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International experience with SO_2 emissions trading mechanisms

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China Thermal Power Efficiency Project

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Executive Summary

The China Thermal Power Efficiency Project seeks to reduce coal consumption from inefficient power plants in a number of ways, including modifying power system operations through changes in dispatching procedures, investing in technology improvements, and shutting down smaller, inefficient units. It is also examining the role of SO_2 emissions trading in Shanxi and Shandong Provinces, in order to help small plants offset closure costs, improve monitoring and evaluation, and help achieve the goals noted above.

SO_2 emissions trading has been conducted at various locations around the world since the mid-1970s. China itself has experimented with a number of such programs, including a previous effort within Shanxi Province (in an Asian Development Bank-sponsored project in Taiyuan). Canada introduced an experimental Pilot Emission Reduction Trading (PERT) program in 1996 in Ontario, and this was followed by a regulatory program addressing the power sector and major industrial facilities in 2001.

But the most extensive and important international experience with SO_2 emissions trading has taken place within the United States, and accordingly, this report pays particular attention to these efforts. The U.S. introduced the idea of emissions trading in 1976, and has developed four distinct SO_2 trading regimes over recent decades:

1. The U.S. Emissions Trading Program (ETP), trading SO_2 emission reduction credits (ERCs);
2. The Acid Rain Program (ARP), developed under Title IV of the Clean Air Act Amendments of 1990, trading SO_2 emission allowances;
3. The Clean Air Interstate Rule (CAIR), adopted by US EPA in 2005 but struck down by the courts in 2008, modifying SO_2 emission constraints in the Eastern portion of the U.S. and allowance trading requirements for those sources;
4. The Cross-State Air Pollution Rule (CSAPR), adopted by US EPA in 2011 and scheduled to begin implementation in 2012, replacing CAIR and also modifying

SO_2 emission constraints and allowance trading requirements for Eastern U.S. sources.

There are two important considerations associated with understanding the U.S. SO_2 emissions trading program, and its relevance for China:

- *The air quality goals of the SO_2 trading programs have changed over time*.

  Initially, in the mid-1970s, attention focused on reducing SO_2 concentrations in order to improve localized air quality, and help attain the National Ambient Air Quality Standards (NAAQS) for that pollutant. US EPA's ETP was designed to help accomplish this objective. In 1990, Congress introduced the ARP, designed to reduce the total loading of this pollutant, and thereby reduce acid rain. After 2005, the CAIR and CSAPR SO_2 trading programs were designed to reduce the formation of fine particulate (i.e., the formation of PM-2.5), and help achieve the PM-2.5 NAAQS introduced in 1997.

- *The different* SO_2 *trading programs operate concurrently*.

  There are three separate SO_2 trading programs operating in the U.S. at the present time, trying to accomplish these three separate goals. The U.S. EPA's ETP began in 1976 and continues today, targeting localized SO_2 NAAQS. The Title IV SO_2 trading provisions became part of the law in 1990, were initially implemented in 1995, and continue today, targeting SO_2 total loading and acid rain. SO_2 trading under CAIR was promulgated in 2005, began implementation in 2010, and is currently operational today addressing fine particulate formation. It will be replaced at the end of this year, however, by CSAPR SO_2 emissions trading, which will have a similar goal.

China faces difficult implementation choices in trying to replace all three programs with one single SO_2 trading program operating at the Provincial level. Nonetheless, the reduction of SO_2 emissions will help to achieve all three air quality goals.

By design, this report focuses on the international experience with SO_2 emissions trading and does not focus on China's previous experience. It begins by laying out the rationale for SO_2 emissions trading within a historical context, describing both traditional (i.e., command-and-control) mechanisms and the development of economic approaches. It then describes the international SO_2 trading programs, and a number of specific topics associated with these international programs which may help guide such choices:

- *Allowance allocation*

  One of the powerful properties of allowance-based trading schemes is the so-called '*independence property*,' which allows equity and efficiency concerns to be addressed separately. This has proven to be a very important factor for U.S. politicians, because it allows them to distribute allowances in a manner designed to reduce political resistance to the pollution control program. It may, however, play a less important role within China's political system.

- *Hot Spots*

  When the government allows trading, it loses the ability to dictate which sources perform the pollution control – and this can lead to 'hot spot' areas which do not receive sufficient control. This was not found to be a problem in the U.S. ARP, however, and the other U.S. trading systems have been sufficiently constrained by design to avoid 'hot spot' problems.

- *Regulatory Oversight*

  The market-based mechanisms employed in the U.S. were initially grafted onto an existing command-and-control regulatory program, and the three environmental goals demand differing levels of involvement and oversight from local, state and federal environmental regulators. The resulting air quality management system is thus somewhat complicated and opaque for many not familiar with its evolution, especially given the legalistic and adversarial nature of the U.S. regulatory process. The high level of emission source compliance and the significant environmental results achieved suggest that it has been effective, however.

- *Continuous Emissions Monitoring*

  The introduction of emission trading led to a regulatory system much more reliant on technology to document compliance, and in particular the use of continuous emissions monitoring systems (CEMS) accompanied by both financial and environmental penalties. Based on these parameters, the U.S. has been able to develop an SO_2 trading program with very high levels of emission source compliance.

- *Ambient Impact Monitoring*

  The SO_2, acidification and PM-2.5 trends are all generally downward over recent years in the U.S., with a 65% decrease in national annual average SO_2 concentrations over the period 1990-2009; a 27% decrease in annual average PM-2.5 over the 2000-2009 period; and a 43 percent decrease in wet deposition of sulfate across the Eastern part of the country between 1989–1991 and 2007–2009. These suggest that the U.S. market-based programs for SO_2 have been quite successful. A small number of locations are still not achieving the SO_2 NAAQS, but non-attainment of PM-2.5 remains a problem in a significant number of areas (and was thus addressed with the CSAPR control program).

- *Institutional Trading Infrastructure*

  While carbon trading has relied heavily upon the role of emissions exchanges to accomplish market efficiencies, this has not been the case with SO_2 emissions trading. SO_2 emissions trading has primarily exhibited 'compliance market' rather than 'financial market' characteristics, with emissions sources rather than financial firms the principal market participants. Emissions exchanges, financial derivatives, secondary trading, and similar carbon market components have not played a significant role in SO_2 trading.

This report concludes with the following recommendations for the design of the Shanxi and Shandong Province programs:

- Begin with one SO_2 trading instrument, utilizing allowances;

- Recognize the limitations on localized air quality associated with such an approach, and track SO_2 impacts (i.e., through both dispersion modeling and ambient monitoring);

- Explicitly address compliance concerns in the SO_2 trading program design, through both CEMs and auditing;

- Try to move the SO_2 trading program towards a market-based (rather than administrative-based) regulatory system by:
  - Undertaking capacity development concerning control option costs and trading opportunities for emission sources;
  - Providing transparency in the reporting system, through governmental publication of registry transactions or even considering a more active brokerage function;

- Explore political opportunities within the allocation scheme, particularly those supporting small sources faced with shutdowns;

- Recognize that SO_2 emissions trading is likely to be an interim strategy. Shifts towards cleaner fuels or full controls on all SO_2 emissions sources will ultimately be necessary to fully accomplish environmental goals; and

- Recognize that the environmental goals must dictate the nature of the economic instrument program, rather than the converse. Emissions trading is designed to accomplish environmental goals using economics, not to meet economic goals (i.e., wealth or job creation) using the environment.

1. Introduction

China's coal-fired power plants operate at low efficiency compared with international norms, and this has significant environmental consequences for the country. A large share of the electrical generation comes from small-scale, inefficient units, which have been dispatched at levels comparable with larger, more efficient units.

In order to increase supply-side thermal power efficiency in the China's power sector, and thereby reduce coal consumption, greenhouse gas emissions, and other environmental impacts, the GEF and World Bank implemented the China Thermal Power Efficiency Project in 2009. This project seeks to reduce coal consumption from inefficient power plants by modifying power system operations (e.g., through changes in dispatching procedures); investing in technology improvements; and shutting down smaller, inefficient units.

Sulfur dioxide (SO_2) emissions trading is fully consistent with such efforts, and one of its notable characteristics is its ability to ease the transition from one regulatory state to another with lower pollutant levels. Accordingly, the thermal power efficiency project is exploring the potential role of SO_2 trading in two of the project's three study regions, Shanxi and Shandong Provinces.

SO_2 emissions trading has been conducted for approximately three and a half decades, in various locations around the world. While China has already undertaken a number of pilot-scale projects, and other countries such as Canada have similarly introduced programs, the vast majority of transactions and the most significant regulatory experience have occurred within the United States. The nature of the environmental goals associated with SO_2 trading has also changed significantly over those decades, moving from a concern about ambient levels of sulfur dioxide, to a concern about the total loading of this pollutant and its impact on acid deposition, to today's increased attention to fine particulate (i.e., PM-2.5) formation.

This report is designed to address that international experience with emissions trading mechanisms for SO_2. It does not address previous domestic SO_2 emissions trading efforts within China, but focuses instead on the international experience. It also focuses specifically on SO_2, ignoring the considerable international (and Chinese) experience with other pollutants such as NOx, particulate (as in Chile), and especially CO_2, which has now developed an extensive international emissions trading infrastructure in Europe, China, and around the world.

The next section, Section 2, provides a theoretical overview of environmental management, focusing on two competing concepts – engineering and economics – which provide alternative regulatory pathways for controlling sulfur dioxide. The section discusses a broad-based transition which has occurred in recent decades, as governments have sought to move from the former command-and-control type regulatory approach towards economic mechanisms.

Section 3 describes the specific applications for sulfur dioxide, paying particular attention to the U.S. experience. It notes applications in other countries, and trading programs in the U.S. in addition to the four noted above, but focuses primarily on those four distinct regimes. Section 4 gives an accounting of the important characteristics of each of those four regimes, including allocation mechanisms; ‘hot spots’; regulatory oversight; emission source and ambient monitoring; and trading institutional infrastructure. Section 5 then discusses these topics within a Chinese framework, making suggestions and recommendations for the China Thermal Power Efficiency project.

2. Regulatory Approaches to Environmental Management

The development of emissions trading markets to address environmental issues represents a strategic shift in the thinking behind environmental management. Pollution control has a long evolutionary history, beginning with traditional engineering approaches and subsequently developing into the economic realm with market-based approaches.

2.1 Engineering "Command-and-Control" (CAC) Regulation

Engineers tend to view any SO_2 emissions source as a process, as shown in Figure 2.1, with both inputs and outputs. That process might be a power plant, a car engine, or a city. Typically, pollution control is accomplished by regulating the inputs (e.g., an input standard such as a limitation on the sulfur content of coal); the process itself (e.g., a design standard mandating use of flue gas desulfurization); or the outputs (e.g., an emission limitation from the stack). Control regulation might also link the input and output in a performance standard, which is an approach used in the U.S. power sector for new sources (i.e., limiting SO_2 emissions output based upon the heat input into a boiler in New Source Performance Standards [NSPS]).

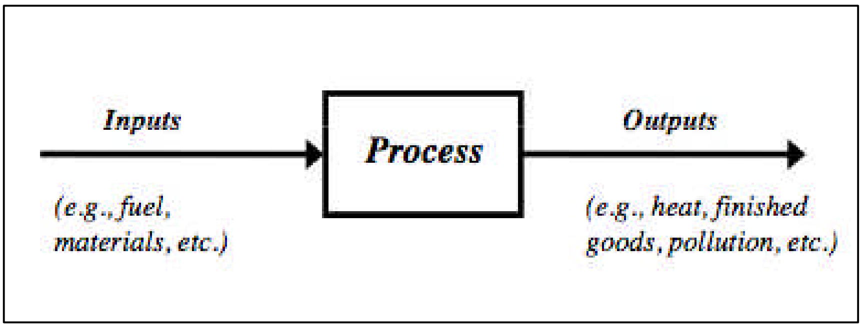


Figure 2.1 An engineer's process view

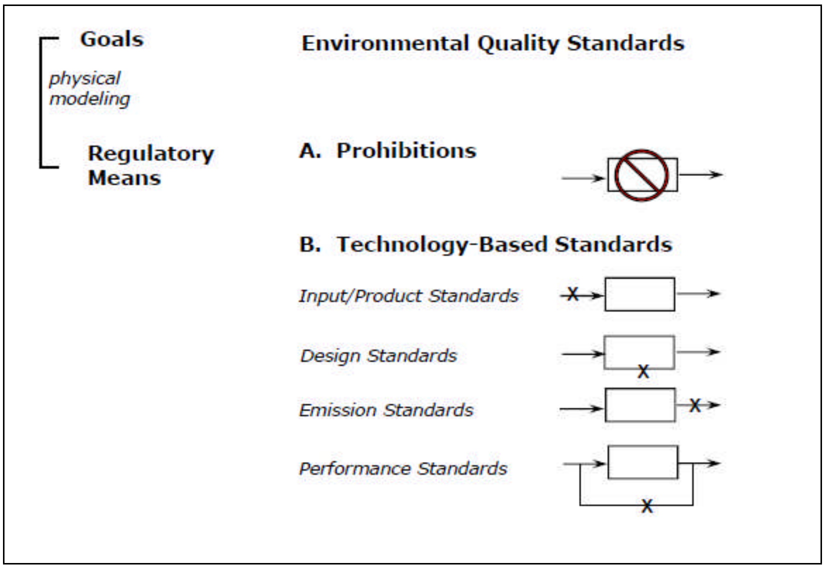
Such regulations are typically labeled 'command-and-control' (CAC) regulations because, as the name suggests, the government issues the mandates as a form of "command" and is then faced with the problem of ensuring that the command is actually followed (i.e., "control"). Control typically includes monitoring, reporting, and verification (MRV) of emissions, as well as punishment for a failure to meet the regulatory command. An absolute form of "command" is prohibition, which is used if the potential damage to the environment is severe and difficult to remediate, (e.g., the prohibited use of polychlorinated biphenyls [PCBs]). More frequently, however, technology-based requirements are employed, typically requiring polluters to meet the types of standards noted above. Monetary fines, or perhaps imprisonment for egregious cases, are now the norms for control.

CAC regulation has a long history in air pollution regulation. In 1272, for example, King Edouard I of England took an absolutist stance and banned the use of coal near his castle, noting that: ""'. . . whosoever shall be found guilty of burning coal shall suffer the loss of his head."[1] A more modern approach could be found in an 1874 amendment to Britain's Alkali Act of 1863, requiring polluters to utilize the "best practicable means" (BPM) of pollution control. From an engineer's perspective, if everyone was utilizing BPM, then whatever happened to the environment simply happened – after all, everyone was doing the best they could with technology.

An alternative regulatory approach was adopted in the U.S. in the 1960s, however. This alternative suggested that the goal of pollution control systems was not simply to use the best technology, but rather, to focus on achieving environmental quality. Technology was just a means of accomplishing such an end, not the goal itself. Environmental goals were thus developed in terms of *environmental quality standards*, and the technology-oriented requirements became recognized as the means to accomplish such goals. The linkage between regulatory means and environmental goals was accomplished by dispersion modeling (to calculate that the regulatory means would be sufficient to achieve the ambient goals), and subsequently by ambient monitoring (to ensure that the goals were actually met).

The resulting CAC programs developed in the 1970s therefore adopted the 'traditional' (i.e., engineering) approach outlined in Figure 2.2.

Figure 2.2 The engineering "command-and-control" approach to pollution regulation

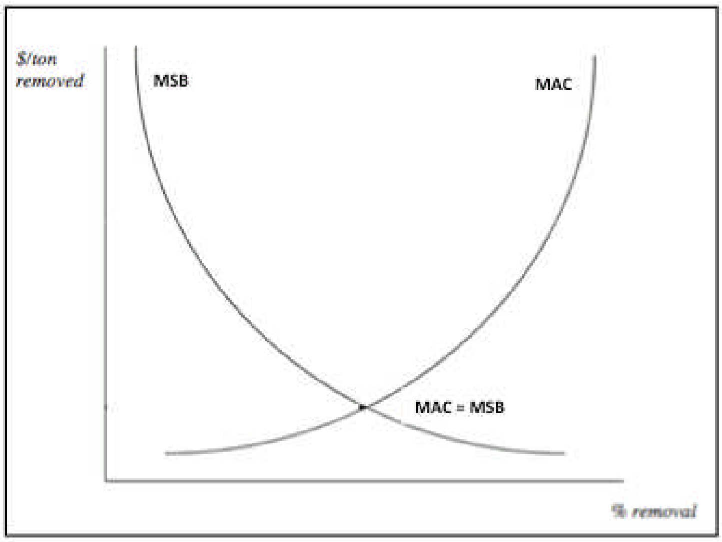


2.2 Economic Pollution Control Regulation

Economists, however, offered a very different approach to pollution control regulation. In their view, air quality is a public good, i.e., a good that can be consumed by everybody in a society, where those who fail to pay for the good cannot be excluded from enjoying its benefits. They further define an 'externality' as the impact of a transaction on a party that is not a direct participant in that transaction. Its price therefore does not reflect the full cost of a certain good. Pollution is a 'negative externality,' since the polluter does not pay the cost of detrimentally altering the public good, and this therefore represents a market failure. It is a responsibility of the government, through environmental regulation, to correct such market failure.

In standard economic theory, the marginal abatement cost (MAC) of pollution control should equal the marginal social benefit (MSB) of such abatement. This means that the goal of the economic control program should be to set a control level such that the next dollar spent on pollution control purchases exactly one dollar's worth of environmental amenities. Figure 2.3 illustrates the marginal abatement cost (MAC) and marginal social benefit curves (MSB).

Figure 2.3 The economists' approach to controlling pollution

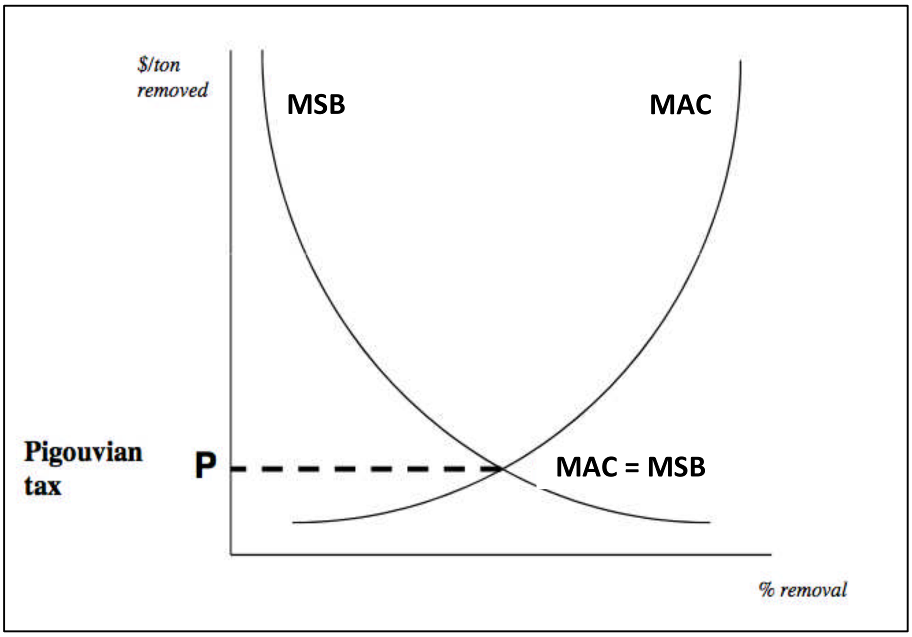


Economists offer two approaches to arrive at that point:

- A price-based mechanism, also called a Pigouvian tax
- A quantity-based mechanism, commonly referred to as emissions trading.

The Pigouvian tax approach was first developed by Arthur Cecil Pigou (1877-1959), a British economist who was a professor at Cambridge. Pigou discussed the concept of externalities in his book *The Economics of Welfare* (1920),[2] and argued that a tax should be imposed on negative externalities such as pollution in order to discourage them. If the MAC of a polluter is higher than the tax, the polluter will find it more cost-effective to pay the tax and continue emitting. If the MAC is lower than the tax, however, then the polluter will try to abate the pollution as opposed to paying the tax.

Figure 2.4 A price-based approach to control pollution: Pigouvian taxation

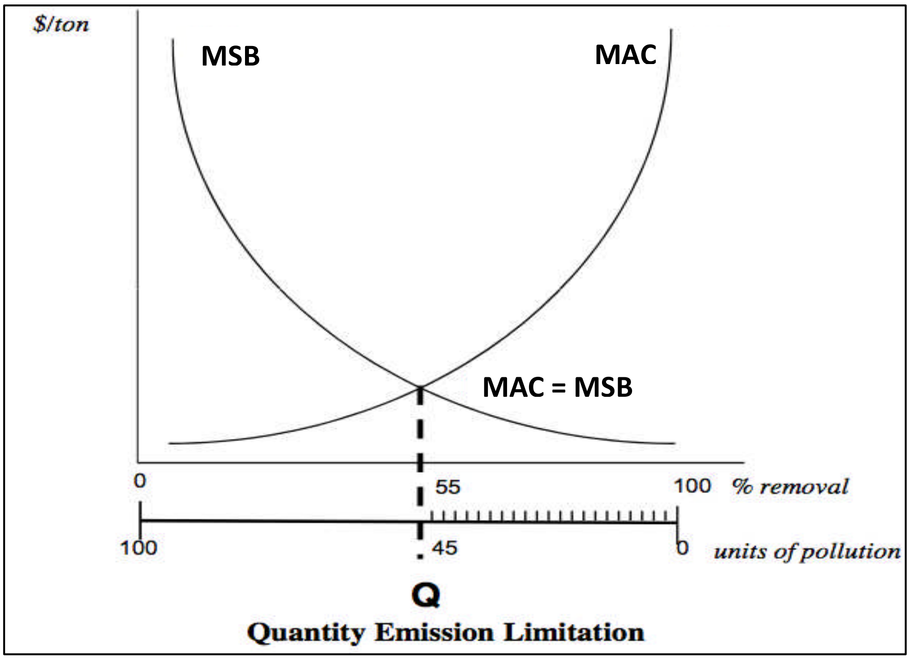


A Pigouvian tax is now considered a well-known and traditional means of bringing a modicum of market forces -- and therefore better market efficiency -- to economic situations where externalities exist. Such a tax will make it more expensive to pollute, and will ensure a change in behavior by the polluting entity, forcing the polluter to either pay the tax or implement technologies to reduce pollution, whichever is more cost-effective. Despite being an efficient solution to controlling pollution, taxes introduce a political dynamic in many countries that raises questions about wealth transfer from industry to government, the distribution of this revenue, lobbying of the government by special interest groups, polluters, etc. Economists have attempted to address the wealth transfer by linking the tax with subsidies (and utilizing the revenue generated by the tax to fund such efforts); by removing other taxes (so that there is tax neutrality); and similar schemes.

The quantity-based market approach, on the other hand, has a more complicated intellectual heritage, as it is rooted in economists' ideas about property rights. An important landmark in this area was Ronald Coase's paper "The Problem of Social Cost," which suggested that bilateral negotiation between the generator and recipient of an externality would lead to the same efficient outcome regardless of the initial assignment of property rights (in the absence of transaction costs). In 1968, John Dales, a Professor of Economics at the University of Toronto, suggested the development of a water pollutant market in his book *Pollution, Property and Prices*.[3] Dales' idea was to have an environmental authority issue a limited number of rights (or permits) to emit a specified pollutant, and then leave the determination of the price of these permits to emitters within a market. Today, transactions in such markets are commonly called "emissions trading." A regulator sets an overall emission limit ("cap"), which is the total quantity of a pollutant that the participants in the scheme are allowed to emit. That quantity is then divided into a number of “allowances,” and polluters are allowed to trade (i.e., buy and sell) such allowances in a market.

Such ‘cap-and-trade’ schemes have become quite popular over recent decades, and their success has led to the development of carbon markets under the Kyoto Protocol. In Figure 2.5 below, a cap is set at the point where MAC = MSB. In this example, it is set at the point where 55% of the pollution is controlled. A second abscissa (using units of pollution instead of percent control, and normalizing existing emissions to 100 units) translates this same cap into 45 units of pollution. These units are usually called ‘allowances,’ and thus 45 allowances could be bought and sold by polluters. Note that those with low marginal costs of control will put on control, rather than purchase such an allowance, and society will ultimately end up at the point where MAC=MSB. This figure also makes clear that those with higher marginal costs should ultimately end up holding the allowances.

Figure 2.5 A quantity-based mechanism to control pollution: Emissions trading



The distributional and other characteristics of the quantity-based approach will be discussed in detail below. It need only be noted at this point that, like the price-based approach, quantity-based schemes are economically efficient. They also have certain characteristics giving governments considerable political leverage in addressing distributional concerns, and politicians can (and have) utilized this to minimize political resistance to the pollution control program.

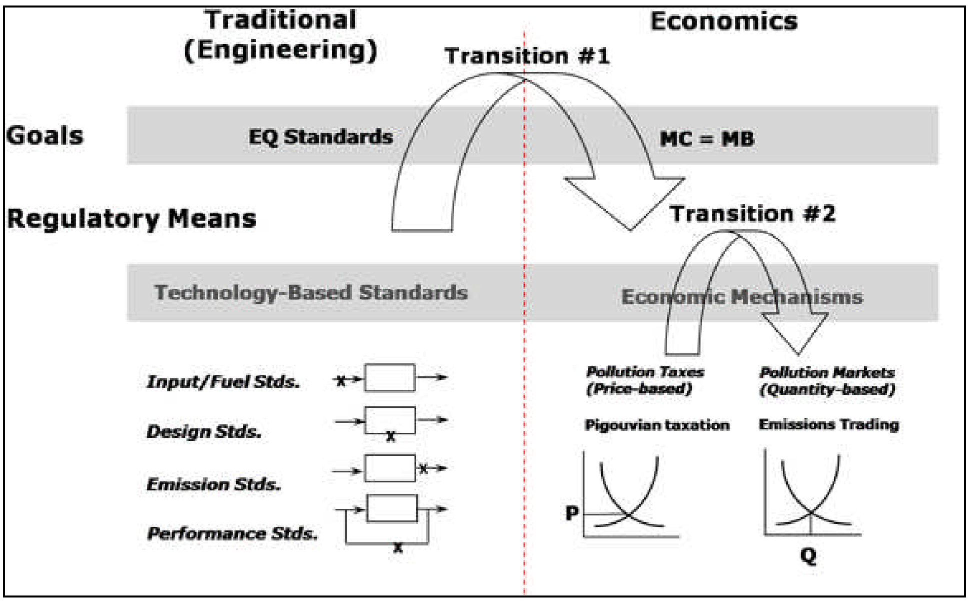
2.3 Regulatory Transition for Pollution Control?

While countries have historically adopted the engineering CAC approach, as noted earlier, there are several reasons why economic approaches have been receiving additional attention in recent years:

- Economic mechanisms allow governments to focus on setting broader environmental targets, a task they are well suited for, as opposed to dictating stack-by-stack technology standards and mandates;
- The market response of polluters will result in economic efficiency, allowing environmental goals to be accomplished at the lowest cost;
- This efficiency can in turn influence goal setting, allowing more aggressive environmental protection; and
- Perhaps most importantly, every ton of pollution has costs, giving facilities an incentive for emissions reduction.

Accordingly, Figure 2.6 suggests that two transitions are occurring today – a shift from an engineering to economic worldview in environmental management, and a secondary shift from price- to quantity-based mechanisms. There are important caveats associated with both potential transitions, however. In the first, the transition is only occurring in the bottom portion of the figure – i.e., within the regulatory means, not environmental goal setting. Governments fully recognize the difficulties associated with developing accurate MSB curves, and thus tend to stay with environmental quality standards or depend upon political compromise to set goals. However, they increasingly recognize the strength of using the economic regulatory means (i.e., Pigouvian taxation and emissions trading) as tools to help accomplish such goals.

Figure 2.6 Engineering vs. economic worldviews



A potential shift from price to quantity within economic instruments must similarly be heavily qualified. Economists make choices about the appropriate price or quantity instruments to use based upon the slopes of the MAC and MSB curves, confidence in the data used to estimate them, and similar information. Certainly many governments – and economists -- are more comfortable using price-based instruments, and it has frequently been suggested that these are a more appropriate tool for dealing with climate change (see, for example, Nordhaus[4] and Cooper[5]). Nonetheless, the political flexibility of quantity-based systems noted above, and the increasing difficulty faced by many governments in imposing taxation schemes, has led to such a longer-term shift over recent decades. Further, many believe that it is more appropriate for the government to focus on the physical goal (i.e., the quantity) and have prices respond than the converse. Notably, the EU has made cap-and-trade its predominant policy mechanism for dealing with climate change.

2.4 The Evolution of Emissions Trading

While the economists' quantity-based approach would go on to play a significant role in environmental management, governments did not make a direct leap from traditional CAC to 'cap-and-trade' in pollution control regulation. Instead, emissions trading evolved at a slow and steady pace, and it took almost a decade and a half to make this transitional leap, utilizing a completely different economic instrument in the interim.

The Clean Air Act (CAA) of 1970 was the first major piece of air quality legislation with rigorous pollution control requirements (and enforcement provisions) in the U.S., and it followed the general CAC approach shown above in Figure 2.2. Cities and states were supposed to achieve the NAAQS air quality goals by 1975. As that date approached, however, it became clear that many cities were not going to meet such targets. These cities faced a real quandary; they already had too much pollution, and the CAA would not allow them to add more. If new sources were built, they would be adding to the excessive pollutant levels, even if these new sources employed stringent pollution control technology. More important for city officials, however, were the implications of such strictures: no new emission sources meant no new jobs, and no new economic development.

U.S. EPA's answer to this dilemma came out of their San Francisco regional office, and was promulgated as national policy in late 1976 as an "interpretive ruling." It stated that new sources could in fact build in areas not attaining the NAAQS, but only if they met two conditions: 1) they had to employ stringent Lowest Achievable Emission Rate (LAER) pollution control technology; and 2) they had to "offset" their new pollution by reducing existing emissions contributing to the non-attainment.

There were two different means of obtaining such an offset: 1) applying 'over-control' on existing emissions sources (i.e., applying controls more stringent than the mandated Reasonably Available Control Technology [RACT]); or 2) shutting down an existing pollution-emitting facility. Sources were required to have more than a 1:1 offset, in order to ensure that there was progress towards attainment. Thus a new source employing LAER but still emitting 100 tons of pollutant might then have to offset 105 tons of that same pollutant – helping to clean up the air, while at the same time providing new economic investment in the community.

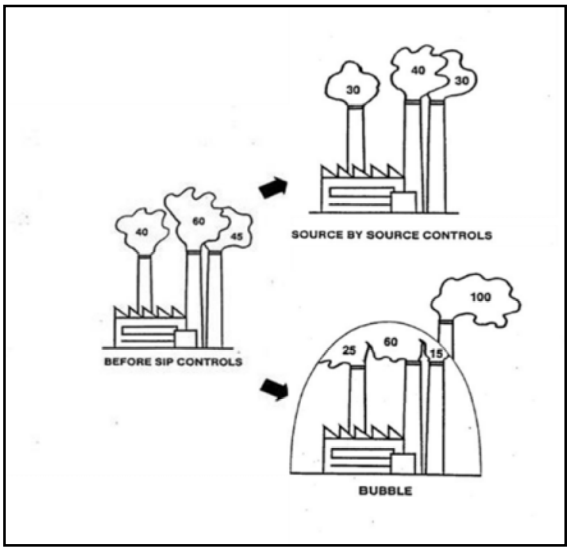
Most people did not recognize the economic implications of offsets, and U.S. EPA did not use the word "market" in its initial offset promulgation -- but a number of economists understood how this opened the door for a very different regulatory scheme. Bruce Yandle, a Professor of Economics at Clemson University, wrote an article entitled "The Emerging Market in Air Pollution Rights" in 1978, pointing out that EPA's ruling had "outlined the conditions for an extremely limited market in emission rights….. but a real market nonetheless."[6] It was very constrained, however, and he identified five constraining rules in the new marketplace: 1) the new source still had to use LAER technology; 2) offsets had to be for the same pollutant; 3) more than a one-for-one tradeoff was required; 4) banking the emissions reductions was not allowed; and 5) only new emission sources could enter as buyers.

President Carter's Council on Wage and Price Stability similarly endorsed the offset idea in 1977, pointing out the market-like characteristics of the policy, and suggesting that the free sale and banking of offsets be allowed (i.e., lifting restrictions 4 and 5 above). More importantly, however, Congress endorsed the idea in the 1977 CAA Amendments, and made it part of U.S. law.

In 1979, U.S. EPA introduced another series of mechanisms that built on these market-oriented ideas. The Agency decided to follow the Council's advice, and allow the free sale and banking of offsets. Thus, anyone – including, for example, an environmental NGO -- was now free to buy and sell them. Thus, an environmental NGO might purchase an offset and retire it instead of using it to build a new factory; there were obviously environmental benefits in doing so.

Similarly, banking provisions had an environmental rationale as well. If an existing plant was going to shut down and provide offsets for a new plant, U.S. EPA wanted to make sure that these two facilities were not operating at the same time -- and so it required the existing plant to shut down exactly when the new plant started up. But it was pointed out that this really didn't make sense; the new plant had to obtain a construction permit before it could start building, and it had to negotiate the offsets in order to obtain that document. Then it might take 18 months or so to build the new facility. Why not allow the new plant to negotiate the offsets, shut down the old plant, and "bank" those emissions reductions until the new plant started up 18 months later? That way the region had *no pollution at all* during the interim 18 month period. U.S. EPA therefore allowed cities and states to set up such banks in 1979. Interestingly, these banks did not give interest like regular banks; instead, they discounted emissions that were stored there. If a

Figure 2.7 U.S. EPA's bubble policy



source put 100 tons of sulfur dioxide into the bank, when it withdrew those emissions a year later it might only find 90 tons.

Another new mechanism expanded the market to include existing as well as new emission sources. This new mechanism was driven primarily by economists, who thought that companies might do a better job of figuring out exactly what was 'reasonable' under RACT than the government's attempts to do so. This new approach put an imaginary 'bubble' over the plant site – and as long as the amount of pollution coming out of the bubble was the same as that required in the government's regulatory plan (called the State Implementation plan, or SIP), then the emission source could figure out how to get the reduction, and thus save money (see Figure 2.7). Emission sources couldn't use the bubble to meet NSPS or other new source requirements, but they could meet their existing source requirements that way.

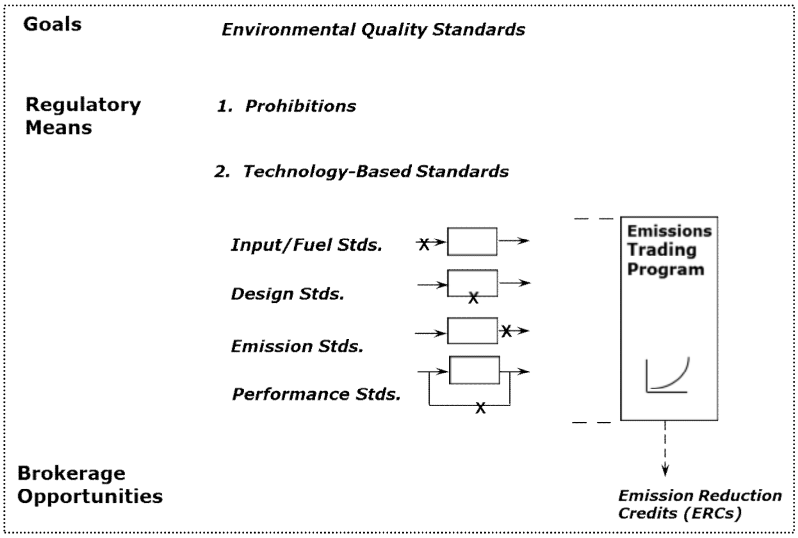


Figure 2.8 U.S. EPA's emissions trading program (ETP)

Finally, another new mechanism was called "netting," and this essentially treated the replacement of equipment as if the facility was trading old emissions for new ones. As long as the 'net' increase in emissions was held within certain limits, the pathway for obtaining permits was simplified.

These four mechanisms – offsets, bubbles, banking and netting – ultimately became known as U.S. EPA's Emission Trading Program (ETP). Economists were encouraged by the ETP, but environmentalists didn't particularly like these ideas – and so U.S. EPA initially referred to the program as "Controlled Trading," to ensure that everyone realized that government oversight remained a key factor in these nascent markets. U.S. EPA consolidated all of the rules in a draft proposal in 1982, but because of the controversy, it took four years before it was finalized.

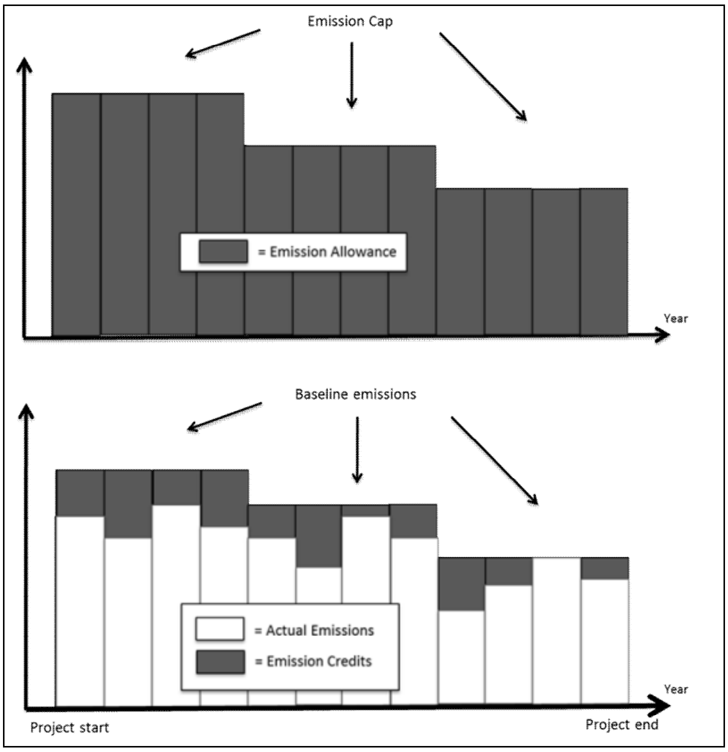
This new economists' world of emissions trading was revolutionary in some ways – but the underlying regulatory scheme of the CAA still remained very much the same, as shown in Figure 2.8. The goals were still set by the NAAQS. All of the U.S. EPA's technology-based RACT/BACT/LAER and SIP requirements remained in place. Dispersion modeling still provided the linkage between technology requirements and air quality goals, and any bubble still had to show that it provided a 'net air quality benefit,' as well as an improvement on the emissions balance sheet. Any improvements in the environment were still largely driven by the traditional 'command/control' regulatory scheme, not the economic one. Certainly there were small improvements since offsets and bubbles usually required a great than 1:1 emissions ratio – but these were still relatively minor compared to the large-scale command/control emission reductions required to meet the environmental quality standards goals.

2.5 Baseline-and-Credit Trading in the U.S. ETP

The actual economic instrument employed in the ETP was an "emission reduction credit," (ERC), which had four defining characteristics. It had to be: 1) quantifiable; 2) enforceable; 3) permanent; and 4) surplus. The first three are things that any regulator would want to see, but the key to the market is that fourth component – "surplus." The credit had to be for something beyond what was required by law, and as noted above, a source could get emissions credits for 'surplus' activities through over-control of other sources, or by shutting down a facility whose emissions were already accounted for in the SIP. That 'surplus' requirement wasn't too hard to document in the tightly controlled regulatory world of U.S. EPA's ETP – but later, when it surfaced again in Kyoto Protocol carbon markets under the label "additionality," it became very troublesome indeed!

The differences between emissions trading of credits and the allowance schemes discussed earlier are shown in Figure 2.9.

Figure 2.9 Allowance vs. credit trading



Source: Adapted from OECD[7]

Note that in the economists' quantity-based scheme utilizing emission allowances, *all* of a source's emissions are included in the emissions market, but under the engineers' base-line-and-credit scheme, only a small portion are traded. [Also note that while Figure 2.9. is a simple illustration of the credit trading approach, the type of credits shown would not meet the 'permanence' requirement in U.S. EPA's ETP and are therefore not ERCs. Instead, this type of credit is called a Discrete Emissions Reduction (DER). DERs have been used in some U.S. states in limited applications, in programs often referred to as 'open trading.'[8]]

3. International SO_2 Trading Programs

3.1. Four Regimes of SO_2 Emissions Trading in the U.S.

Since the U.S. EPA established the offset mechanism in 1976, emissions trading of SO_2 has developed within four regulatory regimes:

1. The U.S. Emissions Trading Program (ETP), trading in SO_2 ERCs;
2. The Acid Rain Program (ARP), Title IV of the Clean Air Act Amendments of 1990, trading in SO_2 emission allowances;
3. The Clean Air Interstate Rule (CAIR), adopted by U.S. EPA in 2005 but struck down by the courts in 2008, modified SO_2 emission constraints in the Eastern portion of the U.S. and allowance trading requirements for those sources; and
4. The Cross-State Air Pollution Rule (CSAPR), adopted by U.S. EPA in 2011, replaced CAIR and also modified SO_2 emission constraints and allowance trading requirements for Eastern U.S. sources; it is scheduled to begin in January, 2012.

A basic introduction to each of these four regimes is outlined below, with a more detailed discussion of implementation concerns outlined in the following chapter.

3.1.1 U.S. SO_2 Emissions Trading Regime 1: The U.S. EPA's ETP

As noted above, the ETP did not substantially change the CAC approach employed in previous years, and its impact as an environmental market was quite limited. The U.S. EPA does not track ERC transactions, but a 1989 analysis estimated that bubbles produced compliance cost savings of $435 million over a six year period (about $70 million per year) for all pollutants; offsets were estimated to have yielded negligible savings, and those associated with banking provisions were similarly very small.

Netting became the most utilized component of the ETP, with estimated savings between $525 million and $12 billion over the six year period (i.e., $90 million to $2 billion per annum[9]). During the years between 1985 and 1992, over 10,000 tons of pollutants were traded in the offset program, with total expenditures on ERCs estimated to be on the order of $2 billion, indicating an average price of traded pollutants of $200 per ton.[10]

Several factors limited the appeal of this trading program. Perhaps most importantly, it was limited by the nature of its goal, the attainment and maintenance of local air quality. The trading mechanisms were grafted onto an existing air pollution control program, designed to achieve NAAQS. Extensive (and expensive) air quality modeling thus had to be performed for every transaction, in order to ensure that the transaction would provide a 'net benefit' for ambient air quality. This resulted in a bias towards 'internal' transactions – where the emission source both created and used the ERC. 'External' transactions, such as those between two companies, were thus quite rare. Fully 90% of ERC transactions in the early emissions trading market were internal. Obviously, economists seek trades between various source types and companies with different marginal cost of control, but this did not occur to any significant extent.

The trading of VOC ERCs tended to be more successful than SO_2 trades, because of the attention given to VOC control for ozone nonattainment -- but also, importantly, because VOC transactions did not require dispersion modeling to document the 'net air quality benefit.' This allowed a greater geographical range of transactions, and also attracted attention from emission brokers, since such transactions could readily be external.

The air quality management authority effectively 'taxed' deposits to emission banks, since ERCs were discounted over time by regulators. Offset ratios used to counter some of the uncertainties from the dispersion modeling and the temporal aspects of trades further depressed the ERC value. A 2001 study by 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."[11] The U.S. EPA's ETP program is still in effect today, with primary focus on netting transactions and offsets for non-attainment areas.

3.1.2 U.S. SO_2 Emissions Trading Regime 2: Title IV of the Clean Air Act Amendments of 1990

While the ETP introduced the idea of emissions trading in the U.S., it was the pioneering acid rain control program which introduced the economists' idea of quantity-based allowance-trading into the air pollution control regulatory arena. That program is the predecessor of most quantity-based trading programs in operation today, including the Kyoto Protocol.

In the late 1970s and early 1980s there was rising concern about the environmental and public-health impacts of acid deposition, including a report by the U.S. National Commission on Air Quality in 1981 calling on the US Congress to "require a significant reduction by 1990 in the current level of sulfur dioxide emissions in the eastern United States."[12] The Reagan Administration was prepared to analyze the problem, but would not support pollution controls. This led to a $500 million acid rain research program during the 1980s called the National Acid Precipitation Assessment Program (NAPAP). NAPAP informed the policy debate, but its final report came out after the Clean Air Act Amendments of 1990 (which contained provisions for acid rain emissions control) had already been passed into law.

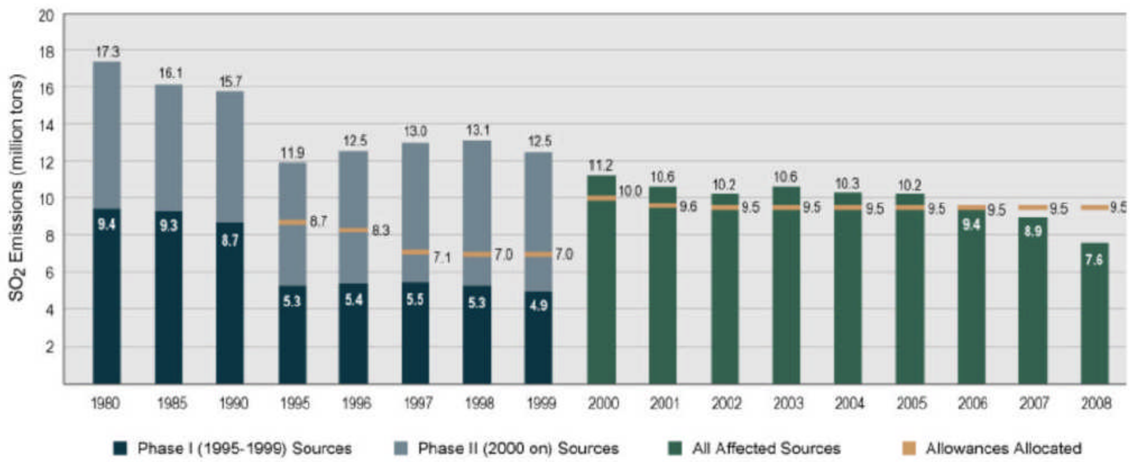
That new law continued efforts to meet local air quality objectives near emission sources, but recognized that acid rain was different. Individual power plants with tall stacks might be able to meet the localized NAAQS requirements, meaning that it was safe to breathe the air nearby – yet the cumulative impact of many such plants might still be contributing to a 'total loading' emissions problem, resulting in acid rain. Like ozone, it wasn't possible to pinpoint the contribution of a single source; instead the atmospheric chemistry and long range transport demanded a regional (or even national) approach.

The U.S. in 1980 was emitting about 26 million tons of SO_2 and 24 million tons of NOx every year, with 67% of the former and 29% of the latter coming from power plants.[13] Sulfur dioxide was the biggest contributor to acid deposition. In Northern Europe and eastern North America, about two thirds of the total atmospheric acidity is due to sulfur and one third to nitrogen. This ratio varied considerably with season and region, however, and in some areas (such as the western United States) it might be closer to 1:1.

Congress tackled emissions of both pollutants, targeting power plants. It controlled NOx using command/control technology requirements, recognizing, however, that future controls would be necessary because of the nation's high ozone levels. These more stringent controls would begin to have an effect later in that decade (i.e., in the late 1990s).

The truly novel component of the 1990 Clean Air Act Amendments, however, was found in Title IV, which for the first time followed the economists' lead and structured a quantity-based approach to pollution control. It did so in two phases: Phase I began in 1995, reducing emissions 25% below 1990 power plant levels and more than 35% below 1980 levels.[14] It was targeted at large SO_2 polluting facilities with an emission rate greater than 2.5 lbs. SO_2/MMBTU, and a nameplate capacity of at least 100 MW (about 110 plants, with 374 generating units, virtually all located east of the Mississippi River[15]). Phase II began in 2000 and represented a 50% cut from 1980 SO_2 emission levels. It was targeted at all power plant SO_2 emission sources greater than 25 MW. The affected source SO_2 emissions totals (and allowance totals allocated) for these two phases are shown in Figure 3.1.

Figure 3.1 Sulfur dioxide emissions under the Title IV acid rain program



Source: US EPA, 2010[16]

Under the ARP, affected utility units are allocated allowances based upon their historic fuel consumption and a specific emission rate, as discussed below. Each allowance permits a unit to emit one ton of SO_2 during or after a specified year. For each ton of SO_2 emitted in a given year, one allowance is retired, i.e., it can no longer be used. Allowances may be bought, sold, or banked. Anyone may acquire allowances and participate in the trading system. Regardless of the number of allowances a source holds, however, it may not emit at levels that would violate federal or state CAC requirements set under the Clean Air Act's provisions for attaining and maintaining NAAQS in order to protect public health.

By creating a cap and limiting the number of available allowances, the ARP created an economic value for the allowances and a marketplace to trade them. Power plants had the flexibility to choose from many alternatives to best meet their emission goals: installing pollution-control equipment, switching from high-sulfur coal to low-sulfur coal, or simply buy allowances from other plants. By allowing banking of the allowances for future use, a tangible, quantifiable economic incentive to reduce emissions beyond the cap was created. Each plant had to install continuous emissions monitoring systems that could account for SO_2 emissions, and ensured accurate monitoring of emissions, compliance and timely reporting.

Thus, the pioneering acid rain program became a prototype for tackling emerging environmental issues, and became the model framework for controlling greenhouse gases under the Kyoto Protocol. In July 2002, *The Economist* deemed it: "probably the greatest green success story of the past decade."

3.1.3 U.S. SO_2 Emissions Trading Regime 3: The Clean Air Interstate Rule (CAIR)

The introduction of a new NAAQS for ozone in 1997, along with a new fine particulate standard for particles less than 2.5 microns in diameter significantly changed the need for both SO_2 and NOx reductions. George W. Bush's Presidential campaign in 2000 had pledged future reductions in four pollutants (SO_2, NOx, Hg and CO_2), but shortly after his inauguration he withdrew the CO_2 pledge, and subsequently withdrew the U.S. from the Kyoto Protocol. He did propose reductions in what was termed "Clear Skies" legislation before Congress in 2002 for the remaining three pollutants, which was unsuccessful and subsequently re-introduced in 2003.

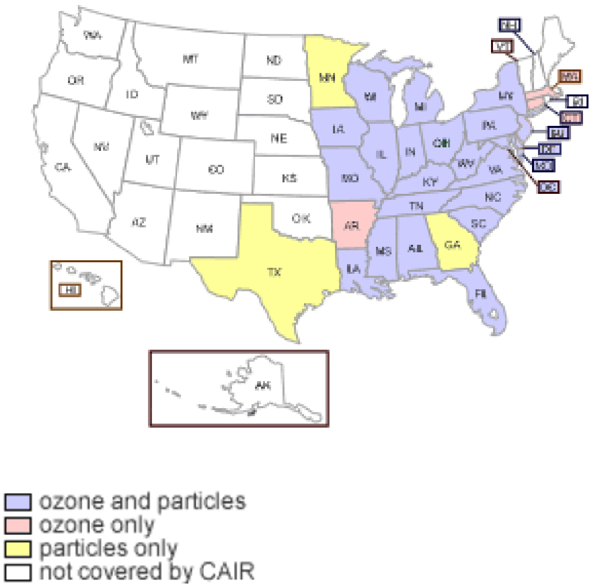


Figure 3.2 U.S. states affected by CAIR

These proposals could not garner sufficient political support, and so in 2005 the U.S. EPA, (a part of the Executive Branch of the U.S. government) issued two programs: the Clean Air Interstate Rule (CAIR), covering SO_2 and NOx; and the Clean Air Mercury Rule (CAMR), addressing mercury. Both of these regulatory programs were subsequently invalidated by the courts.

Adopted in March 2005, CAIR was designed to control power plant SO_2 emissions by more than 70% and NOx emissions by more than 60% from 2003 levels in 28 eastern U.S. states (and DC). It had three trading programs: one for annual SO_2 emissions, much like the ARP, but covering a smaller geographical area; and two NOx trading programs, one annual and one seasonal (i.e., summertime). It also had two phases: Phase I controls for SO_2 began in 2010, while Phase II was scheduled to begin in 2015.

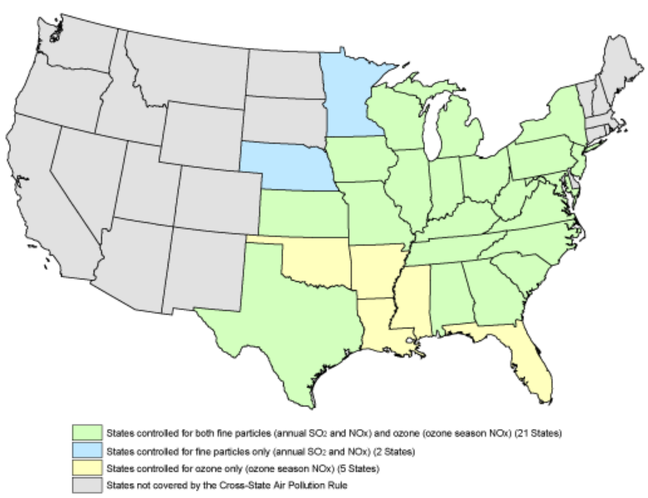
Although CAIR would have important effects on reducing acidification, its primary goal was to help in achieving attainment of both the ozone and particulate NAAQS, and it was issued under the authority of Title I of the Clean Air Act (concerning attainment of NAAQS) rather than Title IV (concerning acidification). Like the acid rain program, however, it also employed the market-based allowance approach, with the first stage of NOx controls beginning in 2009, and SO_2 controls beginning in 2010. One EPA official called CAIR "one of the top three most significant actions in EPA history."[17]

As discussed in further detail below, U.S. EPA built upon the previous acid deposition (Title IV) allocation approach in implementing CAIR, utilizing a more stringent retirement ratio for allowances.

3.1.4 U.S. SO_2 Emissions Trading Regime 4: The Cross-State Air Pollution Rule (CSAPR)

CAIR was found to be invalid by the courts in 2008, in part because it did not address the specific contribution of any individual state to NAAQS attainment concerns in a downwind state. U.S. EPA was thus forced to revise its regulatory program for SO_2 control. In July 2010 it issued a proposed rule entitled the Clean Air Transport Rule (CATR), and finalized that in July 2011 in a program called the Cross-State Air Pollution Rule (CSAPR). This new program is similar to -- but somewhat larger than -- CAIR (see Figure 3.3). It seeks to reduce SO_2 emissions by another 6.4 million tons per year (1.8 million tons beyond CAIR), and will go into effect on January 1, 2012.

Figure 3.3 U.S. states affected by CSAPR



It will do so in a manner considerably different than CAIR, however. CSAPR separates SO_2 trading into two regions; significantly limits interstate trading; and, importantly, does not allow emission sources to use existing SO_2 allowances, instead issuing new ones.

When the CATR was proposed in July 2010, it had an immediate impact on the SO_2 market, with prices collapsing – since Title IV allowances would no longer be valid in the more stringent control program. U.S. EPA's March 2011 auction saw a spot market clearing price of $2.00/ton, while the seven year advance auction price was $0.16/ton.[18] (The Title IV regulatory requirements will remain in place, however. Title IV is a nationwide program, while CSAPR only affects 23 states [for SO_2].)

The two CSARP SO_2 trading regions are shown in Figure 3.4. Like ARP, the new regulatory regime requires emissions reductions in two phases: Phase I begins in 2012, with emissions reductions required in both regions; Phase II begins in 2014, with additional SO_2 reductions required in the Group I states. Intrastate emissions trading is allowed, but interstate trading is allowed only within the same regional group.

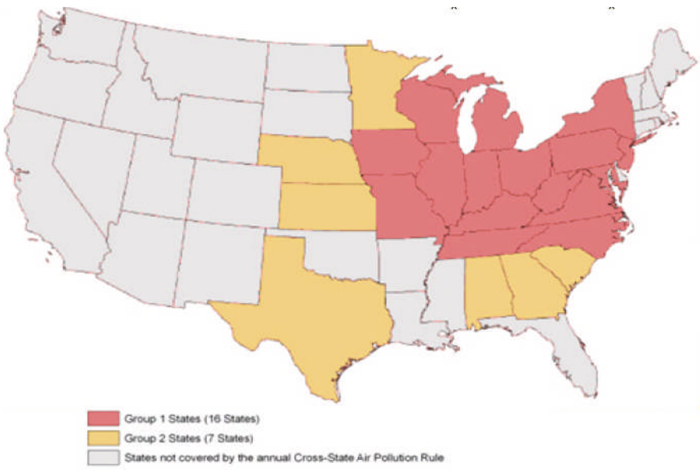


Figure 3.4 SO_2 trading regions under CSAPR

The key to the CSARP is an individual State's 'budget' in SO_2 emissions, plus a 'variability level' of that budget (18% for SO_2 annual emissions); added together, these represent the 'assurance level' that any particular state will not have a major impact on a neighboring state's air quality. If a state exceeds its assurance level, power plants will lose two allowances for every ton of emissions that are over its own assurance level (plus the allowance it originally surrendered to cover the emissions).

As in the ARP, if a source's emissions exceed the number of allowances it holds and thus surrenders at the end of the true-up period, it will be subject to both environmental and financial penalties. However, both are considerably more stringent within the CSARP. The environmental penalty includes both an offset allowance and two penalty allowances (instead of 1:1 under ARP), and the non-compliance penalty can be based upon days of violation per incident (at an inflation-adjusted $37,000) rather than the inflation-adjusted $2,000 penalty included in ARP. So, in addition to the regulatory constraints on the market noted above, companies also face greater compliance risks by relying on the allowance market, helping to shift control actions towards internal activities.

Since the CSAPR program is beginning less than six months after U.S. EPA promulgated it, the federal government has developed Federal Implementation Plans (FIPs) for each state, and as part of this has also allocated allowances within the state to individual units. States have an opportunity to change these FIPs and develop their own allocation approach for 2013 and later years, however.

3.2 Other U.S. SO_2 Trading Programs

While most parts of the country were fully covered by the four regimes noted above, certain cities with significant air quality concerns decided to adopt more aggressive market-oriented air pollution reduction programs. Since ozone non-attainment was the most serious urban air quality program, most of these additional city-oriented programs placed their primary focus on NOx and/or VOC control. Thus, for example, the Chicago area established the Emission Reduction Market System (ERMS)[19] for volatile organic material (VOM) control, the Houston/Galveston Area (HGA) Mass Emission Cap & Trade program was established for NOx, and the South Coast Air Quality Management District (SCAQMD) of California established the Regional Clean Air Incentive Market (RECLAIM).[20]

RECLAIM's was established in 1994, and addressed both NOx and SOx. It was originally intended to include VOCs as well, but technical arguments about reactivity rates, the number and types of sources to be included in the market, and other factors led to that pollutant's exclusion. The market was primarily designed to address the region's severe ozone problem, however, and most RECLAIM attention has therefore focused on NOx rather than SOx. There were about 350 participants in the NOx market, and about 40 in the SOx one. The power industry was the largest purchasers of NOx credits, while petroleum companies were the largest purchasers of SOx ones.[21]

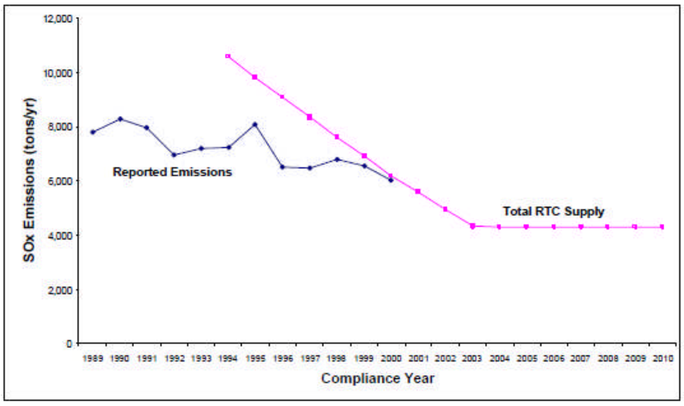


Figure 3.5 SOx caps for RECLAIM

Sources within the SCAQMD market trade 'RECLAIM Trading Credits' (RTCs), which, even though they are called credits, are more like the allowances described above. These credits represent one pound (lb.) of the pollutant, and each participating firm receives RTCs equal to its annual emissions limit. Credits are assigned based on past peak production and the requirements of existing CAC rules and control measures. Credits are assigned every year and can be bought or sold for use within that year; they cannot be banked. No matter who buys or sells RTCs, the regulator reduces the total emissions for the total market each year.[22]

In the early years of the program (i.e., the 1990s), the market was over-allocated for both NOx and SOx (see Figure 3.5), and RTC prices were very inexpensive – and sources did not feel pressure to install any controls (beyond CAC requirements). This changed radically in the year 2000, however, when there was a crisis caused in part by the deregulation of California's power market. The price of NOx RTPs skyrocketed to over $45,000/ton (317 RMB/kg), The following year, the RECLAIM program was significantly restructured, with some power producing facilities required to reduce their emissions in accordance with a schedule provided by the SCAQMD. They ended up shutting down older units, replacing older equipment with more efficient equipment, and installing other NOx controls. NOX allocations and holdings were adjusted, including designations of non-tradable and non-usable RTCs.

The petroleum sector and SOx portions of the RECLAIM program did not suffer comparable spiking problems and market swings, however. In the most recent (non-zero) SOx transaction in late July, 2011, 2,912 lbs. (1,321 kg) of June 2011 SOx RTCs sold for a price of $0.35/lb. ($700/ton, or approximately 4.93 RMB /kg).

3.3 Ontario, Canada SO_2 Trading

In 1993, Canada undertook an extensive examination of emissions trading for SO_2 in that country,[23] mostly in response to the terms of the Canada – U.S. Air Quality Accord signed two years earlier. That Accord required Canada to keep its SO_2 emissions below 3.2 million tonnes beginning in the year 2000, and its focus was essentially a response the U.S. Title IV requirements for acid rain control.

No country-wide programs were implemented, but in 1996 the Pilot Emissions Reduction Trading (PERT) project was set up in Ontario Province. PERT was a self-funded, non-profit organization whose initial focus was on NOx and VOC emissions for ozone control; but the following year SO_2 and CO_2 were added as well. About a dozen SO2 credit activities were registered in that year, representing about 5700 tonnes of SO_2 – of which approximately 10% were retired.[24] SO_2 trading was not a major portion of the scheme, however, as trading activity through 2001 primarily involved first Ontario Hydro and then its successor Ontario Power Generation purchasing ERCs to cover its voluntary commitments for NOx and CO_2 reduction.[25]

Importantly, however, this program – which ran through 2001 – laid the groundwork for an Ontario regulatory program that covers the power sector[26] and the industrial sector,[27] and which started that same year. The Ontario program is a hybrid credit/allowance system (much like the Kyoto Protocol). The regulations affecting power plants, for example, allow them to buy ERCs to help meet their new emission limits. They can trade allowances among themselves, but they can also buy ERCs from other uncapped industries or organizations that have demonstrated ERCs. The use of ERCs is limited to 10% of emission allowances (33% for NOx). ERCs may be created only by sources to which allowances have not been distributed (i.e., there is no internal ERC trading), and then only by reducing emissions of NOx or SO_2 in accordance with approved methods. ERCs are not granted for reductions in business activity or for shutdowns, and all are discounted by 10 percent when they are retired.[28]

The electricity sector reductions occurred in two phases, the first running from 2001 through 2006, and the second after 2007. In the first phase, the program was apparently over-allocated for SO_2, but required a 25% reduction in SO_2 (and a 53% reduction in NOx) beginning in 2007.[29] The SO_2 allocations are made at the beginning of the compliance year, “in proportion to the estimated power produced by the specific generator relative to the total estimated power produced by all generators covered by the regulation."[30] This allows new power generators to receive an allocation, and they do not have to 'buy' their way into the air resource, as new plants in the U.S. ARP, CAIR and CSAPR programs have to do.

In 2005, seven large industrial sectors – petroleum, iron and steel, pulp and paper, flat glass, cement, carbon black, and non-ferrous smelting – were added to the program, and were required to lower their emissions in stages. There have been complaints about the lack of stringency in this program, however, since the iron and steel sector SO_2 caps were actually allowed to increase over time, while the major decreases (in the base metal smelting industry) were already required under a CAC order by the environmental agency.[31]

4. Implementation Concerns

4.1 Allocation

Economists tend to focus on efficiency concerns, but the distributional, equity, and political elements of economic mechanisms rightly draw attention. As noted above, Pigouvian taxation tends to result in a wealth shift from the private to the public sector – and this has been one reason there is considerable resistance to implementing such taxation schemes. Economists have argued that they can be implemented in a manner that is revenue neutral (for example, reducing income taxes, or implementing a tax/subsidy scheme) without losing their efficiency characteristics. But there is still considerable resistance, and this is one of the reasons quantity-based approaches have received increased attention over recent decades.

One of the important properties of the quantity-based scheme is what Hahn and Stavins have labelled the '*independence property*.'[32] This goes back to Coase's Theorem, and suggests that the market equilibrium of the quantity-based approach will be independent of the initial allocation of tradable rights. This is a very powerful property, because, as Hahn and Stavins note:

> "…it allows equity and efficiency concerns to be separated in a relatively straightforward manner. In particular, the property means that the government can establish the overall pollution-reduction goal for a cap-and-trade system by setting the cap, and leave it up to the legislature – such as the U.S. Congress – to construct a constituency in support of the program by allocating the allowances to various interests without affecting either the environmental performance of the system or its aggregate social costs."

This property does not exist with Pigouvian or other price-based schemes. When the U.S. Congress tried to set a price-based energy BTU tax in the early 1990s, it soon became a "legislative travesty,"[33] and was quickly jettisoned. Special deals and exemptions were sought by numerous industries, and each one of these reduced both the tax revenue and the environmental performance of the proposed tax. Finally, the ineffectiveness of the proposed legislation in accomplishing either deficit reduction or environmental protection led to its being scrapped.

The power of the quantity-based approach (and the independence property) over the price-based approach is that such legislative wrangling over distributional and equity matters can be separated from the efficiency concerns. In theoretical terms, the initial distribution of emissions allowances does not affect the efficiency of the system – polluters make pollution control decisions based upon their costs of control and the prices of allowances, regardless of how many allowances they receive.

For example, say that an emission source emits 100 units of pollution, but only receives 50 allowances; how much pollution will it then put out? The firm's management might decide to only emit 50 units, like the allowance share – but then again, they might put on a scrubber that removes 90% of the pollution, and sell the extra 40 allowances. Or they might not put on any control at all, and purchase another 50 allowances. The individual firm's marginal control costs and the price of an allowance determine the source's response in terms of economic efficiency, not the allocation.

Obviously, however, the financial status of the pollution source is very much affected by how many allowances it receives, and there are thus important distributional impacts at stake. If the source has to purchase all of its allowances in an auction, then the distributional impact is the same as the pollution tax, with the same wealth transfer from private to public sector. But if the government provides *some* allowances for free, then the polluter is less likely to complain. And politicians quickly learned that by *grandfathering* existing emission sources (i.e. granting allowances to existing sources at no cost, usually based upon historical emissions or fuel use) they could minimize political resistance to the new pollution control requirements.

Politicians also recognize, however, that each allowance also represents a small fraction of a very public environmental resource – the assimilative capacity of the air resource. Under emissions trading schemes, this has economic value. No country has perfect markets, and participants are never identical. Any new environmental policy is introduced into a 'second best' situation, where economic distortions already exist. Hence allocation issues must be considered in any new emissions trading programme.

4.1.1 Allocation approaches in U.S. SO_2 trading regimes

U.S. EPA's ETP

Under the baseline-and-credit approach, there is no special emission allocation. All existing emissions sources are considered to have legitimate access to the air resource. Credit creation is a voluntary action undertaken by the emission source, subject to governmental approval of the ERC. Every individual emission source has an opportunity to create credits, theoretically ranging from zero to the full amount of their emissions allowed under the CAC regulations (i.e., in a shutdown, or unit retirement). As noted above, however, Ontario will not grant credit for unit shutdowns or decreases in business activity. In the U.S., some state governments chose to treat ERCs created by retirements differently than those created by over-control, typically limiting their application in bubble transactions. The state view was that there would be a transition in air quality over time, as older emissions sources were replaced by newer, cleaner ones – and that giving full credit for older sources would delay that transition. The U.S. EPA's regulatory approach in the ETP did not make such distinctions, however.

The Acid Rain Program Allocations

As a pioneering economics-oriented regulatory program, the ARP design had to tackle two fundamental market questions: 1) how to set the quantity of emissions allowed (Q); and 2) how to allocate those allowances. In most cap-and-trade systems, these questions are closely aligned, even though theoretically they can be separated because of the independence property. When individual countries in the EU ETS developed "National Allocation Plans," for example, they addressed both questions in these plans.[34]

In the ARP, four steps were undertaken in the allocation determination, with different actions and activities undertaken by separate branches of government.

Step 1. Determination of Q.

In the theoretical discussion above, economists propose to determine Q by setting it equal to the point where MAC=MSB. This is a very difficult task, however, particularly in determining the marginal social benefits. During the 1980s, NAPAP had provided information to policy analysts about the nature of the acid rain problem, but ultimately the selection of Q became a political decision.

The acid rain control legislation was contentious, with utilities, coal miners, environmentalists, and other interested parties all having divergent positions. Upon assuming office in 1989, President George H.W. Bush crafted a political alliance that included Western U.S. states (which had cleaner coal burning and did not want to pay for the cleanup in Eastern states); Eastern and Western producers of low sulphur coal (who could benefit when utilities had a choice of control options); advocates of market-based regulation; and the Northeast states (who would benefit from the reduced acid rain, and who had been pressing for legislation). Opposition remained from coal mining unions (representing miners in Eastern high sulphur coal mines); and Midwestern utilities (heavily dependent on high sulphur coal).

These parties obviously had very different views about the feasibility and need for SO_2 emission reductions. The Environmental Defense Fund, an environmental NGO which was instrumental in developing the market-based approach, had sought a 12 million ton SO_2 reduction. Utilities, on the other hand, had suggested that a six million ton reduction might be reasonable. Bush's position ultimately called for a ten million ton reduction of SO_2 (8.4 million tons from power plants[35]), a level of control close to that sought by environmentalists. A key factor in moving closer to the environmental position was the fact that the reductions would be achieved using the market-based regulatory approach, allowing utilities considerable flexibility for achieving such reductions. Bush unveiled his acid rain policy decisions, including the 10 million ton reduction, as part of a larger clean air legislative proposal in June 1989 at a press conference at the White House.

Step 2. Allocation benchmark formulas in ARP legislation

This policy proposal would ultimately become Title IV of the Clean Air Act Amendments of 1990, after a complicated legislative history that also included major action on ozone nonattainment, control of toxic air pollutants, and vehicular emission standards. Congress ultimately implemented the two-phase program noted above. The level of Q was set at 8.90 million tons of SO_2 in Phase II, although other factors discussed below in Step 3 would slightly modify that figure.

Importantly, Congress defined the allocation approach directly within the legislation. Phase I sources were to receive emission allowances at a benchmark rate of 2.5 lbs. SO_2/MMBTU for every unit, based upon its heat rate in a three year (1985-1987) baseline period. The Phase II allocation approach was similar, utilizing an allocation benchmark of 1.2 lbs. SO_2/MMBTU rate for the same baseline period.

Step 3. Political/economy considerations.

While Step 2 above makes the allocation approach seem like a simple (and mostly technical) affair, the true allocation battle waged in the U.S. Congress went far beyond such simple equations. The independence property held that the program would be efficient regardless of the initial allowance distribution, and at that time, regulatory analysts believed that they would be worth approximately $5 billion every year – and so, of course, there was tremendous political in-fighting, deal-making and manoeuvring about their allocation.

Joskow and Schmalensee[1] have conducted a detailed political economy analysis of the ARP program,[36] paying particular attention to the allocation issue. They note:

> “Because emissions permits are valuable and decisions about their distribution are made by political institutions, these decisions are likely to be highly politicized, reflecting rent seeking behavior and interest group politics….. Understanding better how the political process deals with such allocational issues can help us to design environmental programs that are both economically efficient and politically acceptable.”

Given the scale of the acid rain problem and the sums of money involved, it is not surprising then that the political process began to look at various ways of manipulating the allowance equations, including special ‘bonus allowances’, ‘set-asides,’ and various other provisions.

Joskow and Schmalensee determined that the provisions of the law for the initial Phase I allowances remained fairly simple, basically following the allocation procedure determined by the formula. The real battle was fought over the longer-lasting and more significant Phase II process, however, which would begin after the year 2000. For that, the CAA contains “eight dense pages of about 30 complex and convoluted provisions”[37] designed to govern the Phase II allocations.

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[1] Schmalensee participated in the Bush administration’s acid rain proposal development and negotiations with Congress, and Joskow served on EPA’s Acid Rain Advisory Committee. Both were MIT professors at the time.

The provisions cover a wide range of activities: special allowance set-asides for energy efficiency and renewable energy (30,000 allowances/year); up to 530,000 'bonus allowances' (e.g., to modify the formula for certain units in certain 'clean' states); others for 'qualifying clean coal technology' repowering projects; 50,000 'other' allowances for certain Phase I units in specific states; etc., etc.

Joskow and Schmalensee found that the thirty 'special' allocation provisions could be divided into three general types:

1. Special variations from the allocation procedure rules based upon fuel types, unit age, unit capacity, and capacity utilization during the base period;
2. Procedures narrowly focused on specific special interests, either those of individual states or individual utilities; and
3. Special bonus allocations for units located in states that "fall neatly into the 'clean' and 'dirty' camps."[38]

They found that the first type tended to shift allowances away from relatively dirty states towards relatively clean ones. The second type made clear the power of certain influential legislators, and "should remove any doubt that interest group politics was at work in the development of the U.S. acid rain program."[39] And the third type reflected straightforward political balancing and bargaining, "clearly reflect[ing] efforts to 'buy off' two well organized groups of states with utilities at opposite ends of the dirty/clean spectrum."

Step 4. Ratcheting back to Q.

When the politicians had completed their political machinations, the number of bonus allowances and special set asides had increased total SO_2 emissions by about ten percent above the reductions initially sought. The law, however, also included provisions for the U.S. EPA Administrator to re-normalize the number of allowances to meet that original emission reduction goal. U.S. EPA did so primarily by using 'pro rata,' across-the-board cuts, so that the results of the political bargaining would not be affected.

U.S. EPA issued the first set of Phase II allowances allocations in 1993, and subsequently modified them in 1998 to take into account some of the special provisions.[40] They identified and calculated three different types of allowances (i.e., basic, bonus and other), depending upon their regulatory origin and the conditions of their provision (e.g., allowances from some provisions could be ratcheted pro rata, but others could not). The total number of allowances in 2010 (i.e., Q) was 8.95 million tons, with individual units allocated a thirty year stream of allowances, designated by vintage year. Units can store (bank) unused allowances, but cannot borrow from the future stream.

This four step process, with actions by the U.S. President, Congress, and the U.S. EPA resulted in a successful program, which was able to reduce ambient sulfate concentrations by 41-49% in Eastern regions,[41] at a cost estimated to be roughly 50% below that associated with a comparable CAC program.[42]

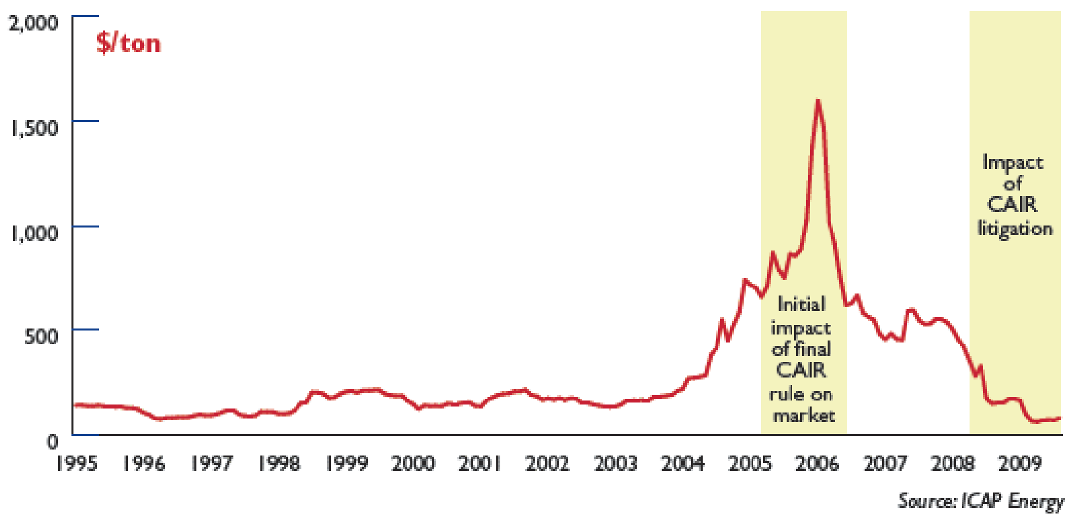
The CAIR Program Allocations

The fact that Congress had issued SO_2 allowances for a thirty year period weighed heavily on the U.S. EPA as it came to issue its new program for SO_2 reduction to help achieve NAAQS standards in 2005. Some argued that there had been considerable change in the electric utility sector since the 1985-1987 baseline period, and others suggested that alternative allocation mechanisms were more appropriate – but U.S. EPA held that "the desire to maintain the trust and confidence that has developed in the functioning market for Title IV allowances" was important, especially "recognizing that it is a key to the success of a trading program under the CAIR."[43]

CAIR therefore employed the same allocation scheme previously employed in Title IV for sources in affected states. But compliance with CAIR was now significantly different: for the Phase I years 2010-2014, two allowances would be required for every ton of SO_2 emissions; and for the Phase II years 2015 and thereafter, 2.86 allowances would be required. This had the effect of reducing SO_2 emissions from the sources by 50% in Phase I, and 65% in Phase II.

While EPA worried about maintaining the trust and confidence of the Title IV allowance market, that market had already been significantly shaken by the prospect of CAIR. A proposed rule had been issued in late 2003, and the final CAIR regulations were issued in March 2005. In late 2004, the allowance market began to become quite volatile,[44] and prices began to increase as shown in Figure 4.1. While 2010 and later vintage allowances would be discounted under CAIR, pre-2010 vintages could still be used 1:1 for CAIR compliance – and so market prices increased in 2004, and continued escalating in 2005. Traders believed that tightening Q would result in increased scarcity, and accordingly the market price increased. The highest point in the market was reached for a very short period in December 2005, when allowance prices were in the $1600/ton range.[45]

Figure 4.1 SO_2 allowance prices before and after the introduction of CAIR



Source: Chartier[46]

The CSAPR Program Allocations

In July 2008, the D.C. Circuit Court of Appeals struck down the CAIR regulatory program, in part because it would not assure protection of downwind ambient air quality. In December 2008, however, the court decided to allow EPA to administer CAIR while it developed a replacement program. That replacement program was proposed in July 2010, and, as noted earlier, SO_2 allowance prices in the market immediately collapsed. The final replacement rule – CSAPR – was promulgated in July 2011.

The reason the prices collapsed was because EPA decided that it could no longer rely on Title IV SO_2 allowances to implement the program – new CSAPR SO_2 allowances would be required.

The new approach that EPA employed to allocate SO_2 emissions focused on the individual states, since the allocations were targeted at downwind NAAQS and were done as part of a FIP for individual states (which states could later chose to revise in a SIP). U.S. EPA took the state's CAIR SO_2 budget (determined from dispersion modelling, cost-effectiveness, and various other analyses), and divided it into three subgroups: a) a set-aside for new sources; b) a set-aside for new sources in Indian Country; and c) a budget for existing emission sources. The latter was the largest category in each state, representing 92-98% of the SO_2 emissions budget.[47]

Existing emission sources were those sources on-line before January 1, 2010. U.S. EPA reviewed data for heat input from existing units over the period 2006-2010, and reported emissions from 2003-2010. It then determined the three highest yearly heat input values (over the five year 2006-2010 data base), and averaged those for each unit. Adding up all of the heat input values for all units in the state, the SO_2 emissions budget was allocated to each unit proportionally. A comparison was made to ensure that no heat-based allocation exceeded the unit's maximum annual emissions reported over the 2003-2010 period – with any adjustments proportionally distributed in an iterative manner. Since the relative proportion is multiplied by the available state SO_2 budget, the same allocation procedure has been applied to both phases of the CSAPR control program.

4.1.2 Allocation Discussion

The $SO_2$2 allocation procedure has clearly undergone a significant transition over recent decades. Early credit trading approaches relied upon the CAC framework for SO_2 ambient air quality, and allocations did not play a significant role in market-based environmental regulatory policy. The ability to generate credits rested solely with existing sources, on a voluntary basis, but subject to governmental approval.

The pioneering acid rain control program introduced a radically different regulatory approach that changed things on several fronts, as noted in section 2.3. The regulator no longer focused on stack-by-stack emissions reductions, but instead sought to define the overall quantity of emissions (Q) that would be allowed. This led to market-based responses by polluters, providing economic efficiency, and also ensuring that all SO_2 emissions had a price. The efficiency of this market was independent of the initial distribution of allowances, and so the allocation process had a strong distributional (i.e., political) characteristics, rather than technical.

But as the SO_2 regulatory target shifted once again after the year 2000, this time from acid rain to fine particulate formation, the allocation procedure once more became technically – rather than politically – driven. The immediate (rather than geographically dispersed) impacts drew corresponding regulatory oversight, and when the EPA sought to rely on the broader Title IV-type markets and control system (albeit with more stringent constraints), the U.S .courts vacated the rule. EPA was forced to develop new regulations, and did so with relatively tight, formula-driven allocation procedures. This time there was no (obvious) political bargaining, other than that which occurred within the regulatory agency.

While the process was thus quite different in each SO_2 trading regime, there are some broader regulatory issues associated with determining such allocations, including:

- *Independence property*

The 'independence property' was obviously a crucial element of the Title IV allocation process. Hahn and Stavins have examined this quantity-based regulatory attribute, and note that while it is valid in theory (as shown by Montgomery in 1972[48]), in the real world its validity is affected by such factors as the market power of individual polluters; transaction costs; uncertainty; the differential regulatory treatment of polluters; and non-cost-minimizing behaviour by the polluting firms.

They examined eight different cap-and-trade systems, and found empirical evidence that the independence property was strong in half the systems, and moderate in two others. Their examination of the Title IV acid rain market found indirect evidence of high transaction costs, differential regulatory treatment of polluters, and uncertainty. Their analysis of Title IV program notes:

> "In summary, it appears that, at least in the early years of the SO_2 cap-and-trade program, a perfectly cost-effective allocation of permits was not achieved, due in part to high transaction costs and utility regulations. But later, as trading became more frequent, transaction costs fell, and utility regulations were clarified. The subsequent market was likely consistent with the independence property."

- *Adjustable allocations*

One proposed allocation scheme which has received attention in recent years is an adjustable one which changes over time to account for changing market conditions and sector composition. This is the approach noted above for the electricity sector in Ontario's emissions trading program.

Fischer and Fox have analysed such 'Output-Based Allocation' approaches,[49] which can serve to minimize the outsized rents sometimes captured by incumbent firms (sometimes exceeding their regulatory burden), and , as noted earlier, also have the advantage that new emission sources receive allocations as they come on-line. These typically use an allocation *rule* based upon outputs (e.g., electricity) in the previous time period. Fischer and Fox suggest that such a scheme might have useful properties for addressing the problem of carbon leakage, and such allocations are therefore often discussed within carbon trading proposals.

Hahn and Stavins have termed such approaches 'conditional allowance allocations,' and note that these could affect economic efficiency and also serve to disrupt the independence property (i.e., with such an allocation rule, firms have an incentive to increase production to obtain more allowances in future periods). Both sets of authors recognize that this type of allocation rule acts as a production subsidy.

- *'Private Rights in Public Resources'*

The Purdue University political scientist Leigh Raymond suggests that while the range of potential allocation schemes seems virtually limitless, there are in fact very deep philosophical and cultural attributes embedded within such public policy decisions.

In a book entitled *Private Rights in Public Resources: Equity and Property Allocation in Market-Based Environmental Policy,* Raymond studied the Title IV allocations and two similar programs (i.e., grazing rights on public lands, and greenhouse gases). He found that:

> "…the range of possible distributions of use rights may be much narrower in practice than in theory. In the abstract…. any initial allocation is possible (and equally efficient under the terms of the Coase Theorem). In practice, the range of possible allocations is substantially limited by certain powerful equity norms."[50]

These equity norms are deeply held philosophical viewpoints within the political system: John Locke's 'intrinsic' ownership, for example, holds that property is based upon the application of labor, is secure, and precedes even government, while Morris Cohen's 'instrumental' views suggest that it is politically constructed, insecure, and will change depending upon changing ideas of the social good. Raymond sees a Hegelian 'dialectic' at play in the Title IV allocation process, with tension between 'intrinsic' views (evidenced by the initial formal rules) and the 'instrumental' views (evidenced by the political wrangling) both evident in the final allocation scheme.

While such philosophical matters lie beyond the purview of this report, the question about the nature of allowances did play an important role in the adoption of Title IV. The Act contains specific language indicating that an allowances is "…a limited authorization to emit sulfur dioxide" and that "such allowance does not constitute a property right." Congress wanted to be clear that the government always had the right to change Q, and could do so without having to compensate those receiving allowances (or holding banked ones). [Note: the Fifth Amendment to the U.S. Constitution contains the clause “nor shall private property be taken for public use, without just compensation”; the language of the Act made clear that the newly created emission allowances were not to be subjected to that ‘takings’ clause.]

From China’s perspective, the control of SO_2 in Shandong and Shanxi Provinces is designed to accomplish all three air quality objectives (i.e., reduction of ambient SO_2, acid rain, and fine particle formation) which occurred in the U.S. SO_2 trading program over several decades. The U.S. allocation schemes designed to accomplish those objectives were significantly different in nature – they were primarily technical for the first (NAAQS) and third objectives (PM-2.5), but much more political for the second (acid rain).

While China may wish to accomplish all three objectives, realistically the program design will find it difficult to do so. Environmental officials will have to give additional weight towards at least one of these objectives, and it is probable that a scheme focused on localized air quality – and thus a more structured allocation scheme – would be appropriate.

The ability of the quantity-based schemes to deal with political pressures (through the independence property) is well-suited to the U.S. political system, but it is not clear that these advantages are as important in China. The U.S. system demands that the legislature wrestle with complex, regionally divisive pollution control efforts, and political bargaining tends to play a key role in such a system. China’s leaders may not need that degree of freedom to implement controls, and this too would favor the more tightly framed allocation approach. An analysis of allocation schemes in Fujian Province followed such an analytical approach, although its criteria were fairness, compliance with total amount control, and promoting consistent development of economy and environment,[51] rather than any of the ambient environmental goals framing the U.S. structured allocation efforts.

Finally, previous experience with emissions trading in China suggests that the country is likely to have significant difficulties in meeting the independence property criteria associated with cost-minimizing behavior. Power sector facilities tend to be highly regulated in most countries around the world, and it is often difficult for their personnel to make decisions in a market-oriented manner. China’s political and regulatory system has led to administrative rather than market-oriented decision making in previous emissions trading efforts,[52] and this too would tend to obviate any advantages of the political allocation approach.

4.2 ‘Hot Spot’ Considerations

When trading pollutants, not all emission situations are identical. Some pollutants are emitted from tall stacks, and some from low level sources. Some are emitted in crowded, urban settings and others in empty, rural areas. Further, if trading occurs over a large region, some of the sources may be ‘clustered’ within a specific region – and pollution may not be reduced sufficiently there.

In carbon trading systems this is not a concern, because CO_2 is not a direct health hazard, and it thoroughly mixes within the atmosphere within about three weeks. But it is an important concern in designing any SO_2 emissions trading program.

Concern was focused on localized NAAQS in the U.S. EPA's ETP and fine particulate formation in the CAIR and CSAPR, and air quality impacts were specifically addressed. The risk of hot spots in these three programs thus dropped dramatically -- as did, unfortunately, the opportunity for SO_2 emissions trading. There was concern about hot spots in the design of the Title IV program, and some consideration was given towards making it a two-region program with the intent of concentrating some control. There were special worries about the cluster of power plants in the Ohio River Valley, which had numerous large coal-fired plants burning high sulphur coal, and which were having a major impact downwind on New York and New England.

A subsequent analysis found that hot spots were not a problem in the Title IV program, however:

> "…data confirm a general prediction about cap-and-trade programs, that they will tend to create incentives for the dirtiest plants to clean up the most, as the per-ton cost of emissions reductions may be expected to be the least (as the capital cost is spread over a larger return). These data show that, if anything, trading may be expected to cool hot spots and not create them."[53]

Despite this rather strong characterization, hot spot concerns should be considered in any emissions trading program design. They can be particularly troublesome in situations where toxic chemicals are being regulated or where there are environmental justice concerns. Trading systems are usually not employed in such situations, and when they are (e.g. for mercury emissions control from U.S. power plants), they tend to be contentious.

4.3 Regulatory Oversight

The specific nature of any air pollution control program is obviously deeply rooted in the laws, customs, and social and political infrastructure of the country conducting the environmental program. The pollution control requirements for power plants that have evolved in the United States are a complex mix of legislation, regulatory agency mandates, governmental exhortations, lawsuit challenges, non-compliance enforcement strictures, agreements with non-governmental pressure groups, and a host of other governmental/industry institutional arrangements and agreements. There are, however, several key areas that must be addressed in any such control program, and these will have an important effect upon its success.

- *Relationship between national and local air quality management*

In the U.S. there has always been tension – as well as overlapping support – between local, state and federal levels of government, and the specific tasks appropriate to each level. Historically, environmental quality was viewed primarily as a local matter, and cities were responsible for their own environmental conditions. In the late 1800s and early 1900s, however, states began to play a more active role, particularly addressing water quality. This was because rivers were often polluted upstream of their municipal users, and as technology became available to address this concern, such polluters were located outside the city's legal jurisdiction. In the late 1960s and early 1970s the regulatory framework was again broadened, and environmental concerns became a national issue -- in part to apply greater resources towards the problem, as well as to provide a regulatory counterweight and technical expertise at a level beyond that which could be provided by state and local governments.

The system that has evolved in the U.S. continues to recognize the primary role of local and state governments in air quality issues, however, and the principal regulatory tool is the State Implementation Plan (SIP). SIPs are developed by the individual states to show how they intend to meet the ambient air quality goals (i.e., the NAAQS), and to show how they intend to carry out other provisions of federal laws. States can choose to be more stringent than the national requirements, but must meet them at a minimum. These SIPs must then be approved by U.S. EPA. If the SIP is deemed insufficient, the U.S. EPA will prepare a Federal Implementation Plan (FIP) to accomplish the air quality goals.

Many states incorporated existing city pollution control programs into the SIPs, and often allow city (or regional) programs to develop their own programs accordingly. Thus, U.S. EPA recognizes 113 jurisdictions with authority to issue permits to a pollution source (all 50 states, plus many cities and regions).[54] These would include, for example, the SCAQMD area noted above which runs the RECLAIM market-based program on a sub-state level.

For the other market-based programs discussed in this report, the states can choose to incorporate federal requirements into their SIP, or be more restrictive. Thus, as noted earlier, some SIPs took a more limited view than U.S. EPA about the role of retirement ERCs in the ETP. Similarly, the U.S. EPA prepared FIPs because of the short implementation schedule of the CSAPR, but the states could revise this – and the allowance allocation scheme that U.S. EPA employed – if they choose to do so.

- *State Implementation Plan (SIP) Management*

While the states and local governments have many air quality-related tasks under the SIP – ambient monitoring, dispersion modeling, plant inspections and auditing, etc. – the principal management tasks related to controlling SO2 emission sources can be organized under two sets of binary conditions found in Table 4.1: (1) existing and (2) new emission sources; located in (1) attainment or (2) non-attainment areas for the NAAQS.

This table is pollutant specific – for example, an existing source may be located in an attainment area for SO_2 but a non-attainment area for carbon monoxide, and the emission source's regulatory requirements will then be different for these two pollutants.

Table 4.1 U.S. SIP management framework

	Attainment Areas (i.e., 'clean')	'Non-attainment' Areas (i.e., 'polluted')
Existing Sources	**ARP/CAIR/CSAPR**	**RACT (*potential for ETP bubble*)** **ARP/CAIR/CSAPR**
New Sources	**NSPS; BACT** ***Prevention of Significant Deterioration (AQ increments)*** **(potential for ETP netting)** **ARP/CAIR/CSAPR**	**NSPS; LAER** ***New Source Review (ETP offsets required)*** **(potential for ETP netting)** **ARP/CAIR/CSAPR**

Existing sources in a non-attainment area have to apply Reasonably Available Control Technology (RACT) for that pollutant, and have the opportunity to employ the bubble mechanism in the ETP (described earlier) if they determine that the requirements are too onerous. Theoretically, existing sources located in an attainment area have no such requirements, since the area is already 'clean' – but the stringency of the ozone and PM-2.5 NAAQS and the regional contribution to its non-attainment means that very few emission sources avoid such control.

All new emission sources have to meet New Source Performance Standards (NSPS) if they are one of the categories affected (i.e., most major emission source categories, including power plants; there are more than 70 NSPS). New emission sources locating in attainment areas also have to meet air quality 'growth' increment limitations, which are evaluated by dispersion modeling; and Best Available Control technology (BACT) requirements (which tend to be more stringent than NSPS, since they 'ratchet' over time).

New emission sources locating in non-attainment areas are subject to New Source Review (NSR), and have to employ an even more stringent technology – Lowest Achievable Emission Rate (LAER) – and also are required to offset their emissions (as discussed earlier).

Thus, for the four mechanisms of the ETP: 1) SO_2 ERC bubble transactions occur from existing sources in non-attainment areas; 2) SO_2 ERC offsets transactions occur for new sources in non-attainment areas; 3) SO_2 ERC 'netting' transactions simplify permitting and allow new units at existing plants to avoid certain PSD and/or NSR requirements (but not control technology mandates); and 4) emission banks can include ERCs from either attainment or non-attainment areas. The other three SO_2 trading programs operate throughout the country (ARP), or in the specific states noted above (for CAIR and CSAPR).

- *The Regulatory Digital Infrastructure*

There was considerable concern in the early years of credit trading about how such a market-based system would work – and, as noted above, EPA initially called the mechanism 'Controlled Trading' to assure outsiders that regulatory oversight would be tight. Every ERC that was created in those early years had to be approved by the state's EPA, and every use of that credit constituted a SIP revision – thereby triggering a full U.S. EPA review as well, publication in the Federal Register, etc. Some states had separate (additional) legal requirements for modifying SIPs. In Illinois, for example, every proposed SIP revision had to be accompanied by an economic impact statement. Thus, every market transaction was treated as though the laws of the State were being changed.

Eventually these harsh oversight requirements were replaced with broader rules which allowed the states to set up 'generic' emissions trading rules, and only these were subjected to the more sophisticated review, instead of every single transaction. Despite such oversight, however, there were still concerns about 'paper offsets' – i.e., credits which did not offer real emissions reductions.[55]

Regulators have a range of tools to ensure compliance, including inspections and audits. Roughly 20,000 inspections of manufacturing facilities are conducted every year under the Clean Air Act, with regulators spending approximately $40 million to do so.[56] The introduction of the Title IV program changed the compliance program considerably, however, because it significantly increased attention towards technological means of tracking emissions. Regulators wanted to know the exact status of a facility's emissions in order to ensure that it holds sufficient allowances for market compliance, while polluters are faced with the fact that all emissions cost money, in the form of surrendered allowances -- and so they too want to make sure that they aren't paying for inaccurate emissions. Henriquez has called information technology "the unsung hero of market-based environmental policies," and notes that "the concept of a market in emission allowances was attractive in theory, but information technology made it happen."[57] He suggests that there were three essential components of the 'digital infrastructure' that made the SO_2 emissions trading program work: a) the allowance tracking system (ATS); b) the emissions tracking system (ETS); and c) continuous emissions monitoring systems (CEMS).

The ATS is EPA's central registry which tracks the issuance of allowances; the holdings of allowances in individual accounts; the deduction of allowances for compliance purposes; and the transfer of allowances between accounts. It also tracks other holdings, such as the reserve accounts for auctions and energy efficiency/renewable energy set-asides. EPA tracks every allowance with a 12 digit serial number, but it does not track other information about emissions trading transactions, such as prices, contract terms, etc. In 2009, there were 2,716 transactions moving 15.1 million allowances; 26 percent of these allowances transferred between economically unrelated parties.[58]

The ETS has been labeled 'the backbone of the system,'[59] and tracks the emissions submitted by individual utility units. A major upgrade of the system released by EPA in 2008, the Emissions Collection and Monitoring Plan System (ECMPS), provides a single, coordinated tool for users to submit emissions data, as well as additional information about monitoring plans, quality assurance/quality control, etc. The system uses an XML file format, and evaluates and checks such data, providing immediate feedback about submission problems. This is the system employed to report emissions under the Title IV, CAIR and CSAPR markets, as well as for other pollutants (such as the Regional Greenhouse Gas Initiative [RGGI] carbon market program in the Northeast U.S.).

The third component of the digital infrastructure, CEMS, is discussed below.

- *Relationship between CAC and economic mechanisms*

As shown in Figure 2.8 and Table 4.1, the economic mechanisms employed in the U.S. did replace the CAC infrastructure established under the Clean Air Act of 1970 (and subsequent Amendments), but rather was superimposed upon it. Thus, all of the NSPS, RACT, BACT and other mandated CAC requirements remain in place, and sources still have to document compliance with these requirements in addition to the economic ones.

New emission sources have to obtain a 'construction' permit which allows them to build the new facility, and this will document compliance with the PSD and/or NSR provisions. The facility will have to provide appropriate ETP offset ERCs, for example, before the NSR construction permit will be issued. Similarly, the permit will specify requirements for the installation of CEMs to document compliance with ARP and CSAPR market provisions. These will be checked after construction occurs to ensure compliance, and only then is an 'operating' permit issued.

The 1990 Clean Air Act Amendments required U.S. EPA to consolidate all of the air pollution control requirements into a single, comprehensive document that covers all aspects of an emission source's air pollution activities. This "Title V operating permit" program began in 1992, and these Title V permits make clear exactly what an emission source is required to do -- and thereby improve compliance. It also provides citizens an opportunity to become involved in the permit process, since public notifications are required when the permits are periodically renewed (usually every five years).[60]

The Title V permit thus outlines all of the mandates – including the monitoring and reporting requirements discussed below – for both the CAC and economic mechanisms affecting individual sources.

4.4 Continuous Emissions Monitoring Systems (CEMS)

The third component of the digital infrastructure, CEMS, are principally the responsibility of the polluters rather than the regulators. CEMS typically take a sample of exhaust gas, run it though a specific emissions analyzer (e.g., for SO_2, NOx, etc.), and then determine actual emissions. These emissions data can then be cataloged in a data acquisition & handling system (DAHS), reported on a mandated time-averaged basis (e.g., quarterly), and integrate with the ECMPS reporting requirements. Like other information technology, the price of CEMS has continued to drop over the years, but their operations and maintenance costs can be high because they operate within a harsh physical environment, and need extensive calibrations and quality assurance/quality control efforts to maintain accuracy.

The owners/operators of all units regulated under ARP must install CEMS on their units, unless they develop comparable alternative reporting approaches with the regulator. CEMS typically include an SO_2 pollutant concentration monitor, a volumetric flow monitor, and a diluent gas (O_2 or CO_2) monitor. Opacity is also recorded on such units, as well as NOx (a pollutant also regulated under Title IV, but with non-market CAC emission requirements). All of these data are recorded in a DAHS, which also performs calculations as required.

All CEM systems must be in continuous operation and must be able to sample, analyze, and record data at least every 15 minutes. All emissions and flow data will be reduced to 1-hour averages, and the regulations contain detailed specifications for converting data to required parameters, the handling of missing data, etc.

Over and above these technological requirements, the CAA also required acid rain emissions sources to appoint a 'designated representative' who would represent and 'legally bind' the owners /operators in matters pertaining to the ARP, including reporting of the CEMS results. This person's name was published in the newspaper, and this designated representative had to:

> "submit a certification in support of each quarterly emissions monitoring report based on reasonable inquiry of those persons with primary responsibility for ensuring that all of the unit's emissions are correctly and fully monitored. The certification shall indicate whether the monitoring data submitted were recorded in accordance with the applicable requirements of this part including the quality control and quality assurance procedures and specifications of this part and its appendices…"[61]

This regulation had a powerful compliance effect, because it essentially 'personalized' reporting requirements for the emission sources under the market-based systems. It was no longer enough to have the utility simply report emissions to the environmental regulator. Now, there was a specific senior corporate individual – legally representing the company – who had to assure the regulator that the emissions reported were correct, and who took responsibility for making reasonable inquiries about such matters. If it turned out that there was fraud or misrepresentation of the data, the EPA knew specifically which person within the firm to target – and the risks associated with being designated that person certainly drew the attention of utility management.

This combination of strong technology-oriented CEMS monitoring and personalized responsibility at the emission source has made the ARP emissions data base one of the most sophisticated emissions management database systems in the world. It is far superior to the routine emissions inventory databases employed by regulators, and if the U.S. EPA is involved in litigation with emission sources, it seeks to employ such data if possible. It has also made subsequent air quality management – such as the development of CSAPR, which relied on this database – much better informed.

The pollution control decisions that utilities make (such as selling or purchasing SO_2 allowances, or installing a flue gas desulfurization unit) are also subject to other types of regulatory oversight (e.g., financial 'prudency' decisions by state Public Utility Commissions). They may also affect the utility's actions in other markets (e.g., for NOx allowances); or compliance plans for other pollutants (e.g., particulate, mercury, toxic emissions, etc.).

Despite these constraints, the use of market-based mechanisms has actually introduced considerable flexibility for utilities, particularly since they can 'bank' both credits and allowances. The compliance rate in the trading programs has been very high, and in 2009, for example, all 3,572 electric generating units in the ARP held sufficient SO_2 allowances to be in compliance.[62]

4.5 Ambient Impact Monitoring

In addition to the emission compliance information data bases noted above, U.S. EPA and individual states and localities are obviously interested in how well their regulatory programs are actually performing. The primary indicators of success are trends in ambient air quality and acid deposition impacts.

There are more than 5,000 active ambient air quality monitors measuring NAAQS pollutants in U.S. EPA's Air Quality System (AQS).[63] Data from these monitors, collected by state, local and tribal environmental agencies and reported to the AQS, can then be used for identification of non-attainment areas as well as trend evaluations and analyses.

Figures 4.2 and 4.3 show the current SO_2[64] and PM-2.5[65] non-attainment areas, respectively. Note that there are only nine areas not meeting the SO_2 NAAQS (five for the primary [health-based] standard only, and four for both the primary and secondary [welfare-based] SO_2 standard). There are many more areas exceeding the 1997 (annual) and 2006 (24-hour) PM-2.5 NAAQS, and this has led to the more aggressive control programs described earlier.

Both the SO_2 and PM-2.5 trends are generally downward over recent years, with a 65% decrease in national annual average SO_2 concentrations over the period 1990-2009 (based upon 252 monitoring sites)[66], and a comparable 27% decrease in PM-2.5 over the 2000-2009 period, based upon 724 monitoring sites.[67]

In addition to the NAAQS pollutants, the National Atmospheric Deposition Program (NADP) measures atmospheric deposition and studies its effects on the environment. The NADP precipitation chemistry network began operations in 1978, but expanded considerably in the early 1980s under the NAPAP research program mentioned above. The network's name was changed to NADP National Trends Network (NTN), and today it has 250 monitoring sites.[68]

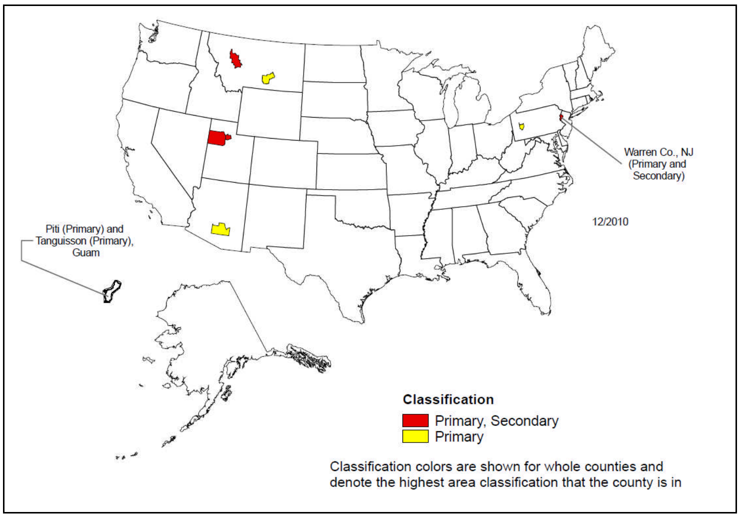


Figure 4.2 U.S. non-attainment areas for SO_2

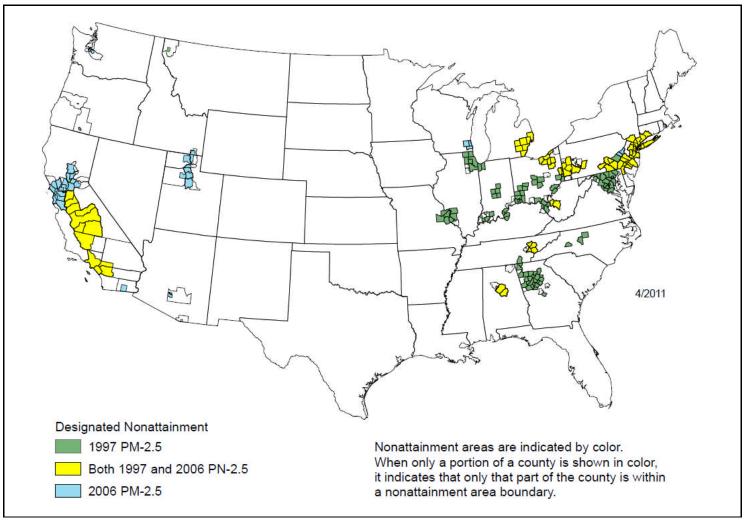


Figure 4.3 U.S. non-attainment areas for PM-2.5

These collect samples weekly, measuring free acidity (H^+ as pH), conductance, calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), sulfate (SO_4^{2-}), nitrate (NO_3^+), chloride (Cl^-) and ammonium (NH_4^+). A second network, the Atmospheric Integrated Research Monitoring Network (AIRMoN) joined the NADP in 1992, and currently has seven sites. It measures the same chemicals as the NTN, but on a daily rather than weekly basis. Finally, another network, CASTNET (Clean Air Status and Trends Network) is a national air quality monitoring network designed to provide data to assess trends in air quality, atmospheric deposition, and ecological effects due to changes in air pollutant emissions. It operates more than 80 regional sites throughout the contiguous United States, Alaska, and Canada, and monitoring sites are located in areas where urban influences are minimal.[69]

The acid deposition trends measured at these sites are similarly encouraging. Between the 1989–1991 and 2007–2009 observation periods, regional decreases in wet deposition of sulfate across the Eastern United States averaged 43 percent. The total (wet + dry) deposition reductions are even more dramatic – over 50% -- but the regional monitoring coverage is less comprehensive, and U.S. EPA will not make such claims about its representativeness.[70] Thus, the SO_2 control programs appear to be working effectively, although further reductions are sought to address all three (i.e., ambient SO_2, acidification and PM-2.5) impacts.

4.6 Trading Institutional Infrastructure

Trading of any commodity tends to occur at three broad levels: a) bilateral trading; b) over-the-counter trading, through brokers and other specialized dealers; and c) exchange trading.

In the U.S., SO_2 trading in the ETP was initially very limited. The air quality constraints meant that only emission sources located in very close proximity would trade, and the markets were 'internal' in nature: the same source that generated the credit would use it. While no precise figures are available, ERCs that were 'externally' traded (i.e., traded between different economic entities) probably represented less than 10% of the transactions, and these were typically for volatile organic compounds (VOCs). VOCs were controlled to meet ozone non-attainment, and the number of sources facing such constraints were much larger than those facing SO_2 non-attainment limits. The fact that VOCs did not have to conduct dispersion modeling (since the impact of an individual source could not be ascertained by Gaussian models) also made such transactions easier to accomplish.

Not surprising, then, brokers therefore tended to focus on VOC rather than SO_2 transactions within the ETP. The program therefore had very few bilateral deals (since most were internal); even fewer broker-aided deals; and no exchange trades.

This changed under the Title IV regulations, since there was now a fungible instrument (i.e., the SO_2 emission allowance), and trading did not require dispersion modeling to document its air quality impact. The number of bilateral trades increased significantly, and brokers also began to play a much larger role. There were no emissions exchanges set up specifically for emissions trading in the U.S., although the Chicago Board of Trade ran the allowance auctions for the U.S. EPA, and received permission to list 'futures' of such products.

The establishment of the Chicago Climate Exchange in 2003 marked an important development for emissions trading. It was an exchange that focused on CO_2 voluntary emission credits (VERs), and it did not directly trade SO_2 ERCs or emission allowances. But importantly, it also represented the point where the financial industry began to take a stronger interest in emission-based commodities. While energy trading companies such as Enron had played a role in the SO_2 trading marketplace, most emissions trading to that point had been conducted as part of a 'compliance market,' where those who conducted the trading used the products for compliance purposes. In the newly developing 'financial markets,' however, speculators, hedge funds and others would purchase emissions trading commodities with the idea of selling them at a later date for profit.

This change was particularly noticeable in the carbon trading arena, where the development of the EU ETS, the Kyoto Protocol, and similar regulatory programs introduced emissions trading on a much larger (and international) scale. The carbon market was valued at $142 billion in 2010,[71] and China has greatly benefited from the sale of certified emissions reductions (CERs) under the Clean Development Mechanism (CDM) of the Kyoto Protocol into this market.

The parent firm of the CCX set up the Chicago Climate Futures Exchange (CCFE) in 2004 to offer derivatives in various emission commodities (carbon dioxide, NOx, SO_2, etc.) that would be attractive to both the compliance and financial market participants. The CCFE offered Sulfur Financial Instrument (SFI) futures contracts, which were blocks of 25 ton SO_2 allowances contracts for future years, based upon the Title IV (and prospective CAIR) programs. This market was hit very hard, however, when the EPA introduced CSAPR, since the previous Title IV allowances would not be valid. On August 5, 2011, the CCFE announced:

> "U.S. environmental market trading volumes are down significantly. The U.S. has not enacted carbon cap and trade legislation *and changes to the EPA acid rain program have reduced trading activity*. Accordingly, Chicago Climate Futures Exchange (CCFE) volumes are down substantially and the exchange is operating at a loss…. Given these circumstances, *CCFE will operate through the first quarter of 2012 and then close*." [emphasis added][72]

Unlike carbon trading, and despite some success in CCFE's seven years of operation, exchanges have never played a very large role in SO_2 emissions trading. Most transactions have been either bilateral or OTC, and even these played a limited role in the early ETP program. Exchange trading only came to fruition when fungible SO_2 emission allowances were introduced in Title IV – but as the trading requirements have become more and more restricted (for air quality reasons), such trading is likely to play a smaller and smaller role within the U.S.

5. Recommendations

Denny Ellerman of MIT studied the potential application of emissions trading within China, and noted: "Although much can be learned from experience using tradable permits in the U.S. and elsewhere, conditions in China are unique."[73] This report has focused solely upon international rather than domestic Chinese experience with SO_2 emissions trading. Nevertheless, it is possible to draw some broad recommendations that can help in the design of the Shanxi and Shandong programs. These include the following:

5.1. *Begin with one SO_2 trading instrument, utilizing allowances*;

A case could be made that China should begin with an SO_2 credit trading program, much like the U.S. did for a fourteen year period before introducing allowances, and like Ontario did in its PERT program before introducing its hybrid credit/allowance system.

SO_2 credit trading could serve to strengthen the CAC regulatory program, familiarize emission sources with the idea of trading, and build upon the existing CDM carbon credit experience which already exists within the country. It also has the advantage that ERCs could be created for 'retired' smaller units (much as was done under the U.S. scheme), and would allow the authorities to focus on localized air quality (as the U.S. did with its early focus on NAAQS). And, as noted earlier, China might not need some of the political advantages of the allowance schemes, and will likely have difficulty meeting the terms of the 'independence property' in any event.

Credit trading does not accomplish environmental improvements, however, as these are driven solely by the CAC regulations. Credit trading merely reduces their cost. Further, ERC markets for SO_2 credits, unlike their carbon counterparts, tend to be rather thin. They can be administratively complex to implement, depending upon detailed understanding of a source's operations and requirements compared with the CAC regulations, and a means of tracking deviations from that baseline. And it would likely take a considerable number of years to develop and implement a viable SO_2 credit trading marketplace.

Allowance trading provisions, on the other hand, tend to be relatively easy to understand, and allow governments to set broader environmental goals rather than stack-by-stack requirements. They allow governments to decrease emission levels incrementally, by tightening the cap over time. Importantly, they also result in a 'price' on emissions – every ton of SO_2 costs money, because it must be covered by an allowance.

The disadvantages are that the regulator loses control over where the emissions are controlled, which can be important when dealing with localized air quality and the formation of fine particulate, as well as any 'hot spot' concerns about acid rain. China's regulators will likely be trying to cover all three air quality goals in these SO_2 trading programs, and losing that ability is troublesome.

It might be technically feasible to develop a hybrid system, utilizing both credits and allowances, as Ontario did, and as the U.S. SO_2 and EU ETS carbon markets have done. But Europe's carbon market development has shown the difficulty of introducing two new systems at the same time – and those occurred in a market where spatial considerations were not important. Considering the complexity and difficulty in introducing emissions trading program, this would not appear to be a viable approach in China.

Accordingly, it seems that the best approach for the two Provinces would be to develop an SO_2 allowance scheme, fully recognizing the limitations of such an approach (as discussed in the following recommendations).

5.2. Recognize the spatial limitations on localized air quality associated with such an approach, and track SO_2 impacts (i.e., through both dispersion modeling and ambient monitoring);

The regulator's loss of control over localized actions affecting air quality can be minimized by including geographical constraints on trading. For example, the RECLAIM program in Los Angeles has both 'coastal' and 'inland' zones, and restricts trading between them. Similarly, the CSAPR program restricts trading between the two U.S. control regions. This may be a viable strategy in Shanxi and Shandong, but the geographical coverage is probably too small for such an approach.

Any allowance-based program should take such spatial concerns into consideration, however, and address them explicitly by including provisions for both dispersion modeling and additional ambient monitoring (as necessary) to address 'hot spot' concerns after the program has been implemented.

5.3. Explicitly address compliance concerns in the SO_2 trading program design, through both CEMs and auditing;

The issue of regulatory oversight and source compliance is just as complicated in China as it is in the U.S. – and perhaps more so, given the radical changes that have occurred in China over recent decades. China is trying to accomplish in a very short period of time the environmental modifications which occurred in the U.S. over decades. It is doing so during a period of strong – almost radical – economic growth, and there have been attendant environmental pressures associated with that growth.

This has caused regulatory oversight and compliance problems for SO_2 control, which have been well documented. While China has made a significant investment in flue gas desulfurization (FGD), a 2006 NDRC survey found that 60% of the FGD units were not being operated – it was less expensive to pay the environmental penalties than the operating cost of the FGD units. Similarly, a 2004 survey of China's CEM situation was even bleaker than the FGD one: only 20% of the installed CEMs were working properly; 53% of the units operated "sporadically"; and another 27% weren't operating at all.[74]

These data were apparently a wake-up call, because new policies were soon developed that sought to improve the situation. In addition to increased regulatory audits and inspections, power facilities were paid a higher tariff for electricity coming from scrubbed units. The results of such efforts were dramatic in at least one province: in Jiangsu, plants that were operating 63% of the time and removing 59% of the SO_2 in the first half of 2007 were operating 97% of the time and removing 93% of the SO_2 in the second half.[75] Recent joint U.S. EPA and China governmental CEMS inspection efforts have shown that, while considerable problems still exist and CEMS operation and supervision remain inconsistent, the country has nonetheless made considerable progress.[76]

The results of these efforts have been confirmed in both satellite data[77] and sulfate loading measurements,[78] which suggest that China has taken significant steps in dealing with its SO_2 problems. However, progress is only that – and the environmental regulatory system continues to face considerable challenges within the country.

The introduction of a new market-oriented emissions trading program for SO_2 is likely to further expose emission source compliance problems and regulatory oversight shortcomings, and detailed attention to all three digital infrastructure elements of the emissions trading regulatory program (i.e., ATS, ETS, and CEMS) is clearly warranted in the program's design.

5.4. Take steps to move the SO_2 trading program towards a market-based (rather than administrative-based) regulatory system:

China underwent a radical transformation in 1978 when it decided to shift from a centralized planning to a socialist market form of economy, and it is still dealing with the implications of that transition.

When emissions trading was adopted in the West, it was imposed on economies which had already been subjected to considerable resource efficiency discipline imposed by the market. Thus, Western countries evolved from: A) market economies; to: B) market economies with command/control pollution regulation; to: C) market economies with market-oriented pollution control regulation. China has not yet fully finalized the transition to step A; it has wrestled with some of the problems in step B, as noted immediately above; and in this project, hopes to implement step C mechanisms.

This is certainly a challenging task, and the RFF analysts working on the ADB-sponsored Taiyuan emissions trading project noted:

> "The challenges involved in introducing a rigorous environmental management system, including emissions trading, in Taiyuan brings to mind the adage, "Rome wasn't built in a day…"[79]

There are steps that can help move the pollution control system away from administrative decision-making towards a more market-oriented framework, however. These include increased capacity development not only for the regulators, but also for those emission sources affected by the new program. These could address, for example, training addressing the trading opportunities available, as well as instruction concerning control technology and fuel switching options, cost evaluations, etc.

Similarly, actions can be undertaken by the regulator to help increase market transparency and liquidity. The collection and reporting of transaction prices provides useful market information which is sometimes (e.g., RECLAIM) but not always (e.g., U.S. EPA) undertaken by governmental regulators. Auctions of even a small amount of allowances can provide for price discovery in newly formed markets. And some governmental agencies which are responsible for economic development have taken a more activist role in some U.S. states, helping to arrange credits for sources planning to build new facilities (i.e., essentially acting as a no-cost emissions broker).

5.5. Explore political opportunities within the allocation scheme, particularly those supporting small sources faced with shutdowns;

One of the tasks included in the China Thermal Power Efficiency Project hopes to utilize the allocation scheme to help support the closure of small, inefficient coal-fired power plants, and this is certainly a worthwhile goal. The independence property provides some opportunity to separate efficiency and distributional concerns, and to the extent that this can be done without compromising air quality goals, it should certainly be pursued.

5.6. Recognize that SO2 emissions trading is likely to be an interim strategy. Shifts towards cleaner fuels or full controls on all SO_2 emissions sources will ultimately be necessary to fully accomplish environmental goals;

The experience within the U.S. has shown that the air quality benefits associated with SO_2 control are very large, even given the control programs already undertaken within the country. The CSAPR regulatory analysis (taking into account both SO_2 and NOx controls) estimated that benefits would exceed costs by at least a factor of 100, due primarily to reduction of premature mortality.[80]

The situation in China is likely very similar (although there are some differences due to the manner in which premature mortality is typically valued). A joint US-China Joint Economic Study determined that the average cost for installing FGD on a Chines power plant was $160/ton of SO_2 removed (1326 RMB/metric tonne), compared with $793/ton of benefits (6556 RMB/metric tonne), a 5:1 benefit to cost ratio-- but noted that “significant additional benefits…. were not addressed.”[81] This study also noted that the situation could be improved by utilizing emissions trading (with savings of 16% on the cost side), making the benefit to cost ratio even better.

While these are average (rather than marginal) costs, they also suggest that societies have to move fairly far up the marginal cost curve before spending on SO_2 control becomes a poor social investment. The data suggest instead that a full and rigorous control program for this pollutant is warranted, and that every opportunity should be taken to minimize or reduce it.

5.7. Recognize that the environmental goals must dictate the nature of the economic instrument program, rather than the converse. Emissions trading is designed to accomplish environmental goals using economics, not to meet economic goals (i.e., wealth or job creation) using the environment.

One RFF participant in the Taiyuan SO_2 trading experiment later wrote:

> "Chinese officials sometimes appear to have the impression that trading is a costless way of achieving environment reductions; there has been less emphasis than I think warranted on the plain fact that in a trading system, someone, somewhere, must engage in concrete emission reduction practices, which are likely to be costly."

China has done extremely well financially under the CDM, where it has sold carbon credits to EU and other Kyoto Protocol buyers. This has helped China make clean energy investments, and has been very beneficial for China's environment. Unfortunately, however, it has also led many in China to believe that emissions trading is simply a way to make a profit from the environment – without ever considering the nature of such markets, or the source of funding for such profits.

SO_2 emissions trading will have no foreign buyers. All of the funding for allowances or credits will have to come from Chinese emission sources. Many of these sources are likely to be extremely reluctant to spend funds for environmental protection, as the high level of non-compliance in previous years has shown.

Further, it is very important to reiterate the fact that emissions trading is designed to use economic mechanisms to tackle an environmental problem. It is not designed to use the environment for economic gain. Clean air is the objective, not profits for hedge funds or jobs in emissions exchanges. When U.S. EPA changed the rules from CAIR to CSAPR, the market in SO_2 allowances collapsed. Speculators lost money, and CCFE was driven out of business. The U.S. EPA changed the rules for environmental purposes, not economic ones. The ultimate goal of emissions trading is environmental protection. China's nascent emissions traders should have no illusions about what emissions trading is designed to do, or what it can accomplish.

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