Climate Change Central

Compliance and the Acid Rain Program

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Contents

Page

Figures

Graphs

Tables

Introduction

The Canadian federal and provincial governments are considering emissions trading as a potential component of any future Canadian regulatory policy for greenhouse gases. Emissions trading gives firms the flexibility to decide how to meet their emission reduction requirements. They may use technology to reduce their emissions or they can pay others to reduce emissions for them. To effectively design and implement an emissions trading program for greenhouse gases it is important to evaluate and understand the experiences of other jurisdictions with emissions trading. One of the most often cited historical models is the sulfur dioxide (SO_2) trading system that resulted from the enactment of the 1990 Clean Air Act Amendments (CAAA) in the United States. This paper will look at the history, implementation and development of the Acid Rain Program and consider whether it was successful in meeting the environmental and regulatory goals that led to its enactment.

To determine the success and accomplishments of the Acid Rain Program, three questions must be answered.

First, if the program had not been implemented, would emissions have been reduced as much over time? Would other standards in place, such as the National Ambient Air Quality Standards (NAAQS), have reduced emissions as greatly as the Acid Rain Program or would companies have voluntarily reduced on their own? To answer this question, an overview of regulatory policies that influenced SO_2 emissions will be presented. Emission trends before and after the implementation of these policies will be discussed. The answers to this question will be developed in sections two, three, and four.

Secondly, was a competitive market for SO_2 allowances created to ensure that emission reductions were cost effective and new sources had full access to permits? If so, there should be a significant amount of trading in the market, no hoarding of allowances from incumbent plants, and easy access into the market for new sources. To answer this question, section three includes an overview of trading behaviors, with a discussion of how these behaviors relate to emissions reductions by the firm (i.e. compliance choices of firms). We will also look at whether the allowances allocated were low enough to require companies to reduce their SO_2 emissions.

The third and last question: were emissions reduced at lowest possible cost? If allowance trading was the least-cost method, did companies choose to trade allowances instead of adopting a new technology (i.e. scrubbing or fuel switching)? To answer this question, data relating to compliance choices and costs made by firms will be discussed in section four.

The answers to these three questions will ultimately allow for a relative judgment relating to the success or failure of the Acid Rain Program. The lessons learned will provide good insights into whether the Acid Rain Program would be a good model for emissions trading policies to reduce greenhouse gas emissions in Canada. These insights will provide input into climate change policy discussions in Canada.

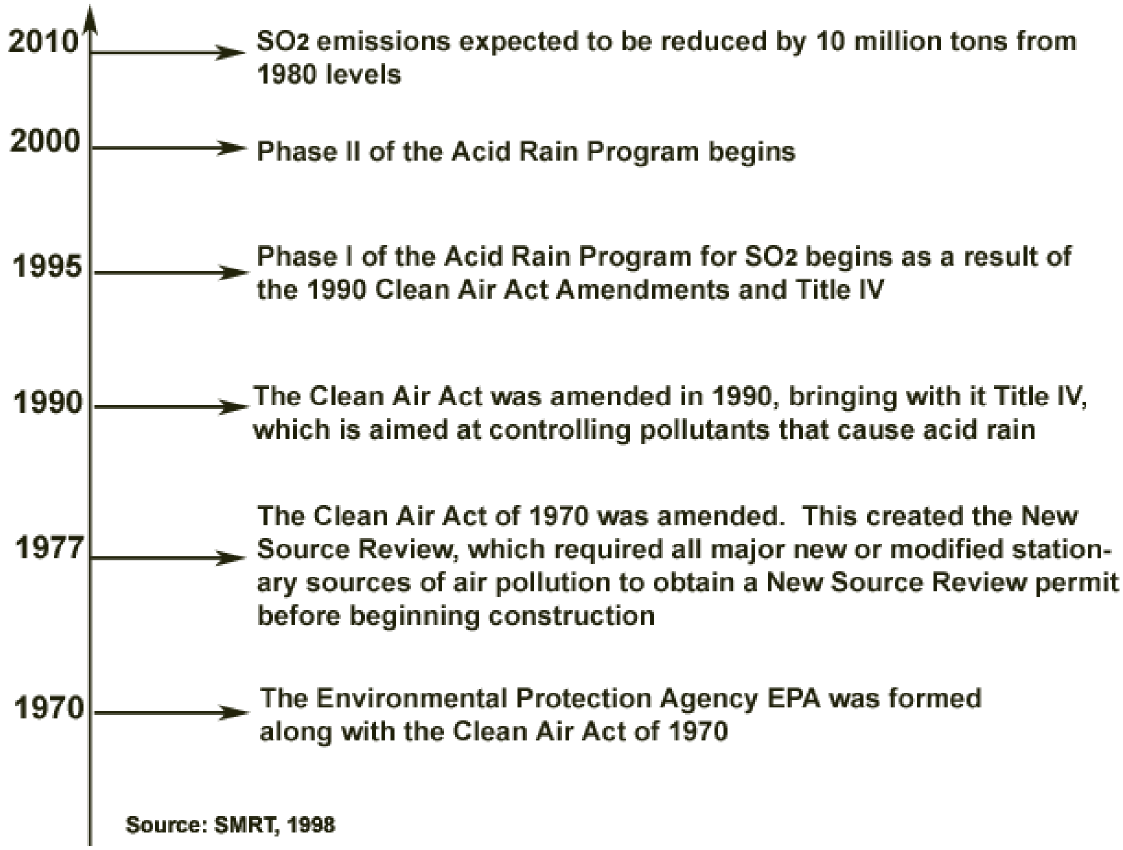
Background

Clean Air Act

By the 1970's, pollution from SO_2, which causes acid rain, was becoming a large problem (for further discussion, see appendix A) In 1970, the Environmental Protection Agency (EPA) was formed. One of its initial pieces of legislation was the Clean Air Act (CAA). The EPA was formed to bring enforcement of pollution laws (SRMT, 2002). As part of the CAA, the agency also established the National Ambient Air Quality Standards (NAAQS). These standards are still in effect today with the goal of minimizing health risks to the public.

The CAA was amended in 1977 and again in 1990. The amendment of 1990 provided the foundation for the Acid Rain Program. Figure 1 below, illustrates the evolution of the CAA and other important dates in the development of the Acid Rain Program.

Figure 1: Timeline of Clean Air Act, Title IV and Acid Rain Program



Title IV

As previously stated, the 1990 Clean Air Act Amendments (CAAA) laid the foundation for the Acid Rain Program. Specific requirements are outlined in Title IV. Title IV's goal was to reduce acid rain by lowering SO_2 emissions 10 million tons below their 1980 levels to 8.95 million tons by 2010 (Natsource, 2001). To achieve this goal, Title IV included an innovative emissions cap and trade program (Tebo, 1997).

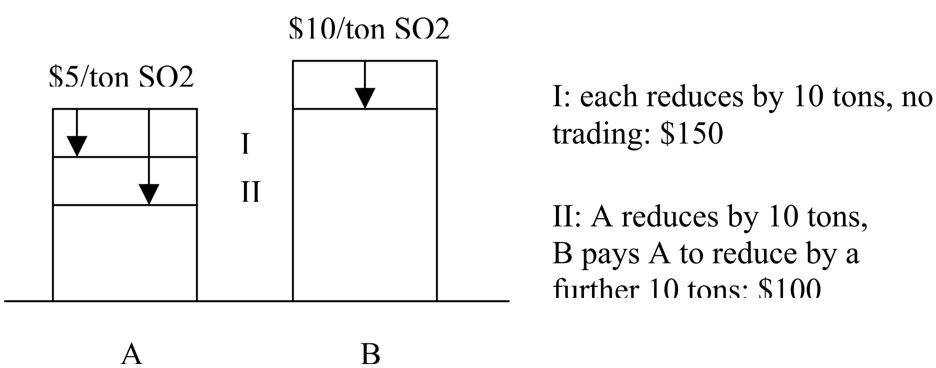
The Acid Rain Program was incorporated in two phases. The first phase began in 1995 and included the 110 "dirtiest plants" emitting SO_2 in the U.S. From these plants, 445 utility units are included (EPA, 1996). The second phase began in the year 2000 and includes 2,262 operating units (EPA, 2001).

Why cap and trade?

Featured in the Acid Rain Program is a cap and trade method of regulation instead of the traditional command and control type of regulation. A cap and trade program imposes an emissions limit (a "cap") across all plants deemed to be participants in the program. Participants are allocated tradable rights to pollute (i.e. allowances). The total number of allowances allocated is limited to the environmental target for the airshed being regulated. In the case of the Acid Rain Program, the eventual goal is to limit SO_2 emissions to 10 million tons below their 1980 levels to 8.95 million tons by 2010.

The purpose of using allowances is to allow for the reduction of emissions at the least cost. The Acid Rain Program features a cap and trade program because it is a "trading system for SO_2 that facilitates lowest-cost emissions reductions and an overall emissions cap that ensures the achievement and maintenance of the environmental goal" (EPA, 1998). It is also viewed by many as more "flexible" than a command and control program because companies get to decide how to meet their requirements rather than the government. Allowances can be bought or sold by anyone and each allowance is good for one ton of emitted SO_2. Allowances may also be banked to use in future years. How this works is illustrated in figure 2. A more in-depth analysis of the role of allowances will be discussed further in later sections.

Figure 2. Trading Benefits



Source: Peace, 2002

In Figure 2, A and B are two emitters with an overall requirement to reduce emissions by 20 tons of SO_2. First, assume that no emissions trading is allowed and both emitters must reduce their emissions by 10 tons. If emitter A can reduce at $5 per ton and emitter B can reduce at $10 per ton, the total cost to reduce is $50 for A and $100 for B, with a total overall cost of $150. However, now assume that emissions trading is allowed. Emitter B could pay emitter A to make the whole 20-ton reduction. If emitter A does this, the total cost for the reduction of the 20 tons is only $100, with a savings of $50 when compared to the first case. The same level of reduction can be achieved more cheaply by using trading.

Market Beginnings and Evolution

Under the Acid Rain Program, allowances are allocated by the EPA on an annual basis and are tradable. For Phase I, (1995-1999) allowances were allocated on a basis of "average fuel consumption in 1985 through 1987 multiplied by 2.5 pound SO_2 per million BTU emission rate" (EIA, 1994). This initial allocation was the same across all plants.

However, plants were able to obtain extra allowances through various means including bonuses for reducing emissions and auctions. Extra allowances were also given when firms needed to use additional units to comply. For example, firms were given extra permits if they needed to use substitution units, which are units brought in to assist another unit that must comply, or compensating units, which are units that compensate for units reduced below their baseline. In addition, opt-in units, a unit that is not required to participate in Phase I, but chooses to do so, were given allowances.

For Phase I, many plants were over-allocated allowances. EPA did this to get the plants to agree to the program or to opt-in. By over-allocating, plants would feel at less risk of under-complying and would be more likely to agree to the program.

In 1995, the initial allocation was 5,550,231 allowances for 445 plants (EPA, 1996). With the addition of extra allowances, resulting from the bonus provisions, plants received an additional 3,193,850 allowances for a total of 8,744,081 allowances in 1995 (EPA, 1996). In 1996, 431 plants participated with an allocation of 8,296,548 allowances (EPA, 1997). However, because 3,435,789 allowances were banked from 1995, the total cap for 1996 was 11,732,337 (EPA, 1997). Since one allowance is equal to one ton of SO_2, the total allowable emissions in 1996 was 11,732,337. Allocated in 1997 were 7,147,464 allowances (EPA, 1998). With the banked allowances from the previous year, the total allowable SO_2 emissions were targeted at 13,435,799 (EPA, 1998). In 1998, 6,969,165 allowances were allocated and with the banked allowances from 1997, the total allowable allowances amounted to 14,928,841 (EPA, 1999). In 1999, the total allocation of allowances was 6,990,132 with a total allowable amount of 16,618,112 (EPA, 2000).

Phase II allowances were allocated using their average fuel consumption in 1985 to 1987 multiplied by 1.2-pound SO_2 per million BTU emission rate (Dean, 2002). Phase II began in the year 2000 and although the amount of allowances that each plant received was reduced, the total cap increased because more plants had entered the program. 2262 units were included in Phase II and 9,966,531 allowances were allocated in the year 2000 (EPA, 2001). With the banked allowances from Phase I, the total amount of allowances that could be used for compliance was 21,583,540 (EPA, 2001). In the year 2010, the targeted amount of emissions will be reduced to 8.95 million tons (Dean, 2002). This means that the allowances allocated will again be ratcheted down.

Methods for Compliance

It should be noted that allowances are not the only way for plants to meet their obligations under the Acid Rain Program. Plants have the choice of using technology, previously- implemented controls, retiring plants, and allowances to comply. Many plants, however, are choosing to use more than one of these compliance methods.

Technology

There are two ways that plants can comply using technology. One way is to install a flue gas desulfurization system, which is also known as a scrubber. Scrubber systems are very effective in removing sulfur from SO_2. They range in efficiencies from 85% to 95% (EIA, 1994). The efficiencies depend on the type of scrubber, re-agent and reactor tank that are used.

There are two main kinds of scrubbers. One is a dry flue gas desulfurization system (producing a dry byproduct), and the other and most common is the wet flue gas desulfurization system (producing a wet, slurry-like product).

There are also several different kinds of wet scrubbers. The differences between wet scrubbers lie in the sorbent or re-agent they use and the absorber tank that contains the reaction between the sorbent and SO_2. Some different kinds of re-agents that are used to react with and break up the SO_2 include limestone and lime. These re-agents are the most popular because they are both effective and cost efficient. The most common types of absorber tanks are packed, spray, tray, and venturi. For example, a New Jersey-based plant, B L England, Unit #2, installed a limestone spray scrubber in 1995. To learn more about how scrubbers work, see Appendix B.

Another way to use technology to comply is through fuel switching, blending, or co-firing. Fuel switching is when a plant switches to a different type of coal or a different type of fuel altogether. Blending takes place when two types of coal are blended together. Co-firing is when coal and a fuel, such as natural gas, are blended together.

Like scrubbing, there are many types of fuel switching and blending. The difference lies in the type of coal or fuel used. Typically, plants that fuelswitch, change to a coal with lower sulfur content. Alternatively, they may switch fuels entirely, from coal to natural gas, for example. Plants that blend fuels, mix together high and low sulfur coals. This may be because it is easier for the equipment in the plants to adjust to a smaller change such as blending than it is to switch completely to a new fuel. Some different types of coal that may be switched to or used for blending include eastern low-sulfur coal and western low-sulfur coal. A more expensive choice is co-firing. In this case, plants combine coal with another fuel, usually natural gas. A complete switch to natural gas is the most expensive option. Appendix C provides more information on fuel switching.

Previously-installed Controls

Some plants do not need to do anything to comply because their emissions are below their allocation. This may be because they had previously installed controls that reduced their emissions to low-enough levels. It may also be due to an over-allocation of allowances at that plant.

Retirements

Retirement is another option that is used when a plant shuts down and is no longer in use. The plants that use this method are still allocated allowances annually until the Acid Rain Program ends. These allowances can then be sold back onto the market. An example of a plant that has retired and is still receiving allowances is Ohio-based Acme.

Allowances

Plants can choose to comply by purchasing extra allowances from other plants or from the EPA auction, thereby increasing the amount of trading.

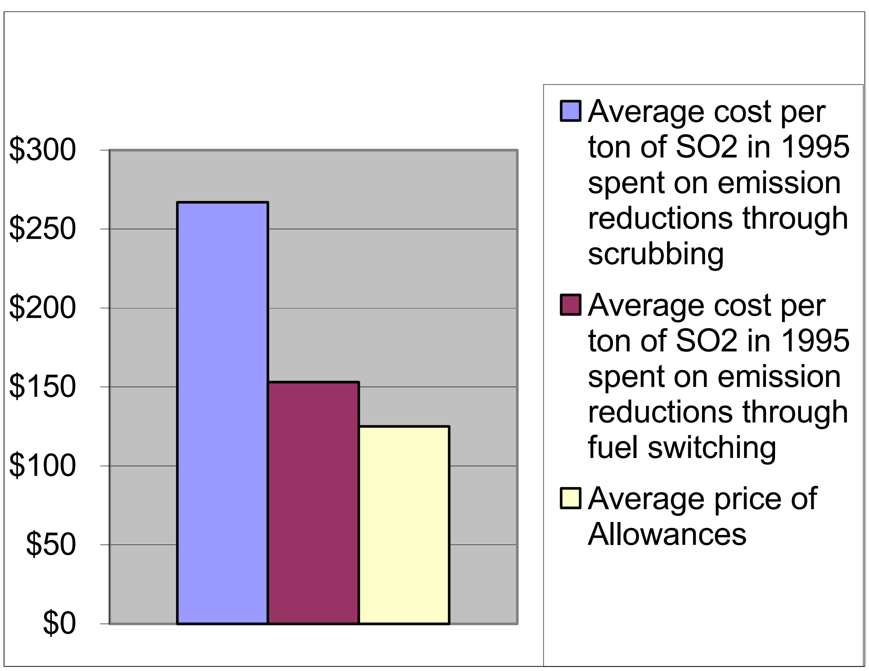
Allowances were over allocated for Phase I, from 1995 to 1999, as evidenced by the high number of banked allowances. The over-abundance of allowances in Phase 1 resulted in little trading and low prices. Allowances were not needed by plants to comply because most plants had more than they needed.

Compliance Methods Chosen

In 1995, thirty percent of firms chose to comply using allowance trading, ten percent chose flue gas desulfurization, and more than fifty percent chose to fuel switch (DOE, 1997). The costs of these three compliance methods are illustrated in Graph 1 below. Allowances were the cheapest method to comply, with fuel switching slightly more expensive. The relatively high cost of scrubbers explains why this compliance method was less favored.

It is interesting to note that, although allowance prices were cheaper than fuel switching, allowances were not used to comply as much as switching. Some believe that companies were more compelled to use technology choices instead of allowance trading. This may be because "Engineers and chemists that had been responsible for compliance under command–and-control [where compliance methods are dictated by regulation] were charged with ensuring compliance with the cap-and-trade program, and often adopted a conservative, even skeptical approach to the new incentive-based compliance tool" (Natsource, 2001).

Graph 1. Costs of Compliance Methods



Source: Natsource, 2001

Another reason that technology may have been chosen over allowance trading was that in 1994 and before, when many fuels switched, most utilities were regulated with a guaranteed rate of return. This means that any costs they had from the technology could be passed on to customers through their rates. Since many chose their compliance method before 1995, they chose to fuel switch because they could do it at least cost.

Also in 1994 and before, plants did not know their full allocation. They only knew what their primary allocation of allowances would be, but did not know how many bonus allowances they would receive. Plants likely feared they would not be able to comply with stated limits by allowances alone. Many plants, therefore, decided to use technology to comply. Since the planning, ordering and installation of scrubber technology takes at least two years, by the time plants received their bonus allocations and found they had enough allowances to comply without resorting to new technology, the investment decision was irreversible.

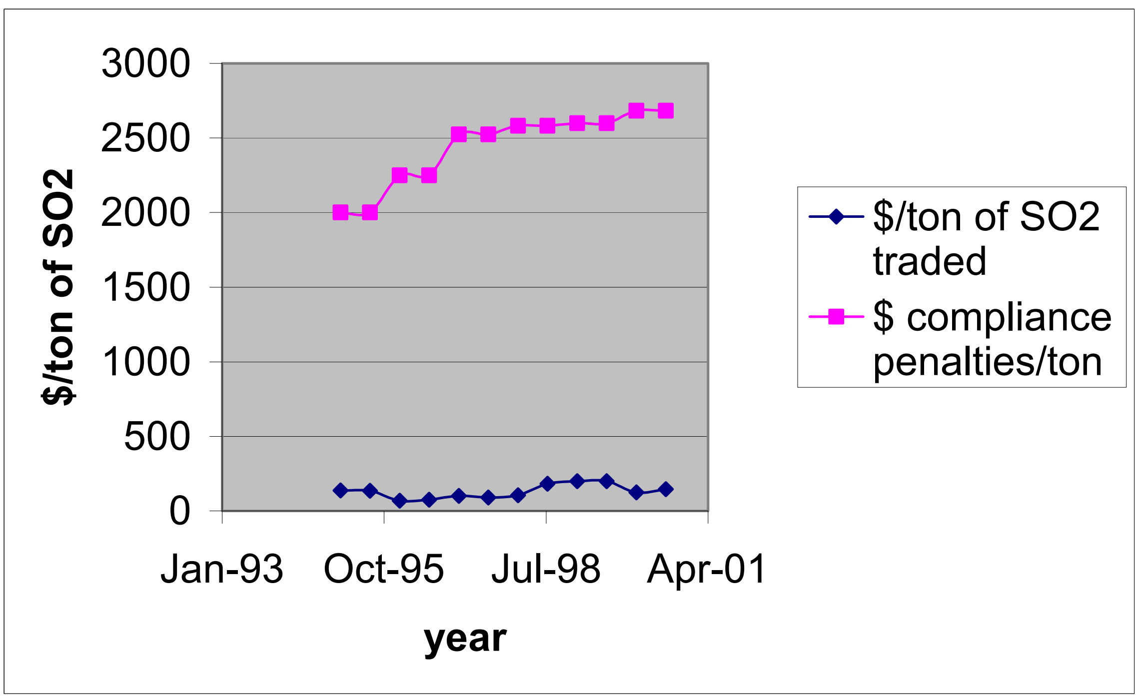
Under Compliance

Although there were still enough allowances for plants to comply in the year 2000, three plants were unable to comply and were over by a total of 54 tons. This may be because of an accounting error and the companies did not realize that they were under compliance. Another reason may be that companies could not find someone to sell them enough allowances to allow them to comply. The first reason, however, is more likely because there was an abundance of allowances and they most likely would have been able to purchase some.

When a company cannot comply, it is faced with several penalties. Not only are its allocated allowances reduced in the following year's allocation, but the company faces fines of up to $2,000 per ton out of compliance, as well as possible criminal charges.

The three plants that exceeded their emission limits in 2000 were forced to pay $2,682 per ton, and totals amounting to $144,828 (EPA 2000 report). As shown in Graph 2, the cost of allowances that could have been purchased from the market was much lower than the cost of the compliance penalties.

Graph 2. Cost/Ton of SO2 Traded Vs. Cost of Compliance Penalties/Ton of SO2



Source: EPA, 1996, 1997, 1998, 1999, 2000, 2001

Predictions

It was not until the year 2000, when EPA ratcheted down the plant caps, that allowances were needed to comply to more stringent allocations. However, because plants were allowed to bank allowances from previous years, most were still able to comply with the standards in the year 2000.

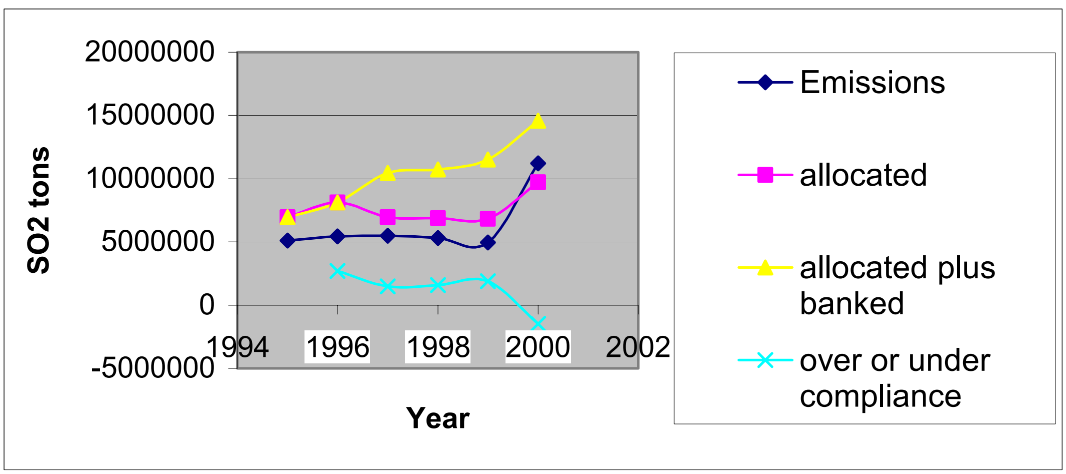
In 2000, emissions were greater than the allowances allocated. However, due to previously-banked allowances, companies were still able to comply without having to install new technology. Graph 3 shows how emissions exceeded the allowances allocated by the year 2000. It also shows how the allocated plus banked amount of allowances is greater than the emissions.

However, in graph 4, it is predicted that by the year 2003, emissions will not only exceed the allowances allocated for that year, but also exceed the amount of allowances allocated plus banked allowances from previous years. This prediction assumes that there will be the same number of allowances allocated and the same amount of SO_2 emitted for the years 2001, 2002, and 2003 as in the year 2000. Banked allowances will be drawn down these years to cover the smaller allocation and higher number of plants participating.

Under these assumptions, by the year 2003, firms will require technologies such as fuel switching and flue gas de-sulfurization in order to comply. In addition, because banked allowances will be depleted, the demand for allowances will increase and plants that previously used technologies to comply will be able to sell their excess allowances at competitive prices, thereby recovering some or all of the money invested in technologies.

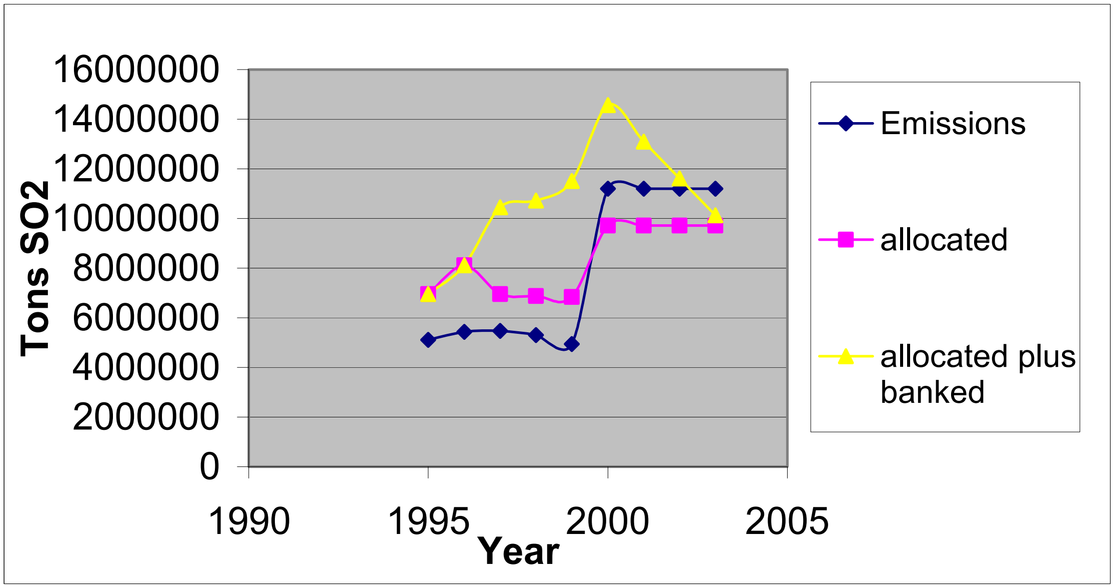
In the year 2010, the cap will again be ratcheted down to 8.95 million tons (Dean, 2002). This ratcheting down will also help to continue market growth by increasing the demand for allowances. Banking allowances will become more difficult and the companies that were relying on allowances may now have to consider installing technologies.

Graph 3. Emissions Vs. Allocated



Resource: EPA, 1996, 1997, 1998, 1999, 2000, 2001

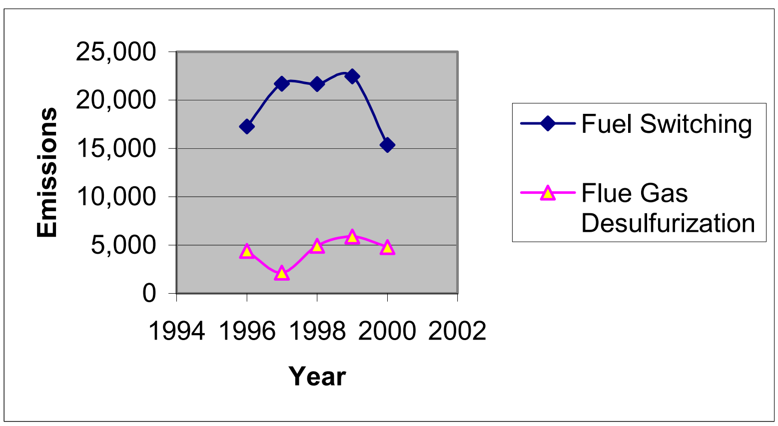
Graph 4. Predicted Allocated plus Banked Vs. Predicted Emissions



Source: EPA, 1997, 1998, 1999, 2000. 2001

Also, companies that chose to fuel switch may now also install a scrubber. Most companies chose the cheaper option of fuel switching rather than a flue gas de-sulfurization method. However, as Graph 5 indicates, if two similar plants are compared, scrubbing has the potential to reduce significantly more emissions than fuel switching. By 2010, when the cap is further reduced, companies that fuel switched may find they need to further reduce their emissions. To meet this new requirement, most plants will likely need to install scrubbers.

Graph 5. Fuel Switching Emissions Vs. Flue Gas Desulfurization Emissions



Source: EPA, 1997, 1998, 1999, 2000, 2001, EIA, 1994

Is the Program Working?

There is some concern that the program is not working, particularly by not encouraging emission reductions at least cost. Reasons cited include the illiquidity of the SO_2 allowance market and the adoption of sub-optimal (i.e. not least cost) compliance methods (Donnelly, 2002). In order for this program to work effectively, firms must have the choice between low cost options. If there are no permits available on the market, firms will be forced to go with a sub-optimal choice (i.e. technology). A competitive and robust market ensures sufficient quantity of allowances will be available to firms at a fair price. Since today's allowance program is not considered by some to be liquid and robust, some believe that the program is not working properly.

Another concern that has been expressed has to do with the number of allowances in the market. Plants were initially over-allocated and trading was not required to obtain additional allowances to comply with limits. This resulted in a significant excess supply of permits in the market. However, a significant number of trades occurred. These trades could have been the result of strategy gaming on the part of marketers. Basically, some are claiming that the trading that did occur was all the result of speculation – and not market induced (Donnelly, 2002). To prove that churning is occurring in the acid rain program, we will look at the total gross transfers and total net transfers in Table 1. Because the total gross transfers are significantly larger than the net transfers to utilities, this shows that churning is occurring. To prove that speculation is occurring in the Acid Rain Program, one might look at the total gross transfers in comparison with total net transfers (Table 1.) Because the total gross transfers are significantly larger than the net transfers to utilities, this suggests speculation.

Table 1. Total Gross Transfers compared to Net Transfers to Utilities from 1994-1999

Total Gross Transfers	19,886,334
Net Transfers to Utilities	3,871,365

Source: Donnelly, 2002

It is also a concern that companies will "hoard" or keep the allowances they do not need to comply. It is believed that allowances represent a company's future market share and if they sell off their allowances, it is as if they are selling off their right to expand their company. Table1 suggests that hoarding is not a significant problem in this market. This is likely because of the surplus allowances available.

The purpose of the Acid Rain Program is to reduce emissions at lowest cost. Although Phase I was not considered to be successful, the Acid Rain Program did have a cost savings of $780 million (US) in comparison to an "enlightened" command and control program and has reduced 4,531,328 tons of SO_2 emissions (RFF, 2000). This shows that despite its problems, it has still managed to accomplish cost savings and reduced emissions.

Conclusion

Although Phase I was not a complete success because of the low market demand for allowances, the program did have its benefits. The problems or failures associated with Phase I were due to the over-allocation of allowances. The EPA chose to over-allocate to get companies to agree or to opt-in to the program. In addition, if the EPA had clearly outlined the bonus provisions in advance, companies might not have installed as much technology and fewer SO_2 emission reductions would have resulted.

Also, up to the beginning of Phase I, when most companies were installing technology, companies were regulated utilities. This means that if their production costs go up as a result of installing technology, they pass those costs to their customers. This allowed plants to install technology at a lowest cost.

Currently, most plants do not need to install technology to reduce their SO_2 emissions. There are enough allowances in the market for total compliance. However, by the year 2003, banked allowances will be depleted, which may result in the installation of technology and an increase in demand for allowances.

The ratcheting down of SO_2 allowances in 2010 to 8.95 million should result in further reduction of the number of banked allowances. This should cause the market to become more liquid and robust.

Because this program resulted in lowered emissions at significant cost savings, it may work as a model for domestic emissions trading of greenhouse gases in Canada. The difference between greenhouse gases and SO_2 is that greenhouse gases are global pollutants and SO_2 is a local pollutant. The implication is that the benefits of reducing greenhouse gases are the same no matter where those reductions occur. In contrast, the benefits of SO_2 reductions are more local in nature. Because of this, in the Acid Rain Program, there is a fear that large emitters will only use allowances to comply, resulting in a large amount of SO_2 emitted in one area. Since SO_2 is a local pollutant, this would cause a problem. This difference in fact, makes this type of system work more effectively for greenhouse gasses than SO_2. Greenhouse gas allowances could be traded and used anywhere. Since greenhouse gases can be emitted anywhere and still have the same effect, if some plants emitted a significant amount while still allowing the total emissions of all plants to be under the cap, this would not become a problem.

One significant concern for using trading to reduce greenhouse gas emissions is that greenhouse gases are not as easily measured as SO_2. With the Acid Rain Program, the measuring system for SO_2 was very accurate and because of this, there were no arguments as to what the emissions were. However, there is no current "cost-effective end-of-pipe, post-combustion emissions capture technology for greenhouse gases" (Natsource, 2001). If a program with a cap were implemented for greenhouse gases, this would force some sort of monitoring system into place. While there may be difficulties to overcome, this type of program provides insights into the type of system that could be applicable to greenhouse gases in Canada.

Appendix A

<u>The Problems with Acid Rain</u>

The main purpose of the Acid Rain Program is to reduce pollutants such as sulfur dioxide (SO_2). This is important because SO_2 is the main contributor to acid rain. Acid rain causes many problems, most significant of which is the acidification of lakes and rivers, particularly the ones located in north to northeast United States. When bodies of water become too acidic, fish and plant life cannot survive. Already, in 140 Minnesota lakes, almost all fish have died because of acidity (Chennai, 2001). Not only does acid rain cause fish to die, it also prevents them from reproducing. The only way to prevent these harmful effects from happening is to reduce the amount of SO_2 from entering the atmosphere. SO_2 is responsible for about 70% of all acid rain (Chennai, 2001). If we can reduce SO_2, we can reduce acid rain.

Appendix B

Flue Gas Desulfurization

There are two main kinds of scrubbers. One is the dry scrubber and the other and most popular, is a basic wet scrubber system. The difference in the two kinds is that the dry scrubber produces a dry by-product and the wet scrubber produces a wet, slurry by-product.

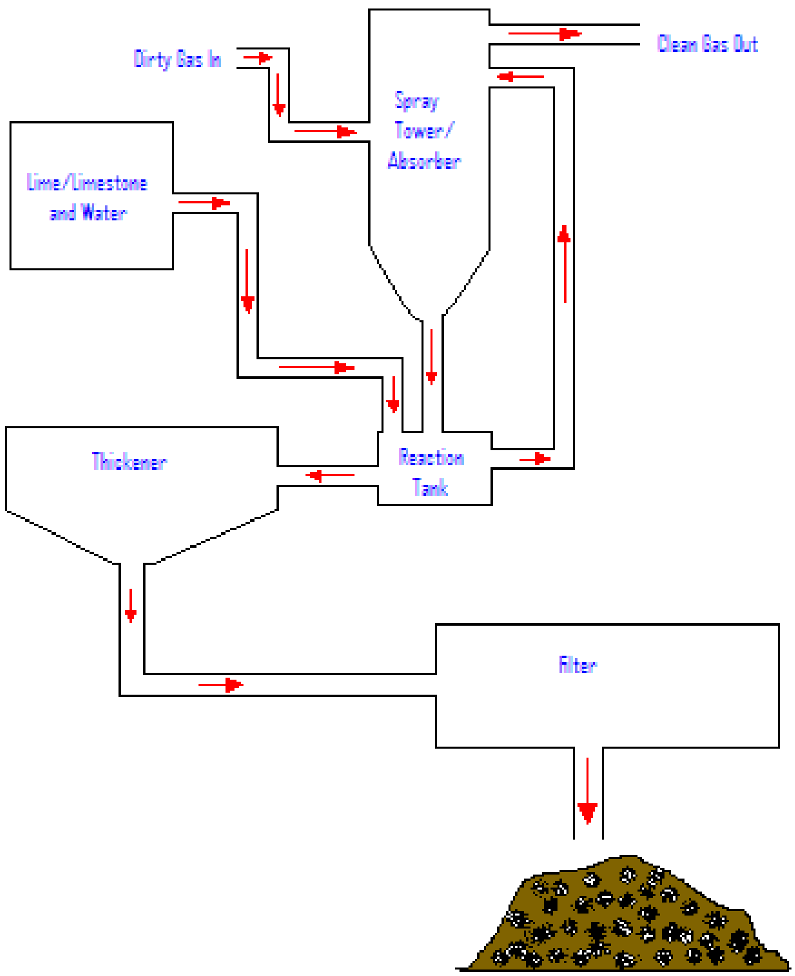
The basic wet scrubber system includes a spray tower/absorber, a tank holding a sorbent and water, a reaction tank, a thickener tank and a filter. Dirty flue gas enters into the spray tower or absorber where it is scrubbed or reacted with a mixture of a sorbent and water. The clean air then goes out of the absorber and is vented to the atmosphere. The by-product is produced using a sorbent material like limestone before it is settled in the thickener and dewatered in the filter. As the by-product settles in the thickener and dewaters in the filter, a solid by-product is created. The by-product is then disposed of in a landfill, or if it has some other use, sold on the market.

There are many different kinds of re-agents or sorbents used in flue gas desulfurization systems. Due to its low cost, one of the most popular is limestone. In the traditional wet scrubber, limestone reacts with the SO_2 to form either calcium sulfite or calcium sulfate. Other sorbents typically used are lime and sodium carbonate. Lime is very similar to limestone and reacts to form calcium sulfite or calcium sulfate. Sodium carbonate is reacted with the SO_2 to form sodium sulfite and sodium hydrosulfite. Other less common reagents include dolomitic limestone, lime/alkaline fly ash, soda liquor waste, magnesium oxide, and sodium ash.

There are also different types of absorbers (i.e. reaction vessels) used in scrubbers. Four types that are commonly used are Packed-Type Scrubbers, Spray-Type Scrubbers, Tray-Type Scrubbers, and Venturi-Type Scrubbers. Packed scrubbers have sorbent particles randomly packed inside them. As the sorbent is sprayed from the top of the column down, the flue gas enters from the bottom and as it goes through the packed sorbent particles, absorption or a chemical reaction occurs between the sorbent and the SO_2. Spray-type scrubbers spray down the sorbent in fine droplets and the flue gas again enters from the bottom, goes through the sorbent spray, and reacts with the spray. In the Tray-type scrubber, the sorbent flows over a tray that has tiny holes in it. As the flue gas rises, it goes through the holes and reacts with the sorbent on the tray. In the Venturi-type scrubber, the flue gas enters at a very high velocity and the sorbent is sprayed at a very low velocity. Because of the differences in velocity, the SO_2 and sorbent drops collide very easily and react. The clean air flows out and the particles from the reaction are caught in a drop collector and filtered out.

An example of a scrubber that is commonly used in the acid rain program is the limestone with forced oxidation scrubber (LSFO). This scrubber uses about 10% limestone and water as the re-agent (World Bank, 2002). The calcium sulfite created in this scrubber's spray reaction vessel is completely oxidized in a separate vessel by bubbling compressed air through it. The oxidization creates the product, gypsum. This product has a commercial value and can be sold on the market.

Figure 3. Scrubber



Source: World Bank, 2002

Appendix C

<u>Fuel Switching</u>

Eastern low-sulfur coal was used by companies to fuel switch as a method of complying with the Acid Rain Program. It has a sulfur content of 0.7 % by weight (EIA, 1994). This type of coal is typically used in plants found in Illinois and Ohio. These plants can easily accommodate the eastern low-sulfur coal because of its high ash fusion temperatures and lower equipment impacts (EIA, 1994). Most plants' equipment does not need to be retrofitted because it is easily able to accommodate the new coal. The only retrofit required for plants switching to eastern low-sulfur coal was the installation of a flue gas conditioning system. This system is required to be installed to improve the precipitator performance and costs $25.50 ($1992) per kilowatt of plant capacity to install (EIA, 1994).

Powder River Basin coal, also known as western low-sulfur coal, has a 0.7% sulfur content by weight (EIA, 1994). This type of coal makes up about 87% of low-sulfur recoverable coal reserves in the U.S. Unlike eastern low-sulfur coals, western low-sulfur coal tends to have a negative impact on plant operations. It is more brittle than eastern coal and, as a result, produces dust. In addition, western coals spontaneously combust more easily than eastern coals. These two properties increase the risk of fire and explosion. Equipment to protect against these risks is required. Western low-sulfur coal also tends to negatively impact plant operations because it has a relatively high moisture content. Plant operators must therefore dry the coal before combustion and this reduces boiler efficiency. In order to use western low-sulfur coal, many plants would have to make retrofits such as installing new fans or replacing fan blades to accommodate higher operating temperatures. Because of these impacts, switching to western low-sulfur coal can be expensive, ranging from $25 to $119 per kilowatt-hour, depending on the type and amount of retrofitting needed.

Work Cited

Chennai , 2001. “Acid Rain – Serious Air Pollutant”. Chennai Interactive Business Services. http://www.chennaionline.com/science/Environment/acid.asp

Dean, Melanie, Office of Air Programs, EPA, Personal Interview. 10 Feb. 2002

DOE, 1997 “Energy Plug: The Effects of Title IV of the clean Air Act Amendments of 1990 on Electric Utilities: An Update”. Energy Information Administration (EIA) - Department of Energy. 7 Apr. http://www.eia.doe.gov/emeu/plugs/plcaaa.html

Donnelly, Aldyen. “Re: Acid Rain Program Trading Data.” E-mail to Kyla Sandor. 1 Apr. 2002.

EIA, 1994. “Electric Utility Phase I Acid Rain Compliance Strategies for the Clean Air Act Amendments of 1990”. Prepared by Energy Information Administration, the independent statistical and analytical agency within the Department of Energy (DOE). Washington, DC. 1 Mar. http://tonto.eia.doe.gov/GTPROOT/electricity/0582.pdf

EPA, 1997. “1996 Compliance Report – Acid Rain Program” United States

Environmental Protection Agency – Office of Air and Radiation Acid Rain Division (6204J). 1 Aug. http://www.epa.gov/airmarkets/cmprpt/arp96/index.html

EPA, 1998. "1997 Compliance Report – Acid Rain Program" United States Environmental Protection Agency – Office of Air and Radiation Acid Rain Division (6204J). 1 Aug. http://www.epa.gov/airmarkets/cmprpt/arp97/cr1997.pdf

EPA, 1999. "1998 Compliance Report – Acid Rain Program" United States Environmental Protection Agency – Office of Air and Radiation Acid Rain Division (6204J). 1 Aug. http://www.epa.gov/airmarkets/cmprpt/arp98/98report.pdf

EPA, 2000. "1999 Compliance Report – Acid Rain Program" United States Environmental Protection Agency – Office of Air and Radiation Acid Rain Division (6204J). 1 Aug. http://www.epa.gov/airmarkets/cmprpt/arp99/arpcomprpt99.pdf

EPA, 2001. "Acid Rain Program: Annual Progress Report, 2000: Compliance and Emission Trends" United States Environmental Protection Agency – Office of Air and Radiation Acid Rain Division (6204J). 1 Aug. http://www.epa.gov/airmarkets/cmprpt/arp00/arpcomprpt00.pdf

Natsource, 2001. "Excerpts From US Emissions MKT Analysis". In house report.

Peace, 2002. "Emission Trading – A Shell Game or Not". Climate Change Central. Working paper. March.

RFF, 1997. Tebo, Michael. "Lessons Learned May Be Applied to Climate Change, Other Policy Arenas". Resources For the Future – Weathervane. 15 Sept. http://www.weathervane.rff.org/research/title4.html

RFF, 2000. Carlson, Curtis, Dallas Burtraw, Maureen Cropper, and Karen Palmer. "Sulfur Dioxide Control by Electric Utilities: What Are the Gains From Trade?". Resources For the Future. Washington, DC. 1 Apr. http://www.rff.org/CFDOCS/disc_papers/PDF_files/9844rev.pdf

SRMT. 1998. "Wind: History of the Clean Air Act". St. Regis Mohawk Tribe– Environment Division Documents. 7 Apr. http://thames.northnet.org/earth/wind8.htm

World Bank, 2002. "Wet Flue Gas Desulfurization (FGD)". http://www.worldbank.org/html/fpd/em/power/EA/mitigatn/aqsowet.stm