A STUDY ON THE EMISSIONS TRADING SYSTEM IN THE SEOUL METROPOLITAN AREA, KOREA: BASED ON EXPERIENCES IN THE UNITED STATES

by

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A THESIS

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Title: A STUDY ON THE EMISSIONS TRADING SYSTEM IN THE SEOUL METROPOLITAN AREA, KOREA: BASED ON EXPERIENCES IN THE UNITED STATES

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This study aims to draw lessons from experiences with emissions trading programs in the US, and based on those lessons, to provide implications for the design and implementation of the new cap-and-trade program that is scheduled to begin in July 2007 in the Seoul Metropolitan Area in Korea. Major lessons from experiences with emissions trading programs in the US are as follows: well-designed cap-and-trade programs work, but they are not a cure-all; with respect to design, banking and minimal governmental intervention are needed. Initial allocations and opt-in provisions do not affect performance; for effective implementation, accurate and reliable measurement, enforcement, and compatibility with pre-existing regulations are important. Implications for Seoul, Korea are: minimizing governmental intervention, relaxing the restrictions on banking, creating public auction, introduction of opt-in provisions, accurate and consistent monitoring, effective enforcement, and ccompatibility with pre-existing regulations including emissions charges and fuel regulations

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I. Introduction

Background

Together with accelerated economic growth, rapidly increasing population and a higher rate of urbanization, air quality in Korea has been deteriorating over time. In particular, the explosive growth of vehicles in the Seoul Metropolitan Area (which takes up 12% of the landmass yet accounts for 46% of the population) has brought about a severe degradation of air quality. The concentration of nitrogen dioxide in the region is about 28 to 48 percent higher than in other mega-cities including New York, London and Tokyo. As a result socio-economic costs related to air pollution including-- respiratory problem and early death-- have been estimated at 10 trillion won (approximately, 10 billion dollars) annually.

In response to these air quality problems, the Korean Ministry of Environment (MOE) decided to introduce a total emission control (TEC) system and an emission trading scheme in the region as an alternative to a traditional command-and-control approach based on emission standards. In December 2003, the Special Act for Seoul Metropolitan Air Quality Improvement was enacted, whereby a cap-and-trade system (targeting larger sources emitting sulfur oxides, nitrogen oxides and particulate matter) will be in effect in Seoul City and two neighboring areas, Incheon City and Gyeonggi Province beginning in January 2007.

Since the US EPA developed its first four emissions trading programs (netting, offsets, bubble and banking) starting in the mid 1970s, the U.S. has led emissions trading programs. More recently the SO_2 trading in the Acid Rain Program, the RECLAIM program in Los Angeles region, the NOx Budget program in Northeastern States have been recognized as successful examples of trading programs.

It seems likely that lessons from experiences with emissions trading programs in the U.S. would be helpful in avoiding possible waste due to trial and error in designing and implementing the emissions trading scheme in Seoul, Korea. Thus, this study seeks to draw practical implications in designing and implementation of the new emissions trading program in Seoul, Korea based on lessons from the U.S., given different socio-economic, political and regulatory contexts.

Research Questions

This study aims to find out major conditions and factors which are likely to contribute to success for the emissions trading system in Korea by drawing on lessons from experiences with emissions trading programs in the U.S.

More specifically, I focus on the following three questions:

1) Under which principles do emissions trading systems function well?
2) What are the factors leading to success in the major emissions trading programs in the U.S. and what lessons can be drawn from those experiences?
3) What are considerations to be taken into account in order to design and implement an emissions trading system successfully in the Seoul Metropolitan Area, given the particular circumstances in Korea?

My hope is that this study will be a helpful guide for policy makers in designing and implementing emissions trading systems in the Seoul Metropolitan Area, and furthermore, it will provide insights into the nature of emissions trading systems for those interested in this scheme, either for scholarly or practical reasons.

Methodology

In order to deal with these research questions, I have undertaken three major tasks.

1) A literature review, involving both primary and secondary sources;
2) Comparative case studies on (a) The U.S. Acid Rain Program, (b) the Los Angeles RECLAIM program, (c) the NOx Budget program in Northeastern States; and
3) A review and comparison of the U.S. and Korean institutional and legal settings.

Chapter 2 provides an overview of emissions trading programs based on an examination of existing documents. Since there is a huge related literature, this study focuses on the literatures directly dealing with at least one of my research questions.

Chapter 3 explains the framework for an emission trading scheme provided in the Special Act for Seoul Metropolitan Air Quality Improvement. It includes current status of air pollution levels and existing air pollution regulations and major features of the proposed emissions trading system for the Seoul Metropolitan Areas in comparison to U.S. cases.

Chapter 4 describes the evolution of emissions trading systems in the United States: the U.S. EPA's emissions trading program, the leaded gasoline phase out program, the Acid Rain Program, the RECLAIM program in Los Angeles Basin, and the NOx Budget program for the Northeastern States. Then, the chapter focuses on a comparison of three major trading programs with respect to their design and implementation issues: the Acid Rain Program, RECLAIM, and the NOx Budget program in Northeastern States.

Chapter 5 summarizes the analysis of the proceeding chapters. In this chapter, I return to the three research questions posed in the introduction. The chapter identifies principles guiding emissions trading programs and outline lessons learned from experiences with emissions trading systems in the United States. Based on lessons from the U.S., I suggest basic principles for success for emissions trading programs and then the implications of these principles for the design and implementation of the emissions trading program in the Seoul Metropolitan Area. Finally, this chapter also briefly discusses questions that are not got resolved and which will require further research.

II. A Review of Emissions Trading Systems

Introduction: the Past, Present and Future of Emission Trading Schemes

The idea of an emissions trading system can be traced back to pioneering works in 1960s by Ronald Coase and John Dales. Based on their concept of establishing markets in pollution rights, a number of economists have advocated emissions trading systems as an alternative to the traditional command-and-control (CAC) approach or environmental taxes (Tietenberg, 1998; Nash, 2001; Ellerman et al., 2003). In practice, the concept of an emissions trading system was born in the 1970s with the policy decision by the US Environmental Protection Agency (EPA) that new emissions in non-attainment areas can be offset by decreased emissions from existing sources. According to the Clean Air Act of 1970, net new emissions in non-attainment areas are prohibited, which threatens industrial growth in non-attainment areas (Zosel, 2000). During the 1970s, the EPA developed four emissions trading programs including offsets, netting, bubble, and banking based on emissions reduction credits (ERCs), but the experience with these earlier trading programs turned out to be disappointing, for a number of reasons that are now better understood.

With the success stories of the Lead-in-Gasoline Trading Program in 1980s, the Acid Rain Program (ARP), and the Regional Clean Air Incentives Market (RECLAIM) in 1990s, emissions trading systems have become popular, and are now applied in a variety of policy arenas: air pollution control, fisheries management, water supplies, and greenhouse gas reduction. In fact, emissions trading programs can be cost-effective approaches by providing regulated sources with the flexibility to select the lowest cost alternative for achieving the given environmental target (Ellerman et al., 2003; Tietenberg, 2003).

Well-designed emissions trading systems, especially cap-and-trade programs, have several advantages over traditional CAC approaches: environmental certainty, minimizing control costs and other long-term effects including innovation incentives and early reductions (EPA, 2003). However, to date relatively few emissions trading programs have been implemented and, as in the case of the UK and Poland, poor design is likely to lead to the failure in some emissions trading programs.

In spite of some of successful cases and expanded popularity of emissions trading, there has still been persistent ambivalence and skepticism about emissions trading systems primarily among policy makers and environmental groups:

- Trades of pollution rights in the marketplace may lead to a concentration of permits and market power, denying small businesses and poorer people access rights to necessary resources;
- Emissions trading may be seen as a way for individual firms to circumvent meeting required targets under an environmental policy;
- By alleviating immediate compliance requirements for individual firms, emissions trading may erode short-term incentives to make necessary investments; and
- Transfers involved in emissions trading may have undesirable local environmental consequences characterized by hotspots (OECD, 2002).

There are several necessary conditions for cap-and-trade systems to function best: the environmental or health concern affects a relatively large area; a number of sources contribute to the environmental problem; marginal abatement costs vary across sources; emissions from individual sources can be measured with accuracy and consistency; and environmental quality and the economy is in sufficiently good condition that a cap-and-trade program may be politically acceptable (Stavins, 2000; EPA, 2003). Despite surprising successes in the U.S., political feasibility, uncertainty about technological development, higher transaction costs and environmental injustice can be obstacles to success in emissions trading programs (Thompson, 2000; Solomon and Lee, 2000). Colby (2000) and Thompson (2000) argue that strong regulations are often necessary before the implementation of an emission trading program because pre-existing regulations can determine the critical emissions trading cap.

While it is not a panacea and still has a long way to go, an emissions trading system can be an effective approach with several advantages, especially considering the fact that emissions trading programs have been used in problematic areas in which traditional instruments had not achieved environmental performance at low enough cost. Actually, cap-and-trade programs, advanced forms of emissions trading, have not only complemented the existing regulations, but have also supplanted them in some cases (Tietenberg, 2004; Ellerman, 2004).

The application areas for cap-and-trade programs have been extended from traditional uses-- such as air pollution management and limiting fisheries catches-- to new areas including climate change, renewable energy transport, transportation, solid waste management, and water resources management (OECD, 2002). As Ellerman et al. (2000) point out, however, an emissions trading program is not an effective option when: (a) in a specific, isolated plant which emits toxic chemicals which cause serious risk to neighboring residents; (b) it is expensive or impractical to measure actual emissions or to enforce trading.

With respect to future development, the following topics need to be considered for further clarifications: (a) emissions trading schemes can be expanded into a number of policy areas beyond traditional areas such as air pollution control and fisheries management; (b) seeing that, in many cases, emissions trading programs primarily cover larger stationary sources, other regulations covering mobile or smaller stationary sources can be needed to achieve a given environmental goal; and (c) in order to enhance cost-savings by expanding affected sources, emissions trading programs can be developed incorporating inter-source trading between mobile and stationary sources and inter-pollutant trading between NOx, SOx, and particulate matter (Kosobud, 2000)

Types of Emissions Trading

In general, emissions trading programs can be classified into three types: cap and trade, project-based trading (offset program), and rate-based trading (averaging program). All of three trading types have similar rationale: trading provides sources with flexibility to develop cost-effective emissions reduction options to achieve a given objective.

Under cap-and-trade programs, the regulator sets a cap on total emissions which is divided into the same amount of allowances (right to emit a unit of a pollutant), and allocates allowances to each source. Each source must hold allowances to cover its cumulative annual emissions by the end of compliance year, with allowances traded among sources.

Project-based trading provides tradable credits to facilities that reduce emissions more than required by pre-existing regulations ("baseline"). These credits must be created through pre-approval by regulating authority before they can be traded. Under rate-based trading, under a given emissions rate ("performance standard") set by the authority, emitting sources can earn credits automatically if they keep their average emissions rates below the performance standard. Unlike project-based trading, there is no pre-approval of trading in rate-based trading. A rate-based trading program could be a preparatory tool for a further cap-and-trade program (Kosobud, 2000; EPA, 2003; Ellerman et al., 2003).

The success of all three types of emissions trading relies on the following preconditions: there must be emissions control requirement in place; there must be differences in marginal abatement costs among regulated sources; and there must be accurate measurement of emissions and reliable enforcement of permit coverage (Ellerman et al., 2003)

Table 1. Comparison of Three Forms of Trading System

Category	Potential to Limit Total Emissions	Cost Minimization	Administrative & Transaction Costs	Applied Cases
Cap and Trade	High	Yes	Low	- The Acid Rain Program - RECLAIM - The NOx Budget Trading
Project-based Trading	Low to Medium	Yes	High	- Offset program
Rate-based Trading	Medium	Yes	Low to Medium	- Lead-in-Gasoline Trading Program

Source: "Tools of the Trade: A Guide to Designing and Operating a Cap and Trade Program for Pollution Control," June 2003 EPA

In terms of three criteria: potential to limit total emissions, cost minimization, and administrative and transaction costs, a cap-and-trade program can be preferable because it can achieve given total emissions reductions more cost-effectively with lower administrative and transaction costs rather than project-based or rate-based trading (EPA 2003). Stavins (2000) also suggests that if possible, a cap-and-trade scheme based on a firm's total emissions should be adopted rather than other forms of trading programs.

Comparing Emissions Trading with Other instruments

Policy instruments for dealing with environmental problems can be classified into these three categories: economic incentives approaches, such as environmental taxes and emissions trading; command-and-control approaches, such as technology mandates or emissions rate standards; and non-regulatory approach, such as voluntary agreements and eco labeling. The conditions under which CAC regulations work best are as follows: limited emission reduction experience by regulators and firms, clearly defined solutions in terms of financial and technical terms, direct monitoring which is not feasible, and emissions containing toxic substances or serious localized health impacts (EPA, 2003).

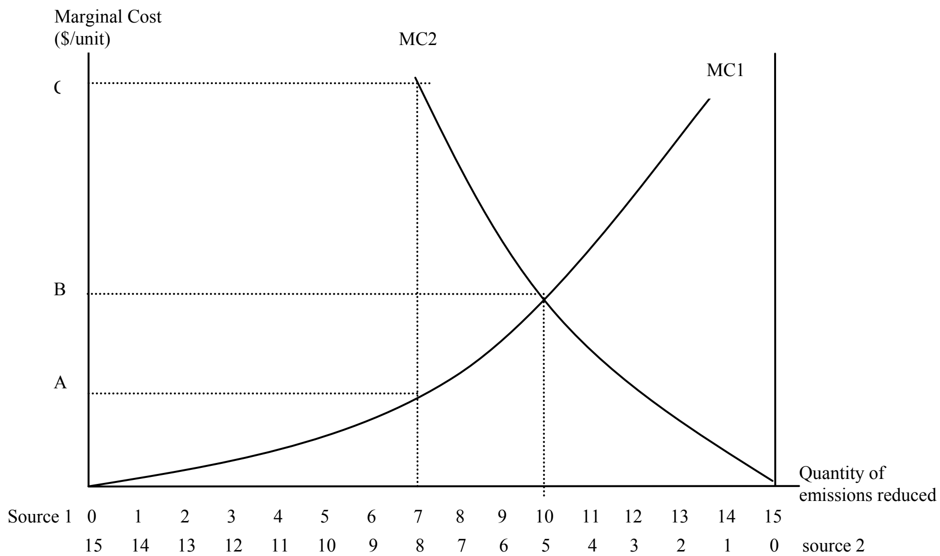
According to the 2002 OECD guidelines, the criteria for choosing between emissions trading and taxes are related to characteristics of market structure, organizational and transaction costs, and redistribution: Taxes are more appropriate if agents are in fact sensitive to prices, organizational and transaction cost for a new trading scheme would be excessive, and the loss of pre-existing tax revenue with an introduction of new emissions trading would be large. In terms of considerations for marginal firms, while environmental tax break provides no incentive to abate emissions, a free initial allocation of allowances under a cap-and-trade program still provides incentive to reduce emissions.

On the other hand, another approach for reducing emissions-- voluntary approaches-- have been introduced to provide regulated firms with more flexibility in achieving environmental targets and the approaches based on voluntary agreement reflect the concerns about competitiveness of industries by not imposing compulsory regulations. In fact, voluntary approaches have been used in a policy mix to supplement other regulations such as taxes and emissions trading programs (OECD, 2002).

As Figure 1 shows, an emissions trading system leads to the cost minimizing allocations without going through a trial-and-error process, as would an emissions tax program. As a result, the greater are differences in marginal abatement costs across firms, the bigger are the gains due to an emissions trading scheme. Suppose that the source 1 was allocated with 7 permits and source 2 was allocated with 8 permits given 15 units of uncontrolled emissions.

In this example, both sources would have incentive to trade each other because they can reduce their marginal abatement costs through a trade. The marginal abatement cost (C) for source 2 is higher than that (A) for source 1. The source 2 could lower its cost if it could buy tradable permits from source 1 at a price lower than C. At the same time, the source 1 could reduce its abatement cost if it could sell tradable permits to source 2 at a price higher than A. Until the permit price reaches B, a trade of permits would happen. At the point of B in which the marginal abatement cost of two sources would be the same and there would be no incentive to trade further (Tietenberg, 2003; EPA, 2003).

Figure 1. Economic Logic of Emissions Trading Scheme



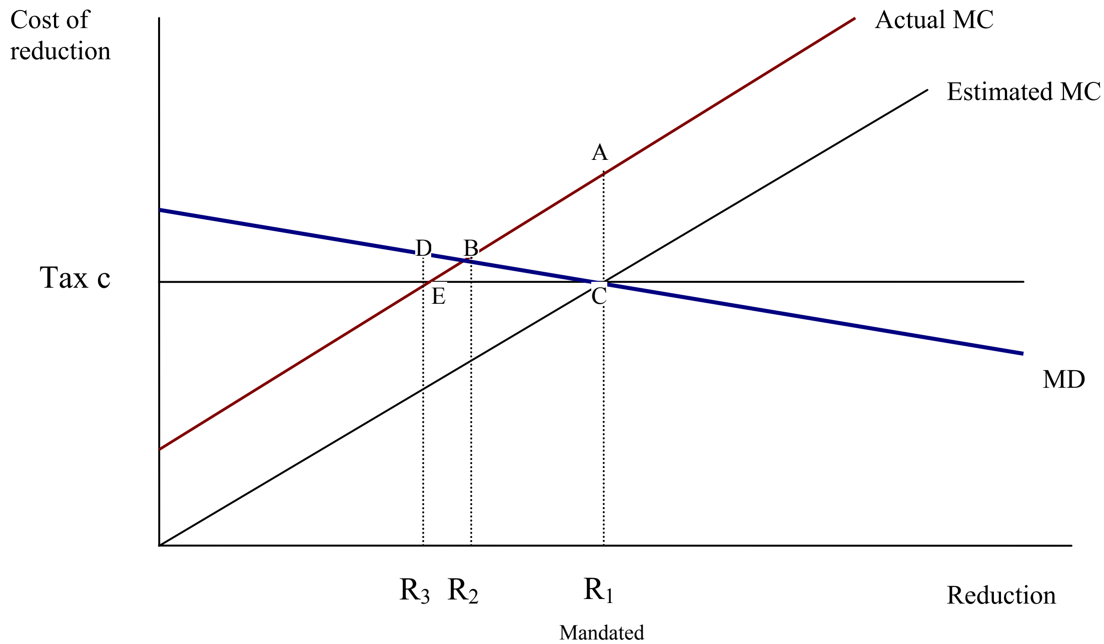
Source: Tietenberg (2003)

There are a number of papers that compare emissions trading systems with environmental taxes. The main difference between an environmental tax and emissions trading rests on whether prices or quantities are controlled. For example, with a carbon tax, the size of the carbon tax per unit emitted is fixed and the quantity of carbon emitted is adjusted. In an emissions trading, on the other hand, the quantity of emissions is fixed and the price of the emission permits takes up the slack. In theory, environmental taxes and emissions trading can have the same overall effects in terms of reducing pollution at least cost , but in practice, they differ significantly because information about marginal damages and marginal costs is not known in advance (Kosobud, 2000; Ekins etc., 2002; Gruber, 2005).

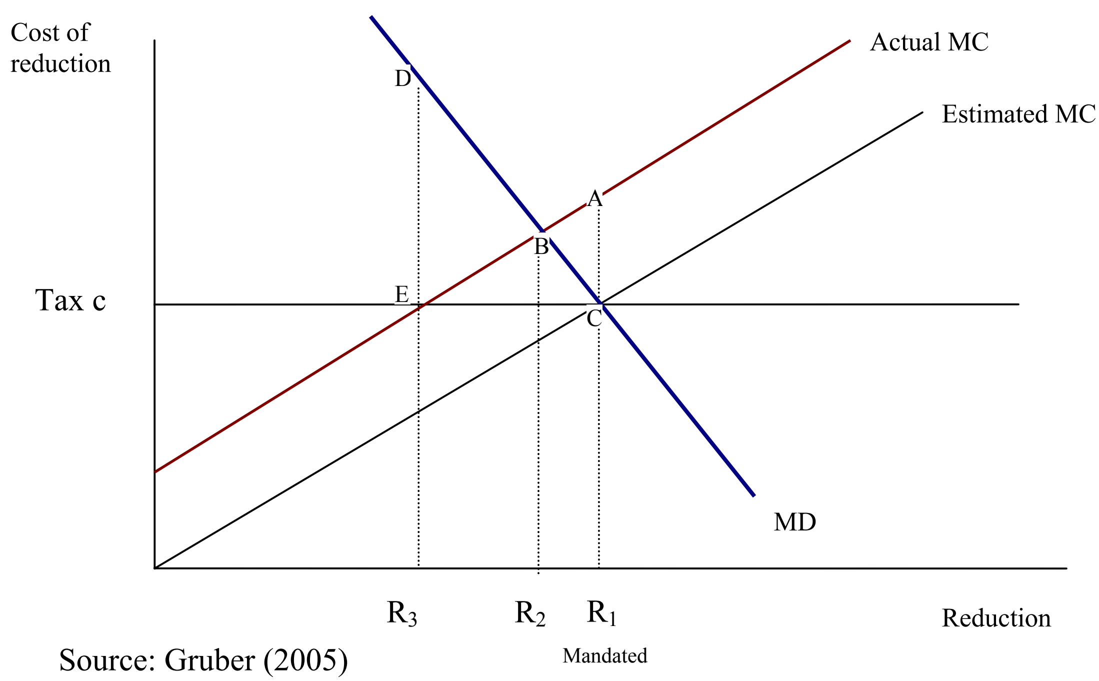
Weitzman (1974) has shown that (1) it is preferable to set the price when there is uncertainty over the control cost function, and a possibility that the control cost is very sensitive to greater-than-optimal emissions reduction, and (2) it is preferable to fix the quantity when there is uncertainty about the damage function, and a possibility that the damage is very sensitive to greater-than-optimal emissions. Gruber (2005) shows that the steeper the marginal damage curve, the more preferable emissions trading is rather than taxation in terms of deadweight loss. Suppose two examples of externalities: global warming and nuclear leakage. Panel (a) of Figure 2 shows the case of global warming with fairly flat marginal damage curve. If the costs are uncertain, taxation at the level of c would produce much lower deadweight loss (DBE) than would quantity-based regulation of R1 (ABC). On the other hand, in the case of nuclear leakage with very steep marginal damage curve as shown panel (b), taxation would bring about a much larger deadweight loss (DBE) than would quantity-based regulation of R_1 (ABC).

Figure 2. Comparison of Environmental Tax and Emissions Trading System

a) Example 1: Global warming (with fairly flat marginal damage curve)



b) Example 2: Nuclear leakage (with steeper Marginal damage curve)



Source: Gruber (2005)

Tietenberg (1998) argues that tradable permits are preferable in the case of changes in external circumstances, like a growing economy, while emission charges are preferable when technological progress is likely to shift the marginal abatement cost downward. In practice, existing environmental tax rates are usually too low to have the necessary incentive effect, and increasing the tax rate is likely to raise political opposition so that emissions charges complement, but do not replace traditional emission standards (OECD, 2004).

Design Issues

The major features of an emissions trading program can be classified into two broad categories: design issues and implementation issues. While design issues can include allocation of allowances, geographical or temporal flexibility, trading market, and relationship with pre-existing regulations, implementation issues involve monitoring, compliance and enforcement (Harrison, 1999; Ellerman et al., 2003; EPA 2003).

A. Allocation of allowances

One of the most controversial decisions in an emissions trading program is how to allocate emission permits or allowances. Among a great number of possible methods, grandfathered allocations or auctions are usually discussed. In general, these two methods tend to provide the same incentives for emissions reductions and, as a result, produce the same environmental outcome. However, the distributional impacts are different. Auctions transfer resources from emitters to the government and therefore yield government revenue. However, grandfathering approaches merely give valuable assets, in the form of tradable property rights, to polluters (Ekins and Barker, 2002).

Many researchers argue that grandfathering is the possible best option for several reasons: political feasibility and respecting the current producers' investments. Allocative efficiency, in terms of a cost minimizing distribution of abatement responsibility, can be achieved regardless of the initial allocations among sources (Tietenberg, 1998; Ellerman et al., 2000; Kosobud, 2000; Ekins and Barker., 2002). On the other hand, some researchers are in favor of auctions in that revenues earned from auctions can be recycled to reduce other distortional taxes and therefore increase economic efficiency. Auctions also give fair access to emissions markets for small sources and new entrants, and remove the need for controversial decisions over permit allocations (Cramton and Kerr, 1998; Goulder et al., 1999). Also, Kling and Zhao (2000) argue that auctioned and free allocations have different long-run efficiency complications depending on the nature of the pollution (or the shape of the pollution damage function) using the following model of efficient proportion of free permits:

$$\frac{e_0}{e} = 1 - \frac{\epsilon_n}{\epsilon_d}$$

where

e_0 = amount of free permits,

e = actual emission,

ϵ_n = the elasticity of pollution damage with respect to the number of firms,

and ϵ_d = the elasticity of pollution damage with respect to each firm's emission.

In the case of uniformly mixed pollutants with linear damage function ($\epsilon_n = \epsilon_d$), only the total emissions matter so that all permits should be auctioned. On the other hand, for the local pollutants which cause environmental damage in a specific area, the damage function of a firm is increasing and convex ($\epsilon_n < \epsilon_d$), which result in free allocation of some of permits.

Without transaction costs, the initial allocations could not affect the final allocations. However, in the presence of transaction costs, an accurate initial allocation is crucial in efficiency of a trading program. If transaction costs are substantial, not just transfer, then the transaction costs means a deadweight loss included in the total cost of an emissions trading system. Consider that as market matures, the long-term marginal transaction costs are constant, it is important that regulators should allocate more allowances to regulated firms with higher marginal abatement costs in order to minimize the overall costs of emissions trading (Cason and Gangadharan, 2003).

In dealing how to allocate allowances, distributional considerations, especially for low-income groups, should probably be taken into account. In theory, an emissions trading system offers a costless trade-off between efficiency and equity so that the initial allocation could be used to deal with equity issues without sacrificing efficiency. In practice, too great a concern about political feasibility often leads to adopting the method of grandfathering, which does not solve equity problems (Tietenberg, 1998). In terms of fairness of permits allocation, the allocating methods including baseline years should not be unfavorable to firms who have invested a lot in emission abatement prior to the introduction of an emissions trading system, or those who have suffered business recessions in the industry (Kosobud, 2000; OECD, 2002).

Another contentious issue related to allocation of allowances concerns defining the nature of allowances. Allowances should be treated as property rights, in order to protect incentives they create for firms to invest in pollution reduction. Meanwhile, as environmental groups argue, air is common property shared by all people so that air itself should not be transferred into private ownership. A practical solution to this issue can be a compromise that permit-holders are given some security with respect to their allocation of allowances, but this security does not amount to a full property right. In the Acid Rain Program, an allowance represents a limited authorization to emit sulfur dioxide. This is not a true property right but it seems to be functionally akin to property right (Tietenberg, 1998; EPA, 2003)

B. Geographical or Temporal Flexibility

Allowances should be traded with few restrictions because any restrictions can impede the market function and then reduce the cost savings that come with maximum flexibility. In many cases, however, there are two types of restrictions on allowance trading: geographical restrictions, and temporal restrictions.

Geographic or spatial restrictions are often a concern with non-uniformly mixing pollutants, such as sulfur dioxide and nitrogen oxide. Trading of local or regional pollutants may lead to excessive pollution concentrations at particular locations, which may create hotspots or local violations of ambient air quality standards (Tietenberg, 2003; Nash and Revesz 2001).

In addition to hotspots, local concentrations of pollution may raise environmental justice concerns because dirty or older sources are likely to be situated in lower income neighborhoods. The problem is that while geographic restrictions help solve or reduce these problems, these restrictions will increase transaction costs as well. Therefore, less restrictive alternatives can be applied: (1) regulatory tiering is provided by the National Ambient Air Quality Standards. If a trading would result in a violation of a pre-existing air quality standard, the trade would be not allowed; (2) zoning, like the RECLAIM two-trading zone program, is more restrictive in that it divides the trading areas into specific zones and trades can be allowable within specified zones; (3) under differentiated trading ratios, a trade might require a greater than 1:1 ratio when there are risky circumstances (Solomon, 2000; Nash and Revesz, 2001).

According to a study of the Acid Rain Program there were no critical hotspots or excessive pollution concentrations in specific areas (contrary to environmentalists' concerns) because SO_2 emissions were reduced by half and the overlapping pre-existing regulations like the New Source Review prevent excessive pollution concentrations in specific areas (Kosobud, 2000; Ellerman et al., 2000).

Temporal restrictions (restrictions on banking and borrowing) are another transferability rule that can hinder the use of allowances. Although banking has many advantages, such as encouraging early emission reductions and removing price volatility, it can also have disadvantages like delaying the achievement of the emissions target. Likewise, borrowing can be helpful in smoothing out price spikes in allowances, but it may have a great risk of future non-compliance in case firms borrowing allowances face financial troubles and try to avoid repayment of allowances (Tietenberg, 2003; Ellerman et al., 2003; EPA 2003).

While the ARP permits individual firms to bank(save) their allowances, but it does not permit them to borrow(use in advance) their allowances, RECLAIM has no banking or borrowing, but it gives a very limited temporal flexibility through the use of two overlapping allowance cycles. In the NOx Budget Trading Program, banking is permitted but there are automatic limits imposed on the use of banked allowances when the banked allowances reach a certain level; i.e. there is no incentive to save more than a certain number of allowances.

Unlike the ARP, the very limited kind of banking system of RECLAIM leads to difficulties beginning in 2000. In the summer of 2000, the price for NOx RTC skyrocketed to more than $45,000 per ton, which was some ten times higher than it was in 1999. As a result of the high NOx RTC prices, coupled with deregulation of electricity markets in California, overall NOx emissions exceeded the cap for 2000 by about 6 percent (after taking advantage of limited banking or borrowing opportunities). In response, the South Coast Air Quality Management District ("SCAQMD") changed RECLAIM rules, whereby electricity generators were temporarily suspended from participating in the RECLAIM and instead, they submitted compliance plans and paid mitigation fees ($15,000 per ton) for excess emissions in 2000 and 2001 (Tietenberg, 2003; Harrison 2004).

In the case of the ARP during the phase I (1995 to 1999), overinvestment in scrubbers was due to the rapid expansion of low-sulfur coal from the Powder River Basin (PRB) in Wyoming and thus, much more emissions reduction occurred beyond what was required to meet the phase I cap. However, this unexpected surprise (exogenous uncertainty) didn't matter because reductions could be saved for the future use through the available banking mechanism (Ellerman et al., 2000).

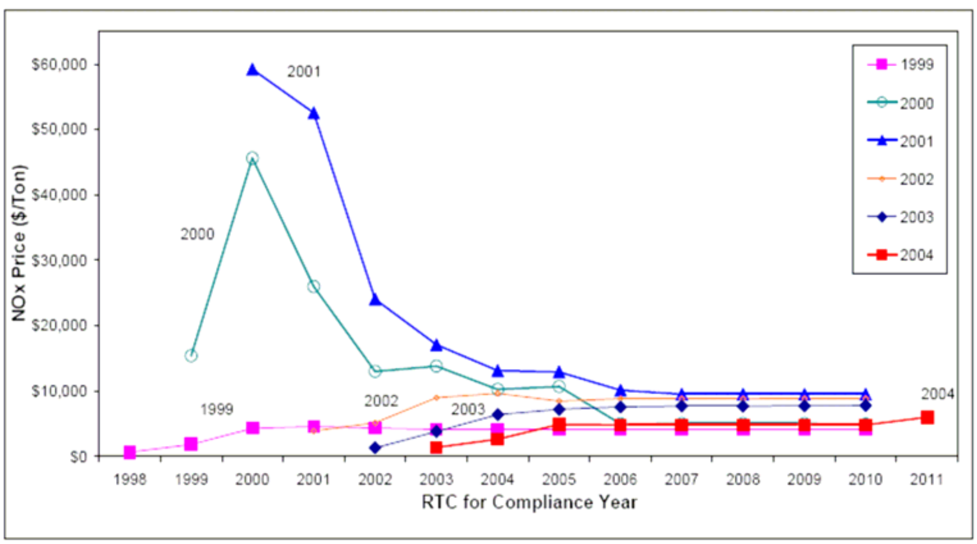
C. Trading Market

Emissions trading markets are efficient or well-functioning under these situations: a single market price of allowance, low transactions costs, sufficient opportunities for arbitrage, and active participation in trading (Ellerman et al., 2000). In the case of the ARP, the key design elements were that de facto rights to emit SO_2 were being traded, rather than reductions in SO_2 emissions relative to a baseline, and that each allowance was worth the same amount regardless of when or between whom it was traded. In order to facilitate trading, the EPA gave up reviewing and approving trades in the process of emissions trading which resulted in lower transaction cost. The EPA also administered an allowance auction (having 2.8 percent retired of all allocated allowances each year) to encourage the identification of a single market price and the development of a private market (Ellerman et al., 2000).

Brokers and individual speculators have participated actively in emissions trading programs such as the ARP and RECLAIM, which has contributed to thick markets (Ellerman et al., 2000; Harrison, 2004). As well as emitting facilities and brokers, public participation (including environmental groups) in purchasing and retiring allowances can help meet the environmental objective (Tietenberg, 2004).

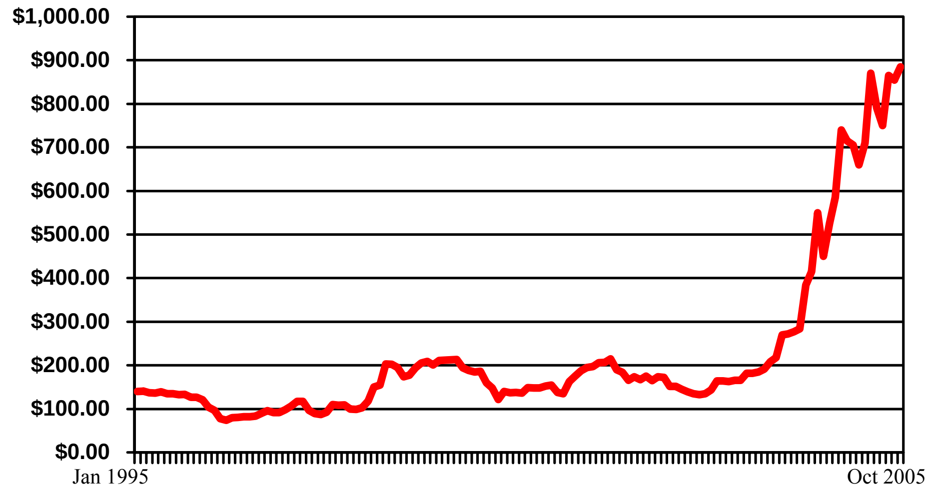
Too-high allowance prices are likely to hinder emissions trading markets. In RECLAIM, the price spike in NOx RTC during 2000 to 2001 lead to a temporary suspension of the program and a return to a traditional CAC approach involving a mitigation fee. In the ARP, on the other hand, prices for allowances during Phase I were stable with prices varying between $100 and $200. Furthermore, actual price of allowances was lower than expected prior to the implementation of the program for several reasons: initial over-investment in scrubbers triggered by high expected allowances prices, and unexpected availability of cheap low-sulfur coal from the Powder River Basin in Wyoming due to the deregulation of rail transportation (Ellerman et al., 2000).

Figure 3. NOx RTC Prices in RECLAIM (1999-2004)



Source: South Coast Air Quality Management District (2005)

Figure 4. SO_2 Allowance Prices in the Acid Rain Program (1995-2005)



Source: Canton Fitzgerald

In emissions trading markets, two types of market power are usually identified: profit-maximizing manipulation-- capacity to influence the transaction price of traded permits, and exclusionary manipulation-- by which a commodity producer hoards permits to prevent market entry by competitors (OECD, 2001). In a laboratory test-bed study for market power in emissions trading, Cason et al. (2003) show that in a double auction institution, a monopoly or duopoly firm cannot dominate an emissions trading market, so prices and volumes traded are closer to the competitive equilibrium than the monopoly equilibrium.

D. Relationship with Pre-existing Regulations

No new policy measure can be born in a vacuum. For a new instrument to be successful, it should be compatible with pre-existing regulatory vehicles. According to the EPA (2003), there are several points to be kept in mind when considering the integration of cap-and-trade methods with other policy approaches: first, a CAC approach can be compatible with a cap-and-trade program but there should not be contradictions or duplications; second, integration with a CAC regulation can help prevent the creation of hotspots; third, in terms of compatibility with other trading programs, allowances from a cap-and-trade program can be interchangeable with offsets from project-based programs or credits from rate-based programs only if those offsets or credits do not detract from the environmental effectiveness of the cap-and-trade program.

Ellerman (2002) suggests two ways in which to use a pollution fee to reinforce a tradable permit system: (1) a higher second-tier penalty rate-- an emitting firm would surrender allowances and pay the low pollution fee for all covered emissions, and the higher penalty for uncovered emissions; and (2) the first tier of the pollution fee as a second instrument for achieving local air quality standards -- within the sensitive areas, the level of pollution fee is higher.

The earlier EPA's emission trading programs were based on the existing regulations which intended to facilitate or complement the existing regulatory scheme. However, recent cap and trade programs, such as the SO_2 trading in the ARP and RECLAIM, are likely to intend to replace technology-based or emissions standards (Tietenberg 1998)

Unlike successes in the U.S., failures of emissions trading programs in the UK and Poland were due to incompatibility with existing regulatory regimes. In particular, sulfur trading in the UK is understood to have failed for these six reasons:

(1) Independent development in energy industry-- privatization of British Gas, monopoly supplier of gas, in 1986 and privatization of the England and Wales ESI, a dominant electricity company, in 1991-- led to drop in gas price, switch to gas turbine from

coal -fired system, and reduction in sulfur emissions. As a result, without additional efforts, including the quota switching system (1992 to 1996), regulated sources could easily achieve sulfur reduction targets. Quota switching had become redundant; (2) a conflict of regulatory principles between the quota switching system and the pre-existing integrated pollution control (IPO). In other words, IPC requires the concept of best available technology not entailing excessive costs (BATNEEC) based on authorization of technical requirements, which is not likely to be compatible with the quota switching system based on cap-and-trade; (3) a conflict of regulatory cultures between the U.S. and the Europe. While regulations in the U.S. use uniform standards, those in UK are flexible and informal through negotiations. Therefore, emissions trading initiated by the Department of Environment was regarded as a complicated government intervention; (4) a conflict over quota allocation among participants; (5) uncertainty of trading regulations including the variable targets for the UNECE's sulfur protocol; (6) inadequate political support: both industries and environmentalists opposed the introduction of a new emissions trading system (Sorrell, 1999; Zylicz, 1999).

Implementation Issues

A. Monitoring

One of the most distinctive features of a cap-and-trade program is that sources measure total emissions with the most possible accuracy and consistency because the emission measurements are the so-called "gold standard" upon which a trading market can operate (EPA, 2003). For example, continuous emissions monitoring system (CEMS) and the allowance tracking system (ATS) were two major implementation tools contributing to success of the SO_2 trading in the ARP. In the ARP, even though the CEMS added administrative costs (about 7% of the total compliance costs), it helped encourage more emissions trading and greater cost savings (Ellerman et al., 2000; Kruger et al., 2000)

B. Compliance and Enforcement

Enforcement is essential for success of emissions trading programs because the ultimate gains from emissions trading depend on rates of compliance. Stranlund et al. (2002) claim that penalties should be higher than prevailing permit (allowance) prices and they should be applied automatically in case of non-compliance based on these two conditions for complete compliance;

1. the marginal benefit of under-reporting, which is the price of permits, is not greater than the expected marginal cost ($p < \pi \times [f + g]$)

where

p: price of permits; π: probability of being caught; f: fine for violators; and g: fine for under-reported emissions.

2. fines imposed on each violator should be greater than the market price of permits ($p < f$)

Levels of sanctions are important: penalties should be neither too large nor too small. Insufficient penalties lead to non-compliance. Too large a penalty will not be credible for compliance. As a good example, the penalty in the ARP is 2,000 dollars per ton of excess SO2 emissions, while the marginal abatement costs approximately 700 dollars per ton (Stavins, 2000).

III. The Framework for Air Pollution Control in Korea

General Context

A. Development of Air Policy Institution

Before delving into specific air pollution control policies in Korea, this study starts with the development of Korea's air pollution control laws. To deal with potential environmental problems caused by rapid government-driven industrialization since the mid 1960s, the Environmental Pollution Preservation Act (the first environmental law except for the Waste Cleaning Act of 1961) was enacted in 1963. However, it was not sufficient for handling environmental problems for several reasons: The law did not go into effect until 1969 its coverage, with only 21 articles, was very limited, and enforcement was completely inadequate.

In 1977, with the rising environmental concerns, the Environmental Conservation Law replaced the Environmental Pollution Preservation Act. While the previous law dealt with municipal and industrial pollution, the new law included new measurements, such as environmental impact assessment, disposal of industrial waste, and preservation of the natural environment.

With the introduction of the idea that citizens have a right to clean and healthy environment in Korea's constitutional amendments of 1980, diversified environmental problems and increasing environmental concerns help divide and specialize the

Environmental Conservation Law into six laws, including the Clean Air Conservation Act, Noise and Vibration Control Act, and the Clean Water Conservation Act. Afterwards, the Indoor Air Quality Management Act (2003) and the Special Act for Seoul Metropolitan Air Quality Improvement (2003), and the Foul Odor Prevention Act (2004) was promulgated and as of now, five air policy related laws has been put into place.

To cope with rapidly increasing air pollution emissions, under the Ministry of Environment (MOE), there has been established one bureau named Air Quality Management which includes six divisions (including Area Based Air Quality Management, Environmental Transportation Policy, and Metropolitan Air Quality Management District).

B. Overview of Existing Air Pollution Control Measurements

The degradation of air quality caused by fast-growing industrial activities and the soaring number of vehicles has been one of the most serious concerns in Korea during the unprecedented economic and social growth that has occurred in the country since the mid-1960s. In particular, air-pollution has concentrated in major cities like Seoul and as a result, health concerns including respiratory diseases and the rate of early death have steadily increased over time[1].

In response, the MOE established ambient air quality standards for six major air pollutants beginning with sulfur dioxide in 1979, based upon which it has implemented several air pollution control measures.

[1] According to the MOE, brain stroke caused by air pollution may have aggravated the death rate by six percent

Table 2. Comparison of Ambient Air Quality Standards between Korea and the US

Category	Standards in Korea	Standards in the US
SO_2		
Annual average	0.02 ppm	0.03 ppm
24-hour average	0.05 ppm	0.14 ppm
1-hour average	0.15 ppm	0.50 ppm (3-hour avg)
CO		
8-hour average	9 ppm	9 ppm
1-hour average	25 ppm	35 ppm
NO_2		
Annual average	0.05 ppm	0.053 ppm
24-hour average	0.08 ppm	N/A
1-hour average	0.15 ppm	N/A
PM10		
Annual average	70μg/m³	50μg/m³
24-hour average	150μg/m³	150μg/m³
PM2.5		
Annual average	N/A	15μg/m³
24-hour average	N/A	65μg/m³
O_3		
8-hour average	0.06 ppm	0.08 ppm
1-hour average	0.1 ppm	0.12 ppm
Lead (Pb)		
Annual average	0.5 μg/m³	1.5 μg/m³ (Quarterly avg)

Source: Environmental White Book in Korea (2005), Tietenberg (2002)

In general, pollution control measures in Korea can be classified into three categories: facility emissions controls, fuel regulations and vehicle exhaust controls.

1. Facility emissions controls

Emissions controls on stationary industrial sources began with the enactment of the Environmental Conservation Law in 1977, and have been strengthened over time. The major regulations in effect consist of the following four tools: emissions standards, emissions charges, controls for severely polluted industrial areas, and a tele-monitoring system (TMS) for continuous emissions monitoring.

In order to control emissions from industrial sites, such as sulfur dioxide and particulate matter, the MOE has set an emission standard on each pollutant. While ambient air quality standards refer to an administrative target to be achieved, emissions standards indicate legal requirements to be met by each pollution source. The emission standard on nitrogen oxide were first set in 1979, followed by the standards on carbon monoxide, nitrogen dioxide, dust, ozone, and hydrocarbons in 1983, and lead in 1991. These were further strengthened in 1993 by establishing new standards on sulfuric acid gas and hydrocarbon. As of 2005, emissions standards are applied to twenty-eight air pollutants and their standards have been strengthened gradually considering the development of technology and financial feasibility. Furthermore, industrial sources are categorized into five types according to the amount of their annual pollution discharge, so as to enhance control over larger sources.

Emissions charges are a major powerful tool to induce each source to comply with emissions standards. In the cases of sulfur dioxide and PM10, regulators impose a general charge according to the quantity of emissions and also an additional charge based on the extent to which each source exceeds the emissions standard. When the quantities of emissions are less than 30 percent of the allowed amounts, the firm is exempt from the general emissions charge. For the other 10 pollutants, including NH3 and HCL, pollutant-specific emissions charges are imposed on firms which exceed the emissions standard for each pollutant.

In severely polluted areas, special plans for air quality are implemented. In two larger industrial complexes designated as Special Control Areas, more rigorous (for existing sources) or special emissions standards (for new sources) are applied and strict equipment requirement for reducing emissions are imposed on these sources. Another category of specially managed areas is designed as Air Pollution Control Areas, and this term is applied to a region where more than 30% of monitored point sources exceed 80% of ambient air quality standards. If an area is designated as an Air Pollution Control Area (as of 2005, these include the Seoul Metropolitan Area, Busan City, Daegu City, and the Gwang-yan Bay Area), the city or province has to prepare and submit its 5-year Implementation Plan to the MOE. Meanwhile, because part of a current Air Pollution Control Area overlaps with the Seoul Metropolitan Area in the Special Act for the Seoul Metropolitan Air Quality Improvement, the Seoul Metropolitan Area covered by the special act should be exempt from regulations associated with Air Pollution Control Areas.

In order to clearly understand air quality status and to secure basic date required for the establishment of improvement measures, the MOE and local governments have installed and operated a total of 10 monitoring networks to keep track of national and regional ambient air quality data, as well as the levels of heavy metals and photo-chemical substances in the ambient air.

There were 372 monitoring stations operating in Korea as of April 2004. In addition, like the CEMS in the U.S., a Tele-Monitoring System (TMS) has also been installed in the individual smoke stacks of high-emission facilities since February 2002. Based on the information collected by the TMS, the MOE mandates improvements and imposes charges on those who exceed emission standards. As of January 2004, TMS units were installed in 1,841 stacks at 317 industrial sites.

2. Fuel regulations

One of the regulatory tools widely used in Korea is fuel regulations. To date, in order to minimize air pollution resulting from fuel usage, three types of fuel regulations have been employed: a ban on the use of solid fuels such as coals, and expanding the use of low-sulfur oil and clean gas fuels like LNG. Since 1981, the use of low-sulfur oil has steadily increased, reducing the amount of sulfur dioxide in urban areas. As of 2005, the sulfur content of heavy oil has been limited to less than 1 percent (nationwide), 0.5 percent (in 56 mid-sized cities) or 0.3 percent (in Seoul and twenty other major cities). In addition, the sulfur content of light oil is restricted to less than 0.1 percent nationwide.

Meanwhile, the use of solid fuels such as coal and charcoal has been prohibited in areas where ambient air quality standards have been continuously threatened since 1985. Regulated entities include apartments and power plants in the Seoul Metropolitan Areas, but some of facilities (such as steel and cement production) can be exempt under exceptions that are approved by the MOE. Air quality had not been significantly improved in spite of the introduction of the above two fuel regulations. Thus, mandatory use of clean fuel was introduced in 1988, just before the 1988 Seoul Olympics. Regulated facilities include apartments, boilers and electric generating units (EGUs) in Seoul and 36 other large cities.

3. Vehicle exhaust control

Air pollution emissions come from vehicles account for about 79 percent of carbon monoxide (CO), 43.6 percent of nitrogen oxides (NOx), and 31 percent of fine particulate matter (PM10). In particular, NOx, particulate matter and volatile organic compound

(VOC) stemming from vehicles are major contributors to levels of urban smog so that strict control efforts are needed, especially in urban areas.

Efforts are also being made to fundamentally reduce air pollution from mobile sources, which is the highest contributor to air quality degradation. (In the Seoul Metropolitan Area alone, roughly 67% of PM10 and 51% of NOx are from vehicle exhaust.) The MOE has set an exhaust emission standard for newly manufactured vehicles, and for in-use vehicles, in addition to fuel production standards. In particular, starting in 2006, emission standards on newly manufactured gasoline and natural gas vehicles were strengthened to the level of ultra low emission vehicle (ULEV) and emission standards on diesel vehicles was also intensified to the level of EURO-4[2].

The MOE has started operating natural gas vehicles (NGVs) as replacements for diesel buses that have long operating lives and high emissions discharges. As of May 2004, 4,876 diesel buses owned by private sector were replaced with NGVs, and 20,000 diesel vehicles, which account for 48% of the total diesel vehicles nationwide, will be replaced with NGVs by 2007. Also, as a policy to control in-use diesel vehicles that are not subject to mandatory replacement, the MOE is promoting another project to encourage the attachment of Diesel Particulate Filters (DPF) and Diesel Oxidation Catalysts (DOC).

C. Context of the Special Act on Seoul Air Quality Improvement

With a population of some 48 million, Korea has the third highest population density in the world at 468 persons per square kilometer. In addition, population pressure, accelerated economic growth within a short span of time since the mid 1960s has led to a

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[2] ULEV for gasoline cars has been applied in the US since 2004, and EURO-4 for diesel vehicles started to be applied in EU countries in 2006.

rapid increase in environmental pollution. There has also been considerable social conflict surrounding various large-scale development projects such as dams and highways.

In particular, with the explosive growth of population and vehicles in the Seoul Metropolitan Area, this region which takes up just 11.8 percent of the total national landmass accounts for 46 percent of the total population and vehicles. Seoul's population density is approximately 4 times higher than that of the rest of the nation. Taken together, this excessive concentration of population and vehicles in a relatively smaller area has brought about a severe deterioration in Seoul's air quality.

Table 3. Population and Vehicles in the Seoul Metropolitan Area

Time	1990	2000	Growth Rate
Population	18,340,000	21,910,000	20%
Number of Vehicles	1,790,000	5,577,000	211%

Source: Unpublished paper by the MOE

Pollution levels of particulate matter and nitrogen oxides in the Seoul Metropolitan area are 1.7 to 3.5 times higher than those in other major cities globally, and is higher than other cities in Korea as well, which results in enormous social costs estimated at approximately 10 trillion Won (10 billion USD) annually.

Table 4. Comparison of Air Pollution between Seoul and Other cities

Category	Nitrogen Dioxide (NO2)	Particulate Matters (PM)
Seoul (2001)	37	71
London (2001)	25	20
Paris (2001)	22	20
Tokyo (2000)	29	49
New York (1997)	30	28
Other areas in Korea (2001)	22	53

Source: Unpublished paper by the MOE

With every indication that the population, the number of vehicles, and energy consumption levels in the metropolitan area will continue to rise continuously, existing CAC measures based on technological and emission-rate standards seem insufficient to deal with the growing number of pollution sources. To overcome such challenges, the MOE developed the Special Measures for Seoul Metropolitan Air Quality Improvement with the launch of a Joint Task Force Team consisting of government officials and expert representatives from industries, universities, professional institutions and civic groups. This team participated in more than 100 consultations until the Special Measures were finally established in 2002.

In December 2003, the Special Act for Seoul Metropolitan Air Quality Improvement was promulgated in an effort to develop an institutional framework for the effective implementation of the Special Measures: a total air pollution load (TAPL) management scheme, an emissions trading system, and mandatory increases in the supply of low emission vehicles. The Special Act went into effect starting in January 2005. Grace periods were granted to a number of industrial plants that required additional preparation work before the adoption of the TAPL management system.

The Cap-and-Trade Program in Seoul, Korea

A. General

The purpose of the Special Act for Seoul Metropolitan Air Quality Improvement is stipulated in the first article of the law: “to develop an institutional framework for the effective implementation of the Special Measures for air quality improvement in Seoul and its vicinities." More specifically, the act aims to improve air quality in the Seoul Metropolitan Area so to reach a similar level to those of major OECD countries within 10 years of the implementation of the Special Measures.

A number of air pollutants, such as nitrogen oxides, have regional or global impact beyond their local consequences. Therefore, controlling ambient air quality based on a local management system within one jurisdiction has some limitations. That is why the MOE introduced wide-ranging and comprehensive special measures to bind the whole metropolitan area into an integrated system for air quality control.

The MOE developed a 10-year framework plan for metropolitan air quality control and three local governments (Seoul, Incheon and Gyunggi) established 5-year Implementation Plans concerning stationary and mobile source emissions reduction programs given their social and environmental features.

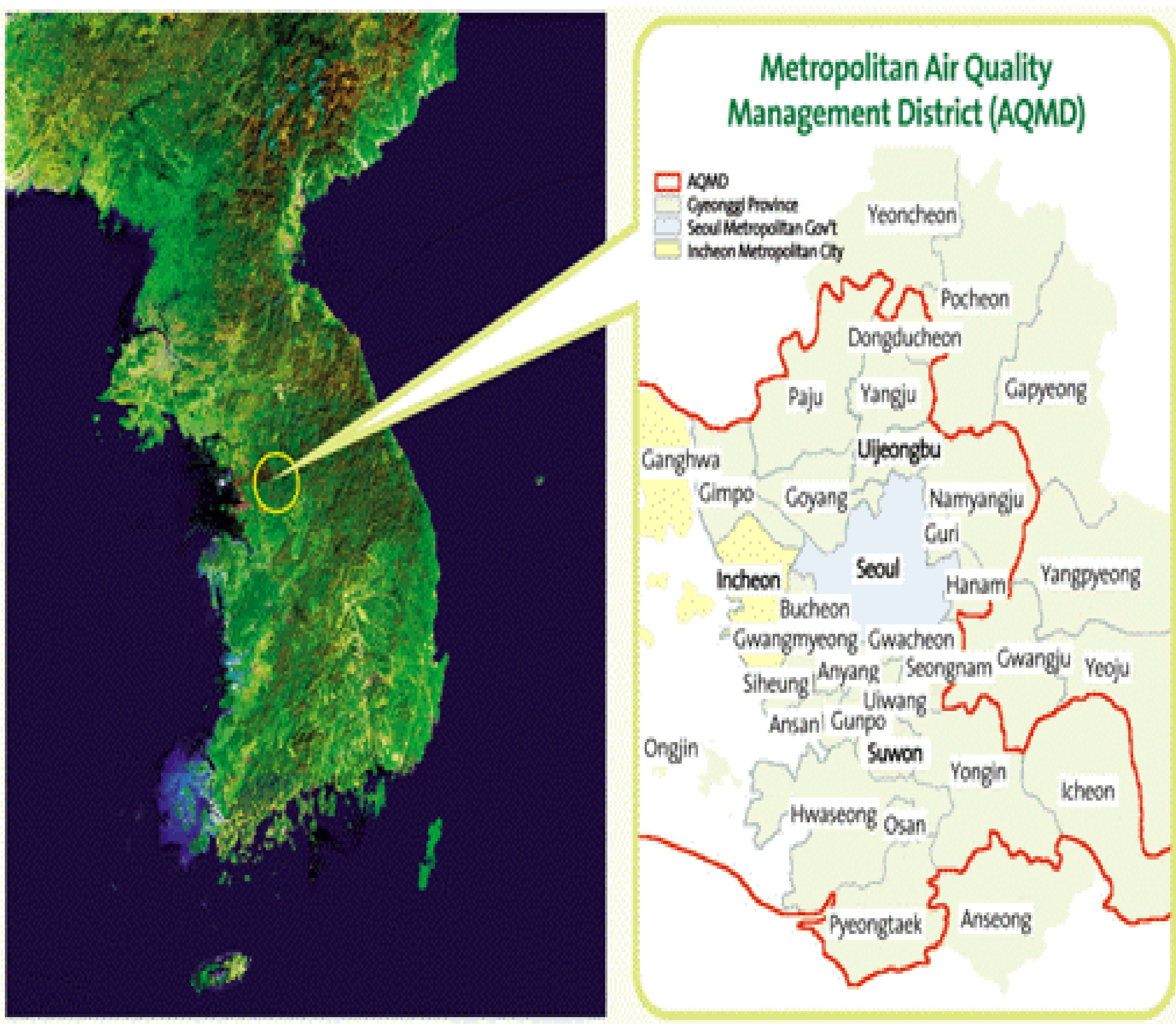
B. Major Features of the Cap-and-Trade Program

1. Applicability

With respect to geographic region, the cap-and-trade program in the Special Act is applied in most of the Seoul Metropolitan Area, which includes Seoul City, Incheon City, and most of Gyunggi Province (including 24 out of 31 cities)

Facilities subject to the cap-and-trade program include power generating plants and industrial facilities emitting more than a certain amount of regulated pollutants such as nitrogen oxides (NOx), sulfur oxides (SOx) and particulate matter (PM). The cap-and-trade program will be implemented into two phases: phase I will start in July 2007 and will involve only larger facilities emitting more than 30 ton per year of NOx, 20 ton per year of SOx, or 1.5 ton per year of PM. Phase II, starting in July 2009, will include all facilities emitting more than 4 tons per year of NOx and SOx, or 0.2 tons per year of PM. Regulated facilities during phase II would number 309, which accounts for 2 percent in terms of the number of facilities, yet covers 84 percent of NOx, 78 percent of SOx, and 57 percent of PM emissions from stationary sources.

Figure 5. Seoul Metropolitan Area



Unlike RECLAIM and the Acid Rain Programs in the US, there is no opt-in program whereby non-regulated facilities can participate voluntarily in the cap and trade.

Table 5. Facilities Subjected to the Cap-and-Trade Program in Seoul

Category	NOx (ton/year)	Sox (ton/year)	PM (ton/year)	Coverage (facilities)
Phase I (July 2007)	More than 30	More than 20	More than 1.5	137
Phase II (July 2009)	More than 4	More than 4	More than 0.2	309

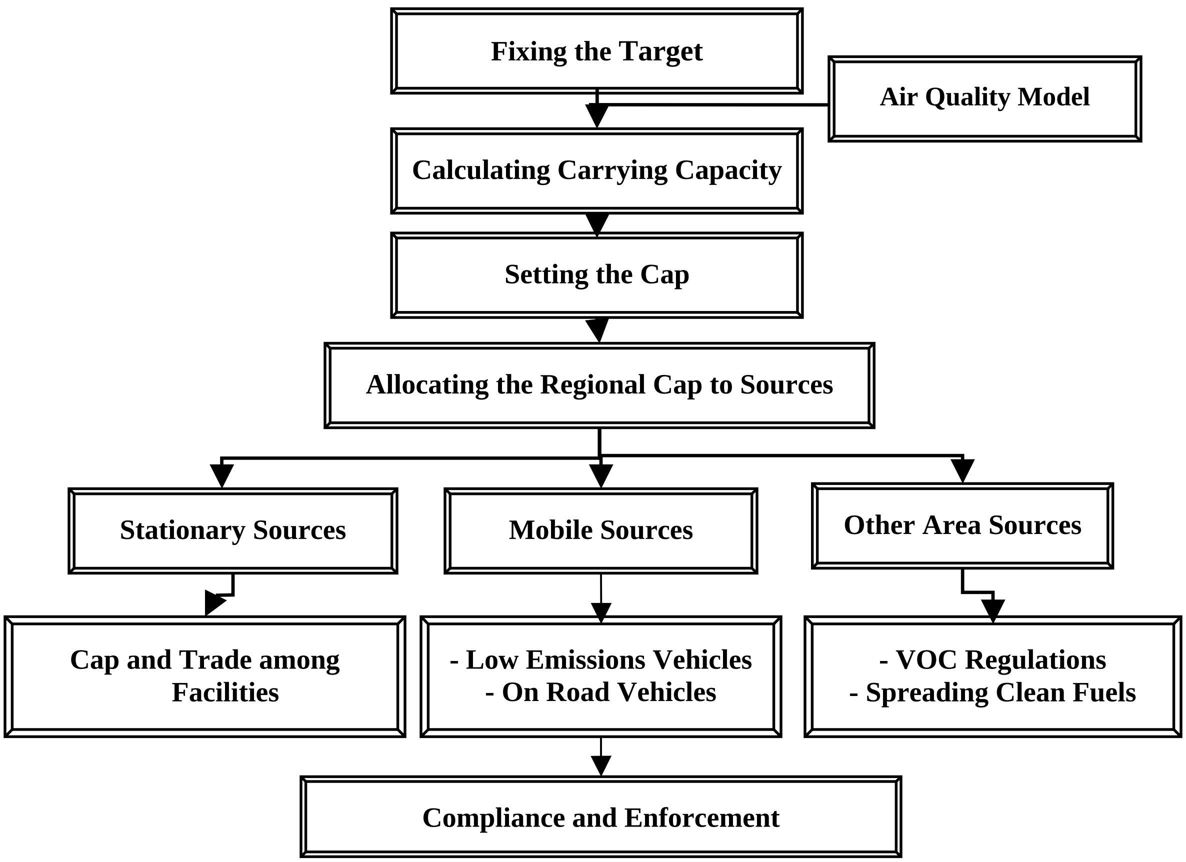
Source: Unpublished paper by the MOE

2. Setting the Cap: Total Air Pollution Load (TAPL)

Until recently, Korea's traditional air pollution regulations, like the emission standards system, monitored the pollution levels by each emitter (e.g. smoke stacks). Although this system was effective in controlling the pollution level of each emitter, it was not successful in reducing the total amount of pollution conditional on absorptive capacity because it lacked control over the increasing number of emitters. For this reason, the MOE introduced the TAPL management system to allocate a total volume of allowable emissions for each industrial site.

In the broader sense, the TAPL management system includes a cap-and-trade program. As Figure 6 indicates, the process of establishing a cap-and-trade involves three stages: (1) fixing the target for air quality in the area, (2) calculating the environmental absorptive capacity, and (3) setting the cap in the region-- equal to the regional atmospheric environmental critical load.

Figure 6. Process of the Total Air Pollution Load (TAPL) Management System



3. Allocation Distribution

Once the cap is set, the next step is to allocate the annual permits or allowances. As for the initial allocation, grandfathering based on historical emissions is applied rather than auctions (due to the constraints imposed by political feasibility).

The starting allowances will be determined by the following formula:

Starting allowances (A_1) = Σ (EF×L)

EF = the applicable starting emission factor for the subject source

L = the activity level for each source emitting NOx, SOx or particulate matter

in the facility for the maximum throughput over the most recent 5 years.

The emissions factor (EF) for a certain unit is calculated by dividing the sum of annual average emissions across units by the sum of amount of fuel or material used by all units. Therefore, the same sorts of sources may well have the same emissions factor: EF = Σ annual average emissions / Σ annual total fuel used. Activity level (A) is the peak throughput such as the amount of fuel or material used in the process over the most recent five years. Even the same types of sources have different activity levels respectively.

After the starting allocations (A_1) are determined based on the above formula, the allowances in fifth year (A_5) would be determined in the similar way. In this case, the emissions factor will be modified in consideration of the Best Available Control Technology (BACT):

Allowances in fifth year (A_5) = Σ (EF*m*×L)

EF*m* = modified emissions factor

L = the activity level for each source emitting NOx, SOx or particulate matter in the facility for the maximum throughput over the most recent 5 years.

After the two allowances allocations (A_1, A_5) are determined, the other allocations (A_2, A_3, A_4) would be set automatically based on a linear interpolation method.

To explain the initial allocation using a numeric example, suppose that there are three facilities in a region: A and B are paper mills, and C is a petrochemical plant. The table shows the activity level, average emissions and maximum emissions of equipment in three facilities.

Given the equation of emission factor (EF = Σ annual average emissions / Σ annual total fuel used), emission factors of boiler T type and incinerator R type are as follows:

$EF_{\text{boiler T}}$ = (1+2+3.8) ÷ (10+15+30) = 0.1236

$EF_{\text{incinerator R}}$ = (0.5+0.75) ÷ (100+150) = 0.005

Table 6. Activity Level and Emissions of Facility A, B and C

Category	Business	Equipment	Activity Level (ton)	Annual average emissions in the most Recent 5 years (ton/year)	Annual maximum emissions in the most Recent 5 years (ton/year)
Facility A	Paper mill	Boiler T (LNG)	10	1	1.2
		Incinerator R	100	0.5	0.6
Facility B	Paper mill	Boiler T (LNG)	15	2	2.6
		Incinerator R	150	0.75	0.95
Facility C	Petrochemical	Boiler T (LNG)	30	3.8	4.2

Therefore, the initial allocations (kg/year) of these three facilities are determined according to the following process:

Allocation to A= (10 tons×0.1236) + (100 tons×0.005) × 1000kg/ton = 1,736kg

Allocation to B= (15 tons×0.1236) + (150 tons×0.005) × 1000kg/ton = 2,605kg

Allocation to C= (30 tons×0.1236) × 1000kg/ton = 3,709kg

According to these initial allocations, while facility A gets initial allocations (1,736kg) more than its average emissions (1,500 kg), facility B and C get initial allocations (B: 2,605 kg, C:3,709 kg) less than their average emissions (B: 2,750 kg, C: 3,800 kg) respectively.

4. Allowance Use

Generally, allowances can be used for compliance with the cap, trading with other sources, or banking for future use. Those who want to trade allowances turn in an application form to the Seoul Metropolitan Air Quality Management District Office (SMAQMDO) seven days prior to the trade.

There may be two kinds of restrictions imposed on allowance use in a cap-and-trade program: geographical and inter-temporal restrictions. In the case of NOx, SOx, and PM trading in Seoul, trading volumes available for each source are limited to a certain proportion of its allocated allowances: that is, the tradable allowances are restricted to 20 percent in the starting year, 30 percent in the second and third years, and then 50 percent in the fourth and fifth years. Since allowance allocations are revised every five year, the above restrictions would be applied to the following allocations.

In the case of a plant shutdown, tradable allowances will be reduced to the allocated allowances multiplied by the operational days as a proportion of 365 days, and starting the next year of shutdown, allowances will be zero.

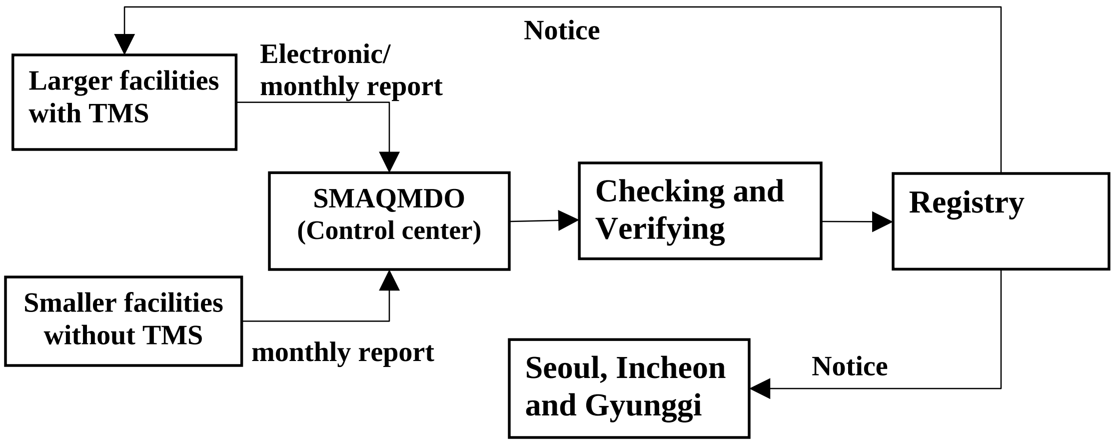
In addition, even if there are no geographical restrictions explicitly, when a trading may lead to violation of ambient air quality standards or creation of hotspot, selling a permit to a plant in a possible non-attainment area is not allowed.

As for inter-temporal restrictions, banking is allowed but borrowing is not allowed. Unlike the ARP and RECLAIM, however, there are offsets from trading: if the amount of banked allowances is less than 10 percent of allowances in the subsequent year, 50 percent of allowances banked are counted in total available allowances. Meantime, if the amount of banked allowances exceeds 10 percent of allowances in the subsequent year, available allowances would be determined by the following formula: the amount of banked allowances×50 percent×0.1× (total allowances of all sources in the subsequent year/unused allowances of all sources in the year)

5. Monitoring and Enforcement

The success of an emissions trading program relies on the rate of compliance, and the compliance rate depends on accurate and reliable monitoring and enforcement. As for monitoring, regulated facilities have to establish a monitoring system and report their measured emissions to the SMAQMDO by the end of each month. Larger facilities subjected to the cap-and-trade in phase I, have already instituted the TMS which measures major pollutants including SOx, NOx, and particulate matter every five minute. Thus, they do not need to set up any additional monitoring system.

Figure 7. Monitoring and Reporting Process



Missing data can occur due to technical problems such as sudden breakdown of monitoring equipment, but since there are no provisions dealing with problems caused by missing data, related rules will be added prior to the program's implementation.

There are two enforcement mechanisms for non- compliance. Any facility that is out of compliance with its cap is subject to a financial penalty according to the following formula:

Penalties = per unit fee × emissions in excess of the cap × adjustment factors

(excess rate factor× violation number factor× region factor) × price index

Table 7. Penalties for Non-Compliance under CATS

<table>
<tr><th rowspan="2">Pollutant</th><th rowspan="2">Per ton Fee (USD)</th><th colspan="8">Excess Rate factor[1)]</th><th colspan="4">Violation Number Factor[2)]</th><th colspan="3">Regional Factor[3)]</th></tr>
<tr><th>Below 2%</th><th>2-4%</th><th>4-8%</th><th>8-10%</th><th>10-20%</th><th>20-30%</th><th>30-40%</th><th>Over 40%</th><th>1</th><th>2</th><th>3</th><th>4+</th><th>I</th><th>II</th><th>III</th></tr>
<tr><td>Nox</td><td>2.9</td><td>1.2</td><td>1.45</td><td>1.7</td><td>2.0</td><td>2.5</td><td>3.5</td><td>5.0</td><td>7.0</td><td rowspan="3">1.2</td><td rowspan="3">1.4</td><td rowspan="3">1.6</td><td rowspan="3">1.8</td><td rowspan="3">2.0</td><td rowspan="3">1.0</td><td rowspan="3">1.5</td></tr>
<tr><td>Sox</td><td>4.2</td><td>1.2</td><td>1.45</td><td>1.7</td><td>2.0</td><td>2.5</td><td>3.5</td><td>5.0</td><td>7.0</td></tr>
<tr><td>PM</td><td>6.5</td><td>1.2</td><td>1.45</td><td>1.7</td><td>2.0</td><td>2.5</td><td>3.5</td><td>5.0</td><td>7.0</td></tr>
</table>

Reference:

1) “Excess rate factor” shall be determined according to the following methodology:

Excess rate factor= (actual emissions- allowances)÷allowances×100

2) “Violation number factor” indicates the number of violations over the most recent 5 years.

3) “Regional factor” differs across region I, II and III

Region I: residential and commercial region

Region II: industrial region

Region III: forest, agricultural and conservational region

In addition to the financial penalty, the amount by which the current allowance is exceeded shall be subtracted from the subsequent allowance allocation: the total subtracted allowances shall be the exceedence of allowances multiplied by the violation number factor above.

C. Other Control Measures to Supplement Cap and Trade

Generally speaking, concerning integration with other regulations, two things should be taken into consideration: (1) the program should complement regulations on mobile and area sources which are not covered by the cap-and-trade program, and (2) the program should be compatible with other pre-existing regulations. The cap-and-trade program in Seoul only covers stationary sources emitting NOx, SOx, PM which account for about 30 percent of emissions in the region. Thus, other regulations on mobile and area sources will be introduced as well.

1. Enhanced supply of Low Emission Vehicles

Emissions from vehicles account for roughly 51 percent of NOx, 58 percent of

PM, and 85 percent of CO emissions in the Seoul Metropolitan Area. This means that enhancing the supply of low-emission vehicles (LEV) and zero-emission vehicles (ZEV) will be one of the most important elements when it comes to improving ambient air quality. The Special Law for Seoul Metropolitan Air Quality Improvement categorizes LEV/ZEVs into type 1, 2, 3 according to the level of pollution reduction they allow: type 1 are zero emissions vehicles such as electric and fuel cell vehicles; type 2 are CNG, LPG or gas-electronic hybrid vehicles which meet the strict emissions criteria and whose NOx emissions are lower by 25 to 50 percent compared to conventional vehicles; and type 3 are gasoline or diesel vehicles meeting the same criteria as type 2 vehicles.

Starting in 2005, nearly all government entities in the Seoul Metropolitan Area will be required to make a certain portion of newly purchased vehicles be LEV/ZEVs. On the manufacturing side, automakers selling more than 3,000 vehicles per year in the area are advised to supply LEV/ZEVs at a rate negotiated with the MOE.

2. Controlling Vehicles in Operation

Older vehicles that were manufactured according to past emission standards emit a greater amount of air pollution than newer vehicles. Therefore, taking active measures to reduce emissions from vehicles that are already in operation is critical to the task of achieving drastic improvements in air quality. First, recognizing that diesel vehicle exhaust emissions account for almost 100% of PM and 75% of NOx discharged by vehicles, the MOE strengthened emission standards for all diesel vehicles currently in operation. Also, those which fail emissions tests will be required to install Diesel Particulate Filters (DPF) or Diesel Oxidation Catalysts (DOC), or to retrofit the vehicle with "cleaner" engines. Governmental subsidies (roughly 50% of installation or retrofit costs) will be provided to encourage these activities.

3. Fuel Quality Improvement

Starting in October 2004, only low-sulfur fuels have been supplied in the Seoul Metropolitan Area. New standards for sulfur content were strengthened from 430 ppm to less than 30 ppm. Furthermore, by introducing a grade scheme for fuel qualities, the MOE is providing information in the hope of helping consumers make environmentally sound choices.

4. New VOC Reductions

VOC, which are highly challenging to control, are organic compounds in their liquid or vapor state. In addition to posing threats to human health, VOC combined with NOx in the ambient air generate ozone due to their high level of photochemical reactivity. In order to reduce VOC at their sources, the MOE mandates that paint manufacturers must decrease the organic solvent content in paints by 30%, and encourages the development and use of water-based paints.

In addition to the introduction of new complimentary regulations, it is important for a cap-and-trade program not to duplicate or conflict with pre-existing technical and emissions rate-based regulations. For example, sources subject to the cap-and-trade program will be exempt from general emissions charges imposed on SOx and PM. Also, sources emitting SOx which participate in the cap-and-trade program are exempt from the requirement for reduced sulfur content in fuels.

Even if it's not sure a voluntary agreement works, any regulated sources, which want to make their environmental efforts public can make an agreement with the regulatory authority that they comply with intensified emissions cap rather than required in the law.

IV. Experiences with Emissions Trading in the US

<u>Introduction</u>

Since the mid-1970s, the US has been a leader in the development of emissions trading programs. In the earlier forms such as the EPA's Emissions Reduction Credits (ERC) trading programs, emissions trading programs were added to an existing regulatory system. Baseline emissions were determined based on the existing technology of the plant and ERC were earned by reducing emissions below this level. However, this approach was not sufficient to meet environmental goals with certainty.

In the mid-1990s, more-successful variants of permit trading emerged, including the ARP and RECLAIM. Cap-and-trade programs, not based on technology standards, could greatly enhance certainty about total emissions while minimizing compliance costs.

Initially, tradable permit programs were implemented mostly in the US mainly in air pollution control. Nowadays, however, trading programs have gained popularity across the world, and their use is spreading to a variety of environmental management problems, including fisheries, climate change, renewable energy transport, transportation, solid waste management, and water resources management (OECD, 2002). In this study, five emissions trading programs which have implemented in the US are explored and then three major cap-and-trade programs-- the SO_2 Trading in the ARP, RECLAIM, and NBT-- are compared one other in terms of eight categories: purpose and framework, coverage, allocations, trading rules, trading market, relationship with other regulations, monitoring and reporting, and enforcement

Overview of the U.S. emissions trading programs

A. EPA Emissions Trading Programs

The EPA developed four types of emissions trading programs in an effort to reduce abatement costs by providing more flexibility for stationary sources. Under the Clean Air Act (CAA) of 1970, technical regulations imposed a considerable burden on emitting plants. Especially in non-attainment areas, new sources were not allowed, which meant that the original CAA imposed serious restrictions on economic growth and regional economic activities. Against a backdrop of the increasing debate about traditional technology-based regulations, the earliest ERC trading programs emerged. The program has been implemented by means of four policies, each of which concerns the trading of ERCs.

Offsets: Offsets, introduced in 1976, apply to new sources in non-attainment areas for the National Ambient Air Quality Standard (NAAQS). Emissions from existing sources should be reduced by at least as much as the new source would contribute. Typically, new or expanding sources must purchase 20% more emissions in terms of offsets than would be added when the new source commences operation;

Netting: Netting, first implemented in 1974, is applied to existing sources which modify or expand their equipment. These sources could be exempt from otherwise applicable new source review procedures as long as existing emissions elsewhere in the same facility are reduced by a sufficient amount;

Bubbles: While the netting and offset policies allow sources more flexibility to meet the NAAQS, those programs apply to new or expanded facilities. Existing facilities were not given similar flexibility until the EPA announced its bubble policy in 1979. The bubble policy was developed to allow a group of sources to combine the limits for several different sources into one combined limit and to determine compliance based on that aggregate limit instead of emissions from each individual source. These bubbles can be extended to cover point sources of emissions in plants owned by other firms as well; and

Banking: Banking was later added to allow firms to store their own ERCs for future use (Ellerman et al., 2003; Tietenberg, 2003).

In 1986, the EPA formally promulgated the netting, offset, bubble, and banking programs in its Emissions Trading Policy Statement. Even though the EPA's ERC trading programs were the first application of emissions trading programs as actual policy, their performance was disappointing. This was mainly due to a requirement for case-by-case certification or prior approval of trading, which made the transaction costs associated with trades simply to high.

B. Lead-in-Gasoline Trade Program

In effect only from 1982 to 1987, the EPA's Lead-in-Gasoline Trade Program can be described as the first real success among emissions trading programs. This averaging program is widely regarded as having been a much more successful trading program than the EPA's earlier ERC trading program.

The EPA's phasing-out of the lead content of gasoline can be partitioned into three stages. Starting in 1973, lead limits for gasoline were implemented based on refinery-specific regulations in which each refinery had to meet an average lead concentration across all of its total gasoline production. In 1982, trading was available across refineries nationwide, which means that any refinery reducing the lead content of their gasoline below their specified limits was able to sell their credits to other refineries that had not reduced their limits. In 1985, the EPA promulgated their lead phase-out program, involving a more-strict lead limit (in two phases) and allowing banking by regulated refineries. In July 1985, each refinery had to reduce lead content from 1.1 grams per gallon to 0.5 grams per gallon, and then in January 1986, to 0.1 grams per gallon. In terms of traded volume, the lead phase-out market was very active, especially after banking was introduced. During 1983 to 1987, the number of lead permits traded steadily increased, from about 10 percent to more than 50 percent of all lead permits.

Even though there have been no studies concerning cost savings from the Lead-in-Gasoline trading program, it can be predicted that there were a considerable cost savings, evidenced by the great number of trades. I believe this program is viewed as a success because of these two factors. First, the Lead-in-Gasoline trading program was an averaging program. Unlike the earlier ERC, averaging can negate any need for case-by-case pre-approval of tradable credits. Those regulated refineries that reduced their lead content below the average limit were automatically certified to be issued credits. Another factor was banking. The use of banking seemed to facilitate a faster reduction in lead content. In fact, without the lead trading program, it would probably not have been feasible to achieve such an aggressive target via conventional CAC methods.

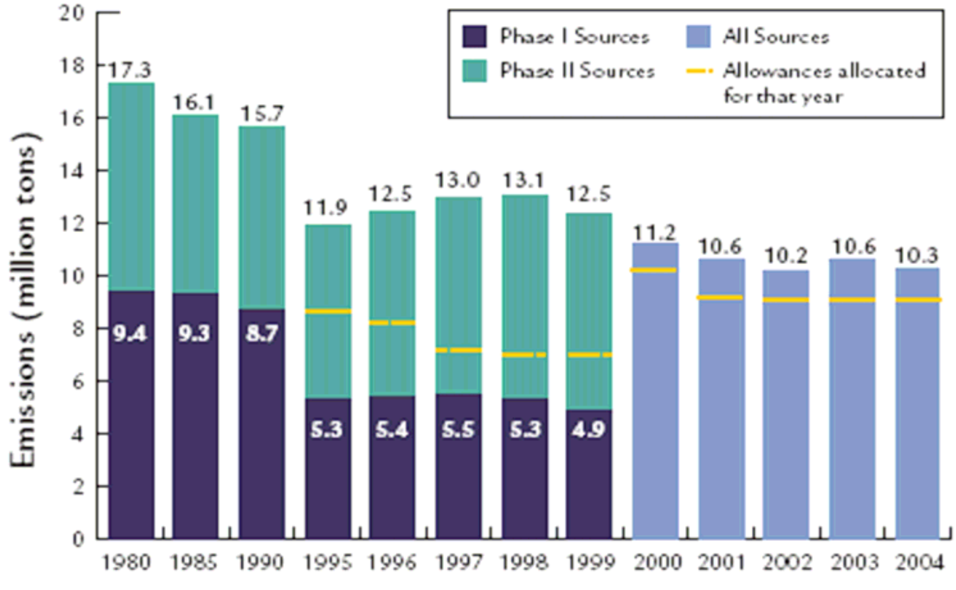
C. SO_2 Trading Program in the Acid Rain Program

The SO_2 Trading Program was introduced under Title IV of the 1990 CAAA to reduce precursor emissions that lead to acid deposition. In addition to the major purpose of reducing the effects of acid deposition, there were two secondary motives as well. The first motive was to reduce fine particulates, another pollutant known to threaten public health (SO_2 emissions were understood to contribute to fine particulate pollution). The second motive was to reduce the difference between emissions limits imposed on existing sources (ahead of the 1970 CAA amendment) by State Implementation Plans (SIP) and stricter emissions limits imposed on new sources in non-attainment areas (after the 1970 CAA amendment) by the New Source Performance Standards (NSPS). As all states in the U.S. could meet the SO_2 standard by the 1980s due to several SO2 reduction regulations, additional regulations beyond just the NSPS would be needed. In sum, the SO_2 cap-and-trade program was introduced for several reasons: to reduce acid deposition nationwide, but mainly in the Northeast; to lessen fine particulates; and to reduce the difference between emissions limits imposed on new sources and those on existing sources (Ellerman, 2004).

The program has been phased in, with the final Phase II SO_2 cap (9 million tons) set at about one half of 1980 emissions (17.3 million tons) from electric power generation units. During Phase I, which lasted from 1995 through 1999, larger fossil fuel burning units with more than 100 MW of generating capacity were subject to the program. In Phase II, beginning in 2000, the program was expanded to include almost all fossil fuel electricity generating facilities greater than 25MW.

In evaluating a trading program, two major criteria should typically be taken into consideration: cost effectiveness ("cost savings), and environmental effectiveness ("meeting the cap"). With respect to environmental effectiveness, throughout all periods, each source's actual emissions did not exceed the sum of its allocated allowances in that year and unused allowances from the previous years, resulting in nearly 100 percent compliance.

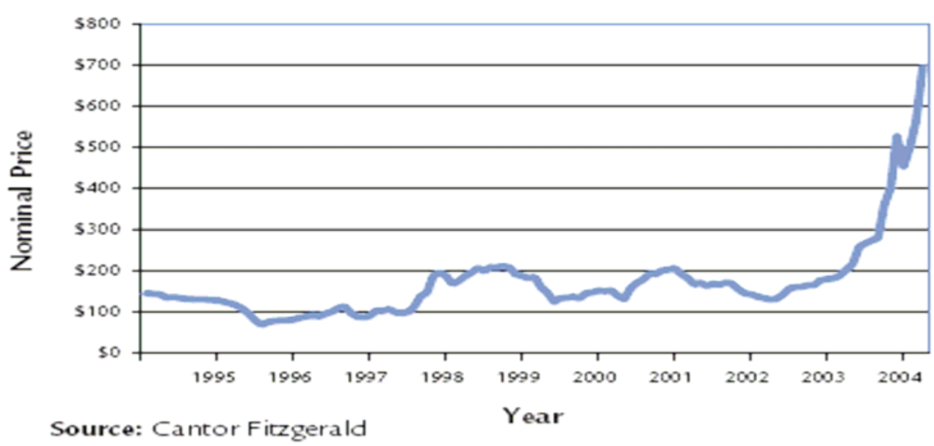
Figure 8. SO_2 Emissions under the Acid Rain Program



Source: EPA (2005)

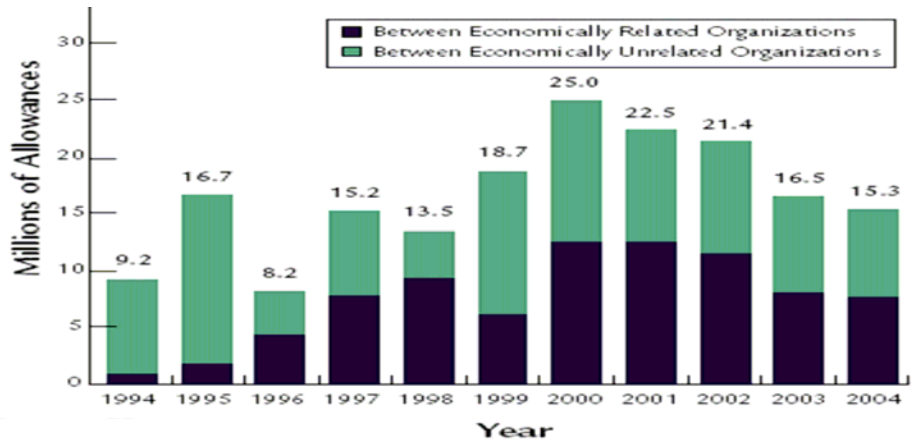
In terms of cost effectiveness, substantial cost savings are implied by two factors: an available single market price, and a significant number of allowances traded. Even though prices have varied over time from $65 in 1996 to $860 in 2006, a single price prevailed. Since 1995, except for recent price spike since 2004 due to EPA's Clean Air Interstate Rule (CAIR) which aims to reduce power industry ozone season NOx emissions by about 50% from 2003, price changes was relatively stable.

Figure 9. SO_2 Allowance Prices under the Acid Rain Program



As a proportion of the overall cap, traded allowances have been substantial during the entire program. In 2004, when 9 million tons of allowances were allocated, roughly 15.3 million were traded, of which 7.5 million were transferred in economically significant amounts between economically unrelated parties.

Figure 10. SO_2 Allowances Traded under the Acid Rain Program



Source: EPA (2005)

Due to the emergence of a single market-clearing price for allowances and in the light of active trading, the cost-savings under the SO_2 trading in the ARP are estimated to be substantial. As Table 8 shows, cost savings for the thirteen years are evaluated 20 billion dollars, which indicates a cost savings of about 55% relative to the assumed CAC regulations.

Table 8. Abatement Cost and Cost Savings under the Acid Rain Program

(Millions of present-value 1995 dollars)

Category	Abatement Cost with Trading	Abatement Cost w/o Trading	Cost Savings from Emissions Trading				
			Phase I Spatial Trading	Banking	Phase II Spatial Trading	Total Cost Savings	Savings as a Percentage of Cost w/o Trading

Average Phase I (1995-99)	735	1,093	358	-	-	358	33%
Average Phase II (2000-07)	1,400	3,682	-	167	2,115	2,282	62%
13-Year Sum	14,875	34,925	1,792	1,339	16,919	20,050	57%

Source: Adapted from Ellerman et al. (2000)

D. Regional Clean Air Incentive Market (RECLAIM)

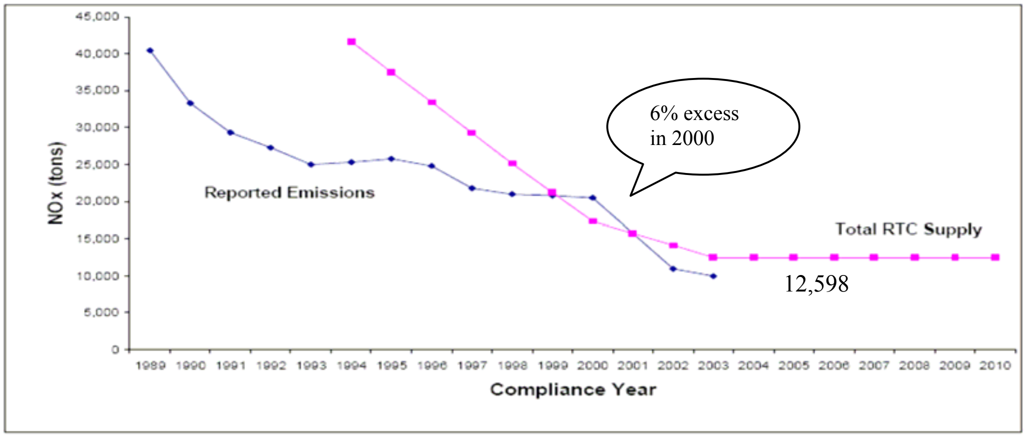
Following the enactment of the 1990 CAAA, along with the SO_2 market under the Acid Rain Program, another cap and trade program developed in the Los Angeles Region. RECLAIM, adopted by the South Coast Air Quality Management District (SCAQMD) in October 1993, after a three year of debate, set an emissions cap and declining balance for electrical power plants and industrial boilers emitting over 4 tons of NOx or SOx per year. The initial purpose of RECLAIM was a 70% reduction in NOx emissions and a 60% reduction in SOx emissions by 2003 so as to bring the Los Angeles Basin into compliance using the most cost-efficient means.

As of the early 1990s, air emissions were subject to the control measures in the 1989 Air Quality Management Plan (AQMP) which was designed to bring the Los Angeles Basin into compliance with federal air quality standards by 2010. However, the compliance costs that the AQMP imposed on businesses were enormous-- up to 13 billion dollars per year so that there was an urgent need for more efficient tools, if air quality regulations were not to push businesses to leave the region.

RECLAIM, developed by a local jurisdiction, has several different features from other emissions trading programs such as the Acid Rain Program. First, it covers heterogeneous pollutants and numerous sectors rather than a homogeneous pollutant focused on a single sector. Second, it has spatial and temporal constrictions on flexibility: the region subjected to the RECLAIM is divided into two geographical zones-- an inland and a coastal zone. Trading from the former zone to the latter is allowed, but the converse is not. In other words, no firm can sell its permits upwind; RECLAIM has no banking system, but provides a limited temporal flexibility by grouping sources into two overlapping 12-month compliance periods.

With regard to achieving environmental targets, RECLAIM has been successful. In every compliance year except 2000, actual emissions in the aggregate have not exceeded emissions caps, even if compliance rates for individual sources have ranged only between 85% and 95%. Exceptionally in 2000, NOx emissions exceeded the RECLAIM cap by about 6% due to the price spike in NOx RECLAIM Trading Credits (RTC) caused by the California electricity crisis. However, the non-compliance in 2000 was due in large part to flaws in California's deregulation process in electricity markets rather than to defects in the RECLAIM program in itself. The excess emissions in 2000 were offset by deduction from the subsequent emissions cap. Moreover, there is no guarantee that the traditional CAC regulations could have dealt with the 2000 crisis better (Harrison, 2004).

Figure 11. NOx Emissions under RECLAIM



Source: EPA (2005)

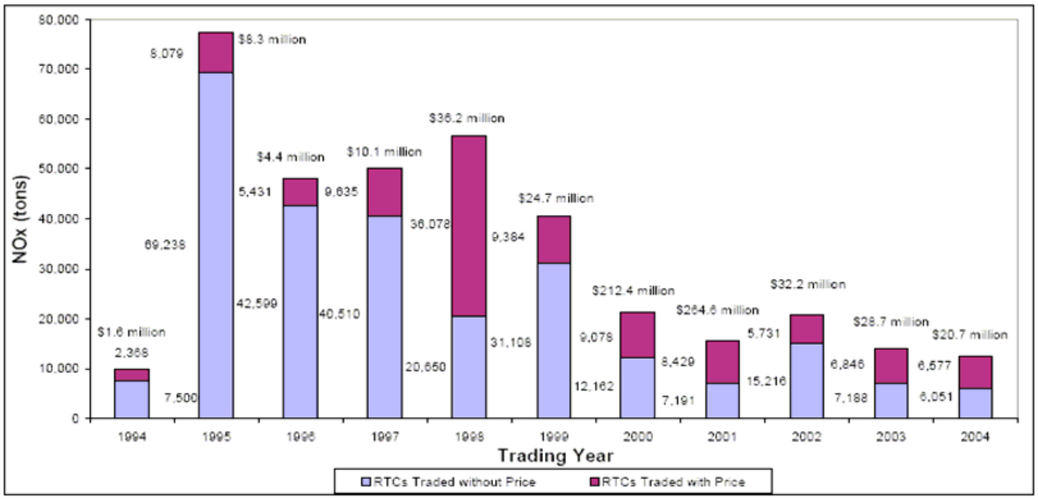
Figure 12. SOx Emissions under RECLAIM

Source: EPA (2005)

The large number of transfer of RTC and evidence of convergence to a single market clearing price suggests that RECLAIM has produced substantial cost savings. Trading volumes have been enormous. In almost every year, the volumes traded in each year have exceeded that year's cap, which implies that many of these trades are in future vintages and there is double counting of trades transacted through brokers.

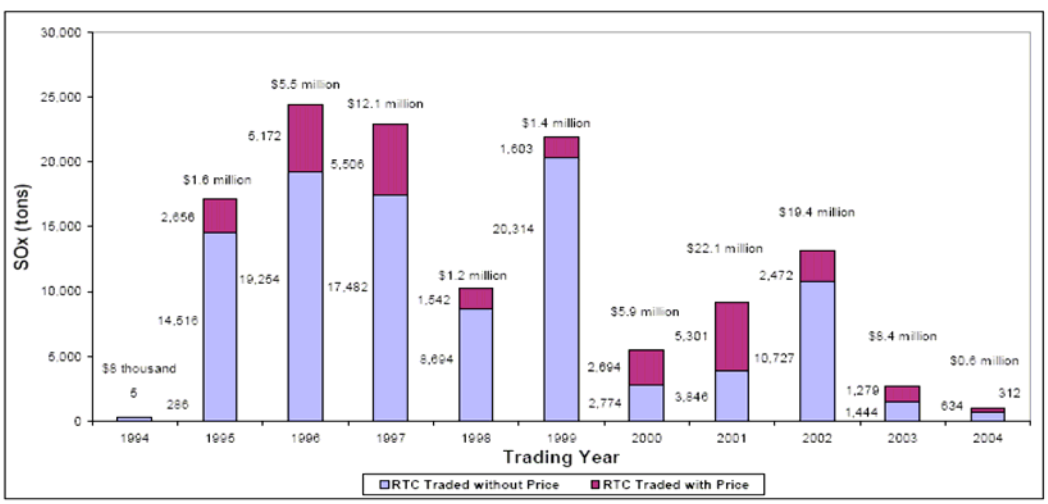
Figure 13 and 14 show the number of NOx RTCs and SOx RTCs traded respectively. These trades include both RTCs traded with price and RTCs traded without price ($0 price). Trades without price generally occur when: a seller transfer RTCs to a broker, there is a transfer between facilities under common ownership etc.

Figure 13. Total Quantity of NOx RTCs Traded under RECLAIM



Source: SCAQMD (2005)

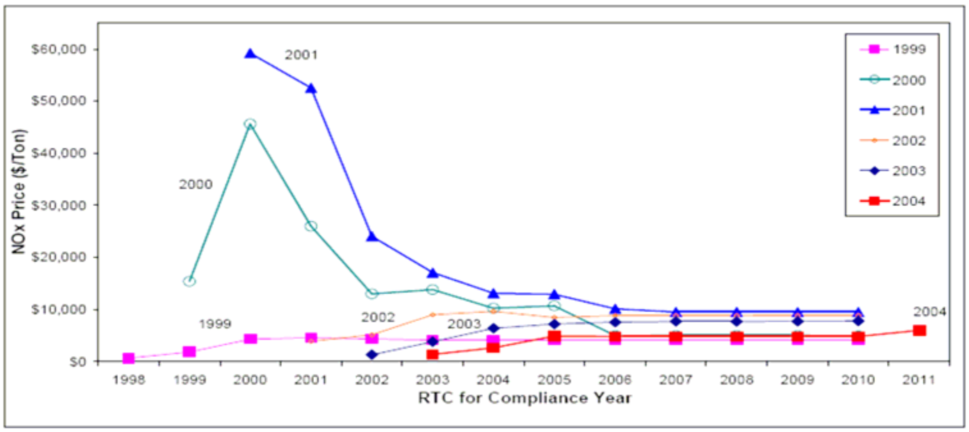
Figure 14. Total Quantity of SOx RTCs Traded under RCLAIM



Source: SCAQMD (2005)

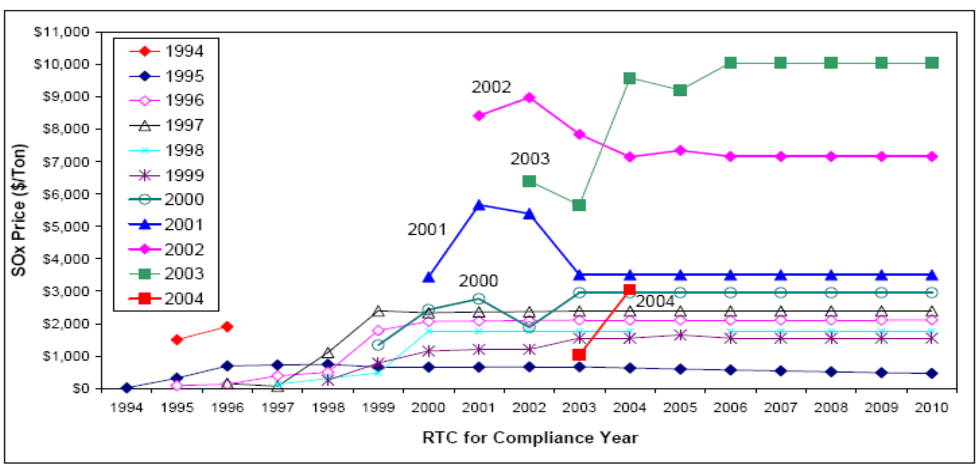
Between 1995 and 1999, prices for NOx RTCs were fairly stable, ranging from $1,500 to about $4,000. In 2000, however, NOx RTC prices shot up to about $40,000 and then to $60,000 in early 2001 due to the 2000 California energy crisis. After the major revisions to RECLAIM in May 2001, including temporary suspended participation in RECLAIM by electricity generators and instead paying mitigation fee of $15,000 per ton, Prices for NOx RTC have been stabilized at under $10,000. Meanwhile, prices for SOx RTC have been lower and more stable than prices for NOx RTC.

Figure 15. Yearly Average Prices for NOx RTCs under RECLAIM



Source: SCAQMD (2005)

Figure 16. Yearly Average Prices for SOx RTCs under RECLAIM



Source: SCAQMD (2005)

E. NOx Budget Trading Program

Since the enactment of the 1990 CAA Amendments, the EPA has developed several programs to limit ground-level ozone ("smog") formation by reducing its key precursor NOx. These programs include the Acid Rain NOx Reduction Program, Ozone Transport Commission (OTC) NOx Budget Program, NOx State Implementation Plan (SIP) Call, and NOx Budget Trading Program (NBP).

The Acid Rain NOx Reduction Program started in 1996, and contributed to reduction of NOx emissions from coal fired electric generating units (by means of averaging) to meet standards for NOx emission rates. However, because it does not involve a cap on total NOx emissions and trades among sources, overall NOx emissions may increase over time as demand for electricity keeps growing.

The other three NOx reduction programs can be categorized as cap-and-trade programs: the OTC NOx Budget Program ran from 1999 to 2002, when it was supplanted by the NOx SIP Call. The NBT was designed to help states meet their NOx SIP Call required reductions.

1. The OTC NOx Budget Program

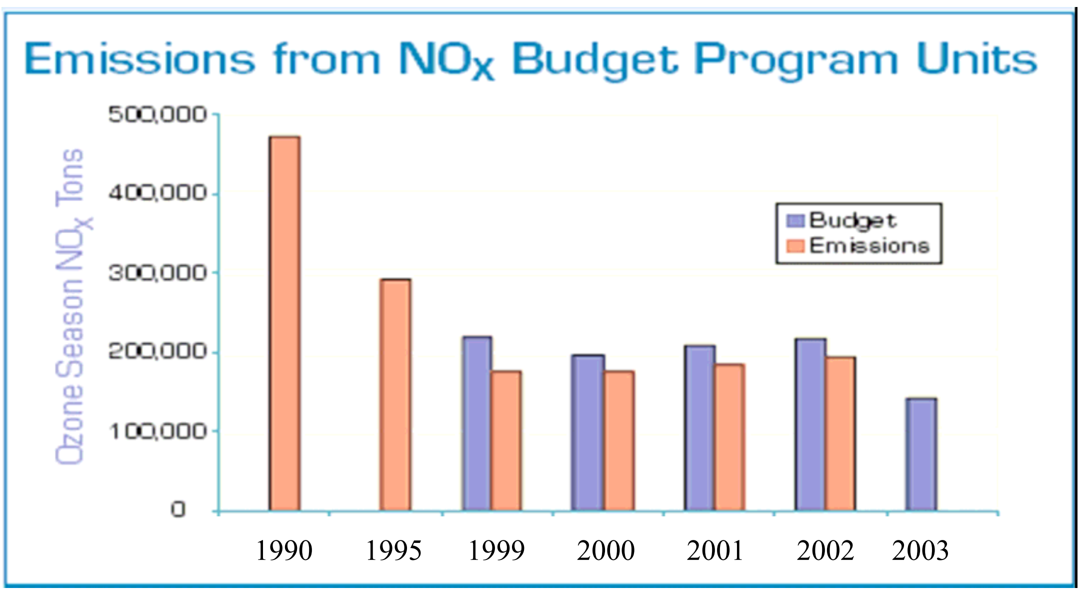
The OTC NOx Budget Program was the first major case of a multi-jurisdictional trading program developed by several states. The OTC was established under the 1990 CAAA to help twelve states in the Northeast and Mid-Atlantic regions meet air quality standards for ground-level ozone from May 1st through September 30th.

Following the development of a Model Rule negotiated by the OTC states and the EPA, nine states and the District of Columbia adopted this multi-state cap-and- trade program to reduce NOx emissions and address the transport of ozone. The OTC NOx

Budget Trading was operated until May of 2003 when it was replaced by the EPA's NOx SIP Call and the NOx Budget Trading Program.

To meet the OTC budget, fossil-fuel- fired power-generating facilities and industrial boilers were required to eliminate roughly 75% of NOx emissions by 2003, relative to 1990 baseline levels. The OTC Budget Program was very successful in meeting the overall emissions target. As Figure 17 shows, the OTC Budget Program helped reduce NOx emissions significantly. In the 2002 ozone season, for example, total emissions were about 60% below 1990 levels.

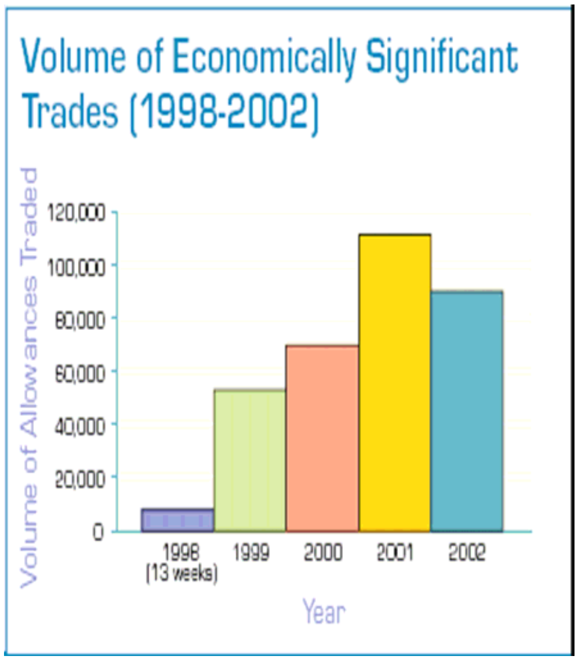
Figure 17. Emissions from the NOx Budget Program

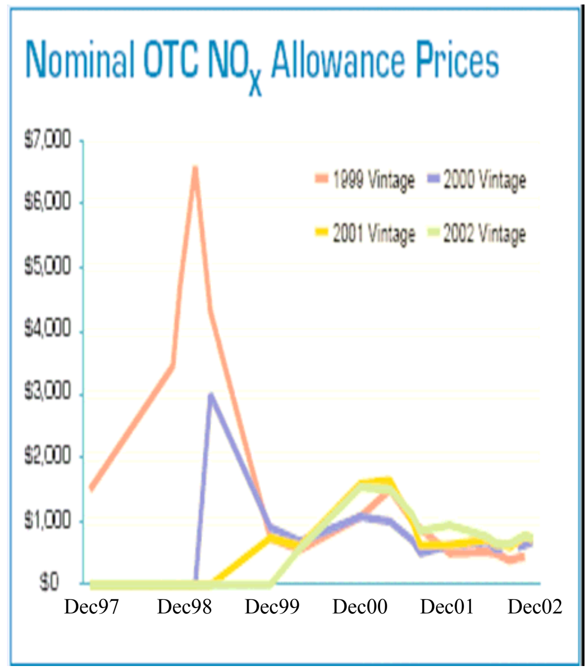


Source: EPA (2003)

In addition, these emissions reductions were made cost-effectively. There are again two pieces of evidence indicating the presence of a maturing market resulting in cost savings. First, the volume of economically significant trades (trades between separate economic entities) was substantial (about 50% of the cap) and generally increased over time. Second, OTC allowance prices were generally stable at less than $1,000, throughout the implementation period (except for the temporary price spike, up to $ 7,000 in vintage 1999, which was due to fears of an allowance shortage).

Figure 18. Volumes and Prices of OTC NOx Allowances





Source: EPA (2003)

2. The NOx Budget Trading Program (NBP) under NOx SIP Call

Despite the efforts of the OTC during 1998 to 2002, ambient smog conditions remained a serious threat to public health and the affected areas showed no signs of achieving the ozone standard, so further NOx reduction efforts became necessary.

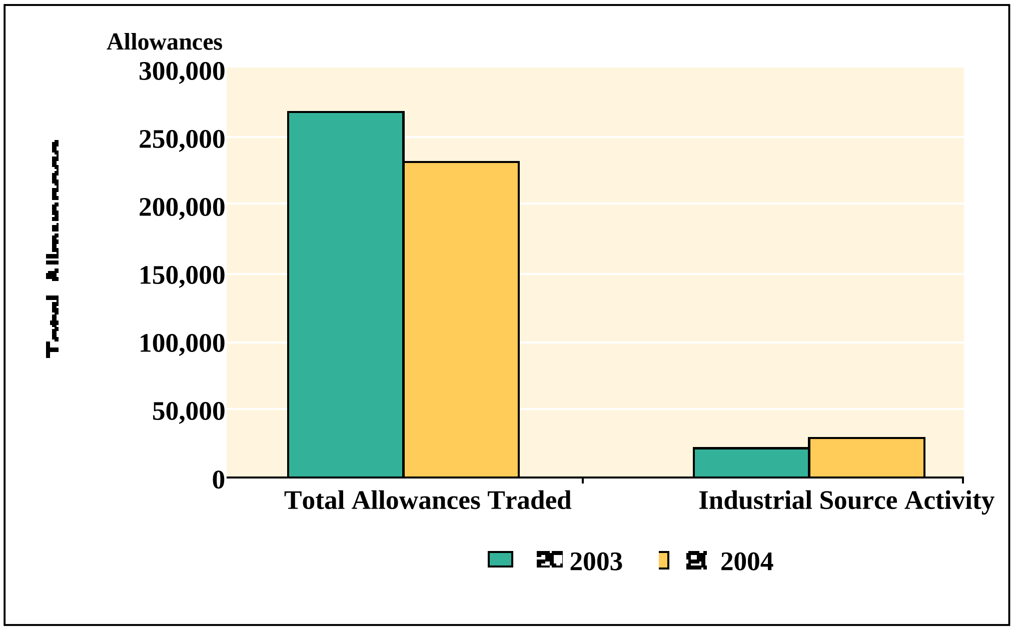
In 1995, the EPA and the Environmental Council of the States formed the Ozone Transport Assessment Group (OTAG) to begin addressing the problem of ozone transport in the eastern states. In 1998, based on the OTAG's assessment, the EPA issued a new rule called the NOx SIP Call to achieve reduction in NOx emissions during the ozone-season across a region that includes most of the OTC states and some southeastern and Midwestern that contribute to another state's inability to achieve the ozone standard. Affected states under the NOx SIP Call had to submit revised SIP.

The NOx SIP Call requires states to meet an overall emissions budget, rather than to require each source to reduce NOx emissions. To give affected states flexibility to choose emissions control options, EPA developed a NOx Budget Trading Program. All affected states chose to comply with the NOx SIP Call by participating in the NOx Budget Trading Program (NBP): the OTC states compliance period started on May 1, 2003, but the other states' compliance was delayed until May 31, 2004.

In response to the NOx SIP Call, aggregate NOx emissions from the power industry dropped significantly after 2002. From 2002 to 2004, the ozone-season NOx emissions reduction in the power industry was an average of 19 percent annually (from 1,222,000 tons/year in 2000 to 819,000 tons/year in 2003 to 593,000 tons/year in 2004), which is dramatic reductions compared to those from other sources: for example, on-road mobile had reduced only 5 percent annually over the same periods.

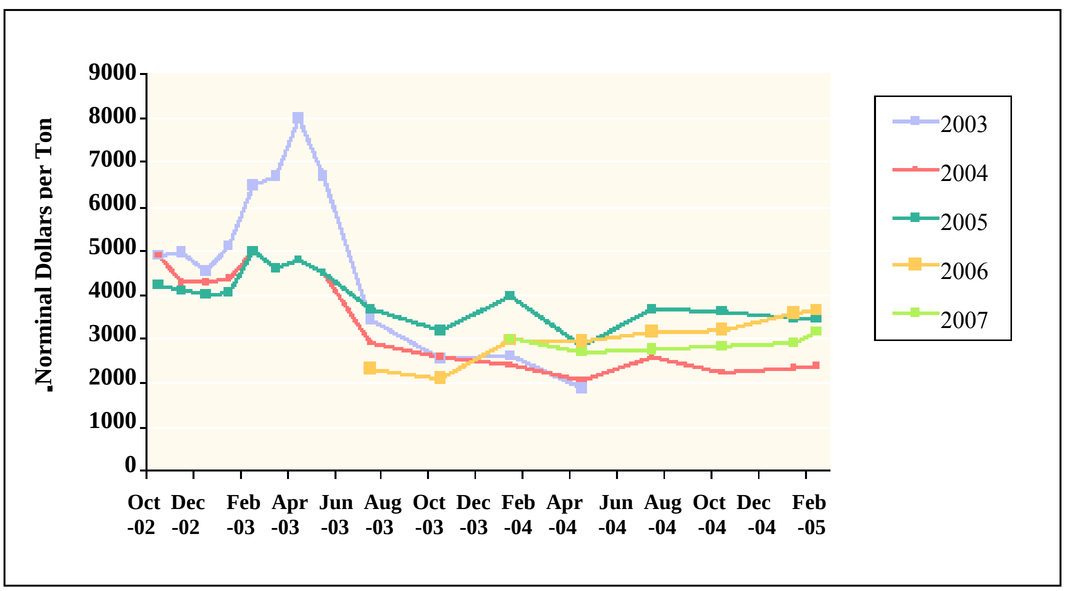
As Figure 19 indicates, there were over 230,000 allowances (about 40% of total transfers) involved in economically significant trades in 2004, slightly lower than in 2003. However, overall trading activity remained robust. Also, allowance prices, showed in Figure 20, stabilized in 2004 and are down considerably from early 2003, which is an indication that the cap-and-trade market has matured.

Figure 19. Economically Significant Trades under the NOx Budget Program



Source: EPA (2005c)

Figure 20. NOx Allowance Prices by Month of Sale under the NOx Budget Program



Source: EPA (2005c)

Meanwhile, the EPA has issued the Clean Air Interstate Rule (CAIR) as of March 10, 2005, intended to further reduce ground-level ozone. NBP will be replaced the

CAIR's trading program from 2009. CAIR reduces NOx more significantly through two different emissions budgets: one for ozone season NOx in 25 states and D.C., and another for annual NOx and SO_2 in 23 states and D.C. After the implementation of the CAIR, EPA predicts that in 2015, only six ozone non-attainment areas will remain in the eastern states: New York, Chicago, Houston, Philadelphia, Baltimore, and Washington, D.C.

Table 9. Comparative Features of Major Trading Programs in the U.S.

Category	EPA Emissions	Lead-in-	SO_2 Trading	RECLAIM	NOx Budget

	Trading Programs	Gasoline Trading	in ARP		Trading Program
1. Type	Emission Reduction Credit (ERC)	Averaging	Cap-and-Trade	Cap-and-Trade	Cap-and-Trade
2. Legal Framework	EPA's regulations	EPA's regulations	1990 CAAA	1990 CAAA and California CAA	1990 CAAA
3. Regulator	EPA	EPA	EPA	South Coast Air Quality Management District	EPA, 12 states, and D.C.
4. Purpose	Providing flexibility to reduce control costs	Phase-out of lead-in-gasoline	50% reduction in acidification	Attainment of ozone standard: 70% reduction in ozone forming substances	Attainment of ozone standard (ozone season)
5. Spatial Scope	National	National	National	Local: Los Angeles Basin	Regional: Northeastern States
6. Years	1970s~Present	1982~1987	1995~Present (Phase I: 1995-1999, Phase II:2000-)	1994~Present	1998~Present (including OTC Program 1998-2002)
7. Pollutants	Various	Lead-in -Gasoline	SO_2	NOx, SOx	NOx
8. Sources	Electricity power plants & industrial boilers and turbines	Refineries	Electricity power plants	Electricity power plants & industrial boilers and turbines	Electricity power plants & industrial boilers and turbines
9. Market	Relatively few trades	Vigorous market; over half of refineries participate	Well-functioning market	Well-functioning market	Well-functioning market
10. Evaluation	Disappointing: higher transaction costs due to pre-approval	Successful: Averaging program and banking	Very successful: minimal restrictions on trades	Successful, but price volatility due to lack of banking	Successful

Source: Modified version from Ellerman et al. (2003)

<u>Case Studies of Three Major Programs</u>

The SO_2 Trading in the ARP, RECLAIM, and the NOx Budget Trading Program in the U.S. are widely considered as successful cap-and-trade programs. In order to draw useful lessons that can be applied for other emissions trading programs, it is necessary to find both similarities and differences affecting the performance of these programs. In this section, three major cap-and-trade programs are compared closely in terms of the following factors: purpose and framework, coverage, allocations, trading rules, trading market, relationship with other regulations, monitoring, and enforcement.

To make this assessment, government annual audit or progress reports, as well as some previous comparative research, are mainly employed (Schwarze and Zappel, 1999; Kosobud, 2000; EPA, 2003, 2005a, 2005b; SCAQMD 2005).

A. Purpose and Framework

In light of the goals of the different programs, SO_2 trading in the ARP is distinguished from RECLAIM and the NOx Budget Trading Program. The SO_2 trading in the ARP aims to reduce environmental damage due to acid deposition from SOx transports across the country, RECLAIM and the NOx Budget Trading Program focus on regional ground-level ozone caused by industrial activities, that results in exceedances of the NAAQS. With respect to the presence of pre-existing regulations, while the SO_2 trading in ARP is an introduction of new regulations in an unregulated problem arena, RECLAIM and the OTC NOx Budget Program (the predecessor of the NBP) replaced control plans established in the 1989 Air Quality Management Plan (AQMP) in California and emissions limits based on Reasonable Available Control Technology (RACT) respectively. Therefore, in the process of establishing trading programs, the SO_2 Trading Program in the

ARP involves more complex political debates and more uncertainty about environmental implications than RECLAIM or the NBP.

The SO_2 Trading Program in the ARP, RECLAIM, and the NBP have several features in common. First, as cap-and-trade programs, these trading programs aim to achieve simultaneously both environmental certainty and cost-effectiveness. In particular, trading schemes were introduced as a last resort to avoid excessive compliance costs imposed on facilities under traditional command and control measures.

Second, trading programs reflect environmental concerns. These three emissions trading programs coexist with pre-existing regulations. For example, in the realm of these three trading programs, NAAQS for sulfur dioxide functions as a backstop provision to avoid possible hotspot problems and technology-based New Source Performance Standards (NSPS) have been applied as well. In addition, RECLAIM and the NBP have restrictions on the use of allowances geographically or temporally.

Third, political and distributional considerations, as well as economic and environmental considerations, play an important role in the development process of the trading programs. Even if auctions have advantages over the grandfathering method in terms of revenue recycling and long-term cost-effectiveness (due to the existence of transaction costs), initial allocations of permits in these three programs were based on grandfathering due to political feasibility. In particular, the exclusion of Volatile Organic Compounds (VOCs) and mobile sources from RECLAIM can be explained as examples of reflecting political feasibility.

Distributional conflict is another factor considered in the development of these three trading programs. Because permits are de facto rights, initial allocations of permits may well be contentious among regulated facilities. In the case of SO_2 trading in the ARP, the Mid-western states argued in favor of grandfathering while the Western states insisted on a permit market less constraining to economic growth. Among the Mid-western states, there were winners and losers depending on their representatives' political influence -- some dirty states, such as Ohio, Indiana and Illinois, gained relatively larger special allowances and bonuses for installing scrubbers.

B. Market Coverage

Market coverage is different in the three trading programs: geographical scope, covered pollutants, and affected sources. With respect to the geographical scope, while the SO_2 Trading in the ARP is now nationwide (covering all states except for Alaska, Hawaii, and Idaho), the NBP and RECLAIM focus on localized ground-level ozone so that their geographical scopes are limited to the eastern states and the Los Angeles Air Basin (the jurisdiction of the SCAQMD) respectively.

SO_2 trading in the ARP and the NBP cover only one pollutant, sulfur dioxide and nitrogen oxides respectively, while RECLAIM regulates two pollutants, nitrogen oxides and sulfur oxides at once. In terms of market coverage of total emissions, SO_2 trading in the ARP covers approximately 70 percent of sulfur dioxide emissions while RECLAIM covers only 33 percent of NOx emissions and 75 percent of SOx emissions, and the NBT covers only 23 percent of NOx emissions.

The difference in coverage rates comes from the fact that sulfur dioxide, nationwide, stems mainly from a relatively small number of large stationary sources, such as power generating plants, while nitrogen oxides are generated from many more widespread sources, such as mobile sources. For example, NOx emissions in the eastern states come from three types of sources: mobile sources (approx. 55%), power industry sources, such as large electric generating units, some large industrial boilers and turbines (approx. 23%), and other sources mostly heating, including some industrial boilers and residential fuel combustion systems (approx. 22%).

While SO_2 trading in the ARP applies only to large fossil fuel-fired electric generating units greater than 25 MW, RECLAIM and the NBP cover relatively smaller stationary sources including an assortment of industrial boilers, as well as electric generating units. In terms of the implementation schedule, while SO_2 trading in the ARP has been applied in two phases, RECLAIM and the NBP were not phased in, just fully applied to all affected sources simultaneously.

In the case of SO_2 trading in the ARP and RECLAIM, a facility can voluntarily participate in ("opt-in" to) the programs regardless of its emissions level. In principle, the opt-in provision helps reduce compliance costs across sources, but in practice, it shows few additional emissions reductions due to overly generous allocations (Ellerman, et al., 2000)

C. Allocations

Major allocation issues can be classified into three groups: initial permit allocations, allocation periods, and baseline periods.

First, initial permit allocations are the most contentious in a cap-and-trade program because permits (allowances or RTCs) are virtual property rights. All three programs adopt a grandfathering approach: free allocations based on historical emissions instead of using an auctioning approach. Even though the auctioning approach with the transaction costs has advantages over the grandfathering approach in terms of long-term economic efficiency and revenue recycling, the latter approach prevails in the real world due to political acceptance. Unlike SO_2 trading in the ARP and the NBP, RECLAIM allows RTCs generated outside regulated sources, such as the conversion of emission reduction credits (ERCs) and external offsets pursuant to the New Source Review regulations.

Second, in terms of allocation periods, there can be three alternative options: permanent allocations, longer-period allocations, and shorter-period allocations. The longer updating periods are, the less it influences each source's future behavior. While the SO_2 allocations in the ARP are permanent, RECLAIM and the NBP adopt updated allocations; in RECLAIM, for example, allocations were scheduled to be updated in 1994, 2000, 2003, and 2007.

Third and the last, with regard to the baseline periods, all three programs adopt emissions-based baselines. While SO_2 trading in the ARP uses average emissions levels over three years (1985 to 1987), RECLAIM employs maximum emissions levels over four years (1989 to 1992). Compared to average emissions in the ARP, maximum emissions over longer years in RECLAIM seem to have led to over-allocations of permits, which reflect the political necessity of favoring current businesses.

D. Trading Rules

There may be two kinds of trading rules constraining transferability of permits: geographical constraints and temporal constraints. More constraints are likely to increase transaction costs, which results in a less-successful cap-and-trade program.

With respect to geographical constraints, even if there were concerns about possible local concentration of emissions (“hotspots”) in the development of the program, SO_2 trading in the ARP adopted no geographical restrictions for three reasons: first, hotspots can be regulated by other overlapping regulatory standards such as NAAQS; second, the large reduction in SO_2 emissions alleviates ambient air quality problems nationwide; third, the most cost-effective reductions can occur in the areas with the largest and highest emitting plants (EPA, 2004). On the other hand, RECLAIM uses two trading zones. Trading from the inland (downwind) zone to the coastal (upwind) zone is not allowed in RECLAIM for fear of creating hotspots. In the Ozone Transport Commission (OTC) Budget Trading Program for reducing NOx emissions, the Ozone Transport Region (OTR) is divided into three zones (inner, outer, and northern zones) in accordance with levels of the ozone problem, but it allows unrestricted trading among three zones.

There are two forms of temporal flexibility, such as banking and borrowing. All three programs are similar in that they don’t allow borrowing-- using future permits for compliance in current period. In terms of banking-- using current permits for compliance in future periods-- SO_2 trading in the ARP has no restrictions on the use of banking. However, in RECLAIM, emissions sources are grouped into two overlapping compliance periods, one from January through December and the other from July through June. Sources in one compliance period can trade allowances with sources in the other compliance period, so that this six-month overlapping period system serves as a kind of limited banking. The

NOx Budget Trading Program allows banking of allowances for future use, but there are automatic limits imposed on the use of banked allowances when the total number of allowances banked for all sources exceeds 10 percent of the total regional budget for the next year. In this case, the flow control ratio, determined by dividing 10 percent of the budget by the number of banked allowances, is applied. For example, if source S holds 2,000 banked allowances at the end of 2005, and the flow control ratio is 0.25, S will be able to use 500 of them on a 1 for 1 basis, but can use the remaining 1,500 on a 2 for 1 basis (EPA, 2003a)

E. Trading Market

With respect to market activation, while the SO_2 Trading in the ARP has mandatory auctions administered by the EPA annually, RECLAIM and the NBP have non-mandatory auctions run by private parties. In the SO_2 Trading Program, 2.8% of the total allocated allowances are set aside for the annual auction, whose proceeds are reimbursed to all sources according to their share of withheld allowances. On the other hand, auctions in RECLAIM and the NBP rely entirely on permits offered by private holders.

In terms of auction type, while an SO_2 Trading auction is discriminatory; in other words, the bidding price can be different case-by-case, auctions in RECLAIM and the NBP are non-discriminatory, which means all permits are traded at one clearing market price.

Open participation for everyone is a common feature in those three programs. Active intermediaries (brokers) help the development of trading markets by reducing transaction costs. Meanwhile, public participation including environmental groups, meets environmental target by purchasing and retiring permits, and enhances public environmental consciousness.

F. Relationship with other regulations

No policy can be implemented in a vacuum. As Thompson (2000) argues, most emissions trading programs must be implemented to complement or replace pre-existing CAC regulations. It is extremely difficult to bring an emissions trading program into effect where there is no prior CAC regulation of sources and pollutants. Also, as can be seen in the cases in the UK and Poland, emissions trading schemes are unlikely to be successful when they are not compatible with pre-existing regulations.

Several overlapping regulations exist in the three programs considered here. In the case of SO_2 trading in the ARP, NAAQS has served as a backstop to protect against potential hotspots and the Best Available Control Technology (BACT) requirements based on the New Source Performance Standard (NSPS) have also been in place. There are similar overlapping regulations in RECLAIM and the NBP, such as national and state air quality standards for ozone and PM10, as well as the NSPS.

With regard to incorporation of mobile or other area sources into these programs, there are no specific provisions as to mobile or area sources in SO_2 trading in the ARP since electricity-generating plants account for about 70 percent of SO_2 emissions nationwide. However, since RECLAIM and the NBP deal mainly with ground-level ozone by reducing NOx emissions, the necessity for regulations on mobile or area sources was widely recognized.

In RECLAIM, several project-based programs, including temporary credit programs, such as the Air Quality Investment Program in 2001, are in place to supplement the cap-and-trade program. Integration of different emissions trading like this may increase the cap through converting ERCs (generated from unregulated sources) into RTCs and as a result, undermine the degree of environmental certainty provided by the program. For the NBP, combining control efforts with mobile source programs such as Low Emissions Vehicle (LEV) has been stressed.

G. Monitoring and Reporting

Reliable monitoring and reporting are the keys to compliance and enforcement. Concerning monitoring, the SO_2 Trading Program requires all affected sources to install continuous emissions monitoring systems (CEMS). The few exceptions include sources which are very small or operate very infrequently, or some large sources burning pipeline-quality natural gas.

However, RECLAIM and the NBP do not mandate the CEMS for all affected sources. RECLAIM has three-tiered monitoring requirements: for major sources emitting more than 10 tons of NOx and SOx emissions, the most accurate and most reliable CEMS is required. Other large sources are allowed to establish fuel meters or continuous process monitoring systems (CPMS) which correlate multiple process parameters to mass emissions instead of directly monitoring NOx or SOx emissions. Small or process units are only required to install fuel meters. In the NOx Budget Trading Program, while coal-fired units are required to use the CEMS to measure NOx and stack gas flow rates, oil- and gas-fired units may use a NOx CEMS, as an alternative.

With respect to report frequency, the SO_2 Trading in the ARP and the NBP require sources to record hourly emissions data and to submit emissions reports to the EPA on a quarterly basis, but in RECLAIM, reporting frequency is different according to source category: daily for major sources, monthly for large sources, and quarterly for other smaller sources. In the area of tracking permits, the three programs are very similar in terms of each source's permits account and electronic tracking system. In the EPA's SO_2 Trading and the NOx Budget Trading program, the transfer reporting moved from an early combination of paper forms and floppy disks to an electronic (on-line) Allowance Tracking System (ATS) over time. In RECLAIM, each transfer of RTC is reported and tracked electronically through Web Access To Electronic Reporting System (WATERS)

H. Enforcement

For compliance, penalties should be based on the nature and severity of the violation. Above all, the total penalties must be higher than the market price of permits. The three programs have similar provisions concerning enforcement: reconciliation or grace periods for compliance, penalties such as monetary penalties and allowance deductions (offsets), and some estimating method for missing data. For reconciliation, RECLAIM and the NBT have two-month window after the end of the compliance year to move allowances between accounts to ensure their emissions do not exceed their allowances held. The SO_2 Trading in the ARP has a shorter grace period of just 30 days.

Concerning penalties for non-compliance, SO_2 trading in the ARP and RECLAIM have both higher financial penalties, but allowance deductions from the subsequent year on a 1-for-1 basis. However, the NBP has an allowance deduction at a rate of 3-for-1, i.e. each source must submit three allowances per ton of excess emissions in the current year to the authority during the next year. In addition, each state can adopt the option of imposing financial penalties.

Comparing financial penalties between SO_2 trading in the ARP and RECLAIM, penalties in the SO_2 Trading in the ARP are as much as three times higher than the expected market price of allowances ($2000 per ton in 1990 dollars, adjusted annually for inflation) and unit penalties are fixed and applied automatically. On the other hand, penalties in RECLAIM are relatively lower (up to $500 per ton) and unit penalties are determined on a case-by-case basis, resulting in uncertainty about the consequences of non-compliance. Because of the relatively lower penalties and case-by-case determination of final penalties, in the period of 1995 through 1999 of RECLAIM, marginal benefits of non-compliance were higher than their marginal costs (the market price of RTC), which is responsible for relatively higher non-compliance rate of individual sources.

Table 10. Substitution Criteria for CEM Missing Data Periods

<table>
<tr><th>Annual Availability (%) of Monitor or System</th><th>Number of Hours Missing (N)</th><th>Value Substituted for Each Missing Hour</th></tr>
<tr><td rowspan="2">Greater than or equal to 95%</td><td>N is less than or equal to 24 hours</td><td>Average of the hours recorded before and after missing period</td></tr>
<tr><td>N is greater than 24 hours</td><td>90th percentile value recorded in the previous 30 days of service or the before/after value, whichever is greater</td></tr>
<tr><td rowspan="2">Less than 95% but greater than or equal to 90%</td><td>N is less than or equal to 8 hours</td><td>Average of the hours recorded before and after missing period</td></tr>
<tr><td>N is greater than 8 hours</td><td>95th percentile value recorded in the previous 30 days of service or the before/after value, whichever is greater</td></tr>
<tr><td>Less than 90%</td><td>N is greater than 0 hours</td><td>Maximum value recorded in previous 30 days of service</td></tr>
</table>

Source: www.epa.gov/airmarkt/monitoring

Finally, all three programs have similar missing data procedures (MDP) that can be implemented when an emission monitoring system fails to yield valid emissions data. To avoid intentional suspension of operating the CEMS in periods of peak emissions, the double (highly) progressive emissions estimates, which are based on the worst-case scenario, are applied for non-monitored periods. The substitute data vary according to the duration and frequency of the missing data periods: as the duration of missing data periods are shorter, less frequent and the historic monitoring systems are more available, the substitute data become less conservative.

Table 11. Features of Three Major Cap-and-Trade Programs in the US

Category	The SO_2 trading in Acid Rain Program	Regional Clean Air Incentive Market (RECLAIM)	NOx Budget program (NBP)
<General>			
1. Purpose & framework			
1-1 Purpose	50% reduction in acidification	Attainment of ozone standard: 70% reduction in ozone precursors	Attainment of ozone standard (ozone season): reduction of ozone precursors below 1990
1-2 Politico-economic Framework	Uncertain benefits and concerns over hotspots	Excess costs of AQMP in 1989	Concerns about interstate transport of ozone
2. Coverage			
2-1 Geographical scope	National except for Alaska, Hawaii and Idaho	Local In LA Air Basin	Multi-jurisdictional in 22 eastern states and Washington D.C.
2-2 Implementation Years	Phase I: 1994-1999 Phase II: 2000-	1994- Present (no phases)	OTC: 1999-2002 NBT: 2003/2004(phase 1) 2007-2008(phase II) (NIER: 2009-)
2-3 Covered pollutants	SO_2	NOx, SOx	NOx
2-4 Affected sources	Electric power plant	Electric power plant and industrial boilers	Electric power plant and industrial boilers
<Design issues>			
3. Allocations			
3-1 Initial allocations	Grandfathering (Average emissions 1985-1987)	Grandfathering (Peak emissions 1989-1992)	Grandfathering (to be determined by each state)

3-2 Baseline for Cap	1980	2003 projection	2007 projection
3-3 Allocation frequency	Permanent	Updated	Updated
3-4 Nature of permits	Allowance (1ton of SO_2) as actual rights	RECLAIM Trading Credit (lbs. of NOx, SOx) as actual rights	Allowance (1 ton of NOx) as actual rights
4. Trading rules			
4-1 Inter-temporal trading	- Unrestricted banking	- No banking, but over-lapping allowance cycles	- Limited banking: flow Control
4-2 Spatial trading	- No geographical constraint	-Two trading zones: trade prohibited from the inland to coastal zone	- Regardless of three zones, no geographical constraint
5. Trading market			
5-1 Auctions	- Mandatory - Public 2.8% - Annual - Discriminatory	- Voluntary and private - Private offers - Semi annual - Non-discriminatory	- Voluntary and private - Private offers - Semi annual - Non-discriminatory
5-2 Open participation	Open to anyone	Open to anyone	Open to anyone
6. Relationship with other Regulations			
6-1 Compatibility with other regulations	NAAQS, New Source Review (RACT)	NAAQS, New Source Review (RACT)	NAAQS, New Source Review (RACT)
6-2 Incorporation of mobile and other area sources	No	RTCs in the conversion of ERC (stationary), MSERC (mobile) And ASERC (area)	Not, but implemented with LEV, etc.
<Implementation issues>			
7. Monitoring			
7-1 Monitoring of Emissions	- Continuous Emissions Monitoring System (CEMS): hourly data and quarterly reports	- Major: CEMS (daily) - Large: CPMS (monthly) - Other process units etc: Fuel meter (quarterly)	- Continuous Emissions Monitoring System (CEMS): hourly data and quarterly reports
7-2 Tracking of Permits Transfer	- Online Allowance Tracking System (ATS)	- Web Access To Electronic Reporting System (WATERS)	-Online Allowance Tracking System (ATS)
8. Enforcement			
8-1 Reconciliation (Grace periods)	30 days	2 months	2 months
8-2 Penalties	$2,000 per ton Automatic application	Up to $500 Determined case by case	Optional for each state
8-3 Offsets ratio	1-for-1	1-for-1	3-for-1
8-4 Emissions estimates for non-monitored periods	Double progressive based on the worst case scenario	Double progressive based on the worst case scenario	Double progressive based on the worst case scenario

Comparisons of major Features between Korea and the US

Drawing on the study of emissions trading programs in Korea and the U.S, in this part, two major trading programs, RECLAIM and the new cap-and-trade in Seoul (hereafter CATS) are compared: both programs are similar in several aspects: their main purpose (reducing urban smog), their geographical scopes (mega-city and its vicinity), their covered pollutants (mainly NOx, SOx), and their affected sources (heterogeneous sources such as power plants and industrial boilers)

A. Purpose and Context

In RECLAIM, the Los Angeles Air Basin, the smoggiest area in the U.S., is required to achieve federal clean air health standards by 2010. Therefore, traditional control plans based on the 1989 Air Quality Management Plan (AQMP) have been in effect since the early 1990s. The problem is that anticipated compliance costs imposed on businesses were so enormous (up to 13 billion dollars) that there were concerns about a possible exodus of regional businesses followed by an economic decline.

RECLAIM is a revolutionary compromise between environmental requirements and economic needs, i.e., the new market-based tool was a last resort designed to bring the region into attainment under the NAAQS without sacrificing huge amounts of economic development. More specifically, the target of RECLAIM includes both a 70% reduction in NOx emissions and a 60% reduction in SOx emissions by 2003 through a most cost-effective cap-and-trade program.

In CATS, the motive for introducing a new cap-and-trade program comes from the perception that traditional CAC regulations, based on technical emissions standards, have not been effective in improving air quality in the Seoul Metropolitan Area because of steadily increasing numbers of emission sources. Despite numerous efforts, such as enhancing the supply of low sulfur and clean fuel and the introduction of natural gas vehicles, air quality in terms of NOx and particulate matter has not improved throughout 1990s to early 2000s.

Like RECLAIM which involved time-consuming collaborations involving workshops, feasibility studies and the advisory committees' efforts, in the development of CATS, there were more than one hundred consultations over three years around the Joint Task Force involving the MOE, three related local governments, businesses, and environmental groups. The direct target of CATS is to reduce more than 40% of NOx and PM emissions by 2014.

With respect to regulatory styles, Korea and the U.S. are similar in that both countries prefer uniform standards rather than site-specific standards, and distrust both industry self-regulation and administrative discretion. However, while the US has a number of previous emissions trading programs to study and plenty of information is freely available, Korea has relatively little experience with market-based tools and the availability of information about firms' abatement technology is limited due to confidentiality. Therefore, it seems to be more difficult in Korea to implement an emissions trading program, market incentives and any information-based instrument.

B. Market Coverage

Market coverage is very similar in both programs. RECLAIM covers the Los Angeles Basin, SCAQMD's four-county jurisdiction including Los Angeles County, Orange County, Riverside County, and San Bernardino County. Its covered pollutants are NOx and SOx, and affected sources encompass all electric plants and industrial boilers emitting more than 4 tons of NOx or SOx annually.

Meanwhile, CATS covers the Seoul Metropolitan area that includes Seoul city, Incheon city and the Gyunggi province. This region is adjacent to the Yellow Sea to the west. Its covered pollutants include particulate matter as well as NOx and SOx, and affected sources are stationary sources including electric plants and industrial boilers. Unlike RECLAIM, CATS will be implemented in two phases. In Phase I (July 2007-June 2009), sources emitting more than 30 ton of NOx, more than 20 tons of SOx, or more than 1.5 tons of PM will be covered. In Phase II (July 2009-), sources emitting more than 4 tons of NOx or SOx, or more than 0.2 tons of PM will be included. In Phase II, SATS shall cover about 84 percent of NOx emissions, 78 percent of SOx emissions, and 57 percent of PM emissions from stationary sources in the region.

C. Design Issues

In their initial allocation, RECLAIM and CATS take a similar grandfathering approaches based on peak emission levels (1989 to 1992, vs. past 5 years) and set their cap based on future projection (2003 vs. 2014). Concerning trading rules, both programs have some restrictions on geographical or temporal flexibility. RECLAIM divides the region into two trading zones, and trading from the inland zone to the coastal zone is prohibited. Also, RECLAIM does not allow banking, but has only two overlapping allowance cycles as a limited banking system. On the other hand, CATS has no geographical constraints on allowance trading, but trading volumes permitted for each source are limited to a certain fraction of its allocated allowances. Specifically, tradable allowances are restricted 20 percent in the starting year, 30 percent in the second and third year, and then 50 percent in the fourth and last year every five compliance year. Also, any source that wants to trade its allowances with other sources must turn in an application to the MOE at least 30 days before the trading day.

As for temporal flexibility, like the NBP, CATS allows banking but there are automatic limits imposed on the use of banked allowances when the total number of allowances banked for all sources exceeds 10 percent of the allowance cap for the next year. In addition to that, the MOE can limit the transfer of allowances when the transfer may result in a violation of ambient air quality standards.

With respect to trading markets, neither RECLAIM nor CATS has a provision about mandatory auctions, so auctions are run in the private sector. As RECLAIM overlays the NAAQS and the RACT requirement of New Source Review (NSR), CATS also coexists with several pre-existing regulations such as emissions standards, emissions charges and restrictions on fuel usage. RECLAIM, unlike CATS, stipulates several offset programs: RTCs generated from the conversion of Mobile Source ERCs and Area Source ERCs can be used; Rules in RECLAIM also permit inter-pollutant or inter-District offsets.

D. Implementation Issues

With respect to monitoring, major sources under both RECLAIM and CATS monitor emissions using CEMS (in RECLAIM) and TMS (in CATS) respectively. However, while RECLAIM employs an electronic reporting system called WATERS, CATS will rely initially on conventional paper-formed reports in earlier years.

Concerning enforcement, both programs have several similarities: each source is given a two-month grace period for reconciliation and; financial penalties, as well as allowance deduction, are imposed. On the other hand, RECLAIM and CATS have differences in some respects: while RECLAIM has an allowance deduction at a rate of 1-for-1, CATS has a progressive rate based on the number of prior violation. Financial penalties under RECLAIM are imposed case-by-case, but those under CATS are imposed according to a prescribed formula. Finally, unlike RECLAIM, there are no provisions concerning missing data procedures built into the protocols for CATS.

Table 12. Comparison of RECLAIM and the Cap-and-Trade Program in Seoul

Category	Regional Clean Air Incentive Market (RECLAIM)	The cap-and-trade program in Seoul (CATS)
1. Purpose & Contexts		
1-1 Purpose	Attainment of ozone standard: 70% reduction in ozone precursors	Reducing more than 40% of NOx and PM emissions by 2014
1-2 Politico-economic Framework	Excess costs of Air Quality Management Plan (AQMP) in 1989	Limitation of emissions standards to deal with serious air pollution due to increasing number of sources
2. Market Coverage		
2-1 Geographical scope	Local in LA Air Basin	The Seoul Metropolitan Area including Seoul, Incheon, and Gyunggi province
2-2 Implementation Years	1994- Present	Phase I: July 2007-June 2009 Phase II: July 2009-

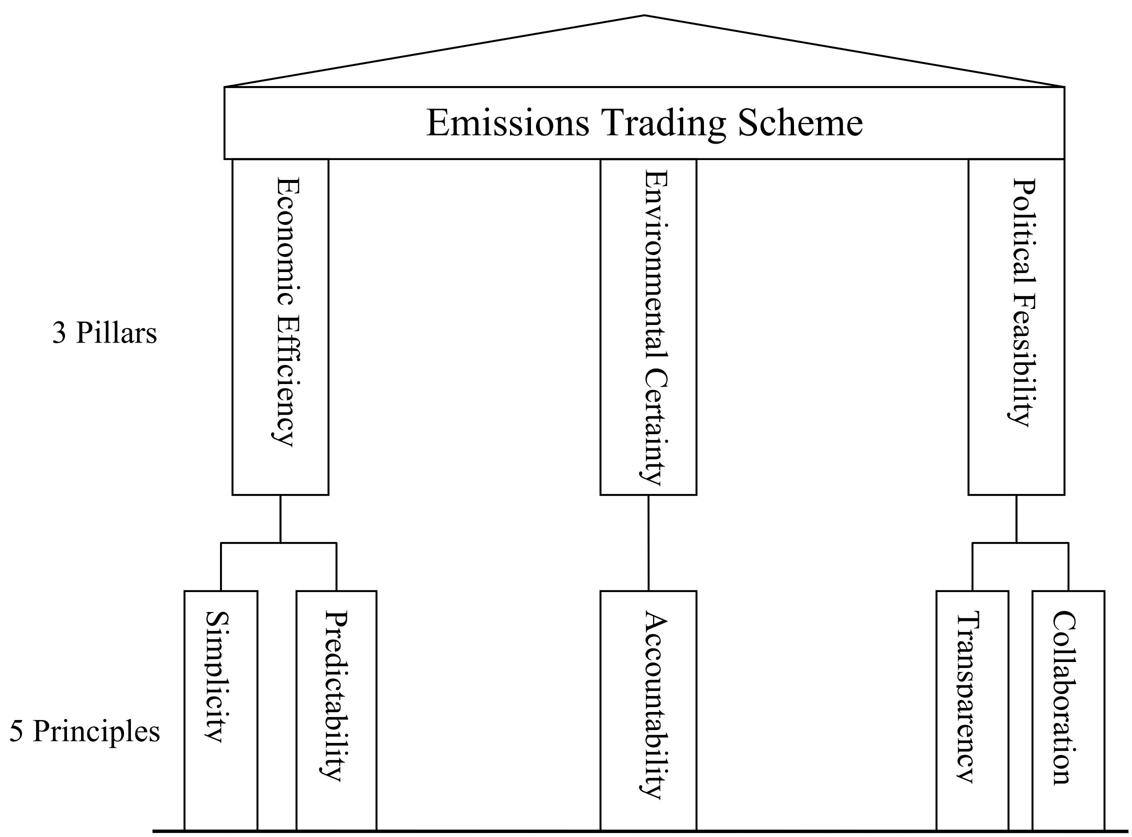
2-3 Covered pollutants	NOx, Sox	NOx, SOx and PM
2-4 Affected sources	Electric power plant and industrial boilers	Electric power plant and industrial boilers
3. Design Issues		
3-1 Initial allocations	Grandfathering (peak emissions 1989-1992)	Grandfathering (peak emissions over past 5 years)
3-2 baseline for the cap	2003 projection	2014 projection
3-3 Inter-temporal Trading	No banking, but two overlapping allowances cycles	Limited banking: flow control
3-4 Spatial trading	Two trading zones: trade prohibited from inland to coastal zone	No geographical constraints
3-5. Trading market	- Voluntary and private - Semi annual - Non-discriminatory	No provisions
3-6 Compatibility with pre-existing regulations	- NAAQS - New Source Review (RACT)	- National air quality standards - emissions standard - emissions charges & fuel regulations
3-7 Incorporation into mobile and area sources	RTCs generated from the conversion of ERC(stationary source) and STC including MSERC(mobile source) and ASERC(area source)	Not, but implemented with LEV etc.
4. Monitoring and Enforcement		
4-1 Monitoring and Reporting of Emissions	- Major sources: CEMS (daily) - Large sources: CPMS (monthly) - Other process units etc: Fuel meter (quarterly)	-Tele Metering System (TMS): every five minute monitoring (monthly reports)
4-2 Reporting type	Web Access To Electronic Reporting System (WATERS)	Paper reports
4-3 Reconciliation (grace period)	2 months	2 months
4-4 Financial Penalties	Up to $500 (Determined case by case)	Not fixed (Determined case by case)
4-5 Offsets of excess Emissions	1-for-1	3-for-1
4-6 Missing Data Procedures (MDP)	Double progressive based on the worst case scenario	No provisions

V. Conclusion

<u>Major principles of emissions trading system</u>

An emissions trading program can be likened to a building supported by three pillars: environmental certainty, economic efficiency (cost-effectiveness), and political feasibility. If one of the three pillars is not in place, the whole system of an emissions trading program cannot work smoothly. Major principles guiding emissions trading programs can be drawn from these three pillars: simplicity, predictability, accountability, transparency and collaboration.

Figure 21. Relationship between Three Pillars and Five Principles in a Trading System



A. Simplicity

As many researchers argue (Stavins, 2000; Ellerman et al., 2000), simplicity is the most basic and important principle in designing an emissions trading program. The attempt to deal with other problems, such as equity and local concentrated pollution, is likely to impose complex restrictions on affected sources, which undermines the powerful merit of the trading program. Earlier EPA emissions trading systems and wetlands credit sales in the U.S. are perfect examples of emissions trading programs imposing highly complicated restrictions on sources. Complexity tends to imply greater information needs, time-consuming decision-making, and controversial debates that may lead to unnecessarily higher transaction costs for both the regulatory authority and the regulated pollution sources.

Concerning simplicity, interexchangeability (on 1-for-1 basis regardless of geographical origin etc.) and flexibility of allowances is especially important. If the market value of a traded allowance varies depending on its geographical origin, generated year, or allowance banking opportunities, transaction costs would increase and the overall social net benefits (savings) from allowance trading would lower. As well as interexchangeability, flexibility is another dimension of affecting simplicity. Any geographical or temporal constraint on allowance trading from concerns over hot spots and environmental injustice may detract from the cost-effectiveness of the system. Although there may be a trade-off between environmental concerns and cost-effectiveness, a society should make an effort to balance these two values based on simplicity (flexibility).

According to the EPA (2003), the principle of simplicity can be applied to almost all elements of the emissions trading programs, such as: applicability, allocations formulas, monitoring, reporting and enforcement.

B. Predictability

Predictability is another principle guiding an effective emissions trading program. Emissions trading systems were created based on the concept of markets' well-defined property rights (Coase 1960; Dales 1966). For emissions trading to operate appropriately, reductions in emissions should be regarded and protected as legal or actual property rights. Unless the economic value of emissions reductions is guaranteed on a long-term basis, no sources have incentives to reduce their emissions under the sources' requirements and invest in innovation that will reduce their marginal abatement costs.

To sustain predictability of a trading system, rules including allocation formulas should be set on a long-term basis, and any changes in the rules must be clear, and consistent across all affected sources.

C. Accountability

Accountability is important in achieving environmental integrity of the trading program. Flexibility provides regulated sources lots of freedom to choose abatement instruments. As responsibility may well comes with freedom, accountability is required to check and balance flexibility in allowance trading. Accountability can be ensured through accurate and consistent monitoring and effective enforcement. Even if there are considerable compliance costs for each source, the continuous emissions monitoring system (CEMS) has been widely adopted and can greatly enhance accountability. In terms of enforcement, penalties for non-compliance should be high enough, and should apply automatically (i.e. with great certainty) to discourage each source from violating its requirement.

D. Transparency

Transparency concerns the full and open disclosure of related decision-making including the process of making all trading rules, the transfer of permits, open participation in auctions, and treatment of non-compliant sources. Transparency is important to both businesses and the public: for businesses, it helps determine behaviors such as bidding prices in auctions, investment plans, and trading or banking of unused permits; for the public, it can enhance both public acceptance and environmental attainment. Emissions data and available technology in industries should be disclosed and open to the authorities and the public, as long as they are not highly confidential to businesses.

E. Collaboration

Recently, collaborative approaches have been widely considered as a new and effective tool to deal with difficult problems involving conflicting interests in a number of environmental policy areas. Collaboration refers to a consensus-building process through which a wide range of participants can constructively explore their differences and search for new solutions that go beyond their own limited interests. It has numerous advantages over the conventional top-down approaches including: learning and educating participants, flexibility in inventing solutions, building-up of social capital, and higher implementability (Gray, 1989).

However, collaboration is not a panacea. There can be several circumstances in which collaborative approaches are most appropriate: (1) problems are bigger than any single entity alone can solve ("indivisible problems"); (2) traditional approaches have limitations to solve current problems; (3) there are increasing environmental turbulence; (4) there are no insurmountable obstacles, including ideological differences, constitutional issues, unilateral power concentration by one stakeholder, historical antagonism (Gray 1985, 1989, Julian 1994).

Collaboration seems especially appropriate for cap-and-trade programs. First, since permits are de facto property rights, many elements of trading systems (including scope and initial allocations) may well be contentious among stakeholders and cannot be solved by one participant. Second, most cap-and-trade programs was introduced as a last resort to solve problems associated with higher compliance costs and environmental uncertainty which traditional CAC regulations did not deal with effectively. Third, with increasing number of sources and technical uncertainty, environmental turbulence has increased. Finally, there are no critical obstacles in introducing cap-and-trade programs. Most contentious issues (including initial allocations and restriction on trade) can be solved through negotiations among stakeholders.

In particular, in the case of a nation like Korea where CAC approaches have been dominant, it is much more difficult to introduce an emissions trading program, so the principle of collaboration to overcome political obstacles is more important in designing any trading program.

Lessons learned from experiences with U.S. emissions trading

Based on three decades of experience with five emissions trading programs in the US, lessons to be drawn can be divided into three categories: general lessons for environmental policy, lessons for design, and lessons for implementation.

A. General Lessons for environmental policy

There are three general lessons for environmental policy. First, emissions trading systems work if they are well designed in terms of the five principles discussed above. Well-designed trading programs can reduce compliance costs considerably compared to traditional CAC regulations. Active transfer of permits among sources with different marginal abatement costs (MAC) is observable evidence that allows one to infer cost savings from trading. In addition to cost savings, emissions trading programs are able to achieve environmental targets with a greater certainty. Under an emissions trading program, more aggressive emission reduction targets can be phased in and earlier emission reduction can be accelerated by way of banking. In particular, emissions trading systems can prevent some sources from resorting to requests for special exemptions from emissions reduction targets based on their technical or financial hardship, as is often the case under traditional CAC schemes.

Second, even if emissions trading systems are widely regarded as very powerful market-based instruments for dealing with air pollution, they are not a cure-all. In some cases, trading programs will be the best instrument, but in some cases, other instruments, such as traditional CAC may remain more suitable. In general, emissions trading systems function well especially when: the environmental or health concern emerges over a relatively large area; environmental damage from air pollution is not critical at small concentrations; a number of sources are involved in creating the environmental problem; marginal abatement costs vary across sources; and emissions can be measured with sufficient accuracy and consistency.

Third, if possible, cap and trade programs based on absolute baselines are more desirable than project-based and rate-based trading programs involving relative baselines. As with EPA's emissions trading programs, rate-based programs generate significant transaction costs because emissions reduction credits (ERCs) have to be identified through a case-by-case pre-approval. Additionally, project-based and rate-based trading programs do not ensure total emissions reduction with certainty because reductions are credited from unspecified or relative baselines.

B. Lessons for Design of a trading system

There are four lessons concerning the design of an emissions trading program. First, opportunity for banking plays a crucial role in enhancing cost savings and achieving environmental targets. Banking provides temporal flexibility for affected sources, so banking not only reduces compliance costs, but it also accelerates earlier emissions reduction for future use. In addition, as can be seen from the experience with RECLAIM in 2000, an emissions trading program without banking system cannot deal as effectively with price volatility stemming from uncertainty. In fact, the price surge in NOx RTCs caused by California's electricity crisis beginning in mid 2000 led to firms exceeding the NOx RECLAIM cap by about 6% and led to a temporary suspension of RECLAIM. If banking was allowed in RECLAIM, as it is in the SO_2 Trading Program, these problems might have been avoided or at least much lessened.

Second, whatever strategy is adopted, the initial allocation of permits cannot significantly undermine an emissions trading program's performance, even though it may have distributional consequences. To date, in almost every case, emissions trading programs (such as the SO_2 Trading Program and RECLAIM) have adopted a grandfathering approach rather than alternative approaches based on auctions. This has been due to political acceptability. The auctioning approach has several advantages over grandfathering approach: it produces government revenue for recycling, and given the presence of transaction costs, the initial allocation would affect the final equilibrium allocation and thus total cost-savings. However, the difference in cost savings between auctions and grandfathering are very small, so that in practice, the different methods of initial allocation of permits minimally influence performance in the trading program.

Third, the evaluation of opt-in provisions is mixed. While voluntary participation in an emissions trading program would reduce abatement costs, it may also lead to overly generous allocation of permits due to adverse selection problems. In the case of the SO_2 Trading Program, the losses from excess allocation of permits may have offset the gains from lower emission control costs, resulting in little net contribution to the overall performance of the program.

Fourth, once emissions trading programs are properly designed, markets can develop privately and as a result, governmental interventions should be minimized. In theory, any type of restriction on trade, including pre-approving trades, would increase transaction costs and detract from the program's viability. However, in practice, given political concerns over possible hot spots and concentration of permits under some groups, there may be some restrictions based on geography. Restrictions should be kept to minimum and should be removed over time if they prove to be inessential.

C. Lessons for Implementation of a trading system

With regard to implementation issues, three lessons can be identified. First, total emissions at sources should be measured as accurately and consistently as possible. Emissions measurements are like the "gold standard' of tradable permits, so accurate and consistent measurements help create a perception of fairness for every participant. In the case of the SO_2 Trading Program, while measurement accounts for roughly 7 % of total compliance costs, CEMS technology enhances confidence and contributes to the success of the program.

Second, reliable enforcement is essential for compliance. In most cap-and-trade programs, both financial penalties and deductions against future permits are employed at the same time. In using enforcement, two factors should be considered: the optimal level ("severity") of penalties and the automatic application ("certainty") of those penalties. It is important to set the optimal level of penalties because insufficient penalties are not effective in discouraging non-compliance by sources. However, an overly severe level may cause political difficulties in implementation. In addition to the penalty level, it is important that penalties be applied automatically. As with RECLAIM, if penalties are applied through case-by-case review, it increases uncertainty of penalties and is less effective in ensuring compliance. Firms respond to the expected penalty, which reflects not only the size of the penalty if they are detected and prosecuted for violations, but also the odds of being detected and successfully prosecuted.

Third, emissions trading systems should be compatible with pre-existing regulations. In virtually every case, emissions trading programs have been implemented in contexts where they overlap with other regulations, such as NAAQS, and the RACT requirements of NSR. Actually, the presence of pre-existing regulations is an apparent prerequisite for a successful emissions trading program. Under emissions trading systems, political conflict may be more contentious than under traditional CAC scheme due to uncertainty. The presence of CAC regulations can help provide information and a practical reference of regulations, both of which are necessary to reach a political compromise that permits introduction of an emissions trading systems.

For example, regardless of time-consuming debates, the exclusion of VOCs in RECLAIM was accountable for by the absence of regulations on VOCs. Moreover, in many cases, without provisions for geographical restrictions on trade, overlapping regulations can be served as a backstop that prevents the formation of hotspots that violate air quality standards. As shown in the cases of the UK and Poland, incompatibility between new trading programs and pre-existing regulations may well lead to the failure of the emissions trading program. Therefore, attention to the incorporation of emissions trading programs into current regulatory systems is important, especially in countries like Korea where CAC regulations have been the dominant form of regulation in environmental policies.

Table 13. Summary of Lessons Learned from Experiences with Major Emissions Trading Programs in the U.S.

General Lessons for environmental policy
Lesson 1: Emissions trading systems work both in terms of cost-savings and environmental goals if they are well-designed, based on a number of principles.
Lesson 2: Regardless of successful cases in dealing with air pollution, an emissions trading system is not a cure-all. In other words, there are situations under which emissions trading programs do not function well.
Lesson 3: Cap-and-trade programs grounded on absolute baselines are more desirable than project-based based and rate-based trading programs that are grounded on relative baselines.
Lessons for Design
Lesson 4: Banking (i.e. temporal flexibility) plays a crucial role in enhancing cost savings, achieving environmental targets, and reducing price volatility.
Lesson 5: Whatever allocations method is used, the initial allocation of permits cannot significantly undermine an emissions trading program's performance.
Lesson 6: Evaluation of opt-in provisions is mixed. While voluntary participation in trading programs can reduce overall abatement costs, it may also lead to overly generous allocation of permits due to adverse selection problems.
Lesson 7: Once emissions trading programs are properly designed, markets can develop. Governmental interventions should be minimized as much as possible.
Lessons for Implementation
Lesson 8: Total emissions should be measured as accurately and consistently as possible.
Lesson 9: Reliable enforcement is essential in compliance.
Lesson 10: Emissions trading systems should be compatible with pre-existing regulations.

Implications for Seoul, Korea

Turning to the research questions in the introduction, the main purpose of this study is to draw lessons from experiences with emissions trading programs in the US, and then, based on those lessons, to provide implications to use in assessing the design and implementation of the new cap-and-trade program which is scheduled to begin in July 2007 in the Seoul Metropolitan Area in Korea.

As is often the case, even the most successful policy in one country can totally fail in other countries if context is not fully taken into consideration. Therefore, suggestions in this part are provided given the specific context in Korea, even if many of principles and lessons drawn from the experiences in the US can be applied without significant modifications.

A. Minimizing governmental intervention

Since an emissions trading system is a market-based instrument intended to provide affected sources with the flexibility to adopt abatement alternatives, its performance can be enhanced by a well-functioning market. Therefore, minimal governmental intervention in the emissions trading program is desirable. However, distributional or equity/justice-related concerns are likely to lead to governmental interventions with respect to the transfer of some permits, especially in a country like Korea in which CAC regulations have been dominant in environmental policies.

According to the legal framework of CATS, all sources that wish to trade allowances must submit allocation forms to the proper authority and receive pre-approval of each transfer. If the transfer of allowances might lead to a violation of ambient air quality standards or create an excessive local concentration in a specific area, the trade cannot be allowed. In addition, the proportion of a firm's allowances that are tradable is limited to 20 percent to 50 percent annually: 20 percent for starting year, 30 percent for the second and third years, and 50 percent for the fourth and fifth years.

While these restrictions on trade may reduce environmental concerns, they will also limit the potential gains from emissions trading systems. Consequently, current pre-approval requirements and annual limitations of transferable allowances, as excessive governmental interventions, should probably be reconsidered. Without both pre-approval and annual limitations of transferable allowances, existing emissions standards can serve as a backstop for dealing with environmental concerns.

B. Relaxing Restrictions on Banking

Even if banking under CATS is similar to that of the NOx Budget Trading Program, banking in CATS is more limited: that is, when the total number of allowances banked for all sources does not exceed 10 percent of the total regional budget for the next year, the available amount of banked allowances is determined by multiplying the total number of allowances banked by 0.5; when the total number of allowances banked for all sources exceeds 10 percent of the total regional budget for the next year, the useable amount of banked allowances is more complicated. It is determined according to the following formula:

$A_{b(t+1)} = A_{b(t)} \times 0.5 \times 0.1 \times$ (total allowances banked for all sources ÷ total unused allowances for all sources.

where

$A_{b(t+1)}$ = the available amount of banked allowances of source A for the next year,

and $A_{b(t)}$ = the unused allowances of source A for a specific year.

Compared to other emissions trading programs in the US, banking options in CATS appears to be restrictive. As a result, some of the advantages of a well-designed emissions trading program-- i.e., gains from banking (including earlier emission reduction, cost savings from temporal flexibility, and a safe valve for price volatility)-- will be foregone.

As in the case of restrictions on the transfer of allowances, the excessive and complicated restrictions on banking should be relaxed in pursuit of simplicity. If there are still concerns about weakening or delaying environmental achievement, then other tools, such as the adoption of a more aggressive emissions target, should be considered instead of inordinate restrictions on banking.

C. Creating Public Auction

Even if grandfathering has prevailed as a politically viable method for, auctions have their own advantages including recycling revenue and long-term efficiency. In the development of an emissions trading system, there would be concerns among regulated sources about the emergence of a trading market and equilibration to one market price. Public auctions in the earlier stage of an emissions trading program can be the answer to these concerns because they can facilitate convergence to one market price for allowances and thus promote the development of a market.

Furthermore, just as the EPA in the SO2 Trading Program auctions 2.8 percent of total allowances, setting aside some portion of all allowances for auction can limit the potential market power of some larger allowance holders, and give new entrants or smaller players an opportunity to buy allowances. Therefore, it is desirable to set aside some small portion of each firm's allowances for an MOE-administered auction, at least until the market is mature.

D. Introduction of Opt-in Provisions

Unlike under the SO_2 Trading Program and RECLAIM, CATS allows voluntary agreement that enables each regulated source to choose more rigorous emissions allowances voluntarily, but does not have an opt-in program by unregulated sources. As discussed in previous chapters, opt-in (i.e., unregulated sources' voluntary participation in a trading program) has mixed impacts on the emissions trading program: it reduce compliance costs among sources, but it could provide introduce excessively generous allowances into the program, resulting in a weakening of environmental quality (For example, consider the "hot air" problem associated with Russian allowances in nascent carbon-trading to limit climate change).

Despite short-term environmental setbacks, long-term benefits seem to be considerable seeing that opt-in can be used not only to reduce costs, but also to extend the applicability of the caps by involving additional previously unregulated sources. As a result, it is probably desirable to introduce an opt-in provisions into CATS.

E. Accurate and Consistent Monitoring

To monitor emissions accurately and consistently, CATS requires larger sources subject to Phase I (July 2007 through June 2009) to install a tele-monitoring system (TMS) that is similar to the CEMS in the SO_2 Trading Program and RECLAIM. Before CATS is applied to mid- or smaller-sized sources in Phase II starting July 2009, TMS "saturation" should be extensive. Unlike the SO_2 Trading Program and RECLAIM, currently CATS has no provisions for missing data procedures (MDP). Therefore, to deter intentional powering-down of the monitoring system during periods of peak emissions, conservative substitutes based on the worst case scenario should be applied for non-monitoring periods.

F. Effective Enforcement

Concerning enforcement, there are two things to consider. First, financial penalties under CATS are imposed on a case-by-case administrative review, which leads to uncertainty about penalties and the possibility of non-compliance when only expected penalties determine firms' behavior. Therefore, the method of levying penalties must change from case-by-case reviews to automatic imposition.

In addition to financial penalties, non-compliant sources are subject to allowance deductions from the next year's allocated allowances, prorated based on the number of violations for the five preceding compliance years: emissions in excess of allowances are multiplied by a factor determined by the number of recent violations, such as 1.2 for 2 violations, 1.5 for 3 violations, and 1.8 for 4 violations. In pursuit of simplicity, deduction rates for penalties should be simplified to a 1-for-1 basis and additional financial penalties should be adjusted so that the expected penalty is high enough to deter violations.

The penalty rate is one of the most important factors in sources' compliance. The current per-unit penalties should be reviewed periodically to determine whether they are too low compared to the possible market price of allowances or actual abatement costs.

G. Compatibility with Pre-existing Regulations

As Schwarze and Zappel (1999) point out, the context in terms of pre-existing and/or overlapping regulations is one of the major common features to consider for the design of applied tradable permits. The UK and Poland cases are the perfect example to show that compatibility with pre-existing regulations is one key to the success of an emissions trading system.

Drawing on current air pollution control measure described in chapter III, three types of conventional regulations are directly related to CATS: emission standards, an emission charge, and fuel regulations. First, emission standards can complement an emissions trading system. Even if an emissions trading program can cap the total emissions in the region, it is often necessary to set maximum emissions limits for specific sources in order to prevent short-term over-pollution. For example, the SO_2 Trading Program has been in effect at the same time as the BACT requirements of the New Source Review (NSR).

Second, emissions charges can be unnecessarily duplicated with an emissions trading system. In the current framework of emissions charges, there are two kinds of emissions charges: general charges imposed on sources emitting SO_2 or PM_{10} according to their total emissions, and; additional charge imposed on sources emitting 10 pollutants including SO_2, PM_{10}, and NH_3 which exceed the emission standards. Affected sources subject to CATS are exempt from the general charges, but this exemption is not sufficient because additional charges can be duplicated with penalties in an emissions trading program. Hence, all sources covered by CATS should be exempt from all emissions charges.

Third, fuel regulations are also unnecessary as overlapping regulations. In the legal framework for CATS, sources emitting SO_2 are exempted from limits on sulfur content in their fuels. To increase flexibility of CATS, besides CAC regulations concerning the use of low-sulfur fuel, regulations mandating the use of clean fuels should not apply to firms participating in CATS.

Table 14. Summary of Implications for the Cap-and-Trade Program in Seoul

Implications for reforming CATS
A. Minimizing Governmental Intervention - Current pre-approval requirements and annual limitations of transferable allowances, as excessive governmental interventions, should be repealed.
B. Relaxing the Restrictions on Banking - The excessive and complicated restrictions on banking (under the current framework, at most 50 percent of banked allowances can be used in trade) should be relaxed to enhance simplicity in terms of environmental effectiveness and economic efficiency.
C. Creating a Public Auction - Some portions of allowances (i.e. 2.8%) should be set aside for MOE- administered auctions, at least until the market is mature.
D. Introduction of Opt-in Provisions - It is desirable to introduce provisions that allow sources to "opt-in" to CATS in order to improve cost savings and extending the caps by involving currently unregulated sources.
E. Accurate and Consistent Monitoring - TMS, a continuous emissions monitoring system, should be expanded into mid- or smaller-sized sources. - To avoid intentional powering down of monitoring systems in peak times, missing data procedures (MDP) should be introduced into CATS.
F. Effective Enforcement - Financial penalties should be imposed from case-by-case reviews to automatic applications. - Deduction rates for penalties should be simplified to 1-for-1 basis, given the presence of additional financial penalties. - The current per-unit penalties must be reviewed to determine whether they are sufficient, compared to the possible market price of allowances or actual abatement costs.
G. Compatibility with Pre-existing Regulations - Emissions standards should be maintained as it is. - All affected sources should be exempt from all emissions charges and fuel regulations in order to avoid unnecessary duplicated regulations.

Final Discussion

Based on experiences with major cap-and-trade programs in the U.S., it is clarified that a well-designed cap-and-trade program has advantages, both in terms of environmental certainty and economic efficiency, over a traditional CAC approach. Along with the trend towards increasing reliance on market-based incentives across the globe, emissions trading schemes are likely to play an increasing role in controlling pollution as an alternative tool to existing CAC regulations.

As many previous researchers argue, however, emissions trading schemes cannot be a cure-all for a variety of environmental problems. The advantages of an emissions trading program can be maximized only if it is applied in appropriate conditions: (1) concerning pollutants, uniformly mixed pollutants, such as CO_2, are appropriate, but toxic chemicals which cause serious risk to neighboring residents are not suitable for emissions trading systems; (2) there should be a sufficient number of sources with different marginal abatement costs; (3) it should be practical and inexpensive to measure emissions and enforce trading (Ellerman et. al., 2000, Tietenberg 2003)

In addition to the above general conditions, an emissions trading program should take into account that each country has specific economic, political, and regulatory settings. If it is adopted without modification corresponding with different settings, an emissions trading program that succeeded in one country, can fail in another country.

To become a dominant regulatory policy tool, emissions trading schemes should deal with several concerns (including hot-spots and concentration of market power) without sacrificing its advantages through excessive governmental involvement or intervention.

In the case of CATS in Korea, environmental concerns lead to excessive governmental intervention, complex restrictions on trading, and duplicated enforcement with pre-existing regulations, which may damage the potential cost savings from CATS.

At present, this study on the CATS was done theoretically. However, after the implementation of the CATS starting in July 2007, the empirical studies to evaluate CATS will be needed.

APPENDIX A

LIST OF ACRONYMS

AQMP: Air Quality Management Plan

ARP: Acid Rain Program

ATS: Allowance Tracking System

BACT: Best Available Control Technology

CAA: Clean Air Act

CAIR: Clean Air Interstate Rule

CATS: Cap-and-Trade Program in Seoul

CEMS: Continuous Emissions Monitoring System

CPMS: Continuous Process Monitoring System

DOC: Diesel Oxidation Catalysts

DPF: Diesel Particulate Filters

EPA: Environmental Protection Agency

LEV: Low Emission Vehicles/ ZEV: Low Emission Vehicles

MDP: Missing Date Procedures

MOE: Ministry of Environment

NAAQS: National Ambient Air Quality Standard

NBT: NOx Budget Trading Program

NGV: Natural Gas Vehicles

NOx: Nitrogen Oxides/ PM: Particulate Matter/ SO_2: Sulfur Dioxides

NSPS: New Source Performance Standard

NSR: New Source Review

OECD: Organization for Environmental Cooperation and Development

OTC: Ozone Transport Commission

RACT: Reasonable Available Control Technology

REC: RECLAIM Emission Credit

RECLAIM: Regional Clean Air Incentive Market

SMAQMDO: Seoul Metropolitan Air Quality Management District Office

SCAQMD: South Coast Air Quality Management District

TAPL: Total Air Pollution Load

TEC: Total Emission Control

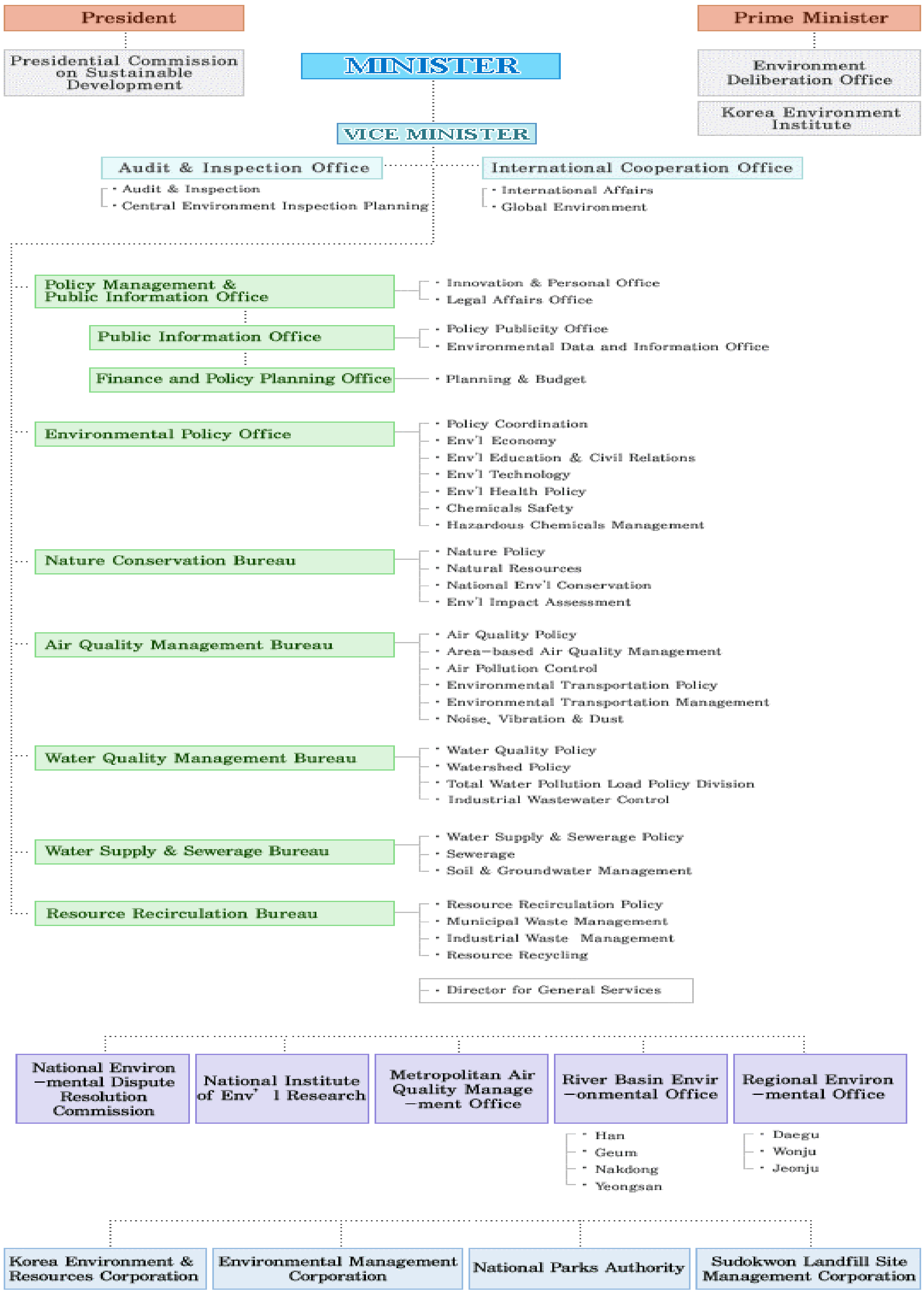
TMS: Tele-Monitoring System

VOC: Volatile Organic Compounds

WATER: Web Access To Electronic Reporting System

APPENDIX B

THE CURRENT ORGANIZATION OF THE MINISTRY OF ENVIRONMENT IN KOREA


President
Presidential Commission on Sustainable Development
Prime Minister
Environment Deliberation Office
Korea Environment Institute
MINISTER
VICE MINISTER
Audit & Inspection Office
· Audit & Inspection
· Central Environment Inspection Planning
International Cooperation Office
· International Affairs
· Global Environment
Policy Management & Public Information Office
· Innovation & Personal Office
· Legal Affairs Office
Public Information Office
· Policy Publicity Office
· Environmental Data and Information Office
Finance and Policy Planning Office
· Planning & Budget
Environmental Policy Office
· Policy Coordination
· Env'l Economy
· Env'l Education & Civil Relations
· Env'l Technology
· Env'l Health Policy
· Chemicals Safety
· Hazardous Chemicals Management
Nature Conservation Bureau
· Nature Policy
· Natural Resources
· National Env'l Conservation
· Env'l Impact Assessment
Air Quality Management Bureau
· Air Quality Policy
· Area-based Air Quality Management
· Air Pollution Control
· Environmental Transportation Policy
· Environmental Transportation Management
· Noise, Vibration & Dust
Water Quality Management Bureau
· Water Quality Policy
· Watershed Policy
· Total Water Pollution Load Policy Division
· Industrial Wastewater Control
Water Supply & Sewerage Bureau
· Water Supply & Sewerage Policy
· Sewerage
· Soil & Groundwater Management
Resource Recirculation Bureau
· Resource Recirculation Policy
· Municipal Waste Management
· Industrial Waste Management
· Resource Recycling
· Director for General Services
National Environ-mental Dispute Resolution Commission
National Institute of Env' l Research
Metropolitan Air Quality Manage-ment Office
River Basin Envir-onmental Office
· Han
· Geum
· Nakdong
· Yeongsan
Regional Environ-mental Office
· Daegu
· Wonju
· Jeonju
Korea Environment & Resources Corporation
Environmental Management Corporation
National Parks Authority
Sudokwon Landfill Site Management Corporation

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