the design of the program, it could provide a disincentive for sources to take early actions beneficial to the environment and human health. One way to avoid this problem is to choose an earlier year as the reference period. However, this may have a negative impact on the availability or quality of the data used. Another option is to choose an allocation method that is not based on historic emissions, but one that may still be based on some historic information. In the U.S. SO_2 Allowance Trading Program the allocation method uses a performance standard applied to historic utilization (i.e., heat input). This heat input data was readily available and did not reward plants with high emission rates.
- **Allocation period:** Policymakers must decide whether allocations will be permanent or updated periodically. Because updating systems change allowance allocations at periodic intervals, entities may have an incentive to do more of the activity that will earn them more allowances. Therefore, updating allocations can influence

future behavior. The time period of the interval will affect the level of influence updating has on future behavior. For example, if updating is done annually based on output, it could provide a strong incentive to increase output in order to receive additional allowances. If, however, the time period is longer (e.g., 10 years) the effect will be considerably less. Permanent allocations, on the other hand, provide no such incentive because changes in behavior will not affect future allocations.[19]

- **Length of allocation:** The regulating authority may decide to allocate allowances to emission sources in advance of the allowance vintage period (i.e., the period in which the allowance can be used for compliance). Having allowances allocated in advance can add liquidity to the market because sources and other market participants can trade future allowances. This also helps emission sources develop and implement compliance strategies in advance of the compliance period (e.g., a source that installs an emission control device can sell future excess allowances to generate revenue to help offset the cost of the control).
- **Preserving the cap:** Once policymakers determine the method for distributing allowances and calculate the sources' allocations, policymakers should compare the resulting total allocations and the size of the cap. If too many or too few allowances were created while calculating sources' allocations, policymakers can employ a ratchet (i.e., a formula that adjusts each source's allocation proportionately). The resulting total allocation will then match the number of allowances in the cap. This ensures that the cap is not inflated through the allocation process.[20]
- **Incorporating new sources:** Policymakers must decide how new entrants into the program will obtain the allowances needed to operate. In some systems with updating allocations, new emission sources may receive some allowances. In the case of permanent allocations, new units may obtain needed allowances from the market. In a permanent allocation system, facilities that are shutdown continue to receive allowances indefinitely. These allowances may then be used by the owners of the shutdown facility to cover emissions at new or other existing facilities that they own, or they can sell the allowances in the market. This system works well when there are many facility and allowance owners and no monopoly exists on current allowance holdings. Alternatively, an allocation set-aside could be created for new entrants. The set-aside could hold a specific percentage of the overall cap to cover growth in new sources.

Finally, some analysts have noted that both economic theory and empirical experience suggest that there is not a competitive barrier to new entrants that do not receive no-cost allowance allocations in cap and trade programs. These analysts argue that emission sources that receive no-cost allowances allocations have the same marginal "opportunity cost" for every ton emitted as the marginal cost paid by the new entrant. In support of this argument, there is no evidence of entry problems for new electric power plants under the U.S. SO_2 program, which requires new power plants to purchase allowances from the market. There has been significant entry by new units, even coal-fired units that do not receive a no-cost allowance allocation (Ellerman, 2003).

Auctions

Auctions are an alternative approach to distributing allowances. Under this approach, sources are required to bid for the number of allowances they would like to purchase (i.e., as opposed to receiving an initial amount of allowances free of charge via allocations). There is considerable research in economic literature that supports the view that auctions are more economically efficient than allocations. Supporters of auctions argue that auctions:

- Create a source of revenue that can be used to offset administrative expenses or distributed to affected groups. If the revenue is used to replace existing distortionary taxes (e.g., labor taxes) it can create additional economic benefits (Crampton and Kerr, 1998). Distributing auction revenues, however, may be politically contentious and there

[19] For further information on alternative allocation methods, see ICF, 1999, and Harrison and Radov, 2002.

[20] In developing the U.S. SO_2 Allowance Trading Program, the U.S. Congress initially allocated about 10 percent more allowances than it established by the cap. However, it also required EPA to proportionally ratchet allocations back down to the cap level.

is no guarantee that revenues will be used for economically beneficial purposes.
- Collect "windfall" profits that might otherwise accrue to emission sources if allowances are allocated at no charge.
- Avoid politically contentious issues regarding allocation methodology and lead to an efficient distribution of allowances.
- Provide an immediate price signal in the allowance market.
- Create an equal opportunity for new entrants into the allowance market.

In establishing the design of an auction, the regulating authority will need to consider the following issues:

- **Frequency of auction:** The following are factors to consider when determining the frequency of conducting auctions (e.g. annually, semi-annually, quarterly, biannually): (a) the lifetime of an allowance and the length of the compliance period; (b) the administrative burden of conducting auctions; and (c) other methods of distributing allowances. If the auction is used in conjunction with other allowance distribution methods and is intended as a means to provide an early price signal to the allowance market it may not be necessary to conduct auctions as frequently.
- **"Spot" and "Advance" auctions:** Spot auctions refer to allowances that are sold for current use. Advance auctions refer to allowances for a future compliance period that are auctioned in the current year, even though they cannot be used for compliance until the future compliance period. Early auctions can facilitate development of an active future and options market, thus improving risk allocation.
- **Bidding procedures:** There are many approaches to conducting auctions. The auction can be designed so that all successful bidders pay the same price or the price they bid. Bidding options for conducting the auctions can be categorized as either sealed bid, ascending bid, or declining price auctions. Ascending bid auctions may take the form of "ascending-clock," or English auctions.[21] Generally, with sealed bid auctions, potential buyers submit bids for a specific quantity of allowances. The auctioneer ranks the bids by price and, starting with the highest bids, tallies the requested allowances until it is equal to or greater than the number of available allowances. The price of the last winning bid is called the clearing price. Those who bid at least as much as the clearing price receive allowances at that price (i.e., uniform pricing methodology) or the price they bid (i.e., "pay-your-bid" methodology.) With ascending bid auctions, potential buyers have the opportunity to increase their bids, changing losing bids into winning bids. When there are no more bids, the allowances are distributed to the highest bidders. Descending price actions, also called Dutch auctions, are the reverse of ascending bid. Generally, the auctioneer starts with a high price for each allowance. Potential buyers can accept the price for a specific number of allowances. The auctioneer decreases the price until all allowances are sold.

The different auction approaches have different effects on bidding behavior, which can thus influence the efficiency of the allowance distribution.[22] With "pay-your-bid" pricing, potential buyers try to bid slightly above the estimated clearing price. Ascending bid auctions reveal greater information about what a potential buyer is willing to pay for allowances. This improves a bidder's value estimates and, as a result, the efficiency of the final allowance distribution (Fischer, et al., 1998).

U.S. Experience with a Direct Sale Set Aside

In the U.S. SO_2 Allowance Trading Program, a small direct sale set aside provision was included for the first several years of the program to provide assurances to new sources that allowances would be available for purchase. The direct sale offered a small percentage of allowances at a fixed price of $1,500 each (adjusted for inflation), which was about two to three times the projected allowance price (marginal cost) at the start of the program. The direct sale was eliminated in 1997 because allowance prices were much lower than expected, and the allowance market was highly liquid.

[21] For more information about forms of auctions, see Crampton and Kerr, 1998.

[22] For more information about the effects of bidding behavior with different forms of auctions, see Crampton and Kerr, 1998.

The U.S. Conservation and Renewable Energy Reserve Program of the U.S. SO_2 Allowance Trading Program

The U.S. SO_2 Allowance Trading Program featured a special set-aside of allowances as an added incentive for electric power companies to undertake demand-side energy efficiency and renewable energy generation programs. Under the program, known as the Conservation and Renewable Energy Reserve, EPA can award allowances to sources for actions taken before a source was required to comply with emissions limits under the U.S. SO_2 Allowance Trading Program. Allowances for the set-aside were taken from the cap and were limited to a maximum of 300,000 allowances.

Under the program, electricity generators applied for these extra allowances by submitting information to EPA on specific energy efficiency programs or renewable energy projects. Sources were required to submit information on energy savings or renewable energy generation, and EPA awarded allowances at a pre-determined rate one allowance per 500 megawatt hours of energy saved or renewable energy generated.

As the first program to provide actual emission credits or allowances for efficiency and renewable energy projects, the program provides many valuable lessons. On the positive side, the program featured several elements that reduced transaction costs including a standard award formula, a pre-approved list of eligible measures, and standardized measurement protocols that allowed companies to use conservative default values for energy savings as a way to reduce measurement costs. On the negative side, it is unlikely that the program spurred actions that wouldn't have happened in the absence of the program. This is largely because the award formula was too conservative and allowances prices were too low to provide an adequate incentive for additional activities.

Auctions may also be used to distribute only a portion of allowances with the remainder distributed by an allocation method. Some analysts have proposed beginning with an allocation system and transitioning to an auction-based system over time (Kopp, et al., 1999). This would increase economic efficiency over time and decrease political opposition from emission sources worried about the cost of allowances.

Set-asides

Another tool that can be used in allowance distribution is an allowance set-aside. Under a set-aside, the regulating authority withholds a certain number of allowances from within the cap for a specific purpose. The set-aside can be a fixed number of allowances or a percentage of the total amount of allowances.

The regulating authority can distribute the set-aside allowances for purposes such as an incentive for certain technologies, as a way to address equity issues, or as a reserve for new units as explained in the earlier section. Policymakers can create set-asides that last for a fixed period, such as five years, after which the set-aside expires, or it can last in perpetuity.

Policymakers or the regulating authority should also address how excess allowances from the set-aside will be managed if they are not distributed. Options for managing excess set-aside allowances include canceling the allowances, saving them for future use, and distributing them to sources through an allocation or auction. Canceling decreases the quantity of allowable emissions (i.e., the cap) and may therefore increase compliance costs for sources. Saving excess allowances for the future can provide flexibility in the future for unforeseen circumstances (e.g., many new emission sources in the cap and trade program) but it reduces the number of available allowances in current years and can lead to increased compliance cost for current emission sources. Distributing excess allowances through an allocation or auction is perhaps the most common approach for existing cap and trade programs, but policymakers must address the same issues discussed earlier in the sections for allowance allocation and auction.

The most important aspect of set-asides is that the allowances come from within the cap so that new allowances do not inflate the cap and undermine the ability to achieve the environmental goal. If a set-aside will be used, policymakers will need to decide the basis for awarding allowances from the set-aside and the size of the set-aside allowance pool that will be awarded.

Allowance Use

Policymakers or the regulating authority must create rules governing the use and trading of allowances. These rules should be neutral (i.e., favoring no particular individuals or groups of market participants) and provide for low-cost exchange among participants.

Accounting for allowances works like a banking system. Each affected emission source should have an allowance account for holding their allowances. Transfers of allowances between these accounts should be made as simple as possible, with few limits or restrictions to impede the market. There are, however, two possible categories of restrictions on allowance trades that may be considered — temporal and spatial.

Temporal Considerations

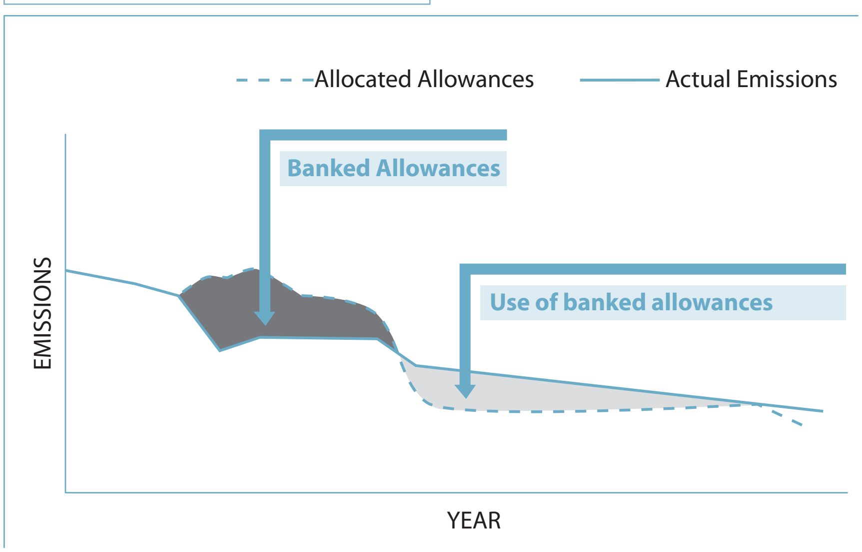
Allowances are typically allocated for use in a specific compliance period. Policymakers might consider whether current allowances can also be used for compliance in future periods, referred to as "banking" (see Figure 9). Allowing banking in a cap and trade program creates additional flexibility for sources, encourages early emission reductions, can reduce compliance costs, and, partly for these reasons, can increase economic and political support for the program.

Although the ability to bank allowances in a cap and trade program can provide significant reductions early in the program, policymakers must recognize that banking can also delay the achievement of the emission target if banked allowances are used. Because banking does not delay achievement of cumulative reductions, this tradeoff does not represent an environmental concern for problems such as acid deposition and climate change, where the environmental problem is caused by total accumulation of a pollutant in the atmosphere. However, for problems such as ground-level ozone, where the environmental problem is caused by short-term episodes of high emissions, analysis should be undertaken to weigh the potential effects of banking. Nevertheless, the U.S. experience with limits on banking has shown that such limits complicated or hindered the operation of cap and trade programs and failed to provide apparent benefits.

"Borrowing" is another form of temporal flexibility. With borrowing, allowances from a future compliance period are brought forward to meet a compliance obligation in an earlier period. As with banking, borrowing provides compliance flexibility and can be helpful in smoothing out spikes in allowance prices (Ellerman, 2002). For example, if prices reach a certain level, sources might be allowed to buy allowances from the government that would be deducted from allowances available in future compliance periods. The potential downsides of borrowing are that emission reductions are delayed and there is a greater risk of future noncompliance if an emission source cannot "repay" the borrowed allowances. In addition, borrowing can create an incentive for emission sources to act to disrupt the cap and trade program's performance and longevity in order to avoid "repayment" of allowances. Furthermore, the health and environmental benefits of emission reductions today are delayed until the future. All else being equal, benefits in the near term are better than benefits in the future.

There is little experience with borrowing, so policymakers should carefully assess the potential environmental and programmatic effect of delaying some emission reductions and weigh these effects against the potential flexibility and cost savings of borrowing. In addition, policymakers should apply a discount, or interest, rate on borrowed allowances that is at least as high as the discount rate applied to the capital the source saves by not undertaking the abatement or purchasing

Figure 9. **Banking Emissions**



Limits on Banking in the United States: RECLAIM and the OTC Regional NOx Trading Program

In the Southern California RECLAIM program, emission sources are grouped into two categories with overlapping compliance periods (i.e., some sources' compliance is based on January to December emissions and others are based on July to June emissions). The RECLAIM program permits sources to use allowances to cover emissions within the period for which they are issued, so any allowances not used within that period effectively expire. However, sources in one compliance period can trade allowances with sources in the other compliance period thereby enabling limited banking and borrowing. One reason program designers chose to limit banking was that the locality faced a severe air quality problem and policymakers were concerned that banking would cause potential emission spikes. Policymakers initially allocated allowances in excess of actual emissions by a significant amount to provide sources with flexibility. Combining these high allocations with banking could have inflated the cap in future years, delaying the achievement of environmental goals. In practice, the absence of banking provisions may have discouraged sources from undertaking early reductions and may have contributed to volatility in the market that required major program revisions to address.

In the OTC Regional NOx Trading Program in the Northeastern United States, the banking of allowances for future use is permitted. However, there are automatic limits imposed on the use of banked allowances whenever the bank reaches a certain level of allowances. These limits require that sources using more than a percentage of their banked allowances for compliance must surrender allowances at the rate of two allowances for every ton of emissions. The limits are imposed in order to guard against the excessive use of banked allowances in any single compliance period, while still attempting to maintain the incentives associated with banking. What has resulted is a segmented allowance market and a stratified price structure which values banked allowances significantly less than present year allowances (Farrell, et al., 1999).

allowances. In lieu of this discount rate, sources will find it less expensive to delay abatement, invest the capital saved, and borrow allowances.

Spatial Considerations

Because a cap and trade program allows for the flexible use of allowances across the geographic scope of the trading program, a common concern for a cap and trade program aimed at reducing emissions with localized impacts (e.g., SO_2 and NOx) is that hotspots may occur.[23]

Assuming that a firm's objective is to maximize profits, those with low marginal abatement costs will offer to sell their allowances to firms with higher marginal abatement costs. If sources with high marginal abatement costs (i.e., net buyers of allowances) are congregated in specific areas, those areas are likely to experience less environmental improvements than others (depending also on meteorology and wind patterns). Furthermore, such areas could experience increased emissions and harmful local environmental or human health effects, even as the larger goal of aggregate emission reductions is achieved.

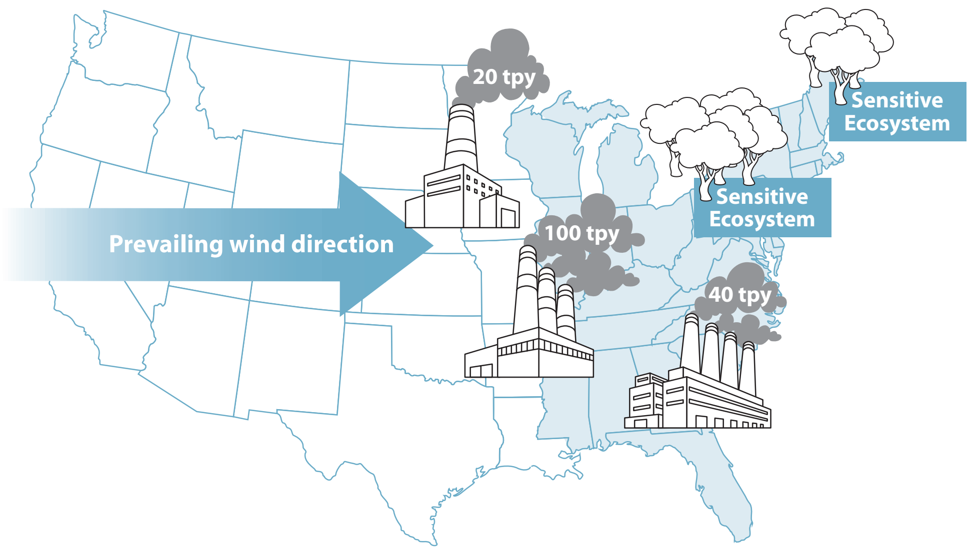
For pollutants with localized impacts, an evaluation of potential trading patterns may be useful. Potential trading patterns can be assessed with economic models or with less resource-intensive methods such as spreadsheet analysis. If the results indicate that geographic trading patterns will arise, it may be necessary to assess where the largest emission reductions are likely to take place compared to where the most sensitive environmental areas are, and whether the program will adequately address the environmental problem (see Figure 10) or be less effective than direct controls on sources. This involves an analysis of the source-receptor relationship and includes predicting changes in concentrations or deposition resulting from changes in precursor emissions, the influence of emission sources in one region on concentrations or deposition in other geographic regions, and the levels of concentrations or deposition in certain sensitive receptor regions.

If spatial issues are likely to arise, then the cap and trade program will need to be designed accordingly.

[23] This issue is not relevant for greenhouse gas emissions since these emissions do not have local air quality impacts, and trading patterns will not have localized environmental effects. However, ancillary reductions of criteria pollutants may have local benefits.

Figure 10. **Spatial Considerations**

Where are emission reductions most likely to occur?



How U.S. Trading Programs Address Spatial Issues

While environmentalists initially feared the potential creation of hotspots from the U.S. SO_2 Allowance Trading Program, no such local impacts have been observed and overall air quality has improved (Swift, 2000). There are several reasons why the trading provisions have not led to hotspots.

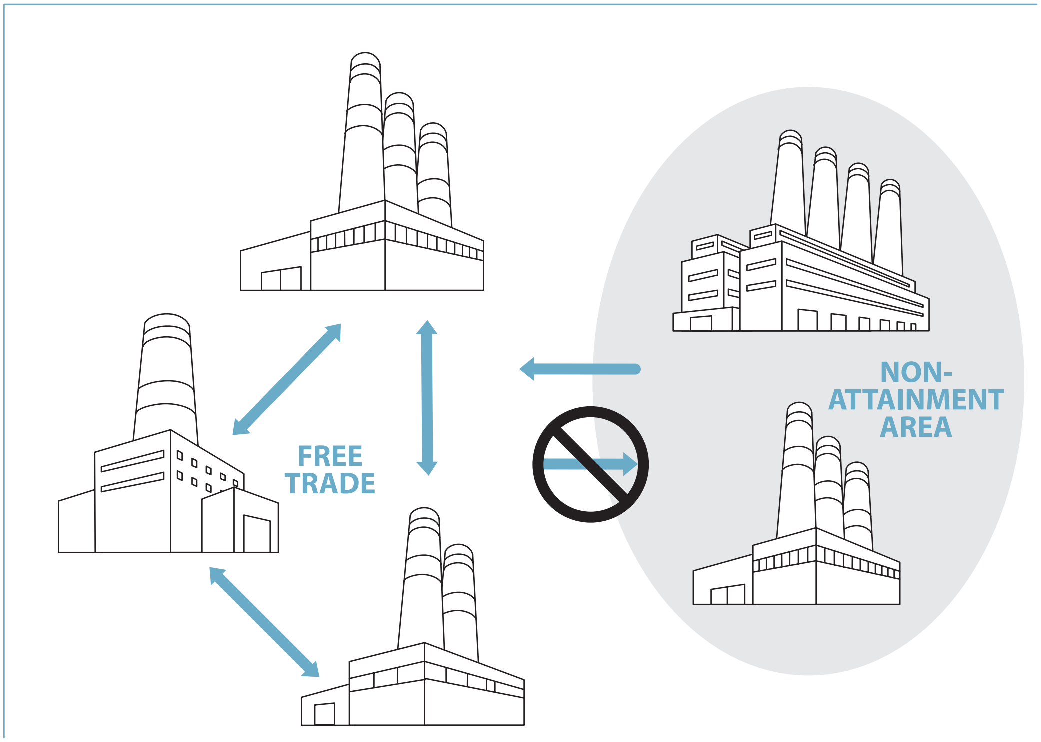
First and foremost, other regulatory standards (e.g., ambient air quality standards, technology and performance requirements) protect the local air quality from excess pollution. The United States employs conventional pollution regulations (e.g., mandated emissions limits or air pollution control equipment) that are designed to achieve health-based air quality standards (Schreifels, 2000). The U.S. SO_2 Allowance Trading Program represents an additional level of pollution control that is designed to reduce total loading of sulfur into the atmosphere. Hence, all utilities regulated under the U.S. SO_2 Allowance Trading Program are also required to comply with all other requirements of the Clean Air Act—in particular, the requirement to meet the health-based National Ambient Air Quality Standards, New Source Performance Standards, and Prevention of Significant Deterioration provisions. These requirements are independent of the trading program and cannot be circumvented through purchase of allowances.

Second, the significance of the reductions required under the U.S. SO_2 Allowance Trading Program—50 percent below 1980 levels—ensured that the majority of high-emitting facilities would have to reduce emissions significantly, even with the flexibility provided by emission trading. Third, the most cost-effective emission reductions are often at the largest, highest-emitting plants and areas with such facilities have reduced emissions more than average. As a result, there have been significant benefits to human health and the environment (Burtraw and Mansur, 1999).

The RECLAIM program employs two trading zones. Trading is restricted so sources in the downwind zone may not sell or trade allowances to sources in the upwind zone.

The OTC Regional NOx Trading Program in the Northeastern United States chose a different tactic. The OTC is composed of three zones with varying levels of ozone problems, and thus varying levels of emission reduction requirements in accordance with the severity of each zone's air quality problem. In the program development phase, the OTC conducted an analysis to determine whether trading restrictions were needed between zones to ensure reductions were achieved. When analysis failed to provide affirmative proof that a trading ratio would influence air quality, the OTC opted to minimize program complexity and allow unrestricted trading between zones — with the caveat that the issue may be revisited in future years as new information becomes available from implementation of the program.

Figure 11. **Trading Zones**



approach can be effective if the cap and trade program includes sources with different characteristics that influence the local effect of the sources' emissions (e.g., stack height). For example, the regulating authority may restrict a tall-stack source from trading allowances to a short-stack source because the shorter stack will likely have a greater impact on local air quality.

The third approach is to adopt a "tiering" of environmental policies, requiring sources to comply with local environmental quality provisions as well as those imposed by the cap and trade program. In its simplest form, this allows the appropriate regulatory authority to limit emissions of the sources identified as contributing to the local air quality problem, while not tampering with the allowance program. This third approach is the one employed by the U.S. SO_2 Allowance Trading Program.

Generally, there are three approaches for addressing this issue. The first is the possibility of introducing spatial restrictions on trading. For example, if unacceptable concentrations or deposition are expected to arise in a particular area, trading restrictions could be imposed by introducing "zones" where net flows of allowances into the sensitive area are prohibited or discounted by an appropriate amount (see Figure 11). A drawback of trading restrictions is the effect on fungibility of allowances and market efficiency. Spatial restrictions on the use of allowances mean that an allowance is not a standard commodity that is fully interchangeable with all other allowances. This lack of full fungibility can diminish the economic efficiency of the cap and trade program and can complicate the allowance market (e.g., lead to price stratification between allowances of different zones).

A simpler way of achieving the same effect as discounting without affecting fungibility is to have a higher retirement rate (e.g., 1.5 allowances per ton of emissions) in the zone of concern. This does not prohibit trading or differentiate among types of allowances; it simply makes it more expensive in such zones.

The second approach is to restrict trading between different categories of emission sources. This

Allowance Accounting

Each source that is responsible for compliance should have an allowance account. These accounts are the official records for allowance allocations, holdings, and transfers and can be used to track compliance. Initial allocations (or initial winning bids in an auction) provide the beginning balance for the allowance accounts.

Policymakers might also consider whether the program will allow other interested parties to have allowance accounts and hold allowances. These non-source accounts provide the vehicle through which organizations, such as brokers or environmental groups, can hold and trade allowances. Brokers, investors, and other market makers may play a crucial role in facilitating allowance trades. Because the allowance brokering and pooling functions are intended to facilitate sources' efforts to maximize the cost savings of their compliance strategies, these non-source accounts should be integrated with the account system for emission sources.

Allowance Serialization

Allowances can be serialized to facilitate tracking the allowance from creation to use for compliance. There are a number of benefits to identifying allowances by serial number. Although tracking serial numbers increases the administrative burden to both regulators and industry, it provides additional transparency and protection against accounting discrepancies. The use of serial numbers could also facilitate record keeping so allowance holders can track the different costs incurred in acquiring allowances. This may be necessary for tax purposes. Finally, the inclusion of serial numbers in the allowance tracking system provides the opportunity to analyze trading patterns and the movement of allowances over time. This may be useful for assessing the impacts of the trading program.[24] At a minimum, allowances should be identified by vintage (i.e., the compliance period for which they are issued) to identify when the allowances are authorized for compliance use.

Property Rights

The program rules must clearly define the legal rights and responsibilities of emission sources and the nature of allowances. Because allowances can be traded, the rights and responsibilities of ownership must be established so that these rights and responsibilities can be transferred from one participant to another (AGO, 1999).

When addressing allowance use, the regulating authority might want to consider certain property rights issues, namely entitlements and takings. Both can be addressed in the implementing legislation or program rules. The type of legal system in place will also affect whether or not allowances are perceived as property rights.

- **Entitlements:** Sources that have historically polluted with limited or no restrictions might argue that they have an implied right to allowances based on their historical emissions levels (AGO, 1999).
- **Takings:** If the implementing institution reduces the number of allowances at a later date, participants might argue that they are entitled to compensation from the regulating authority based on the value of the lost allowances.

> ### How the U.S. SO_2 Allowance Trading Program Dealt With Property Rights
>
> In the SO_2 Allowance Trading Program, the legislation specifies that allowances are not property rights. This provision was inserted to obviate a challenge of an unconstitutional "taking" should the government decide to alter the emissions cap (i.e., to reduce the number of available allowances). Functionally, however, the ownership rights and responsibilities of allowances are similar to property rights (Ellerman, 1999).

Compliance Determination

The compliance determination process for a cap and trade program should be simple and straightforward. Prior to implementation, the rules should clearly specify the deadlines for reporting and for holding sufficient allowances to cover emissions. At the end of the compliance period, the emission sources should be given enough time to verify emission data for the period and to submit them for compliance. This verification period should not be so short as to cause the emission sources to submit data that has not been properly quality assured, but not so long as to unreasonably delay compliance assessment. It should also allow enough time for the regulating authority, once it receives the data, to finish conducting the compliance determination well before the end of the subsequent compliance period, when the process will begin again. At the end of each compliance period and during the time when sources are assuring the quality of their emission data, the rules should provide for a short grace period (e.g., 60 days) so that sources can make final allowance trades. This will allow sources to assure that their account has allowances equal to or greater than their emissions. The regulating authority should specify an allowance transfer deadline—the final date for sources to trade allowances for use in the compliance year—in advance.

It may be advisable to freeze allowance transfers into or out of accounts after the transfer deadline until

[24] For example, EPA has conducted analysis showing no adverse environmental impacts from trading under the U.S. SO2 Allowance Trading Program (Kramer, 1999).

the regulating authority completes the compliance determination and deducts allowances for compliance.

Enforcement

Penalties for Noncompliance

Stringent penalties for noncompliance are an integral feature of a well-functioning cap and trade program. These should be applied automatically in cases where a source does not have sufficient allowances to cover mass emissions during the compliance period. In cases where there is noncompliance with requirements of the cap and trade program (e.g., measuring emissions, reporting, and other requirements), the penalties should be determined based on the nature and severity of the violation. The penalties should be sufficiently high to provide the appropriate incentives for compliance and can take the form of allowance, financial, and/or criminal penalties.

Excess Emission Offsets

In cases where a source does not have sufficient allowances to cover its emissions, an allowance restoration rate of at least one-to-one should be applied to maintain the environmental integrity of the program. Under a one-to-one rate, one allowance from the next compliance period would be retired for every unit of excess emissions in the current compliance period. Alternatively, the shortage of allowances can be purchased from the allowance market.

Aside from the one-to-one allowance restoration rate to maintain environmental integrity, the regulating authority should apply financial penalties for noncompliance if the goal is to deter such behavior. The existence of a one-to-one restoration rate without other accompanying punitive measures for noncompliance implies that sources can, in effect, use allowances from future compliance periods to attain their emissions reduction target. This can result in a scenario in which the emission cap is never attained. Hence, it is very important that the incentives deter noncompliance.

Financial Penalties

Deterring noncompliance can either take the form of allowance or financial penalties. With allowance penalties (i.e., where a source would have to turn in a multiple of its allowance shortfall at a ratio greater than one-to-one) the aggregate cap of emissions in the next compliance period is reduced. The environmental benefits of the program increase due to the allowances that are deducted as a penalty, but this could lead to further noncompliance because the necessary reductions are greater in the following compliance period.

Alternatively, market volatility may tempt some to speculate and intentionally be in noncompliance if they believe the market price for allowances will drop in the future. Furthermore, taking allowances out of the market reduces the supply and raises the price of allowances for all participants, not just those that are out of compliance. However, this should not be a significant factor unless there is large-scale noncompliance. For these reasons, a financial penalty (in addition to the one-to-one offset) may be preferable to deter noncompliance. Policymakers or the regulating authority should set the level of the financial penalties significantly higher than the expected marginal abatement cost—the expected

Penalties to Deter Noncompliance in U.S. Trading Programs

Under the U.S. SO_2 Allowance Trading program, the penalty consists of a one-to-one allowance restoration rate and a financial penalty applied at a level of US$2,000 (1990 dollars), adjusted annually for inflation, for each ton of excess emissions above allowances held. In 1990, this level of financial penalty was thought to be approximately three times the expected market price of an allowance. Based on the inflation adjusted penalty amount and actual market price of allowances, this is actually on the order of 20 times the market price of allowances, and could, in retrospect, be too stringent. For example, when non-compliance results from imperfect or late data or miscalculations, these penalties may be viewed as inappropriately punitive.

In contrast, the penalty for non-compliance in the OTC Regional NOx Trading Program is an allowance penalty at a ratio of three-to-one. In other words, for each ton of excess emissions, a source must submit three allowances to the regulating authority. Additionally, states within the OTC have the option of imposing financial penalties. This penalty, however, may not be sufficiently high. For example, during 1 year, the price of a NOx allowance fluctuated between US$500 and 3,000. Some sources might have sold allowances for US$3,000 and purchased for US$500 at the end of the year.

market price of allowances—to create an effective deterrent for noncompliance. Policymakers could also create a graduated financial penalty to reflect the severity of the violation or the length of delay in making payment. For example, if a source exceeded its emission cap because of an accounting error, the penalty might be twice the price of allowances, payable in 30 days. For a more serious violation or if the penalty is not paid in 30 days, it could grow to several times the price of an allowance. If the penalty is in dispute, the source could put funds into an escrow account awaiting adjudication.

The allowance price from which the penalty is calculated can be based on a projection of the allowance price (established during the development of the program) and adjusted for inflation. Alternatively, it can be based on a multiple of either the actual average price or the highest monthly price of allowances for the preceding year in which the program was in operation. Establishing the penalty based on a multiple of the projected market price of allowances can be difficult because different economic models often yield substantially different estimates. However, indexing the compliance penalty to actual prices can also be difficult without a liquid market/exchange. In some cases, a periodic, government-run auction can reveal price information that the regulatory authority can use to set the penalty level.

If a source is out of compliance with the monitoring, reporting, and/or other requirements specified by the regulating authority, financial penalties should also be applied. These also can be graduated depending on the nature of the noncompliance (or "degree of fault"), with higher penalties for repeat. To maintain consistency, the penalty levels should, to the extent possible, be defined in advance. Finally, to ensure that the penalties are enforced in a timely manner, the penalty rate might increase if the source does not pay the penalty within a specified period of time.

The revenues from these penalties might be collected and redistributed in several ways. For example, they can be collected by the national treasury and redistributed in the same way as income taxes or they can be paid directly to the regulating authority to offset program costs. The revenues may also be collected in a special fund to provide resources for research and development into abatement technology and/or environmental purposes related to the pollutant being regulated.

Regardless of the type and severity of penalties, they should be objective and automatic. Eliminating penalty negotiations between regulating authority and emission source promotes impartiality and equity and reduces opportunities for dishonest behavior. In addition, it sets clear expectations so that sources know the consequences for noncompliance.

Criminal Penalties

The regulating authority might also impose criminal penalties on individuals who knowingly violate any requirements, with maximum sentences for first-time and repeat offenders. Criminal penalties provide direct incentives for the legally responsible individuals ("designated representatives" or owners and operators) at the affected sources to behave responsibly. Owners, operators, and designated representatives should be required to sign each form that is submitted to the regulating authority for the source (e.g., allowance transfers or emissions reporting) indicating that they are liable for acts and omissions within the scope of their responsibilities under the cap and trade program.

Other Design Considerations

Integration of Cap and Trade with Other Policy Approaches

There are a number of ways in which policymakers can integrate cap and trade programs with other approaches for environmental policy. Command-and-control approaches can be compatible with cap and trade, but policymakers should identify the relationships between the different policies and ensure there are no contradictions or duplications. With command-and-control, the regulating authority specifies sector-wide technology and/or performance standards that each of the affected sources must meet, whereas cap and trade provides sources with the flexibility to choose the technologies that minimize their costs.

Depending on the type of pollutant that is being regulated by cap and trade, integration with command-and-control approaches can aid in the prevention of hotspots that may result from the use of allowances. For example, additional reductions through a cap and trade program could be layered on top of existing requirements.[25]

Finally, with regard to integrating alternative forms of emission trading, if the regulating authority decides to establish more than one type of emission trading program, each should affect distinct sectors. If desired, allowances from a cap and trade program could, in theory, be fully interchangeable with offsets from project-based mechanisms or credits from a rate-based program. However, the regulating authority must ensure that project-based mechanisms do not undermine the environmental integrity of the cap. Stringent oversight, verification, and conservative crediting methodologies need to be established to account for uncertainties and to avoid the creation of "anyway" tons, paper credits, leakage, or double counting (see Chapter 2).

The United Kingdom 'Gateway' Mechanism: Trading Between Allowances and Credits

One mechanism that has been proposed to enable trading between allowances and credits from rate-based trading is the 'gateway' in the U.K.'s Emissions Trading Program for greenhouse gases. Under this approach, sources affected by the rate-based trading program can purchase as many allowances from sources regulated under the cap and trade program as they wish. However, sources regulated by cap and trade program can only purchase credits from sources under the rate-based program if the net flow of units in this direction is zero. The U.K. Emissions Trading Program is still in its infancy; hence, it is too early to evaluate this approach. It is likely that the transaction costs associated with undertaking these inter-program trades (vs. intra-program trades) are likely to be higher due to the administrative costs associated with assessing net flows.

[25] For more information about layering command-and-control and market-based programs, see Schreifels, 2000.

4

How to Implement and Operate a Cap and Trade Program

Introduction

The credibility of the cap and trade program and confidence in the market depend on the accuracy of emission measurement and enforcement by the regulating authority. Because allowances, and therefore emissions, have an economic value, sources might misrepresent emission data if there are no consequences or low probability of discovery. The regulating authority must ensure that enough resources are dedicated to verifying emission reports and auditing affected sources.

The regulating authority must also ensure that allowance accounting is undertaken with the appropriate scrutiny and security to avoid errors and fraud. Computerized accounting systems for emissions and allowances can facilitate the management of these responsibilities.

This chapter describes the functions necessary to implement and operate a successful cap and trade program including tracking information on emissions, allowances, and compliance; auditing and verifying emissions reports; providing technical support and policy guidance to regulated sources; and costs and resources necessary to operate a cap and trade program.

Integrated Information Systems

Perhaps one of the most important lessons learned from existing cap and trade programs is the need for comprehensive, accurate, transparent, and timely information about emissions and allowances. The regulating authority that operates the program must collect, verify, maintain, and disseminate the data if the program is to operate with environmental integrity, economic efficiency, and public credibility. Computerized information systems are the most effective method available today to process and disseminate these data.

Using an information system to collect and manage large amounts of data on emissions and allowances can provide numerous benefits, including:

- **Increased data accuracy:** Tools such as electronic reporting and automated data quality checks reduce errors and eliminate redundant data entry.
- **Reduced time and costs:** Electronic reporting and automated data quality checks reduce the time and costs required to complete, process, and review paper forms. In addition, the electronic storage of data can significantly reduce, or

even eliminate, the costs associated with the collection, transportation, storage, and dissemination of paper forms.

- **Enhanced access:** Electronic data storage makes it easier and faster to retrieve, analyze, and evaluate relevant data on demand. Improved access to data can also promote confidence in the trading program by permitting emission sources and interested members of the public to retrieve data to ascertain compliance, evaluate a program's effectiveness, and make informed decisions. Data transparency can also facilitate efficient markets, build public acceptance, and foster credibility (Kruger, et al., 2000).
- **Improved consistency and comparability:** Electronic reporting and electronic data storage encourage consistency by requiring all emission sources to report the same information in a common reporting format. This consistency promotes comparability across time and among program participants, leading to a fully fungible tradable commodity and efficient market.

In the early stages of a cap and trade program, the data system may be as simple as a spreadsheet with manual audit procedures. As an interim measure, this approach can be reliable if volume is low, and it might provide an opportunity to assess whether automation is necessary and to what extent. As resources become available and the program evolves, the information system can be modified, expanded and, if appropriate, automated to address the needs of the program.

A comprehensive information system should include modules to collect, review, and manage data on emissions and allowances and a module to determine compliance.[26]

Emissions Tracking Module (ETM)

The most data-intensive component of the information system may be the emissions tracking module, or ETM. The purpose of the ETM is to collect, review, and maintain relevant emission-related data from each source. The type and quantity of data collected will depend on the measurement requirements for the cap and trade program. For example, a program that relies on emission factors to calculate emissions from combustion sources might require participants to report data on the type and amount of fuel consumed, the combustion technologies installed, and the emission factors used. A cap and trade program requiring continuous emission monitoring systems might collect data on measured pollutant concentration and volumetric flow of exhaust gas. Although the frequency of reporting will depend upon the calculation method, the length of the compliance period, and administrative requirements, it should be frequent enough to supply sources, the regulating authority, other market participants, and interested parties with timely information about emissions and facilitate compliance determination.

Regardless of the method used to calculate emissions, the data must be consistent, accurate, and objective if sources, market participants, and the public are to have confidence in the program. To facilitate access to the data, the regulating authority can make the emission data from the ETM available to interested parties through a publicly accessible interface (e.g., the Internet). The data are useful to market participants who can use them, along with allowance data, to gauge potential supply and demand for allowances. The public, interest groups, and academics can use the data to evaluate the effectiveness of the cap and trade program (e.g., emission reductions and environmental effects). However, simply making data available may not be sufficient. True transparency necessitates making the data available in a useful and usable format (Teitenberg and Wheeler, 1998). Determining the appropriate format will depend on the type and quantity of data collected, as well as their end use.

Due to the potentially large volume of data, the regulating authority operating the program might benefit by requiring all sources to submit emission-related data electronically. Electronic submissions improve accuracy and reduce the burden on sources and the regulating authority by eliminating the need for redundant data entry, facilitating automated data quality checks, and providing immediate feedback about data quality. In the event that electronic submission is not feasible, sources might submit data on diskettes, compact discs, or paper forms. The regulating authority can then transfer the data to the ETM. This manual process could be cumbersome for the regulatory authority and prone to data entry errors.

After sources submit emission data, the ETM should check the data for omissions, mathematical

[26] For more information about data systems for cap and trade, see Schreifels, 2001.

errors, and methodological problems. If the ETM uses electronic reporting, it can acknowledge the submission and report the results of the quality check directly to the sources. The ETM can also perform in-depth analysis and quality assurance checks. For example, the system might compare the submitted data to historical data from the source and similar facilities to search for inconsistencies. Potential problems that the ETM identifies might be reported to the regulating authority so an auditor can check the data and, if necessary, request additional information from the source. In the absence of a computerized information system, the regulating authority should oversee these functions.

Once the data passes the data quality check, it can be recorded in the ETM and made available to interested parties. An automated data quality check reduces the time and cost of data review in two ways. First, the ETM identifies minor errors immediately and reports to the source so they can correct the errors. Second, the regulating authority can focus on problems identified by the second stage of the review in order to prioritize in-depth reviews. The automated data quality check can also reduce processing delays and provide interested parties with faster access to emission data.

Allowance Tracking Module (ATM)

The Allowance Tracking Module, or ATM, is the accounting system for the trading program, keeping track of account information, account holdings, and transactions. As with other components of the system, public access to the data is important. Market participants, including sources, brokers, and other allowance owners, can use the data to verify transactions and monitor holdings. The public, interest groups, and academics can use the data to evaluate the effectiveness of the cap and trade program, identify barriers to cost-effective trading, assess overall market activity, identify trading trends, and analyze the emission implication of trades.

The potentially large volume of transactions in a trading program may necessitate electronic submission of transactions. As discussed earlier in the section on submissions of electronic emissions data, electronic submissions have many benefits, including improved accuracy, reduced burden on the regulating authority, immediate feedback and transaction confirmation to participants.

The ATM can play a critical role in all allowance transactions, including the issuance, transfer, retirement, and cancellation of allowances. The regulating authority can use the ATM to issue and distribute allowances according to a prescribed method (e.g., allocation formulas, auctions, sales). A computerized ATM can also ensure that trades are valid by reviewing the data to verify that account numbers are correct, the seller owns the allowances being transferred, and the allowances are still valid (i.e., they have not been retired for compliance or cancelled). Once the information is verified, the ATM can deduct the traded allowances from the seller's account and add them to the buyer's account. If the transaction is not valid, the ATM should notify the buyer and seller and, if appropriate, record the failed transaction as an acknowledgement that the transaction was submitted.

The ATM, in conjunction with the Reconciliation and Compliance Module, can facilitate compliance assessment by retiring the appropriate number of allowances from each account. In addition to issuance, transfers, and retirement, the ATM can facilitate canceling allowances for environmental or other reasons (e.g., administrative penalties, purchases by environmental groups).

Public Participation in the U.S. Allowance Market

The public can participate in emission trading programs by purchasing allowances. Environmental and student groups have taken advantage of this option, purchasing allowances with the intention of retiring them from the system. Retiring allowances for the environment prevents them from being used to emit pollution. For example, in the U.S. SO_2 Allowance Trading Program, these groups acquired a total of 934 allowances in the period of 1994 to 1997. In RECLAIM, environmental activists acquired a total of 1,925 allowances in the first year of the program. This represented about 4 percent of the annual allocation. Despite the small volume of allowances, these transactions are symbolic of the openness of the system and the ability of the public to take direct action on behalf of their environment.

Reconciliation and Compliance Module (RCM)

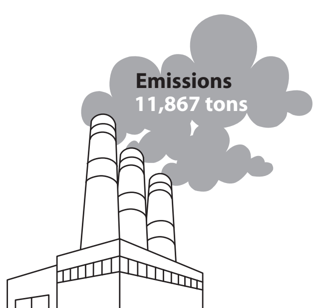
The Reconciliation and Compliance Module (RCM) is the vital link between the ETM and ATM to determine compliance. At the end of each compliance period, the RCM compares a source's allowance holdings against the total emissions from the period. If the source's emissions are equal to or less than their allowance holdings, the source is in compliance (see Figure 12). Conversely, if emissions are greater than the allowance holdings, the source is not in compliance and is subject to any noncompliance consequences and penalties.

The RCM, in conjunction with the ATM, should deduct the appropriate number of allowances from each source's account. The deductions might be made on a prescribed basis (e.g., first in, first out) or by specific instructions as to which allowances are to be deducted. The latter approach may be desirable for a variety of reasons (e.g., tax consequences, forward trade contracts).

If the source is not in compliance, the RCM should:

- Instruct the ATM to deduct all allowances from the source's account and withhold future allowances equal to the overage penalties.
- Report the noncompliance and emissions overage to the regulating authority for enforcement.

Figure 12. **Reconciliation**



Allowances	
Beginning of year	15,812
Net Allowance (Bought and Sold)	-3,201
Total Allowance Available for Compliance	12,611
Deductions for Emissions	-11,867
Allowances Remaining (Source in Compliance)	744

Auditing and Verification

Auditing and verification of emission data can take several forms. If data submitted by sources are required in a standard electronic format, regulating authorities can use software to audit the data and identify potential discrepancies or issues to investigate. The regulating authority can use these electronic "desk" audits to target more in-depth audits. If sources submit emission data using paper forms, the audit and verification will be more resource intensive. For this reason, requiring sources to submit emission data in standard electronic format is strongly recommended.

When sources use measurement devices, either to measure actual emissions or to measure some other parameter involved in calculating emissions, such as fuel flow, the regulating authority should review data collected from measurement devices for reasonableness. In addition, the audit should review results of any quality assurance and quality control tests performed on the measurement equipment to ensure that the equipment is operating properly. If possible, the regulating authority should compare submitted data to independently obtained data.

Verification of submitted emission data should also involve field audits — visits to the emission sources — especially when sources use measurement equipment. Such field audits can include observing quality assurance tests, reviewing on-site records, inspecting measurement equipment, and/or comparing installed measurement equipment to independent reference methods. Such field audits can be performed on a random sample of all sources, and/or field audits can be performed on sources identified with potential measurement or data problems during the electronic desk audits.

Auditing in the U.S. SO_2 Allowance Trading Program

Under the U.S. SO_2 Allowance Trading Program, the state and local environmental agencies, EPA regional offices, and U.S. EPA Headquarters form an auditing team. Where possible, regulatory officials (usually from the local agencies) observe QA/QC testing of emissions measurement equipment that is undertaken by regulated sources. The purpose of the audit is to verify that the testing is completed according to standard procedures and accurately represented in the reports to EPA. In addition, emissions and test data are reported to EPA in a standard electronic format, are screened for errors, and are electronically audited to identify potential discrepancies. Problems found in electronic audits are used to target facilities for field audits. Regulatory officials perform both random and targeted field audits during which they visit facilities to inspect measurement equipment and on-site records to verify that the data reported to EPA accurately reflects what is happening at the facility. In support of this process, EPA provides training and audit software for regional, state and local inspectors.

Technical Support for Regulated Sources

An important element of implementing and operating a cap and trade program is the ongoing technical support for sources. The program is more likely to be successful if the regulating authority and emission sources keep open lines of communication on the rules and procedures of the program. Before implementation of the program begins, sources may benefit from workshops that explain and clarify the rules of the program. In addition, throughout the life of the program, as new issues arise, new sources and new employees enter the program, and revisions are incorporated into program rules, a continued dialogue between the regulating authority and the sources will facilitate the smooth operation of the program.

It is wise for the regulating authority to plan workshops for sources after the rules of the program have been publicly disseminated but prior to the beginning of the program. The workshops can address all aspects of implementation for which the sources are responsible, and should inform them about the role of the regulating authority. For example, the workshops could:

- Explain the applicability criteria of the program and address questions about which sources are and are not affected.
- Explain the allocation process, including when and how each source will know its allocation or the procedures for participating in an auction, if applicable.
- Address source responsibilities, such as the procedure for identifying the person who will be responsible for making submissions and demonstrating compliance for each source.
- Discuss the requirements for measuring emissions and reporting to the regulating authority.
- Outline the procedures for reporting allowance trades to the regulating authority.
- Answer any questions related to the determination of compliance and potential enforcement actions.

During implementation of the program, it might be necessary to supplement the initial published rules of the program with guidance documents that focus on specific questions or clarifications regarding the rules. It is likely that the initial rules of the program will not cover all of the situations that actually arise.

Sources may need interpretations of the rules by the regulating authority to help apply the rules to the source's unique circumstances. This may be particularly true for emission measurement and reporting. The more individualized the measurement methods and the more options available, the more questions are likely to arise. For consistency in the program, it is important that sources receive the same guidance. One option to ensure consistency is for the regulating authority to create a guidance document that includes answers to both commonly asked questions and unique questions. The regulating authority can modify the document as new guidance is created. Such a document is useful as an internal reference to help maintain consistency over time, as well as to provide information to the public and sources.

Administrative Costs Associated with Cap and Trade

Although cap and trade programs can cost significantly less than more traditional policy options, the programs require resources to operate efficiently and effectively. Regulating authorities should consider these costs when designing the program so they can identify appropriate funding sources and budgets.

The smaller a cap and trade program is, the more likely it can operate effectively and efficiently with a simple spreadsheet or paper-based system. However, as the number of participants or data requirements increase, a computer-based system with automated data processing becomes necessary. The costs of designing and developing[27] such a system can be considerable, but the savings in staff time and error reductions can help offset some of the expense. Additionally, the system may undergo modifications as program rules change, automation is enhanced, or technologies improve.

Enforcement

Oversight and enforcement assure that sources are accountable for their emissions and compliance with the program requirements. The functions of oversight and enforcement include the verification of emissions and the enforcement of penalties for fraud or noncompliance.

Additional Costs

Other costs associated with cap and trade programs may include:

- General administration.
- Recording allowance trades.
- Providing public access to program information (e.g., emission reports, allowance holdings and trades).
- Monitoring program results.
- Responding to questions from program participants and the public.

Operational Resources for the U.S. SO_2 Allowance Trading Program

The U.S. SO_2 Allowance Trading Program requires significantly fewer administrative and operational resources than traditional command-and-control programs in the United States. This is due in part to automation and the use of information systems, as well as the fundamentally new approach whereby administrators can focus on verification and compliance rather than reviewing compliance plans, baseline calculations, and emission reduction transactions. Approximately 100 government staff members nationwide play a role in the SO_2 or NO_X allowance trading programs.

- 25 to 30 federal headquarters staff members provide policy guidance, develop and operate the information systems to track emissions and allowances, certify monitoring equipment, verify reported emissions data, audit facilities, determine compliance, and enforce penalties when necessary. The vast majority of these staff members perform quality assurance and verification of emissions measurement data.
- 15 federal headquarters environmental staff members assist with administration, outreach, training, assessment, and operation of a national network of monitors to track acid deposition and environmental impacts.
- 15 federal regional environmental staff members and approximately 40 state and local staff members help verify the emission measurements by conducting field audits at participating sources.

All federal costs for development and operation of the U.S. SO_2 Allowance Trading Program amount to less than $1 per ton of SO_2 reduced (McLean, 1997).

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[27] EPA has created comprehensive design documentation for an integrated emission and allowance information system. This documentation is available to interested governments through the Clean Air Markets Division.

Assessment and Communications

Introduction

This chapter describes how outreach and communications can facilitate a credible and successful cap and trade program and discusses some of the communication issues that are unique to emission trading programs. The chapter emphasizes the importance of transparency (i.e., the full and open disclosure of relevant public and private decisions) for cap and trade programs. Finally, the chapter discusses ongoing data collection and assessment recommended for cap and trade programs to determine whether they are delivering the desired environmental and economic results and to identify potential improvements. These include environmental, economic, and market assessments.

Communicating Status and Results

Research has shown that public acceptance of a government policy is critical to ensure successful implementation; keeping stakeholders informed and involved helps build trust in both the policies themselves and in the regulating authority (Jasanoff and Wynne 1998). In addition to simply conveying information, communication and outreach activities can help generate public support for cap and trade programs. This support is particularly important in the case of environmental issues, which frequently engender considerable public debate between competing interest groups with differing values and objectives. Because there are many misconceptions about cap and trade, regulating authorities implementing cap and trade programs need to provide complete, accurate, and balanced information on how the program works and how it will help achieve environmental objectives. It is also important to engage in communication and outreach activities in the beginning of the policymaking process and use these activities throughout implementation to develop credibility for the new approach to emission control.

Multiple Audiences for Outreach

The audience for most outreach activities is highly varied, and each constituency has a unique set of concerns. For example, the general public and the environmental community may be primarily interested in learning how the trading program affects human health and ecosystems, particularly in and around their own communities. The affected emission sources, on the other hand, may need access to account information or guidance on how to measure and report emissions (see Chapter 4). The academic community might show a preference for technical information, such as data on long-term emission trends or prices. Policymakers might be interested in whether program goals are being met (e.g., whether emissions are decreasing, by how much, and where). Policymakers might also be interested in the program's overall cost-effectiveness. The needs of each of these stakeholder groups can be met through a well-designed monitoring, assessment, communication, and outreach program.

Information for the Market

Another important role of a communication program is to provide information to the emission sources to help facilitate market operation. Sources need to know what their reporting requirements are under the system, how to comply with program rules and regulations, and whom in the regulating authority to contact regarding questions. Moreover, for a cap and trade system that relies on trades recorded in near real time, it is necessary for the regulating authority to provide data on allowance availability and individual accounts.

Fortunately, recent advances in information technology are making it possible to provide data relevant to cap and trade programs in real time and in many highly useful forms (Kruger, et al., 2000). For example, before an allowance trade is completed and money changes hands, the party acquiring allowances may want to know that the ATM has recorded the transaction. Availability of this information helps keep the program running smoothly and efficiently without long lag times. Ultimately, transparency of information makes the market more efficient by letting those who wish to buy and sell allowances know who is trading and what volume of allowances are being traded. This information allows participants to make trading and compliance decisions more easily and quickly than if critical information were not available.

Public Involvement in the Design Stage of U.S. Trading Programs

Both the U.S. SO_2 Allowance Trading Program and the U.S. RECLAIM program involved the public in their design and implementation. During the development of the SO_2 Allowance Trading Program regulations, members of the utility, coal and natural gas industries; environmental organizations; consumer interest groups; regulatory commissions; and members of academia provided input through participation in the Acid Rain Advisory Committee (ARAC). RECLAIM was also developed through the use of advisory committees comprising representatives from public agencies, the business community, trade unions, environmental organizations and financial institutions. In both instances, the involvement of these groups early in the design process helped to overcome misconceptions about the use of this new instrument and to educate stakeholders on the process of program development and implementation (Schwarze and Zapfel, 2000). In addition, it helped facilitate implementation because it produced a cadre of knowledgeable individuals who were committed to making the program work.

Communication Issues Unique to Emission Trading Programs

There are some unique communication issues associated with cap and trade programs. These programs are sometimes met with skepticism from the environmental community and the public. Unique concerns or misconceptions about emission trading are summarized below.

- **"Emission trading is immoral."** Some critics of emission trading start with a philosophical opposition to what they call "the right to pollute." Even under conventional regulation, however, permitting establishes the "right" to emit pollution at a certain level. Sometimes this right is in the form of an emission rate and sometimes it is in the form of the emissions that result from specific, mandated pollution control technologies. Unlike cap and trade, most of these traditional mechanisms do not limit the total tonnage of pollutants from each plant (i.e., plants can emit more when they operate more). The market-based incentives in cap and trade can also spur innovation and new technologies.

- **"Emission trading is unfair."** A second misperception of emission trading is that it is unfair because companies can buy their way out of their responsibilities to reduce emissions. Similarly, some have argued that emission trading favors large companies at the expense of small companies. These arguments ignore the fact that under a cap and trade system, companies that buy allowances are essentially paying for emission reductions at other companies. Moreover, small companies often benefit the most from cap and trade because they may have fewer internal options for emission reductions and they may benefit from the flexibility of buying allowances. In addition, the largest and highest emitting facilities often have the lowest cost per ton for reducing emissions. This was the case in the U.S. SO_2 Allowance Trading Program, where the highest emitting plants in the Midwestern United States made the most significant emission reductions.
- **"Companies will cheat."** Some believe cap and trade will allow companies to avoid their obligations because enforcement and oversight is left to "the market." In fact, if programs are properly designed, accountability can be better under a cap and trade program than under conventional approaches. Cap and trade programs require the creation of compliance structures that are useful regardless of whether any trading occurs. Participating sources must fully account to the government for each ton of emissions according to stringent emission measurement protocols to ensure completeness, accuracy, and consistency of emission data. Automatic financial penalties can be used that are set at levels that discourage noncompliance. The regulating authority's role in the program is to ensure emissions are measured accurately and that all participating sources are in compliance. Finally, reported information on emissions can be made available to the public on the Internet or through other means. This transparency can help build the necessary confidence in the efficacy of the cap and trade approach.
- **"Trading doesn't clean the air."** Critics of emission trading sometimes argue that trading does not reduce emissions; it merely shifts the location of existing pollution. However, this argument fails to account for the cap. Under a cap and trade system, the overall level of emissions is reduced and capped. The environmental objective is embodied in the cap and the economic objective in the trade. Moreover, the larger the overall reduction reflected in the cap, the less concern there is about the environmental impacts of any individual trade or group of trades. This point is particularly relevant in addressing concerns about hotspots that may arise due to trading. Economic and atmospheric modeling done in conjunction with an EPA study of the U.S. SO_2 Allowance Trading program showed that in the Eastern United States, the difference in acid deposition with and without trading was less than 5 percent. Differences in deposition of less than 10 percent are not expected to measurably change the acidification of lakes and streams (USEPA, 1995).

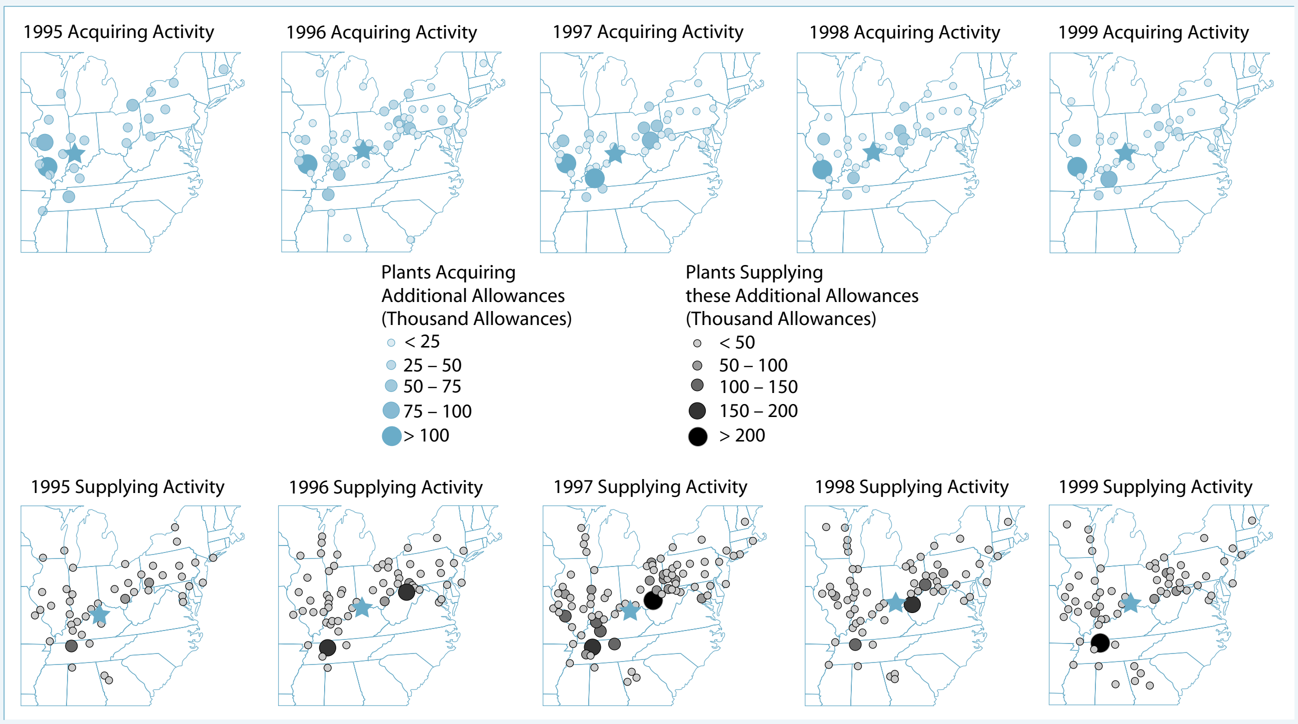
Public Reaction to the U.S. SO_2 Allowance Trading Program

Although reactions to some of the initial SO_2 trades in the United States were negative, acceptance of emissions trading has grown as the program has achieved environmental results. Several observers have noted that the key to effectively communicating the benefits of the SO_2 cap and trade program to the public and environmental groups has been to make the point that the flexibility of emission trading was tied to a significant environmental benefit (Loeb, 1995). Essentially, the argument is that the cost savings from the allowance trading program were used "to buy" additional environmental benefits and to therefore ease the concerns of environmentalists over this nontraditional form of regulation. Ultimately, once the emissions and environmental results of the program became available, the program began to receive more favorable media treatment. In addition, a broader range of environmental groups began to embrace cap and trade (Kruger and Dean, 1997).

Clean Air Mapping and Analysis Program (C-MAP)

EPA's Clean Air Markets Division uses geographic data to assess the environmental effectiveness of the Acid Rain Program and to help the public better understand the results and benefits of its SO_2 trading program. One of the most sophisticated electronic information sources is the Clean Air Mapping and Analysis Program (C-MAP), which allows users to assess national and regional impacts of the Acid Rain Program. C-MAP is a Web-based Geographic Information System (GIS) assessment tool used to better understand and characterize the environmental results and benefits of national and regional pollutant emission reduction programs. The geographic component of GIS allows for a clearer understanding of the spatial relationships between emissions reductions and the associated effects to air quality, surface water quality, acid deposition, forest health, and sensitive ecosystems. The user can analyze national-, regional-, and state-level trends, according to the geographic and environmental area of interest. C-MAP files are provided via the Web site and are also included in written reports (see: www.epa.gov/airmarkets/cmap).

Figure 13. **Allowance Trading Activity 1995 – 1999**



For example, this map from C-MAP illustrates the geographic mean centers of SO_2 allowance trading (buying activity of plants emitting more than their allocation in a given year, and selling activity of sources) for 1995 through 1999. The proximity of centers of trading each year indicates that there was no significant shifting of emissions from one region to another among these units. The tight geographic correlation corroborates EPA's observations that units tend to acquire additional allowances from within their own company (or geographic region).

Independent analysis also shows that emission trading can lead to greater human health and environmental benefits than non-trading policies (Burtraw and Mansur, 1999).

Modes of Communication

By far the most effective means of communication and outreach is the World Wide Web. Electronic information can reach a vast audience at low cost. For example, visitors to EPA's Clean Air Markets Web site[28] read more than 300,000 files every month. A well-designed Web site should be user-friendly, rely on intuitive navigation, and, ideally, undergo usability testing before it is made available to the public. It should also be regularly updated to reflect the latest program data and developments. An up-to-date Web site can greatly add credibility to the trading program and can be used to provide information that builds confidence in the cap and trade program (see box on C-MAP).

Information can also be made available to the public via print media. Depending on available budget, a regulating authority may prepare and distribute fact sheets, brochures, and topical reports that can be distributed by mail. Periodic newsletters are another effective means of keeping the public informed of the program's status and results, including emission reductions to date, auction results, and allowance prices. Similarly, information can be conveyed at workshops and conferences.

Regardless of the mode of communication, it is important to bear in mind that keeping the public informed about the status and results of the cap and trade program can help ensure the program's success by highlighting its environmental and economic benefits, facilitating market operation, and building public and decisionmaker support. To ensure that adequate resources are available to meet public demand for information throughout a program's lifetime, a communication function should be designed at the program's outset, rather than on an ad-hoc basis after results are available. Consistently available, up-to-date information will help build public confidence in the cap and trade program.

Continued Assessment

Environmental Assessment

A cap and trade program, by setting a quantifiable emission goal and using accurate and consistent emission measurement, lends itself well to periodic assessment. Reviewing emission levels will help determine how effectively the program is operating and whether the emission cap level has been achieved. Equally important to program success is determining how the environment is responding to emission reductions and whether overarching objectives for environmental protection are being met. Periodic measurement of these environmental endpoints will help provide information on how well the cap level is protecting the environment.[29]

The scope of the assessment is determined, to a large extent, by the specific policy questions being addressed. Continued assessments can include evaluation of emission data, ambient air concentrations monitoring data, and pollutant deposition monitoring data. Assessment may also include an evaluation of endpoint parameters or receptors, such as changes in surface water chemistry resulting in decreases in acid deposition. Examples of environmental endpoints include acidic levels of rainwater and sulfate deposition levels for acid rain, and ground-level ozone levels for NOx emissions.

In order to evaluate the effectiveness of environmental policies and programs, a strong commitment to long-term monitoring programs is critical. Effective assessment requires a full suite of monitoring capabilities, including tracking stack emissions, analyzing atmospheric concentrations of pollutants, measuring wet and dry deposition to land and water surfaces, and evaluating environmental impacts through surface water chemistry and biological monitoring. These programs not only help in evaluating environmental compliance and progress towards program goals (e.g., through tracking emissions reductions), they also enable assessment of the effectiveness of emission controls in addressing human health and environmental concerns. Over the long term, investment in such program accountability mechanisms will yield great benefits through their contribution to the credibility of the policy.

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[28] The Web site's URL is www.epa.gov/airmarkets.

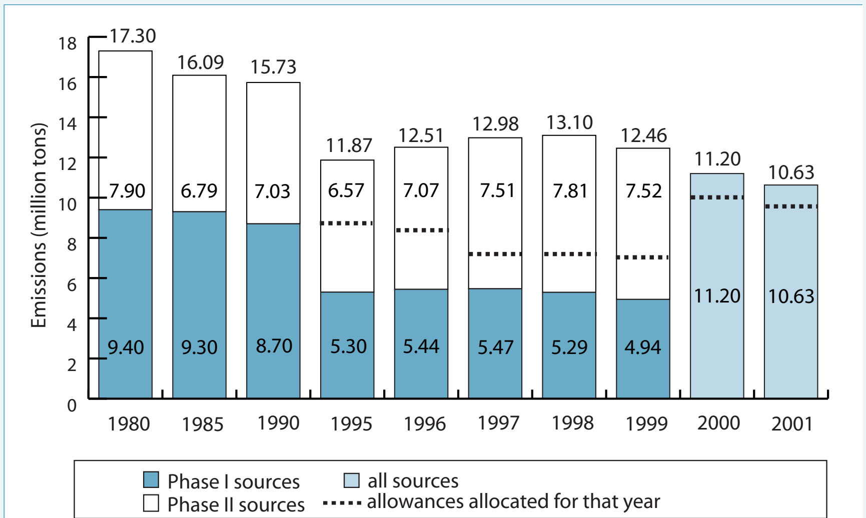
[29] For a detailed discussion on ecological assessments and analytical tools in the context of acid deposition in the United States, see USEPA, 2001.

Environmental Assessment in the U.S. SO_2 Allowance Trading Program

Since its first year of operation in 1995, there has been extensive assessment of the impacts of the U.S. SO_2 Allowance Trading Program. This assessment has been critical in evaluating the success of the program and in building support for the cap and trade approach. Some of these results are summarized below:

Emissions: One benefit of using continuous emissions monitors is having accurate, complete, and timely emission data that can be used to quantify the overall environmental effectiveness of the program. In 2001, the second year of Phase II, affected emission sources achieved total SO_2 emission reductions of approximately 39 percent relative to 1980 levels (33 percent relative to 1990 levels). Compared to 2000 levels, these sources reduced their SO_2 emissions by 5 percent or 569,000 tons. Figure 14 shows the trend in SO_2 emissions for all affected sources since 1980.

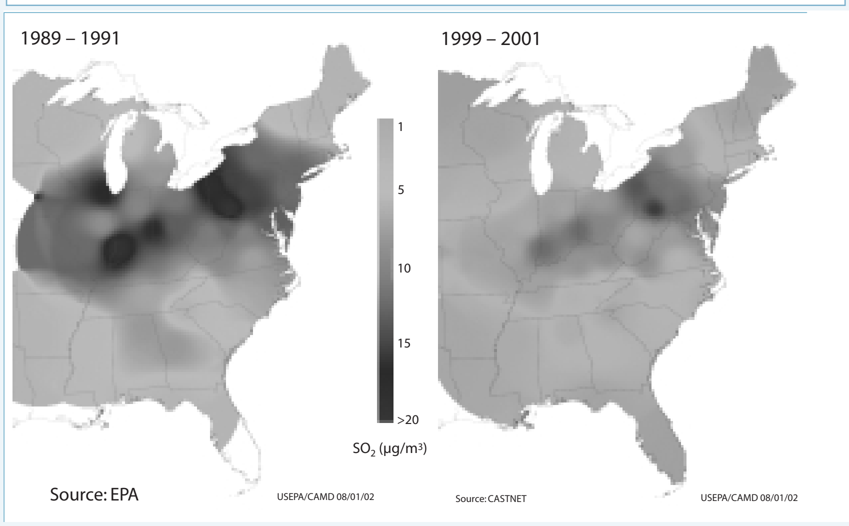
Figure 14. **SO_2 Emissions From Affected Emission Sources**



Source: Clean Air Markets Division, EPA

Air Quality: Data collected since 1988 indicate that ambient SO_2 concentrations are declining (see Figure 15).

Figure 15. **Regional Trends in SO_2 Concentration Sources**



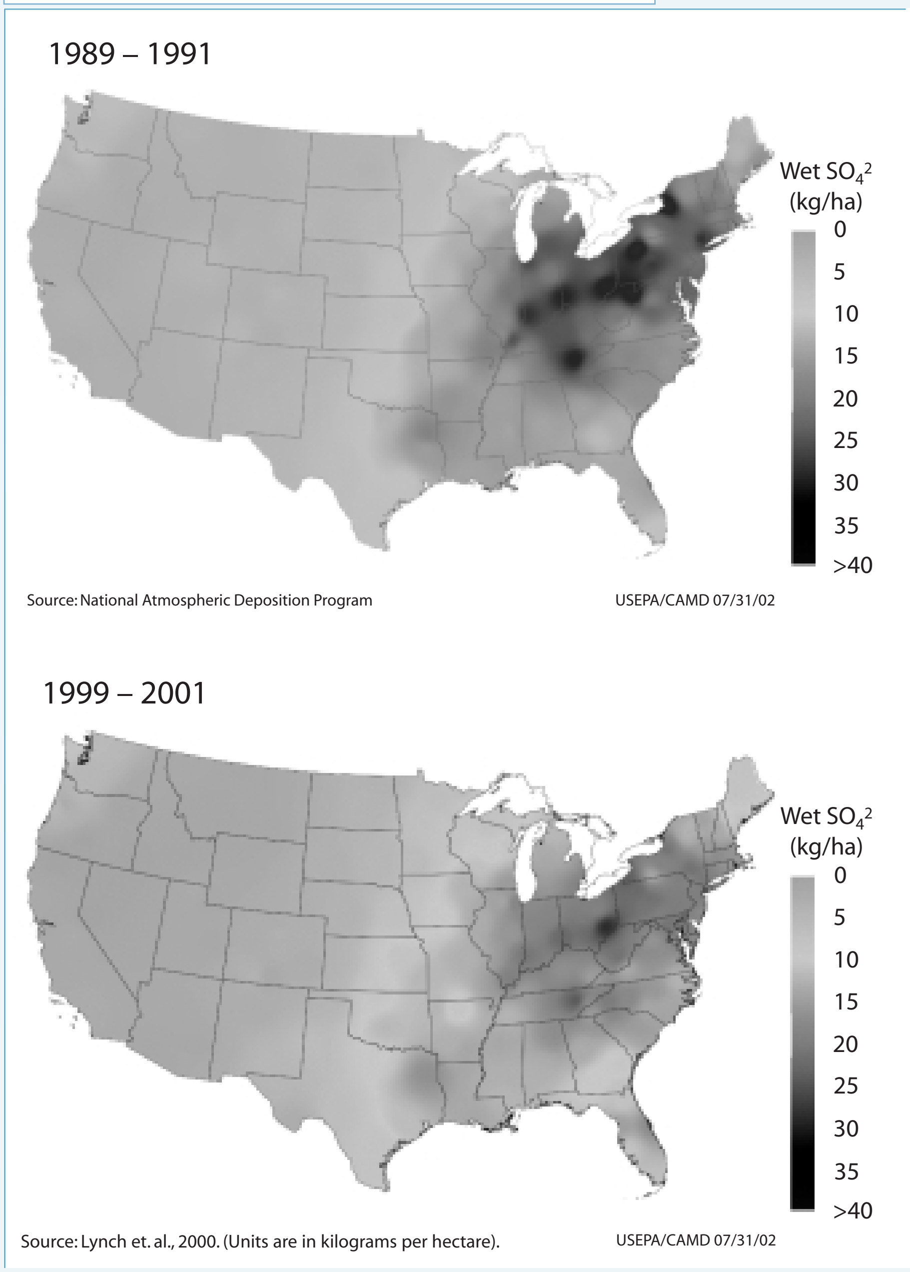
Wet Deposition: Field data collected by the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) show that sulfate levels in precipitation have dropped sharply since the SO_2 Emissions Trading Program began in 1995 (see Figure 16) (Lynch, et al., 2000).

Dry Deposition: The Clean Air Status and Trends Network (CASTNet) measures dry deposition of sulfur and nitrogen at approximately 100 sites. Like wet deposition, dry deposition can cause acidification of surface waters. It is also linked with damage to materials. CASTNet data show that dry deposition sulfate concentration levels also have declined by approximately 30 percent in the Northeastern United States and Mid-Atlantic (Holland, et al., 1999).

* Regional trends in ambient SO_2 concentrations. Percentage is the percent drop in SO_2 concentration in each Region. Trends are decreasing, with most prominent trends in the Northeast and Mid-Atlantic states.

Surface Water Impacts: A recent study examining surface water quality in acid-sensitive regions of the United States found that, since the beginning of the U.S. SO_2 Allowance Trading Program, sulfate concentrations in lakes and streams have declined significantly in all monitored regions of the Eastern United States, except Virginia. Nitrate concentrations have decreased significantly in the Catskill and Adirondack Mountains and Vermont since 1990. Increasing Acid Neutralizing Capacity (ANC) demonstrates that recovery is occurring in the Adirondacks and Pennsylvania, spurred by the sulfate reductions achieved by the program. (USEPA, 2003).

Figure 16. **Trends in Wet Sulfate Deposition**



Continued Economic Assessment in the U.S. SO_2 Allowance Trading Program

To evaluate the scientific (and economic) effects of acid deposition in the United States, a National Acid Precipitation Assessment Program (NAPAP) was established in 1980. After a decade of research on the causes and effects of acid rain, NAPAP produced a comprehensive Integrated Assessment Report, published in 1991. Part of this effort included an economic evaluation of environmental impacts in selected affected areas for which data were available and where the valuation methods could be credibly applied. The report explicitly recognized that there were limitations in the assessment due to a lack of proper scientific or economic data and models and that the results did not present a full picture of the total value of the damages caused by the regional air pollutants.

A decade later, as methodologies for the economic evaluation of environmental effects improved and continued research was undertaken, more comprehensive estimates indicate that the benefits of the SO_2 reductions achieved are very high, particularly the reduced health risks of premature mortality and morbidity. Estimates of the annual health benefits alone in 2010 are in the order of 17 to 70 billion 1995 U.S. dollars per year (Ostro, et al., 1999). An updated analysis conducted in 2000 projects annual benefits of about 50 billion 1997 U.S. dollars per year beginning in 2010 (Watkins, 2001).

In addition, recent estimates of the costs of attaining the emission reduction target have been significantly lower than expected. In 1989, the EPA estimated annual costs of the program to participating sources at full implementation (2010) to be approximately $5.7 billion annually. A current EPRI estimate predicts annual costs of $1.6 billion in 2010. Other recent annual cost estimates have been as low as about $1 billion per year by 2010 (Carlson, et al., 2000).

Economic Assessment

Economic assessments are useful to evaluate whether the cap and trade program is delivering the expected economic benefits. Assessments include a comparison of the environmental and human health benefits (or damages avoided) as a result of the program, and the total costs of compliance (NAPAP, 1998; Burtraw, et al., 1998). These types of analyses can be used for a more comprehensive cost-benefit analysis to evaluate whether further emission reductions and/or additional control programs are warranted.

Market Assessment

Market assessment (i.e., tracking allowance trading activity and prices) is another important aspect of a cap and trade program. The volume of activity (i.e., the number of transactions that occur) indicates whether the market for allowances is liquid and whether it is working effectively to minimize the economic costs of achieving the emission reduction target. Of particular importance is a measure of the number of allowances traded in "arm's-length" transactions, or trades that occur between unaffiliated companies. It is these trades that have market significance (Kruger and Dean, 1997) and demonstrate that an allowance market has developed.

Program Refinement

Once a cap and trade program has been implemented, assessment of the program is valuable to ensure its effectiveness. It is important not only to assess the environmental and economic effectiveness of the program, but also to assess the implementation. Policymakers should consider whether these procedures could be improved or if they could be more cost-effective.

After gaining some experience of program implementation, policymakers should consult with the emission sources, as well as use the experience from the sources to assess whether changes are warranted in the implementation rules and procedures. In addition, input should be solicited from other stakeholders. Based on such input, it can be determined whether the program would benefit from refinement and if so, a process and timetable can be established. It is important to minimize disruption in the program and realize that some changes, even if they would have been a better choice from the start, are not worth implementing because of the disruption they would cause. The sources, as well as the regulating authority, have learned the rules and any changes, even improvements, might require more time on their part to learn and implement. On the other hand, it is very possible that there will be changes where the benefits will outweigh the disruption caused by change.

Rule Revision Based on Implementation Experience in the U.S. SO_2 Allowance Trading Program

Under the U.S. SO_2 Allowance Trading Program, EPA initiated a stakeholder process after the first few years of implementation to solicit input on the implementation and experience with the emissions measurement requirements of the program. The EPA office responsible for the design and implementation of the program led the stakeholder process. The process involved the regulated power plants that were implementing the requirements, the state and local environmental agencies that help EPA perform field audits of affected facilities, and environmental groups interested in the integrity of the program. Based on the input from the stakeholder process, EPA developed a revised set of emissions measurement rules and procedures aimed at streamlining the process for both the sources and the regulators. While maintaining or improving the quality of the emissions data and the integrity of the program, the revised rules clarified sections that were unclear or misleading, increased the cost-effectiveness of the rules, and addressed real-life situations that were not envisioned when the rules were first written. EPA released the revisions in draft form to interested stakeholders and requested comments on the revisions, which were incorporated, as appropriate, before finalizing the revised rules. Once the revised rules were finalized, EPA provided an additional year before requiring their use. This gave sources time to learn and implement the new rules.

Glossary of Terms

Acid deposition: The process by which acidic particles, gases, and precipitation leave the atmosphere. More commonly referred to as acid rain, acid deposition has two components: wet and dry deposition.

Acid rain: The result of sulfur dioxide (SO_2) and nitrogen oxides (NOx) reacting with water in the atmosphere and returning to earth as rain, fog, or snow. Broadly used to include both wet and dry deposition.

Acid Rain Program: The regulatory program created under the U.S. Clean Air Act to reduce acid rain. It employs a cap and trade framework to reduce SO_2 emissions from electric power plants. The Acid Rain Program is also known as the U.S. SO_2 Allowance Trading Program, the U.S. SO_2 cap and trade program, and the U.S. SO_2 emission trading program. The Acid Rain Program also requires reductions in NOx emission rates from coal-fired power plants.

Additionality: A determination of whether emission reductions from a project would have occurred under normal business conditions (i.e., in the absence of a crediting program).

Affected source: A facility that produces emissions and is subject to the provisions of an emission control regulation.

Allowance: An authorization to emit a specific amount of a pollutant under a cap and trade program. For example, in the U.S. SO_2 Allowance Trading Program, one allowance is the authorization to emit 1 ton of SO_2. Allowances are used for compliance and can be traded among sources participating in the cap and trade program.

Anyway tons: See “Additionality.”

Arm’s length transactions: Allowance transactions between companies that are unaffiliated with one another.

Ascending bid auctions: An auction in which both price and allowance quantity are determined through a process of open competition. Each bidder has full information about the current clearing price and can update their bids to increase price or change quantity, changing losing bids to winning bids. Those willing to pay the most win the allowances.

Banking: A form of temporal flexibility that gives sources the opportunity to save unused allowances and/or offsets for use in a later compliance period.

Broker: The person who acts as an intermediary between a buyer and a seller, usually charging a commission.

Bubble: A regulatory term that applies to the situation when a company combines a number of its sources in order to control pollution in aggregate; under a bubble facility operators are allowed to choose which sources to control as long as the total emissions from the combined sources is less than or equal to the amount each source would have emitted under the conventional requirement

Cap: The overall emission limit that a group of affected sources cannot exceed under a cap and trade program. May also be referred to as the aggregate emission quota, level, target, or budget.

Cap and trade: A market-based policy tool that establishes an aggregate emission cap on total emissions from a group of sources and creates a financial incentive to reduce emissions. The emission cap is expressed as allowances distributed to individual emission sources that must surrender allowances to cover their emissions. The program provides the flexibility for sources with low-cost reductions to reduce even further and sell allowances to others with higher costs of control, resulting in achievement of the environmental goal at lowest cost.

Clean Air Act Amendments (CAAA) of 1990: A reauthorization of the Clean Air Act passed by the U.S. Congress in 1990. The CAAA, which included provisions for the U.S. SO_2 Allowance Trading Program, strengthened the ability of EPA to set and enforce pollution control programs aimed at protecting human health and the environment.

Command-and-control: A policy tool in which the regulating authority establishes the necessary emission reduction or applicable emission limit for specific sources, typically by setting a source-specific emission rate standard or mandating the installation of specific emission reduction technology.

Credit: Under a rate-based trading program, credits can take the form of an authorization to emit a specific quantity of emissions (e.g., 1 ton) when an emission source achieves an emission rate below the specified performance rate. Under a project-based trading program, once certified by an authorized expert to ensure the emission reduction is real, additional, and long-term, a credit is an authorization to exceed a rate or other pre-existing standard by a specific amount (e.g., 1 ton).

Crediting period: the number of years during which an emission reduction project is eligible to receive credits for actual emission reductions.

Designated representative: Under the U.S. SO_2 Allowance Trading Program, the individual who represents the owners and operators of an affected source and performs allowance transfer requests, emission reports, and all correspondence with EPA concerning compliance with the U.S. SO_2 Allowance Trading Program.

Downstream: A type of cap and trade system in which affected sources are those facilities or consumers after the point in the product cycle where the emissions actually escape to the atmosphere. For example, electricity consumers are downstream from the emissions that occur at the electricity generator.

Emission target: The level of allowable emissions in a cap and trade program. See also "cap."

Environmental integrity: The ability of an emission control policy, such as an emission trading program, to achieve its environmental objective (e.g., reduce or limit emissions to a specific quantity).

Flue gas desulfurization (FGD): Post combustion control technologies designed to remove SO_2 from flue gases. FGD technologies can be grouped into two general categories of wet and dry processes. In the most common type, a wet limestone scrubber, the flue gas enters a large reaction vessel (spray tower or absorber), where it is sprayed with water slurry containing limestone. The calcium in the slurry reacts with the SO_2 to form calcium sulfite or calcium sulfate that is removed from the reaction vessel and the water is removed. The thickened waste can either be disposed of or used to produce a by-product such as gypsum.

Fuel flow meter: An instrument that measures the volume or mass of fuel burned.

Fungibility: The interchangeability of allowances, credits, and/or offsets, assuming that each represents a consistently measured and standardized unit of emissions.

Ground-level ozone: The occurrence in the troposphere (i.e., at ground level) of a gas that consists of three atoms of oxygen (O_3) and is formed through a chemical reaction involving oxides of nitrogen (NO_x), volatile organic compounds (VOC), heat, and light. At ground level, ozone is an air pollutant that damages human health, vegetation, and many common materials and is a key ingredient of urban smog.

Hotspots: Geographically and temporally concentrated pollution levels that exceed desired emission levels or ambient air quality standards. Under some circumstances, hotspots may result in conjunction with an emission trading program if appropriate safeguards are not designed into the program (e.g., a stringent cap).

Leakage: Occurs when economic activity is shifted as a result of the emission control regulation and, as a result, emission abatement achieved in one location that is subject to emission control regulation is offset by increased emissions in unregulated locations.

Marginal abatement cost (MAC): The amount of money a source will need to spend to reduce the next ton of emissions of a specific pollutant.

Mass balance approach: An emission estimation method in which inputs and outputs are compared to calculate the emissions of the relevant pollutant.

Net buyer: Under a cap and trade program, an allowance trader that acquires more allowances than they sell.

Nitrogen Oxides (NOx): Gases produced during combustion of fossil fuels in motor vehicles, power plants, industrial furnaces, and other sources. NOx is a precursor to acid rain and ground-level ozone.

Offset: An emission reduction of a specific quantity of a pollutant (e.g., 1 ton) verified through a project-based trading program. An offset can be applied to regulatory emission limits as an authorization to emit that specific quantity of pollutant. See also definition of "credit."

Ozone Transport Commission (OTC) Regional NOx Trading Program: A NOx cap and trade program adopted by jurisdictions (states and the District of Columbia) in the Northeastern United States to address ozone transport in that region.

Paper credits: Generated under project-based trading programs if the emission baseline for a project is set at a level greater than the one at which the source actually operates. If such a baseline is used to calculate the quantity of credits or offsets generated by the project, the resulting credits or offsets do not reflect real emission reductions. Similarly, paper credits could also occur under a rate-based trading program if the performance standard is set at a level above which a source actually operates.

Performance standard: A quantity of emissions allowed per unit of heat input or product output.

Permanence: A concept associated with project-based trading that refers to whether carbon stored in the biosphere (i.e., carbon sequestration and sinks) might later be emitted to the atmosphere (e.g., by a forest fire). Permanence should be addressed so that offsets awarded for carbon stored in a tree which later burns down are not used to allow extra emissions elsewhere.

Point of emission: A type of cap and trade system in which affected sources are those facilities where the emissions actually escape to the atmosphere. For example, the U.S. SO_2 Allowance Trading Program is a point of emission program because the affected sources are electric generating units that combust fossil fuel and emit pollutants into the atmosphere. This kind of program is often referred to as a downstream program in the United States and a midstream program in Europe.

Project host: An emission source that hosts a project to reduce emissions and generate offsets under a project-based trading program.

Price signal: An indicator of what people or businesses are willing to pay for allowances or what firms are willing to accept as payment for their surplus allowances (or credits). Transactions, whether auctions or sales, provide a signal of the price that emission sources and other market participants are willing to pay for allowances.

Ratchet: A procedure that adjusts each source's allocation proportionately, so that the total allocation matches the number of allowances in the overall cap. This system promotes environmental integrity by ensuring that formulas used to determine allocations do not inflate the cap.

Rate-based trading: A trading approach in which the regulating authority determines an emission rate performance standard (i.e., an amount of emissions allowed per unit of heat input or product output) for a sector (e.g., tons/kWh) and allows sources that over- and under-comply with the standard to trade credits. (The rate difference needs to be multiplied by each sources' utilization to establish a tradable mass emission based credit or offset.)

Scarcity value: The economic value of an allowance or credit due to the limited quantity available.

Scrubber: A post-combustion control technology utilizing a sorbent to remove SO_2 from the emission stack. See also "Flue gas desulfurization."

Stationary source combustion: The process of burning fuel by a source, such as a boiler, that is in a fixed location (i.e., not mobile).

Source: An entity that releases airborne pollutants into the environment.

Sulfur dioxide (SO_2): A gaseous pollutant that is primarily released into the atmosphere as a by-product of fossil fuel combustion. The largest sources of SO_2 are power plants that burn coal and oil to make electricity.

Trade: An exchange of allowances, offsets, or credits for cash or other considerations under an emission trading program.

Trader: Anyone who buys or sells allowances.

Transaction costs: Financial costs associated with a transaction under an emission trading program. The costs are usually related to identifying, verifying, and certifying emission reductions. These may include partner search costs, travel and communication, negotiation activities, legal and contracting costs, potential litigation costs, ex-post challenges, opportunity costs associated with delays and uncertainties, and other related costs.

Upstream: A form of cap and trade where the obligation of compliance is placed 'upstream' of the actual emission sources (e.g., at the fuel producer), such that the affected sources under the program are not the facilities where emissions actually escape to the atmosphere.

Vintage: Represents the first year, or compliance period, in which a particular allowance can be used for compliance in a cap and trade program.

Acronyms

ARAC	Acid Rain Advisory Committee
ATM	Allowance Tracking Module
CAAA	Clean Air Act Amendments
CEMS	Continuous Emission Monitoring System
CH_4	Methane
C-MAP	Clean Air Mapping and Analysis Program
CO_2	Carbon Dioxide
DAHS	Data Acquisition and Handling System
ELI	Environmental Law Institute
EPA	U.S. Environmental Protection Agency
EPBs	Environmental Protection Boards
ETM	Emissions Tracking Module
FGD	Flue Gas Desulfurization
GHGs	Greenhouse Gases
ISO	International Standards Organization
MAC	Marginal Abatement Cost
MMBTU	Pounds per million British Thermal Units
MSD	Marginal Social Damage
NAPAP	National Acid Precipitation Assessment Program
NOx	Nitrogen Oxides
OTC	Ozone Transport Commission
QA/QC	Quality Assurance/Quality Control
RCM	Reconciliation and Compliance Module
RECLAIM	Regional Clean Air Incentives Market
RFF	Resources for the Future
SIP	State Implementation Plan
SO_2	Sulfur Dioxide
TEV	Total Economic Value
USD	U.S. Dollar

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A

The Optimal Level of Pollution

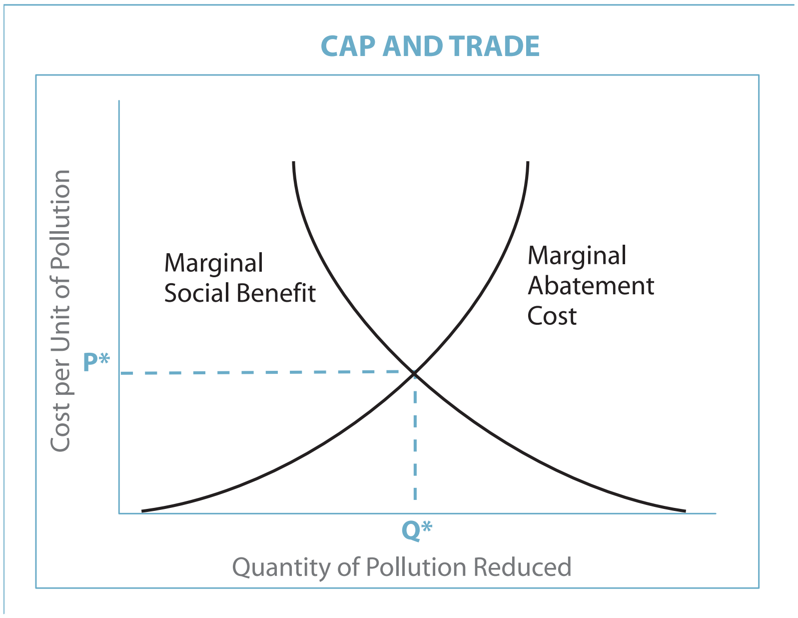
According to economic theory, excessive levels of pollution occur due to so-called “market failures,” such as the public goods nature of environmental quality, imperfect information, and other factors. Hence, according to economic theory, governments should intervene to provide the correct incentives for pollution control. Determining the optimal level of pollution control requires an analysis of the level of the environmental externality that is being generated as a result of an economic activity. An externality is defined as a cost or a benefit that is not being properly accounted for by either the producers or the consumers of the activity. For example, consider the case of a firm located upstream that is emitting pollution into a nearby stream. As a result, ecosystems downstream may be adversely affected (e.g., fish population decline, decline in recreational fishing and swimming, adverse health effects from contaminated drinking water). These are all examples of negative externalities (i.e., costs). If these effects are not reflected in the firm’s production costs, and hence in the market price of the economic activity, the firm will emit a level of pollution that is above the social optimum. Generally, two conditions need to prevail for an external cost to exist: (1) an activity by one party causes a loss of welfare to another party; and (2) the loss of welfare is uncompensated.

Figure A-1 depicts the socially optimal level of pollution. The Marginal Social Benefit (MSB) curve shows that initial emission reductions provide greater benefit than subsequent emission reductions.

Pollution abatement, however, costs less for the initial reductions but each additional (or marginal) unit of pollution control costs more than the previous unit. Thus, the Marginal Abatement Cost (MAC) curve is steeper as the quantity of emission reductions is increased.

The optimal level of pollution control occurs where MAC = MSB. Hence, to achieve this level, the regulating authority would want to limit the aggregate level of emission reductions to the level Q*, which reflects the marginal cost associated with that level of economic activity, P*.

Figure A-1. **Economically Efficient Control of Pollution**



The Economics of Emission Trading

Cap and trade programs are superior to the more traditional command-and-control approaches for environmental regulation because the emissions target—established via the cap—is achieved at a minimum economic cost through the trading of the allowances. The regulating authority determines the total allowable level of emissions and issues allowances for this amount (ideally Q* in Figure A–1 above). The allowances are then allocated to the sources, which are allowed to trade with other sources in the allowance market. In this way, firms with low marginal abatement costs will opt to reduce emissions beyond the number of allowances they hold and sell the excess allowances to firms with higher marginal abatement costs. Thus, marginal abatement costs across all sources are equalized and the costs of attaining the environmental target are minimized.

B

Example Assessment of the Potential For Cap and Trade

Case Study of SO_2 in the United States: Assessing the Potential for Cap and Trade

Questions for Consideration	A Case Study of SO_2 in the United States
ENVIRONMENTAL SCIENCE ISSUES	
What is the nature of the environmental problem?	Emissions of SO_2 and sulfates damage human health, ecosystems, visibility, and materials (e.g., buildings and monuments (NAPAP, 1991)). During the 1980s, the most pressing concern was the impact of acid deposition on lakes and streams. Today, there is more research linking sulfate particles to human health problems and mortality (USEPA, 1995). New studies also show links between acidic deposition and forest damage.
What is the geographic scope of problem?	Acid deposition was greatest in the northeast United States and Canada, but other regions of the United States had some impacts and emissions were known to travel from west to east across the country. Electric utilities operate in more than one state so national coverage was important to minimize generation and emission shifting outside of the control area.
Can emission sources be linked to the environmental problem or health issue?	A decade of research collected by the National Acid Precipitation Assessment Program (NAPAP) quantified the transformation and long-range transport of sulfate particles (NAPAP, 1991). The largest emission sources were located in the Midwest and found to impact downwind areas.

Case Study of SO_2 in the United States: Assessing the Potential for Cap and Trade

Questions for Consideration	A Case Study of SO_2 in the United States
What are the major sources of emissions?	In 1980, electric utilities were responsible for more than 70 percent of total SO_2 emissions in the United States (NAPAP, 1991).
Are there accurate measurement methods for the sources identified?	Technology existed to accurately measure emissions but was not widely applied. The trading program required continuous emission monitors for all coal-fired boilers in the program, and all sources were required to provide a complete accounting of emissions.
What are emission projections from each sector?	Emission projections showed that emissions from the utility sector alone would increase to nearly 20 million tons by 2010 if action was not taken (NAPAP, 1991).
ECONOMIC ISSUES	
Are there available emission reduction options?	A variety of cost-effective technological, fuel switching, and energy efficiency options existed.
Do different sources face different costs?	Sources faced a wide range of compliance costs and control options (e.g., installing scrubbers, switching fuels, increasing energy efficiency).
What do different marginal costs imply about where to expect reductions?	Generally, the highest emitters had lowest costs to reduce emissions (on a cost per ton basis). In the United States, most of those sources were located in the Midwest and Ohio River Valley.
What are the overall costs and benefits?	Economic models were used to estimate the costs of different alternatives. The cost of emission trading was estimated to be significantly lower than traditional approaches. The NAPAP report estimated significant benefits, but were not initially monetized.
Are there any adverse environmental implications to using emission trading?	Analyses were undertaken to predict which sources are likely to be buyers of allowances and which sources are likely to be sellers of allowances. Estimates of the location of emission reductions and trading activity can then be made. This information can be used to predict trading activity and air quality impacts. There are also ways to incorporate specific requirements to prevent problems, like "hotspots."
Are there sufficient sources for a fluid market?	The electric power sector contained over 2,000 sources including coal burning, natural gas, oil and wood-fired sources (serving generators larger than 25 MWe).
INSTITUTIONAL AND TECHNICAL ISSUES	
Is there sufficient enforcement authority to make a trading program work?	Automatic penalties for not holding enough allowances were established. These penalties were set at $2,000 per ton, with annual increases to reflect inflation. Allowances for the following year are confiscated for every ton emitted over allowance levels. The CAAA has additional criminal and civil penalties of up to $25,000 a day per violation.

Case Study of SO_2 in the United States: Assessing the Potential for Cap and Trade

Questions for Consideration	A Case Study of SO_2 in the United States
Is there an infrastructure to measure, report, and manage source specific emission data?	The existing infrastructure was not sufficient to provide the needed accuracy and handle the volume of data in a timely fashion. EPA established standard measurement and reporting protocols for affected sources. Tracking systems were developed for unit specific (i.e., boiler-level) emission data and for allowance transfers. Data are available to the public on the EPA Internet site.
Are there adequate resources to manage emission data?	Approximately 75 percent of administrative resources in the U.S. SO_2 Allowance Trading Program are devoted to measuring, tracking and quality assuring emissions. An electronic emission tracking system was developed to receive emission data electronically directly from sources.
Is there a system and central authority that can be used to determine compliance?	In the United States new systems were created (emission and allowance tracking systems) to determine compliance. Authority for determining compliance was part of the legislation, and EPA historically had been responsible for a variety of compliance and enforcement actions.
Does legal authority exist for an emission trading program?	New legislation was developed for the SO_2 Allowance Trading Program—Title IV of the 1990 CAAA.
How can an emission trading program be integrated with existing policies?	Title IV of the CAAA requirements was separate from existing regulatory programs and written to interface smoothly with other policies. Sources still have to comply with existing ambient standards and permitting requirements for SO_2.
What developments are occurring in the affected source sector?	Energy power restructuring has proceeded as the U.S. program has been implemented. Cap and trade is compatible with a competitive energy sector.

OTHER CONSIDERATIONS

Are there any social or economic factors limiting fuel choices?	Concerns about unemployment in the coal mining industry were a significant factor in the United States.
Are the needed emission reductions politically acceptable? Is emission trading politically acceptable?	The process for assessing policy approaches to address acid rain involved many government agencies. After the Act was passed, there was an extensive stakeholder process, including an Acid Rain Advisory Committee, to solicit input into implementing regulations. Outreach is continuously needed to help educate the public about the environmental benefits of emission trading.

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