The Price of clean air: A consideration of market based emissions trading

Mark W. Miller
University of Nevada Las Vegas

Follow this and additional works at: https://digitalscholarship.unlv.edu/thesesdissertations

Part of the Environmental Health and Protection Commons

Repository Citation
https://digitalscholarship.unlv.edu/thesesdissertations/334

This Thesis is brought to you for free and open access by Digital Scholarship@UNLV. It has been accepted for inclusion in UNLV Theses, Dissertations, Professional Papers, and Capstones by an authorized administrator of Digital Scholarship@UNLV. For more information, please contact digitalscholarship@unlv.edu.
The Price of Clean Air: 
A Consideration of Market Based Emissions Trading

Thesis Submitted in 
Partial Satisfaction 
Of 

B.A. Environmental Studies 
University of Nevada Las Vegas 

Mark W. Miller 
Thesis Advisor: Dr. Helen Neill 
May, 1 1998
Table of Contents

A. Forward ................................................................................................................. 1

1. Introduction ........................................................................................................... 2
   1.1 PM$_{10}$ in the Las Vegas Valley ................................................................. 3
   1.2 Regulatory Response ................................................................................ 3
   1.3 Purpose .......................................................................................................... 3
   1.4 Description of Sections to Follow .............................................................. 4

2. Background ............................................................................................................ 4
   2.1 Definition of Market Incentives ................................................................. 4
   2.2 Rationale for Incentives ........................................................................... 5
   2.3 Command and Control Approaches .......................................................... 5
   2.4 Economic Critique of CAC ..................................................................... 6
   2.5 Characteristics of Market Based Instruments ........................................... 7
   2.6 Resistance to market incentives ............................................................... 8

3. Literature Review ................................................................................................. 9
   3.1 Key Design Issues ...................................................................................... 11
      3.1.1 Letting Go of the CAC Core .............................................................. 11
      3.1.2 Non-Uniformly Mixed Pollutants ....................................................... 12
      3.1.3 Monitoring Enforcement .................................................................. 13
   3.2 Historical Experience ............................................................................... 14
      3.2.1 Acid Rain Program .......................................................................... 14
      3.2.2 Evaluating the Acid Rain Program .................................................. 14
      3.2.3 RECLAIM ......................................................................................... 15
      3.2.4 Trading Emissions Under RECLAIM ............................................ 16
      3.2.4 RECLAIM Evaluation ..................................................................... 16
   3.3 Lessons Learned .......................................................................................... 17
   3.4 Market Simulation: Emissions trading vs. CAC ......................................... 17
      3.4.1 Direct Regulation Costs ..................................................................... 18
      3.4.2 Measuring Results ............................................................................ 20
      3.4.3 Compliance Cost .............................................................................. 20
      3.4.4 Analyzing Results ............................................................................ 21

   4.1 Implementing a Trading Program .............................................................. 21
   4.2 Key Design Issues ...................................................................................... 22
      4.2.1 Establishing the Trading Universe .................................................... 22
      4.2.2 Allocating Emissions ....................................................................... 24
      4.2.3 Creating PM$_{10}$ Credits ................................................................. 25
      4.2.4 Compliance Options ....................................................................... 25
      4.2.5 Monitoring PM$_{10}$ Sources ............................................................. 26
   4.3 Evaluating Feasibility ................................................................................... 26
      4.3.1 Impacts to Air Quality ..................................................................... 26
      4.3.2 Cost Effectiveness .......................................................................... 28
      4.3.3 Firm Level Trading Decisions .......................................................... 30
      4.3.4 Resistance and Political Factors ...................................................... 31
   4.4 Feasibility Determination .......................................................................... 31

5. Conclusion ............................................................................................................ 32
Abstract

Traditional regulatory approaches for environmental protection do not consider the costs and benefits of the standards they impose. Further, imposing strict performance standards on firms with heterogeneous control costs leads to an inefficient allocation of resources devoted to pollution control. This paper explores the use of emission allowance trading as a way to improve economic efficiency within the context of environmental protection. PM10 air pollution from sources within the Las Vegas Valley is used as the case study.

This paper found that an emission trading program in this particular case study would not live up to the theoretical expectations. Although, emissions trading did show some potential for reducing the amount of money spent to reduce PM10 air pollution, technical problems such as increased monitoring costs, and complicated trading rules would detract the any cost savings that would accrue through allowance trades. In addition, political and legal factors would pose a significant obstacle to implementing the considered trading program.

Although, this particular case study did not prove to be especially conducive to a decentralized regulatory structure, allowance trading proved to be an attractive policy instrument, offering many advantages over traditional regulatory approaches.
Foreword: Pollution in a growing economy

The environment and the economy are inter-linked. The environment supplies material and energy inputs to the economy. The economy transforms these inputs into forms useful to society, and produces waste as a byproduct. The environment, however, has a limited ability to assimilate this waste. The end result of this interaction is increased ambient levels of pollution. Given this relationship, it is no surprise that as economic development progresses in Las Vegas, environmental quality is decreasing.

The problem facing Las Vegas is one of resource allocation. Resources in our society are limited. Government agencies and the business community both face budget constraints. The resources devoted to pollution control take away from resources that could be devoted to other things like the creation of more jobs through continued business investments. Pollution control also adds an additional expense to the production process, making products more expensive for consumers. Both of these impacts can adversely affect the economy. In point, almost everyone wants pollution free air and water, but few are willing to achieve this if it means higher prices and the loss of jobs. (Table 1)

This paper does not hope to solve the complicated resource allocation problem facing Las Vegas as it continues to grow. What it will address, is an alternative policy instrument that can be used to help improve this resource allocation problem by achieving a specific level of environmental quality at a lower cost.

![Environmental Quality vs. Economic Development](image-url)
1) Introduction

Protecting air quality in a growing urban area such as Las Vegas is a dim reality. Simply stated, cleaner air costs money and lots of it. While the environmental conscience in each of us cries out for cleaner air, few are willing to achieve this if it means sacrificing employment, or higher prices. This is especially true for local politicians whose very livelihood depends on “pro-business” policies. Firms who face high pollution control costs must raise prices, or lay off workers to compensate for these costs. In many cases firms are forced out of business due to environmental regulations. Needless to say, cost-effective regulatory policies are becoming increasingly prominent. This trend can be attributed to the growing awareness of budgetary trade-offs, concerns over marketplace competitiveness, and the economics of demand which suggest: “make pollution control cheap and easy, and more might buy it”. The latter will be the focus of this paper. The harsh reality of pollution control is not hopeless. Pollution control policies can be reformed or modified so environmental goals, such as improved air quality, can be achieved at a lower overall cost. Emission allowance trading is an example of such a policy.

Emission allowance trading is a regulatory policy that is gaining importance as an alternative to traditional command and control policies for protecting air quality. Emission trading is an incentive based approach that rations the quantity of allowable emissions. The reduction goal determines the amount of emission allowances available for trade, and market forces set a price for each emission credit. The fact that each increment of pollution is given a price creates a strong incentive for businesses to reduce their emissions. Firms enter a new business namely pollution control.

Emission trading is not a new concept. Economists have long extolled the benefits of market based approaches on the grounds of efficiency. They reduce the amount of resources devoted to pollution control. Recent trends in regulatory policy suggest a strong preference for incentive based approaches due to their cost saving advantages. Ground breaking programs such as the Acid Rain Program and California’s RECLAIM program have shown that emissions
trading can lower the cost of meeting a desired level of ambient air quality. This historical experience, along with the theoretically modeled efficiency gains make emissions trading an attractive alternative relative to the command and control methods traditionally used. In an era where cost-effectiveness is given a high priority, these benefits should be especially appealing to policy makers.

1.1) The Problem: PM$_{10}$ in the Las Vegas Valley

The Las Vegas Valley is classified by EPA as a serious non-attainment area for particulate matter with a diameter of 10 microns or less (PM$_{10}$). PM$_{10}$ consists of minute particles that obscure visibility and cause severe respiratory problems when inhaled into the lungs. The primary contributors to man caused PM$_{10}$ in the Valley are construction activities, accounting for approximately 40% of the PM$_{10}$ inventory annually. Aggregate processing, and disturbed land are also substantial contributors. Based on current growth trends, industrial sources, and construction activities will continue be a major constraint to attainment of the National Ambient Air Quality Standard for PM$_{10}$.

1.2) Response

Under pressure from the community and from EPA, the Clark County Health District Air Pollution Control (APC) Division has tightened the regulations governing PM$_{10}$. The County has responded to this problem in many ways. First, APC has adopted strict and complicated performance standards for PM$_{10}$ sources. They have also mandated the use of “Best Available Control Technology” (BACT) for all stationary sources in the non-attainment area. This BACT requirement prescribes what kind of control equipment each stationary source must use. Also, APC has added enforcement personnel, and increasing fines for violations. APC continues to extend their regulatory hand to include smaller and smaller sources categories where resulting air quality gains are minimal. Soon the County will run out of things to regulate. These efforts, though well intended, only add to the total allocation of resources devoted to pollution control, because facilities are all subject to the same rigorous standards irrespective of their relative contribution to PM$_{10}$ emissions in the Valley. In total, the County now pays more for enforcement and industry pays more for compliance with little measurable gain in air quality. By all counts, this defies the very definition of cost-effectiveness. Clearly, the need exists to explore alternative policies to address this problem.
1.3) Purpose

The purpose of this paper will be to assess the feasibility of implementing an emissions trading (ET) program focused on PM10 emitting sources in the Las Vegas Valley. The criteria used to determine feasibility will include cost-effectiveness, technical problems, and program acceptability. The question “Is emission trading a better alternative to command and control regulations for this particular air quality problem?” provides the primary motivation for the paper.

1.4) Descriptions of Sections to Follow

The first section of this paper will provide background information on emissions trading (ET) and command and control regulatory approaches. Included in this section will be a definition of ET along with its key characteristics, economic critique of CAC, and reasons for resistance to ET. The second section will include a literature review, highlight past experience with ET under the “Acid Rain Program” and “RECLAIM”, and a market simulation that compares costs under both ET and CAC regulatory approaches. The third section will cover issues related to implementing a trading program in Las Vegas and analysis of feasibility. The paper will conclude by re-stating the major findings of the paper.

2) Background

2.1) A Definition of Market Incentives

Market-based instruments are regulations that encourage behavior through price signals. These policy instruments, such as tradable permits or pollution charges, are often described as “harnessing market forces” because if they are properly implemented, they encourage firms, through economic incentives, to undertake pollution control efforts that both are in their financial self-interest and that will collectively meet policy goals.

Emission trading is a quantity rationing instrument. Emission permits or allowances as they are often called, specify a predetermined total level of emissions. Firms that keep emissions below their allotted level may sell their surplus permits or use them to offset higher emissions at other locations. Once permits have been issued, market forces decide how control...
responsibility will be allocated among polluters. Instead of equalizing control responsibility across emission sources, emission trading equalizes control costs. The primary advantages of emissions trading over traditional regulatory methods, are cost-effectiveness (they lower the price of achieving a given level of environmental quality), and dynamic efficiency which are secondary effects that lower costs in input markets through increased competition. Dynamic efficiency is a direct result of the efforts firms make to invest in innovative emission control strategies.

2.2) Rationale for Economic Incentives

The rationale for tradable permits is straightforward. The market mis-allocates resources in the face of negative externalities because individual firms do not bear the full consequences of their polluting activities (Nichols 1984). As a result, firms have little incentive to control their pollution. The use of tradable permits corrects this problem by creating a market for pollution and a corresponding market price for the right pollute. The idea is simple enough. Trading programs make pollution a valuable commodity; firms realize it is in their financial best interest to reduce emissions.

Market based trading structures allocate control efforts in terms of marginal control costs. Control efforts are focused where they will yield the greatest benefits. This allows firms the flexibility to decide their own privately optimal level of control. It also allows environmental goals to be attained at a lower overall cost. This is cited as one of the primary virtues of incentive based alternatives.

Under a emission trading program, firms are issued or may purchase permits for each ton of pollution they emit. Once permits have been initially distributed, firms are free to buy, sell, or trade pollution permits with other firms in the market. Each firm's decision to buy or sell permits will depend on the market price of the permit relative to their control costs.

2.3) Command-and-Control Approaches

Conventional approaches to regulating the environment are referred to as "command-and-control" regulations since they allow little flexibility in the means of achieving goals. Early environmental policies, such as the Clean Air Act of 1970 and the Clean Water Act of 1972, relied almost exclusively on these approaches.

In general, command-and-control regulations force firms to shoulder identical shares of
the pollution-control burden, regardless of the relative costs to them of this burden. Command-and-control regulations do this by setting uniform standards for firms, the most prevalent of which are technology-based and performance-based standards. Technology-based standards specify the method, and sometimes the actual equipment that firms must use to comply with a particular regulation. For example, all electric utilities might be required to employ a specific type of scrubber to remove PM10. A performance standard sets a uniform control target for firms, while allowing some latitude in how this target is met. For example, a regulation might limit the number of allowable units of a pollutant released in a given time period, but might not dictate the means by which this is achieved. Holding all firms to the same target can be expensive and, in some circumstances, counter productive. While standards can effectively limit emissions of pollutants, they impose high societal costs in the process, by forcing firms to resort to expensive pollution control technologies.

2.4) Economic Critique of Command and Control Regulations

Economists have long been critical of the traditional command and control regulatory response for protecting the natural environment. First, command and control (CAC) regulations are inherently inefficient. Economic theory provides a strong argument that incentive based regulation is preferable to direct regulation on the grounds of efficiency. In terms of economics, efficiency is achieved when resources are allocated such that all gains from trade are exhausted. Regulatory standards do not provide a mechanism through which gains from trade can be explored. As Nichols (1984) notes, applying inflexible performance standards to heterogeneous firms with different processes and control costs defies this efficiency condition because variations in control costs and benefits are not considered. The result is a highly inefficient allocation of control efforts across emission sources, too tight in some instances, and too lenient in others.

Another major criticism of environmental regulations is that they fail to consider the cost and benefits of the standards they are imposing. Most standards do not even acknowledge the tradeoff which exists between protection and control costs. The level of control defined by BACT may cost one firm $1000 per ton of PM10 abated, and another firm only $500 per ton of abatement. Despite ones views about how much money should be spent to protect the environment, it cannot be denied that gains could be made by reallocating control efforts to
firms with lower control costs.

Standards do not create an incentive for firms to seek innovative control methods to reduce emissions. A firm already in compliance with the standards set on their permit, stands to gain nothing by reducing their emissions below the prescribed level. If firms were rewarded by decreasing their PM10 output, then such measures would not be seen as an expenditure, but rather as an investment. Under an incentive structure, firms would gain both community recognition and economic rewards for their innovative abatement efforts.

Finally, CAC standards discourage R&D and innovation. Under CAC regulations, firms are afraid that any efforts made to reduce emissions beyond that which is stipulated by BACT will be used to set even tighter BACT requirements. This fear makes firms unwilling to invest in control technologies. Without this investment, dynamic efficiency or gains made through the competition in inputs to pollution control are substantially reduced.

2.5) Characteristics of Market-Based Policy Instruments

Market-based instruments have captured the attention of environmental policy makers and businesses because of the potential advantages they offer over traditional command-and-control approaches. The two most notable advantages are (i) cost effectiveness and (ii) dynamic efficiency.

Market-based instruments are cost-effective because they require fewer total resources to achieve the same level of pollution control. Instead of equalizing pollution levels among firms as is the case under CAC regulations, market-based instruments equalize the incremental amount that firms spend to reduce pollution or their marginal cost. As Stavin’s (1996) points out, “Command-and-control approaches could theoretically also achieve this cost-effective solution; However, this would require that different standards be set for each pollution source, and, that policy makers obtain detailed information about the compliance costs each firm faces. Such information is simply not available to government” (p6). In contrast, under economic incentives, market forces assure that control responsibility is rearranged until costs are equalized.

Dynamic efficiency is often overlooked when noting the benefits of emissions trading. Dynamic efficiencies are secondary benefits that accrue as a result of technology innovation and diffusion. (Burtraw 1995) Under an emissions trading scenario, firms realize that each ton of pollution emitted has a price associated with it, and that it is in their financial best interest to
seek new and cheaper ways to reduce these emissions. As a result of this effort to actively seek out control technologies, competition increases in input markets to pollution control. This places downward pressure on prices making the next round of pollution control investments even cheaper.

In theory, if properly designed and implemented, market-based instruments allow any desired level of pollution cleanup to be realized at the lowest possible overall cost to society. Or, alternatively, they offer more control for the same level of resources. They provide incentives for the greatest reductions in pollution by those firms that can achieve these reductions most cheaply.

2.6) Resistance to Market Incentives

While the arguments for emissions trading are compelling, market based incentive programs such as emissions trading have yet to see wide spread application. After over 20 years of theoretical speculation, market incentives play only a small role in the formation of environmental policies, or private firms’ decision on pollution control. The reasons for this are many.

A major reason for a lack of initiative to pursue incentive based regulatory approaches is due to the anti-regulatory climate that has developed during the last decade. This is evident in the fact that there has not been a great deal of new environmental regulation passed by congress. In fact, since 1990, the Clean Air Act, and the Clean Water Act have been the only major environmental laws re-authorized. In an era where any new efforts by the government regulate industry are met with strong opposition, even innovative regulatory approaches are resisted.

There also exists a general fear by environmental compliance and enforcement personnel that if the regulatory framework is changed, then their skills will no longer be needed (Stavins 1996). Traditional regulatory programs call for personnel with technical or legal backgrounds, but market based programs would require a much different skill mix including economists. It is a rationale response to resist programs that could affect ones employment security.

Environmental groups and the uniformed public are often opposed to emissions trading programs. In their view, issuing emission allowances to firms and then allowing them to trade them amongst one another is like licensing pollution, or selling it to the highest bidder. What these groups fail to take into account is that traditional regulatory approaches have been giving
away this right for free. Environmental groups also feel like letting go of the "environmental reigns" on firm behavior by switching to ET would be taking a giant step backward in the fight to improve environmental quality.

Fear of Change and the tendency to adhere to the status quo is another major reason for opposition to ET. In general, businesses are cautious of the regulatory process especially when the process involves spending time and money to learn new operational frameworks for pollution control. Despite how flexible or cost-effective the regulation is supposed to be, the tendency to resist the unknown is strong. Firms often perceive that political forces beyond their control might unfavorably distort the design of the program in an effort to simply up the ante on environmental cleanup.

3) Literature Review

Emissions trading is not a new concept. The idea dates back to Pigou’s (1932) *Economics of Welfare*. In this work, Pigou developed the polluter pays principle. He suggested that when economic activity creates undesirable pollution, the government should impose a charge equal to the damages caused by the pollution thereby forcing firms to internalize those costs. His work has been greatly expanded and modified since its inception, but the core idea remains the same. Externality problems are best dealt with by harnessing market forces, rather than through the imposition of direct regulation.

Ronald Coase (1960), in what has become known as the Coase theorem, furthered the case for economic incentives. Coase’s work unlike Pigou’s was not dependent on the polluter pays principle. In the famous Coase Theorem, it is argued that as long as property rights are well defined, and transaction costs are negligible, the market can be used to efficiently allocate non-market goods such as clean air. According to this theory, regardless of the initial allocation of rights to pollute, disputing parties will work out a mutually beneficial agreement that is pareto efficient. This theory has seen broad application, and can be used to solve a variety of externality problems. Marketable permits are an extension of this theory.

Permits rely heavily on the assignment of property rights. Firms may be required to buy entitlements, or they may be issued them free of charge. In either case, once these entitlements are allocated, the property rights of the permit holder must be clearly defined, secure, and
enforceable in order for the market to work. Firms that reduce their emission below their allotted number of permits may sell their excess permits to other firms for a profit, or apply them to other sources under their control to offset higher emissions elsewhere. As Hanley (1997) notes, in order for permits to serve their purpose as incentives to change pollution control to the desired level, total emission levels within a region are limited so that the permits are valuable to producers. Limiting the amount of permits available, makes emission a valuable commodity, providing the correct incentive for firms to trade, and seek cost effective reductions in emission levels.

The supply of permits available is the single most important factor of a market based trading program. (Figure 2) The supply influences the market price of each permit. The price provides the correct incentive for firms to arrange emission levels such that the cost minimizing solution is reached (Hanley et al 1997). At the margin each firm will evaluate the cost of each permit relative to their own cost per ton of abatement. A firm will then decide on their own privately optimal level of control. If the market price is lower than abatement costs at the margin, a profit maximizing firm will buy permits instead of implementing further emission controls. When too many permits are on the market, the price will fall. The permits will have lost their scarcity value. When the market is flooded with low cost permits, a firm will hold more permits rather than invest in pollution control since this is the least cost option. Refer to Figure 2 for a graphical representation this result. In this example, the MAC curve represents a firms demand for permits. At S* P*, the market for permits has cleared. A firm will demand permits for all levels of activity above this level because abatement costs are higher than the price of each permit. It is clear from this graph, that issuing too many permits (S*) will lower the market value of each permit. Firms will chose to hold more permits, and abatement efforts
will end at $P^*S^*$. The opposite will occur if too few permits are issued. Firms will find it cheaper to abate than hold permits. In extreme cases, constricting the supply of permits may force firms to consider levels of abatement that are not technically feasible, or put some firms at a severe competitive disadvantage. For these reasons, implementing agencies must carefully consider technical feasibility, control costs, and ambient goals when deciding on the number of permits to issue.

 Tradable permits are attractive to regulators because of their power to control the supply of permits. This provides permit programs with a margin of safety even if control costs are higher than expected. This quantity rationing mechanism alone however, is not sufficient to ensure tradable permits meet their intended purpose of lowering the cost of meeting emission goals. Hahn and Noll (1990) identify other key criteria the permit market should satisfy in order to function efficiently and meet air quality goals. First, the number of permits must be limited and well defined so that they are valuable. Second, permits should be freely tradeable with minimal transaction costs. Third, permits must be storable in order to guarantee firms a supply of permits in times of thin trading. Fourth, penalties for violating a permit must cost more than the price of the permit itself, in order to keep firms within the rules of the game. Finally, firms must be allowed to keep any profits they earn as a result of permit trading. The result will be a complete market for pollution trading, which provides firms capability to achieve cost minimizing objectives.

3.1) Key Design Issues

3.1.1 Letting go of the CAC Core:

Many critics, afraid of relinquishing control to ET believe that it is not necessary to rely entirely to a emission trading market to ensure that air quality objectives are met. Instead, it is believed that incentives can be grafted to a CAC core and and still obtain cost savings benefits. As Merrifield (1990) elaborates, “despite growing recognition of the Clean Air Act’s shortcomings, efforts to address them are focused on gradual evolutionary change, rather than a complete overhaul” (p.368). Baumol and Blackman (1980) have argued that economic incentives can be gradually implemented into traditional regulatory approaches. They also suggest that this approach can yield similar results as a permit trading market. Levin (1987) furthered the case for grafted implementation based on the power of inertia. He argued that the
evolutionary approach is the only viable alternative. Regulators and polluters as Levin puts it “will stick with the devil they know”. Efforts to implement revolutionary policies will be wasted.

Merrifield suggests that existing air quality policies cannot be addressed with piecemeal modifications that combine a CAC regulatory core with “add-on opportunities” to trade emissions based on economic incentives. Preserving firm level controls distorts incentives, and severely constrains the performance of trading markets.

3.1.2) The Problem with Non-uniformly Mixed Pollutants

Many pollutants, including PM10, do not mix evenly in the atmosphere. Instead, they exhibit high concentrations in localized areas near the actual source(s) of emission. In cases where emissions depend on both the amount of pollution discharged, and the spatial distribution of the pollution in the atmosphere the use of ET becomes a major concern for air pollution control authorities. The question becomes, how to ensure that neither local nor regional air quality is compromised as a result of emission trades.

The use of Ambient Permit Markets (APM) are one way to ensure that emissions trades do not compromise air quality standards at local monitoring points. Under a APM, the tradable commodity is standardized around a given monitoring station. This ensures that local air quality does not exceed a pre-determined air quality standard. Unfortunately, as Tietenburg notes, APM are currently not administratively feasible due to transaction complexity. An ambient permit system is complex because it involves a separate permit around each monitored receptor. Since a source’s emissions affect each monitored receptor differently in each market, a rather complex pattern of trading transactions would develop (p343). This complexity detracts from a firm’s ability to make informed trading decisions.

Another measure used to ensure that non-uniformly mixed pollutants do not violate air quality standards is rules governing trades. Trading rules regulate each trading transaction. All emissions transactions are constrained pending the evaluation and approval by the air pollution control authority. In many cases, large emissions trades are subject to expensive air dispersion modeling to ensure that the trade will not cause a violation. In addition to adding administrative costs to trades, trading rules also discourage firm’s from investing in emissions abatement technologies. Trading rules create a large amount of uncertainty. A firm will not invest in
pollution control if they fear that trades will be blocked by overly strict trading rules.

Finally, the use of a "cycle and zone" trading system can be used to mitigate against violations at local receptor points. The cycle and zone system creates trading markets with clearly defined trading boundaries and compliance time frames. Firms may only trade across zonal boundaries during specified time frames. Cycle and zone trading can be set up in such a way to allow for maximum trading flexibility without compromising air quality. If cross zonal trades do occur out of cycle, then modeling requirements may be imposed. Although, this method does limit potential cost savings, it is by far the most preferable method in the case of non-uniformly mixed pollutants.

3.1.3) Monitoring and Enforcement Problems

Monitoring and enforcement are other areas of concern under an emissions trading market. The ability to accurately quantify emissions is especially important under emissions trading. Compliance with required reductions, and claimed reductions cannot be certified without an accurate record of emissions. But continuous emission monitoring is expensive and would consume resources that could otherwise be devoted to pollution control or the purchase of permits. With strict monitoring requirements in place potential cost savings would be reduced. This is often cited as one of the primary deterrents to emission trading. Enforcement can also detract from the cost savings advantages. It is expensive to hire enforcement personnel to make sure firms are not cheating. Without adequate enforcement personnel to police cheating behavior, a plant manager would have an incentive to claim false emission reductions. There are other options that can be used to record emissions such as periodic sampling. These methods are less accurate, and still quite costly.

3.2) Historical Experience

3.2.1) Acid Rain Program

"In 1992, the Tennessee Valley Authority (TVA), a major producer of electric power, purchased the rights to generate more pollution due to emissions trading. Specifically, TVA bought 10,000 tons of pollution allowances from Wisconsin Power and Light. This transaction was made possible by Title IV of the Clean Air Act of 1990, which required power companies to reduce their emissions of Acid Rain causing pollutants such as sulfur dioxide, but provided
flexibility in how firms could achieve the reductions" (Miller p. 96). This flexibility allowed TVA to fail their reduction requirement since Wisconsin Power and Light exceeded their reduction. In essence, Wisconsin Power and Light was paid to reduce TVA’s emissions. Provided the overall reduction goal is met, the allocation of control is left to the market.

Title IV of The Clean Air Act initiated a historic experiment in incentive based regulation through the use of tradable emission allowances. The “Acid Rain Program”, as it is called, was the first major step taken to put economic theory into practice. The program applies to electric generating facilities that emit sulfur dioxide. The program imposed a sharp emissions cap on generating facilities, but allowed firms the flexibility to select the most cost-effective method to meet the reduction requirement. Compliance options under the Acid Rain Program include the purchase allowances from other firms that have exceeded their requirements, installing emissions controls such as scrubbers, upgrading plants, closing plants, switching to cleaner fuels such as natural gas, or fuel blending (blend coals w/ various sulfur content to lower average emissions). Depending on the market price of allowances relative to their own private abatement costs, firms choose their own privately optimal compliance strategy.

3.2.2) Evaluating the Acid Rain Program

The Acid Rain program has provided substantial cost savings relative to what would have achieved under command and control, yet the program has fallen short of the theoretically envisioned expectations. Trading volumes in the allowance market have been far lower than expected. In contrast to this fact, Burtraw indicates that industry’s cost of compliance has been surprisingly low. This has defied the belief that low cost compliance can only be achieved under active trading. Burtraw (1995) explains this phenomenon by pointing out that active trading is neither necessary nor a sufficient condition for cost effectiveness. Theoretically, cost could be minimized if control responsibility was allocated according to marginal pollution. In this case, no trading would be needed.

It turns out that low control costs despite inactive trading can be attributed to lower than expected control costs. Prices in input markets to pollution control have dramatically decreased as a result of dynamic incentives. For example, the price of rail transport of low sulfur coal decreased substantially under the Acid Rain Program, due to increased competitive pressure. The price of scrubbers and fuel blending also decreased. The increased demand for pollution
control greatly accelerated competitive forces and led to overall lower prices. It remains to be seen whether the trading market can continue to demonstrate lower costs without increasing trading activity.

3.2.3) RECLAIM

The Region Clean Air Incentives Market (RECLAIM) program was established by the South Coast Air Quality Management District (SQAQMD) to give companies flexibility in meeting emission reduction requirements and lower the cost of compliance by as much as 50%. Under RECLAIM, companies are allowed to choose their control methods and timing of the required reductions. This experimental market based program was designed to be more cost effective than the old command and control rules because it allows the opportunity to choose an emission reduction program that best fits the needs of the facility. A facility that finds innovative ways to exceed their reduction requirement may sell their excess allowance credits to other firms to help offset compliance costs.

Facilities were included in the RECLAIM program if their emissions historically exceeded 4 tons per year. Each RECLAIM facility is issued a single facility permit, and based on its historical emissions were given an annual emission allocation. This allocation is generally referred to as an emission cap which shrinks annually. Each year the emission allocation shrinks by 7%. RECLAIM facilities are forced to achieve their yearly emission reduction through the use of add-on controls, modernization, process improvements, or purchasing RECLAIM Trading Credits (RTC’s). An emission reduction credit authorizes the holder to emit one pound of NO\textsubscript{x} for a specified year, and at the end of each year any remaining credits expire. RTC’s under RECLAIM may not be banked for use in future years.

3.2.4) Trading Emissions Under RECLAIM

Trading is a term used to identify a sale or purchase of an RTC. The term trading is used in the emissions trading market much the way it is used on the New York Stock Exchange. Once a facility evaluation has been conducted, and the point where its estimated emissions exceed its allocation has been identified, a company may decide whether or not to trade RTC’s. RECLAIM companies whose annual allocation is insufficient for current production levels may either decide to purchase RTC’s or install control technology. Facilities that do not use all of their allocation in a given year may sell them to other companies.
The trading rules are set up under RECLAIM to allow for maximum flexibility without compromising air quality objectives. The trading is structured on a Zone and Cycle basis to avoid impacts in localized areas. Strict monitoring and reporting requirements ensure that facilities are meeting the reduction requirements. Trading rules do not require that the RTC's be banked prior to use as with command and control rules, and authorization is not required to execute a trade. This ensures that the administrative costs of the program remain minimal. RTC's are traded on a 1:1 ratio, and are not subject to devaluation. RTC's are traded for specific years, and therefore can be used to achieve both short and long term compliance.

3.2.5) RECLAIM Evaluation

Emissions trades under RECLAIM have been active relative to the Acid Rain Program. More than $10 million in trades have been registered since the program started in 1994. However, complicated trading rules, strict monitoring requirements, and a market flooded with low cost RTC's has stalled overall performance. It is estimated that as the supply continues to ratchet down market prices will increase correcting the faulty price signals that are prevailing in early years. At the present time, an ample supply of low cost permits is the compliance option of choice. Firm's will continue to use this option until the price of RTC's causes firm's to think seriously about other control options. The price of RTC's is expected increase substantially in the year 2000 as other trading credits that were grandfathered into the RECLAIM program are used up, and as emission reduction requirements continue to ratchet down. RTC prices averaged $26/ton for 1994 and $1500/ton for credits in 2010.

Overall, implementation of RECLAIM has been highly successful. Analysis after two years of operation indicates that the program is meeting its emission reduction goal, and has substantially reduced compliance cost (SCAQMD 1997 RECLAIM Annual Report). Aggregate actual emissions from facilities under RECLAIM were below allocations for the first two compliance years. Despite some early successes, two fundamental deficiencies have surfaced. First, the market is made up of uniformed buyers and sellers. This has led to erratic prices set by buyers who do not understand the market, or firms selling permits for based on their own cost evaluation rather basing prices on market trends. The immature market combined with a lack of confidence many managers have with the trading program have caused many to delay purchasing credits or installing emission controls. Another program flaw is that permits for
compliance in a specified year must be used in that year. Companies who hold excess credits must pay a penalty for each excessive credit. This causes facilities to dump cheap permits on the market without respect to market prices. It also discourages managers from investing in cost effective emission controls. Managers are not willing to take risks on uncertain market conditions when they alone must take responsibility for a bad business decision.

3.3) Lessons Learned

In order to achieve optimal results, trading rules should be designed to deliver the following benefits: 1) reduce transaction costs; 2) increase certainty as to the rights bestowed under the program; 3) ensure competitive market conditions; 4) offer incentives to participate; and 5) provide sufficient information to program participants.

3.4) Market Simulation Under Emissions Trading and CAC

The following hypothetical example will compare compliance costs under a CAC regulatory structure and under a emissions trading structure. Although the example will assume that firms have the information needed to make calculated decisions, (a condition that does not always hold true in the real world) the example will be sufficient to make general comparisons about firm behavior and compliance costs. Firms will be divided into three different classes based on their marginal abatement cost (MAC) in order to simplify the example. A graph will be used to show firm behavior and outcomes under a trading market scenario. In order to see if the market leads to a more efficient outcome, the compliance costs of a 20% reduction in PM10 emissions will be compared to the cost of achieving the same standard through the direct regulation of each firm.

Given the three types of construction firms, type A firms emit a larger percentage of PM10 than type B or C firms. Each firm class faces different abatement cost owing to company size, project size, labor costs, construction practices, time table, and weather conditions present during construction activity. The abatement costs given will assume a maximum 60% removal efficiency. This accounts for technical imperfections. No matter how much money a firm spends on abatement, it is not possible to reduce emissions to zero. The inequality in abatement costs provides the motivation for market permits. Firms with the lowest marginal abatement
cost (MAC) have an incentive to reduce emissions the most provided they can sell their unused allowances to other firms for a profit.

Table 1 Market Simulation Data

<table>
<thead>
<tr>
<th></th>
<th>Type A</th>
<th>Type B</th>
<th>Type C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of firms</td>
<td>60</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>current emissions in tons</td>
<td>13800</td>
<td>11385</td>
<td>9315</td>
</tr>
<tr>
<td>Allowable emissions</td>
<td>11040</td>
<td>9108</td>
<td>7452</td>
</tr>
<tr>
<td>Reductions required to meet goal</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Abatement costs/ton</td>
<td>500</td>
<td>350</td>
<td>250</td>
</tr>
</tbody>
</table>

3.4.1) Direct Regulation Costs

The data above indicates that Type A firms must cut PM10 emissions by 2,760 tons in order to meet the 20% reduction goal. Type A firms will pay a total of (2760*$500)$1.38 million dollars if each firm individually meets the standard reduction. Type B firms must reduce emissions by 2,277 tons. At a cost of $350/ton this will cost Type B firms a total of $796,950. Finally, Type C firms must cut emissions by 1,863 tons at $250/ton, Type C firms will pay $465,750. Totaling the individual control costs of each firm results in a total cost of $2,642,700.

This figure only reflects control expenditures. In order to determine total compliance costs, record keeping, emission reporting, and other administrative compliance expenditures must be added to this.
If firms are allowed to trade pollution permits, the total cost of meeting the 20% reduction should decrease. Refer to Figure 3 for a graphic model of the trading scenario. The supply curve is upward sloping, indicating that as the price of each permit increases, the quantity supplied increases. The supply PM10 credits is created by firms that reduce their emissions by more than the 20% requirement. The total market supply equals 16,500 allowances. This figure is the total of each firm’s allowable emissions after the 20% reduction factoring in a PM10 removal efficiency of 60%. The supply curve begins at a price of $250. No firm will supply reduction allowances if the price is below this amount.

When the market price exceeds $250, Type C firms will begin to supply reduction credits. Type C firms will find it profitable to reduce their PM10 emissions by the maximum amount possible, and sell their reduction credits to other firms since their abatement cost/ton is less than $250. Type B firms will begin to supply reduction credits when the market price exceeds their MAC of $350. Like Type C firms, they will find it profitable to exercise the maximum amount of abatement and sell their reduction credits. Type A firms will not supply credits until the market price exceeds $500 per ton. Type A firms supply will never enter the market though since the 6,900 ton reduction requirement will have already been supplied by C and B firms by the time prices reach $500.

At a market clearing price of $400 per ton, Type C firms will have supplied 2,609 allowances, and type B firms 3187 allowances, however, only 151 of B’s allowances will be demanded. Type A firms will find it advantageous to buy allowances from these firms (2609 from A and 151 from B) rather than abate emissions at this price level.
The economic model above shows three separate demand curves owing to the different abatement costs of each firm class. The demand curves are upward sloping indicating that as the permit price falls, the quantity demanded will increase. The above market simulation model shows when each firm will enter the market for PM10 allowances. Type C firms will demand reduction credits equal to 1863 tons as long as the price is below $250. Type B firms will demand 2277 allowance credits when the price is below $350, and Type A will demand 2760 permits until the price exceeds $500/ton.

3.4.2) Measuring Results

The air quality goal called for a 20% reduction in PM10 from all construction sources within the valley. Last year PM10 emissions from construction sources totaled approximately 34,500 tons. Based on the 1995 PM10 inventory, a 20% reduction would cap PM10 emissions at 27,600 tons. This means that collectively or individually, emission would have to fall by 6,900 tons. Under the standard regulatory approach this would require that each firm reduce emissions by 46 tons. Under, the market trading model, the collective amount of control did not change, only the distribution of control. In the above example, 40 Type C firms contributed 4,472 tons of reduction requirement, and the remaining 2,428 tons were supplied by Type B firms.

3.4.3) Compliance Cost

Under the market trading scenario, type A firms bought 2,760 tons of allowance credits for $400 per credit totaling $1,104,000. Type B firms will reduce emissions by 2,428 tons which is more than their required reduction. This reduction will cost ($350*2,428) $849,800. This amount will be partially offset by the sale of 151 reduction credits for $400/credit for a $60,400. This will reduce Type B firms compliance costs to $789,400. Type C firms will reduce emissions by the maximum amount possible to 4,472 tons. Type C firms will pay ($250*4,472) $1,118,000 for this level of reduction. This amount will be offset by $1,043,600 from the sale of 2609 (4472-1863) reduction credits at $400 per credit. This will reduce Type C firms compliance costs to $74,400. The total compliance cost for all firm classes in the trading market is $1,967,800. Comparing this total to the $2,642,700 paid by firms under direct regulation reveals a savings $674,900. The market trading approach reduced the cost of meeting the desired air quality goal by over $700,000.
3.4.4) Analyzing Results:
The market simulation, although hypothetical, showed that emissions trading is an attractive policy instrument. The example could easily apply to any group of sources with heterogeneous control costs. Emission trading substantially reduced compliance costs of meeting the desired air quality goal. Clearly this method represents a more efficient allocation of resources. Control efforts were redistributed to firms with the lowest control costs. Firms with low control cost gladly accepted this control burden, since in effect high cost firms pay them an attractive price to handle their share of the control burden.

4) Building On Experience: Considering Emissions Trading In Las Vegas

4.1) Implementing a Trading Program

Building on what has been discussed so far, the focus of this paper will move to considering the feasibility of implementing a “full blown” PM10 Trading Market in Las Vegas. “Full blown” means that it will not represent a supplement to the CAC regulatory structure already in place. Feasibility will be determined based upon analysis of control costs, obstacles to implementation, political acceptability, and impacts to air quality. The PM10 market will include all stationary sources within the Las Vegas Valley that emit over 1 ton of PM10, and all construction sources that emit over 5 tons of PM10. The program will require all facilities included in the trading universe to reduce their emissions by 20% based on the Clark County Health District 1995 PM10 Emission Inventory. Facilities included in the trading program will be free of all tradition regulatory requirements except BACT requirements, and New Source Review requirements. Regulatory requirements that will be dropped include:

- ATC requirements will be dropped
- New Source Performance Standards requirements will be dropped
- Permit costs and emission fees for permit review will be dropped
- Source modification requirements will be dropped
- Annual emission fees and emission unit fees will be dropped
- Offset requirements will be dropped for all PM10 emissions

The objective of the trading program is twofold. The first objective is to increase value; (the ability to buy more air quality for each dollar spent). This is accomplished by giving firms
flexibility to decide their own privately optimal compliance strategy. The second objective is to provide the correct incentive for firms to make proactive rather than reactive emission control decisions. The 20% emission cap will provide this incentive.

4.2) **Key Design Issues**

4.2.1) **Establishing the Trading Universe**

This section will identify sources to be included in the PM10 trading market and subject to the 20% emission cap. As mentioned above, all stationary sources with historical PM10 emissions over 1 ton per year, and all construction activities that disturb over 1 acres would be included in the trading universe.

According to the Clark County Health District Air Pollution Control, there are approximately 850 stationary sources permitted in the Las Vegas Valley, of these about 119 facilities would be included in the PM 10 trading universe. The 119 facilities include all permitted stationary sources with historical emissions in excess of 1 ton per year (TPY). Together these sources account for about 1,800 tons of PM10 per year. If all sources met their reduction goal of 20% valley wide PM10 emissions from stationary sources would be reduced to 1,440 TPY.

As Table 2 indicates, construction sources, which include all temporary processes involving land clearing, grading, trenching, material unloading, and building, are categorically the largest contributor to PM10 emissions annually. This is due to the rapid rate of growth Las

<table>
<thead>
<tr>
<th>Source Category</th>
<th>1995 Emissions (tons)</th>
<th>20% reduction</th>
<th>% Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary Sources</td>
<td>1,855</td>
<td>1,484</td>
<td>2.1</td>
</tr>
<tr>
<td>Residential Wood Burning</td>
<td>309</td>
<td>247</td>
<td>.4</td>
</tr>
<tr>
<td>On Road Exhaust</td>
<td>823</td>
<td>658</td>
<td>.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>---</td>
<td>---</td>
<td>-----</td>
</tr>
<tr>
<td>Paved Roads</td>
<td>6,759</td>
<td>5,407</td>
<td>7.7</td>
</tr>
<tr>
<td>Unpaved Roads</td>
<td>6,142</td>
<td>4,913</td>
<td>7.1</td>
</tr>
<tr>
<td>Construction Activities</td>
<td>34,849</td>
<td>27,849</td>
<td>39.9</td>
</tr>
<tr>
<td>Disturbed Land</td>
<td>4,944</td>
<td>3,955</td>
<td>5.7</td>
</tr>
<tr>
<td>Off-Road Racing</td>
<td>166</td>
<td>133</td>
<td>.2</td>
</tr>
<tr>
<td>Background</td>
<td>31,414</td>
<td>31,414</td>
<td>36</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>87,261</strong></td>
<td><strong>76,092</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Vegas continues to experience. These activities account for 40% of PM10 emissions annually. Capping emissions at 80% of the based on 1995 emission level would reduce PM10 by almost 7,000 tons per year.

Unlike stationary sources, construction sources are not required under the Clean Air Act to obtain an operating permit. This is because construction activities due to their non-permanent nature defy the definition of a stationary source. As a result, it is difficult to determine the exact number of facilities to include in the market. Also, due to the nature of construction sources, it is not practical to allocate emissions based on historical production in any given year.

Construction sources would not be “pre-qualified” for the program like stationary sources. Instead, construction activities would be required to opt into the trading program for all site activities involving the disturbance of 1 acre or more.

4.2.2) Allocating Emissions

In the case of Stationary Sources, each of the facilities included in the trading universe will be issued permits free of charge at the beginning of each operating year. Each permit will equal 1 ton of PM10. Allocations will be based on the average PM10 emissions for the last three operating years. At the beginning of each year, each facility will be issued allowances. Any facility that exceeds their allocation, must purchase permits from another firm who has exceeded their reduction requirement. Stiff penalties will be imposed on firms who do not have enough permits to cover their emissions at the end of the operating year.
The 20% reduction in emissions will be gradually imposed rather than instantaneous. This will allow facilities time to get used to the trading market, and plan their compliance strategy (Figure 4).

Allocations will shrink by 5% a year until the 20% reduction goal is met. As allocations begin to fall below expected emissions, permits will become especially valuable. Firms that find ways to make cost effective reductions could make substantial profits as permit prices increase.

In the case of construction sources, allocating permits will not be quite so simple. Since emission levels with construction sources are highly unpredictable from year to year, there is no fair way to allocate credits to each facility. Instead, permits worth 1 ton of PM10, would be issued to all facilities required to obtain permits on a quarterly basis. Permits would be issued based on a control efficiency of 85%, and allocated to facilities on a quarterly basis. Additional permits, if available, could be purchased at the prevailing market price. If a facility demonstrated that they had not used all of their allocation, they could sell their excess credits to other firms or keep them for future projects. PM10 credits would be rationed over a period of 4 quarters. This would amount to 7,000 tons per quarter, totaling 28,000 ton per year. All unused credits would be transferred to the next quarter; however, at the end of each year unused allocations would dumped. Discounting would be applied to credits held by firms used in years other than the year of issuance. This way, firms would not be completely discouraged from investing in emission controls under conditions of market uncertainty.

4.2.3) Creating Tradable PM10 Credits

Flexibility is achieved by giving firms multiple compliance options instead of just one. There are a variety of options available to create tradable PM10 credits. However, in order to sell permits a firm must certify that their emissions are below their allocation. A firm may install hardware that improves control efficiency thus generating excess credits (refer to Table 2) for a list of available PM10 control methods and hardware. Other credit generating activities include plant shutdowns, road paving, and stabilization of disturbed land.
Table 3 Control Options

<table>
<thead>
<tr>
<th>Control Method</th>
<th>Application</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baghouse Filters</td>
<td>Stationary sources that can be enclosed</td>
<td>99%*</td>
</tr>
<tr>
<td>Water Trucks</td>
<td>Stationary/Construction</td>
<td>87% @2% moisture**</td>
</tr>
<tr>
<td>Water Spray Systems</td>
<td>Stationary Sources</td>
<td>90%*</td>
</tr>
<tr>
<td>Water Foggers</td>
<td>Stationary Sources</td>
<td>95%*</td>
</tr>
<tr>
<td>Foam Spray Application</td>
<td>Stationary/Construction</td>
<td>85%*</td>
</tr>
<tr>
<td>Wind Dams</td>
<td>Stationary/Construction</td>
<td>25%***</td>
</tr>
<tr>
<td>Chemical Dust suppressants/stabilizers</td>
<td>Construction/Stationary/Disturbed Land/Unpaved roads</td>
<td>90%*</td>
</tr>
<tr>
<td>Staged Project Planning</td>
<td>Construction</td>
<td>50%***</td>
</tr>
<tr>
<td>Install Pavement at Unpaved Sites</td>
<td>Construction/Stationary (used to mitigate land dist)</td>
<td>50***</td>
</tr>
</tbody>
</table>

* Efficiency obtained from manufacturers
** EPA document AP-42
*** Best engineering guess

4.2.4) Compliance Options

Facilities subject to the trading market have a variety of compliance options available to them. Facilities may meet emission targets by purchasing additional credits, implement cost-effective emission control methods, retire plants, or limit operating hours. In order to determine the best compliance option, a cost analysis of each alternative is required.

Although some facilities may choose to reduce their emission by closing down plants or postponing projects, for many companies installing control technology or improving existing processes may be the best compliance option. The installation of hardware may cost less than purchasing credits on the open market, it may also enable the facility to generate excess credits, thereby further offsetting compliance costs.

4.2.5) Monitoring & Enforcement

Monitoring and enforcement are key areas of concern. The ability to accurately record
emissions is critical in determining compliance with emission targets. Also, enforcement must be regular and swift so firms will not cheat or attempt non-compliance. Cheating firms, and non-compliance both have the ability to undermine program goals. As such, emissions monitoring and reporting would be a strict requirement of the program.

Monitoring and reporting is a major strike against the case for a PM10 trading market. The cost of continuous emissions monitors (CEM), and other suitable equipment is extremely prohibitive. Efforts to impose this requirement would be strongly resisted by industry. Further, installing CEM equipment at non-permanent locations such construction sites is simply not feasible. A possible alternative to CEM installations is periodic emissions sampling done with portable mass flow monitors. Period emissions "spot checks" could be used to estimate average emission rates. The spot checked emissions would be converted into pounds per hour and then multiplied by operating hours to determine total PM10 emissions. Although periodic sampling alleviates the need for CEM's in many cases, even this method would be quite expensive. The County would have to staff additional positions and purchase expensive portable monitoring equipment in order to conduct spot checks on all non-CEM facilities.

4.3) Evaluating Feasibility

4.3.1) Impacts To Air Quality

One of the most notable benefits of the trading market is the 20% emission cap. Reducing PM10 emission by 20% based on 1995 production levels would save about 7,400 ton of PM10 annually. This saving would have a positive affect on air quality in the Las Vegas Valley. Despite this benefit, there is a legitimate concern that PM10 trades could result in violations of air quality standards at PM10 monitoring stations.

Policy makers have good reason to fear incentive based regulations. Under an emission trading structure, individual or firm decision makers do not look beyond the direct benefits and costs when choosing one compliance option over the other. Air quality decisions made on a decentralized basis where cost is the primary consideration, not air quality results, is a dangerous prospect especially in the case of non-uniformly mixed pollutants. As discussed previously, PM10 does not mix evenly in the air. Its concentration is highly dependent on spatial and intensity factors. Trading rules and modeling requirements would need to be imposed to ensure compliance with PM10 Air Quality Standards.
The need for complex trading rules and emissions modeling is another major strike against using a market based approach. Trading rules detract from the overall cost saving that can be achieved from a trading emission because it excludes many trading opportunities. A cycle and Zone trading structure is the best alternative available, but even this type of arrangement would severely limit the effectiveness of the trading market. It would require that "micro-markets" be set up in zones corresponding to area monitoring stations. Cross zonal trades, if allowed would be subject to modeling to ensure that pollution transferred from one zone to the other did not cause violations.

Although zonal trading boundaries reduce cost savings, they do offer some benefits. In the case of Las Vegas such a system, would be an improvement to the current system of offsetting. Offsetting requires that firms pay a fee of $300 dollars per ton of PM10 emission equaling twice their actual emission output. This fee is used for road paving and other projects that reduce valley-wide emission levels. The problem is that the emissions that are offset do not necessarily improve air quality because the PM10 emissions that are offset by road paving are not always next to the affected monitoring station. This means that ambient PM10 concentrations could actually increase around certain stations even though firms are offsetting emissions at a ration of 2:1. Zonal trading boundaries improve the current offsetting system by ensuring that improvements are made around each affected monitoring station.

4.3.2) Cost Effectiveness

Cost effectiveness is above all, the most important criteria of any incentive based structure. Theoretical conditions have shown that the potential cost savings of incentives relative to CAC depends on heterogeneous control cost. Greater disparity in control cost among firms means greater cost savings. Therefore, it stands to reason that without this variation in pollution control cost, little can be gained by reallocating emissions.

Marginal Abatement Cost (MAC) determines the cost-effectiveness of one compliance strategy over another. MAC refers to the incremental cost incurred by a firm to remove each addition unit of PM10 in this case from the air. Up until this point, the subject of MAC has been skinned over in making observations about the advantage of rearranging emissions based on control cost. However, in order to assess the feasibility of using a market for PM10, actual cost
data for various PM10 control strategies needs to be assessed. Cost effective evaluations are used to identify the incremental cost of removing each ton of PM10. Each firm must evaluate their own private abatement costs relative to the price of permits if they cannot meet their emission allocation in order to find the least cost solution.

Cost data obtained from equipment manufacturers, and operators indicates that enough variation in operating cost exists to provide incentives to trade control responsibility. However, in many cases, especially in water applications, the variation is small. The cost of decreasing PM10 emission falls as emission output increases. Firm's with high emissions stand to gain the most by installation of control equipment. Factors that influence control costs include water costs, labor costs, fuel costs, and operation and maintenance expenses. Water cost is the largest single input cost for wet suppression. Most operators that use rely on water for dust suppression must obtain an industrial use permit. The cost of water under such a permit according to the Las Vegas Valley Water District is $1.92/1000 gallons. The difference in control cost does not come from the varying cost of water, but the varying efficiencies with which different wet suppression systems consume water. Systems that do not use water efficiently, and that require a lot of labor time for maintenance are less cost effective at any given emission levels. The data included in Table 4 should provide a general estimation of control cost. Facilities have different needs, and their processes differ significantly. As a result precise cost estimates can only be provided on a case by case basis.

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Water Truck**</th>
<th>Baghouse Filter*</th>
<th>Foam Spray*</th>
<th>Water Spray Bars*</th>
<th>Water Foggers*</th>
<th>Wind Dams**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Costs</td>
<td>40,000</td>
<td>$125,000</td>
<td>30,000</td>
<td>$25,000</td>
<td>$20,000</td>
<td>5,000-10,000</td>
</tr>
<tr>
<td>Uncontrolled Emission Rate</td>
<td>56.0</td>
<td>56</td>
<td>56</td>
<td>56</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>Control Efficiency</td>
<td>87%</td>
<td>99%</td>
<td>86%</td>
<td>90%</td>
<td>85%</td>
<td>25%</td>
</tr>
<tr>
<td>Expected Emissions TPY</td>
<td>7.5</td>
<td>1</td>
<td>8.4</td>
<td>6</td>
<td>8.4</td>
<td>42</td>
</tr>
<tr>
<td>Water Consumption gal/min*</td>
<td>20.0</td>
<td>4</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Annual Consumption gallons</td>
<td>1872000</td>
<td>4992000</td>
<td>1248000</td>
<td>4992000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Annual Water Cost @ $1.92/1000 gal</td>
<td>3594</td>
<td>958</td>
<td>2396</td>
<td>958</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>O&amp;M Costs*</td>
<td>27872</td>
<td>20000</td>
<td>10500</td>
<td>3620</td>
<td>4120</td>
<td>1000</td>
</tr>
<tr>
<td>Total Annual Operating Costs $</td>
<td>31466</td>
<td>20000</td>
<td>11458</td>
<td>6016</td>
<td>5078</td>
<td>1000</td>
</tr>
<tr>
<td>Cost-Effectiveness $/ton removed</td>
<td>$ 656</td>
<td>$ 364</td>
<td>$ 244</td>
<td>$ 120</td>
<td>$ 107</td>
<td>$ 71</td>
</tr>
</tbody>
</table>
### Low Emissions Case

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Water Truck</th>
<th>Baghouse Filter</th>
<th>Foam Spray</th>
<th>Wind Dams</th>
<th>Water Foggers</th>
<th>Water Spray Bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Costs</td>
<td>40,000</td>
<td>$125,000</td>
<td>30,000</td>
<td>5,000-10,000</td>
<td>$20,000</td>
<td>$25,000</td>
</tr>
<tr>
<td>Uncontrolled Emission Rate</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Control Efficiency</td>
<td>87%*</td>
<td>99%</td>
<td>85%</td>
<td>25%</td>
<td>85%</td>
<td>90%</td>
</tr>
<tr>
<td>Expected Emissions TPY</td>
<td>3.3</td>
<td>3.25</td>
<td>19</td>
<td>3.75</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Water Consumption gal/min*</td>
<td>15.0</td>
<td>0</td>
<td>2</td>
<td>1.5</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Annual Consumption gallons</td>
<td>140,400</td>
<td>0</td>
<td>249,600</td>
<td>0</td>
<td>187,200</td>
<td>599,040</td>
</tr>
<tr>
<td>Annual Water Cost @ $1.92/1000 gal</td>
<td>2696</td>
<td>0</td>
<td>479</td>
<td>0</td>
<td>359</td>
<td>1,150</td>
</tr>
<tr>
<td>O&amp;M Costs*</td>
<td>20,904</td>
<td>15,000</td>
<td>7,500</td>
<td>1,000</td>
<td>4,120</td>
<td>3,620</td>
</tr>
<tr>
<td>Total Annual Operating Costs</td>
<td>23,600</td>
<td>15,000</td>
<td>7,979</td>
<td>1,000</td>
<td>4,479</td>
<td>4,770</td>
</tr>
<tr>
<td>Cost-Effectiveness $/ton removed</td>
<td>$1,085</td>
<td>$625</td>
<td>$170</td>
<td>$154</td>
<td>$211</td>
<td>$214</td>
</tr>
</tbody>
</table>

*Cost data obtained from equipment vendors and plant operators. A labor rate of $12/hr was used, and $1.92/1000gallons for water.

### High Emissions Case

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Water Truck</th>
<th>Baghouse Filter</th>
<th>Foam Spray</th>
<th>Water Foggers</th>
<th>Water Spray Bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Costs</td>
<td>40,000</td>
<td>$125,000</td>
<td>30,000</td>
<td>$20,000</td>
<td>$25,000</td>
</tr>
<tr>
<td>Uncontrolled Emission Rate</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Control Efficiency</td>
<td>87%*</td>
<td>99%</td>
<td>85%</td>
<td>85%</td>
<td>90%</td>
</tr>
<tr>
<td>Expected Emissions TPY</td>
<td>9.8</td>
<td>11.25</td>
<td>11.25</td>
<td>7.5</td>
<td>56</td>
</tr>
<tr>
<td>Water Consumption gal/min*</td>
<td>25.0</td>
<td>0</td>
<td>6</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Annual Consumption gallons</td>
<td>234,000</td>
<td>0</td>
<td>748,800</td>
<td>748,800</td>
<td>149,760</td>
</tr>
<tr>
<td>Annual Water Cost @ $1.92/1000 gal</td>
<td>4493</td>
<td>0</td>
<td>1438</td>
<td>1438</td>
<td>2875</td>
</tr>
<tr>
<td>O&amp;M Costs*</td>
<td>34,840</td>
<td>25,000</td>
<td>12,500</td>
<td>4,120</td>
<td>3,620</td>
</tr>
<tr>
<td>Total Annual Operating Costs</td>
<td>39,333</td>
<td>25,000</td>
<td>13,938</td>
<td>5,558</td>
<td>6,496</td>
</tr>
<tr>
<td>Cost-Effectiveness $/ton removed</td>
<td>$605</td>
<td>$333</td>
<td>$219</td>
<td>$87</td>
<td>$71</td>
</tr>
</tbody>
</table>

*Cost data obtained from equipment vendors and plant operators. A labor rate of $12/hr was used, and $1.92/1000gallons for water.

### 4.3.3) Firm Level Trading Decisions

Figure 5 below shows marginal abatement costs (the incremental cost of each additional unit of PM10 removed) for a variety of PM10 emission control techniques. Note that as emissions levels increase emission control becomes more cost-effective. Firms with low uncontrolled emissions will find it more expensive (per ton of PM10 removed) than firms with higher uncontrolled emissions. If armed with information on marginal control costs, firms can make calculated buy and sell decisions at any given level of emission output. For example, if XYZ Company used foam spray applicators to control emissions, at an emission output level of 55 tons per year the MAC or put another way, their cost of producing emission reductions would
be approximately $250/ton of PM10 removed. At any market price below $250/ton XYZ Company will find it profitable to buy allowances. Similarly, if the prevailing market price is above $250/ton, XYZ will enter selling market. Once their reduction requirement is met, XYZ can sell all excess reductions to other firms for a profit.

Assuming that all firms in the PM10 market exhibit the same profit maximizing behavior as XYZ company, the trading market will result in a cost minimizing solution; control efforts will be allocated according to marginal control cost.

4.3.4) Resistance and Political Factors

No matter what the benefits of a new policy initiative there is a strong tendency to adhere to the status quo. Regulator’s and industry groups alike have legitimate reasons to fear new policies. There are a great many political factors that underlie the policy process. The most important of these is industry resistance to a proposed policy. In the case of a PM10 trading market in Las Vegas reviews from industry would differ significantly between stationary sources and construction sources. Stationary sources are already heavily regulated under various requirements of the Clean Air Act (CAA). Any relief from the narrow regulatory prescription currently enforced would be welcomed.

Resistance from construction sources on the other hand would be strong. Construction
sources are not subject to the same rigorous requirements under the CAA as stationary sources. They escape the permitting requirements, offsetting requirements, and other fees that stationary sources must pay despite their large contribution to PM10 air pollution. Any attempt to impose new regulations on construction sources would result in litigation. It could take an act Congress to modify the Clean Air Act so that implementing agencies had the statutory authority to regulate construction sources. The construction industry has a powerful influence on local politics. Policy makers would be very reluctant to endorse a program that was opposed by such a powerful industry group even if legal barriers could be overcome.

4.4) Feasibility Determination

In consideration of using a emission trading market to regulate PM10 emissions in the Las Vegas Valley, it is the finding of this paper that the program is not feasible at the present time. Although control cost data indicate that there is enough variety in abatement costs to provide opportunities to gain from trading, complex trading rules, and expensive emission monitoring requirements would severely limit the effectiveness and popularity of an emissions trading program. In addition, legal and political barriers would make implementing such a program nearly impossible. Until these factors can be overcome, the present system, though more costly, may be the only viable alternative.

5.0) Conclusion

Economics is becoming increasingly important in today’s regulatory environment. Businesses and policy makers are becoming more aware of the trade-off that exists between environmental protection and economic development. As a result cost-effective environmental policies that take into account the cost and benefits of the standards they impose will continue to gain popularity. This paper found that economic incentives can play a powerful role in correcting or at least improving externality problems such as air pollution by placing a price on each increment of pollution. The price provides the correct incentive for firms to control their
emissions. Under CAC regulations pollution is not given a price, as a result plant managers do not make the association that their pollution is worth money.

Incentives provide the flexibility firms need to decide their own privately optimal level of control. This enables the cost minimizing solution to be reached. They also provide a mechanism through which value is placed on a non-market good namely pollution. This market value prompts firm’s consider whether it is cheaper to buy pollution or prevent it. In practice and theory emission trading showed substantial overall cost savings advantages over the direct regulatory approach. This saving is achieved by reallocating control efforts to firms with the lowest control costs.

As for the PM10 market in Las Vegas, the paper found that although in theory it was a good idea, this particular pollutant is not especially conducive to decentralized regulatory structures. Trading market complexities, difficult and expensive emission monitoring, and political and legal barriers would all combine to make the prospect nearly impossible. Emission trading could be applied to stationary sources alone with much greater effectiveness, however, the gains from this would be too small to make it worth pursuing. Stationary sources are only responsible for about 2% of PM10 emissions annually.

Although the analysis conducted in this paper didn’t find that implementing emission trading was feasible for this particular air pollution problem, opportunities remain to explore other areas where incentives can be applied. Despite the fact that this paper uncovered many deficiencies, I believe it also showed that incentives play a strong role in environmental policies. It is no longer a question of if incentives work, instead the question is where to apply them in order to achieve the best results. The bottom line is make pollution control cheap and easy, and more might buy it.
Bibliography


South Coast Air Quality Management District.(1997) “1997 RECLAIM Annual Audit Report”


Bibliography


-34-