US EPA ARCHIVE DOCUMENT

Sam Napolitano *is Director of the U.S. Environmental Protection Agency's Clean Air Markets Division. He can be reached via email at napolitano.sam@epa.gov.*

Jeremy Schreifels *is a Senior Policy Analyst at the Clean Air Markets Division (email: schreifels.jeremy@epa.gov).*

Gabrielle Stevens *is an environmental scientist at the division (email: stevens.gabrielle@epa.gov).*

Maggie Witt *is an environmental specialist at the EPA's Region IX Office in San Francisco (email: witt.maggie@epa.gov).*

Melanie LaCount *is a Senior Policy Analyst at the Clean Air Markets Division (email: lacount.melanie@epa.gov).*

Reynaldo Forte *is Manager of the emissions measurement group at the Clean Air Markets Division (email: forte.reynaldo@epa.gov).*

Kenon Smith *is a Senior Policy Analyst at the division (email: smith.kenon@epa.gov).*

The authors acknowledge the willingness of Congress, several environmentalists, and the electric power industry to undertake the ''great experiment'' that is the Acid Rain Program, and Brian McLean and a small group of EPA staff who, in the early 1990s, built the program to the Clean Air Act's specifications.

The U.S. Acid Rain Program: Key Insights from the Design, Operation, and Assessment of a Cap-and-Trade Program

The authors' 15 years of experience with the Acid Rain Program suggests that for regional or larger-scale air pollution problems, such as acid rain and pollution transport, a well-designed cap-and-trade program can be cost-effective, flexible, and easy to implement with clear benefits that can be sustained into the future.

Sam Napolitano, Jeremy Schreifels, Gabrielle Stevens, Maggie Witt, Melanie LaCount, Reynaldo Forte and Kenon Smith

I. Introduction

Since its inception in 1995, the U.S. Acid Rain Program (ARP) has earned widespread acclaim due to dramatic sulfur dioxide (SO_2) and nitrogen oxides (NO_X) emission reductions, far-ranging environmental and human health benefits, and far lower-than-expected compliance costs. By the end of 2006, regulated sources in the ARP had decreased annual SO_2 emissions by more than 40 percent and NO_X emissions, in conjunction with other programs, by almost 50 percent. Notably, these reductions occurred while the combustion of fossils fuels for electricity generation, as measured by ''heat input,'' has increased by almost 40 percent (**Figure 1**).[1]

As emissions declined, so did associated environmental problems. In most areas of the northeastern and midwestern U.S. wet sulfate deposition, a

 1040-6190/$–see front matter. Published by Elsevier Inc., doi:/10.1016/j.tej.2007.07.001

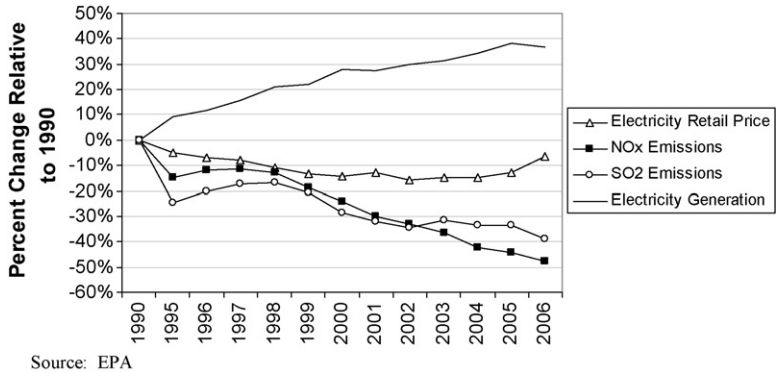


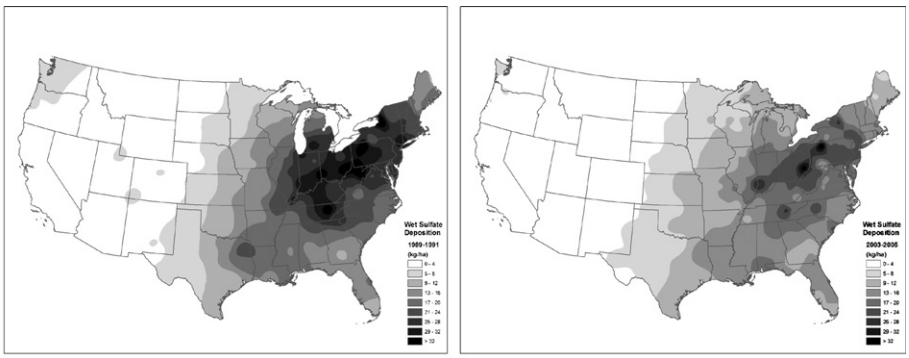
Figure 1: Trends in Electricity Generation, Fossil Energy Use, and Emissions from the Electric Power Industry, 1990–2006

major component of acid rain, declined by 25 to 40 percent from 1990 levels (**Figure 2**). The reductions in wet sulfate deposition contributed to improvements in the ability of many lakes and streams, including very sensitive regions like the Adirondacks, to buffer acid deposition. These improvements are an important signal that recovery from decades of acid rain has begun.

The annual ecological and health benefits resulting from the ARP emission reductions are estimated at $142 billion by 2010 compared with annual compliance costs of $3.5 billion.[2,3] The vast majority of these benefits come from the expected avoidance of nearly 19,000 premature deaths.[4]

The success and cost-effectiveness of the ARP has led to greater interest in the use of cap-and-trade policies to control emissions. In the U.S., the Environmental Protection Agency (EPA) has established cap-and-trade programs for SO_2, NO_X, and mercury air emissions; the European Union has established a carbon dioxide (CO_2) cap-and-trade program; and other countries, including Australia, Canada, Chile, China, Japan, Korea, and New Zealand, are considering the use of cap-and-trade to address their own environmental challenges.

EPA has accumulated over 20 years of experience designing, implementing, and assessing cap-and-trade programs. As governments and regional organizations design and implement new cap-and-trade programs, the lessons from the ARP – what worked well and what could have been done differently – can provide valuable insights to policymakers and the public. This article identifies some of the key lessons that can be drawn from EPA's experience designing, operating, and assessing the ARP. Numerous outside observers have also critically assessed the ARP and provided valuable perspectives for consideration.[5]



Source: EPA

Figure 2: Annual Mean Wet Sulfate Deposition, 1989–1991 and 2003–2005

II. Design of the Acid Rain Program

The 1990 Clean Air Act Amendments established the ARP—the world's first large-scale cap-and-trade program for air pollution. The program is designed to reduce electric power sector emissions of SO_2 and NO_X through a national, market-based cap-and-trade system for SO_2 emissions, and a flexible, emissions-rate-based program for NO_X emissions, with the goal of reducing the adverse effects of acid rain.

A. Sulfur dioxide program

In general terms, the ARP SO_2 program set a cap, or strict limit,

 1040-6190/$–see front matter. Published by Elsevier Inc., doi:/10.1016/j.tej.2007.07.001

on total SO_2 emissions from the electric power sector in the 48 contiguous states to achieve broad regional reductions of SO_2 and acid deposition. EPA issues allowances – authorizations to emit – equal to the cap and distributes them to regulated sources using defined formulas. EPA also auctions a small portion of the allowances (2.8 percent) each year. Regulated sources, including newly affected sources, other market participants, and the public, are free to bid on allowances at the auction, in addition to purchasing them any time through the active allowance market.

Regulated sources must monitor, quality assure, and report to EPA hourly emissions of SO_2, NO_X, and CO_2.[6] Because the cap ensures emissions will be at or below the specified level, EPA does not need to define how or where the electric power sector will make emission reductions; regulated sources are free to design and implement customized compliance strategies and to buy, sell, or save – ''bank'' – allowances for optimum flexibility. Because allowances can be traded, regulated sources that can make low-cost reductions have an incentive to reduce more than required and sell surplus allowances to regulated sources with higher costs of control, thereby achieving the environmental goal at lower overall cost. The critical compliance element of the SO_2 program is a requirement for each regulated source to have sufficient allowances in its account to offset its annual SO_2 emissions. If a regulated source exceeds its SO_2 allowances, each ton of excess emissions is subject to penalties of $3,152 per ton[7] for the 2006 compliance year and the surrender of one allowance from the source's account to make the environment whole. Compliance rates with the allowance holding requirement average over 99 percent each year.

Because allowances can be traded, regulated sources that can make low-cost reductions have an incentive to reduce more than required and sell their surplus.

The SO_2 program also included a special provision to encourage energy efficiency and renewable energy projects through a Conservation and Renewable Energy Reserve—a pool of 300,000 SO_2 allowances set aside to award regulated sources that implemented efficiency or renewable energy measures to produce early emission reductions. Other special provisions included an ''opt-in'' program that provides sources not required to participate in the ARP the opportunity to voluntarily enter the program, subject to certain requirements, and receive SO_2 allowances.

The SO_2 program was implemented in two phases. The first phase of the program from 1995 to 1999 included 263 of the largest, highest-emitting coal-fired electricity generating units and between 135 and 182 substitution, compensating, and opt-in units (the number varied each year). The second phase began in 2000 and included the remaining regulated sources—coal-, oil-, and gas-fired electricity generating units greater than 25 MW. The emission cap for the second phase started at 9.97 million allowances in 2000 and gradually declines to 8.95 million allowances in 2010. In 2006, approximately 3,550 fossil-fueled electricity generating units were affected by the SO_2 portion of the ARP.

The SO_2 program's innovations and successes have paved the way for additional SO_2 reductions under the Clean Air Interstate Rule (CAIR) in the eastern U.S., slated to begin in 2010.

B. Nitrogen oxides program

The ARP also requires NO_X emission reductions from the vast majority of coal-fired electricity generating units in the contiguous 48 states. The NO_X portion of the ARP sought to attain a 2 million ton annual NO_X emission reduction from year 2000 projected emissions through a flexible rate-based regulatory program. Emission rates were established for specific boiler types, but electricity generating

 1040-6190/$–see front matter. Published by Elsevier Inc., doi:/10.1016/j.tej.2007.07.001

companies were offered the flexibility to comply with the applicable rate-based emission limit, expressed in pounds of NO_X emissions per million British thermal units (Btu) of heat input, in one of three ways: (1) meet the standard annual emission-rate limitations at each combustion unit; (2) average emission rates at two or more units that share a common owner, which allows companies to focus controls at combustion units where it is technically easier and less expensive to control emissions; or (3) apply for a less stringent alternative emission limit (AEL) if the NO_X emission control technology used to set the emission rate is installed and fails to achieve the required emission-rate limit. Emissions averaging has been a popular method of compliance, affording sources with more than one unit in the program the flexibility of operating at different emission levels to address different situations and still meet the requisite emission limit—the critical compliance element of the NO_X program. If a regulated source or company exceeds the NO_X emission-rate limit, each ton of excess emissions is subject to a penalty of $3,152[8] per ton for the 2006 compliance year. Compliance rates for the NO_X portion of the ARP average over 99 percent each year.

Like the SO_2 program, the NO_X program was phased in. Beginning in 1996, emission-rate limits applied to the largest coal-fired plants. This helped demonstrate the cost-effectiveness of NO_X controls. By 2000, the NO_X program had encouraged the installation of advanced NO_X combustion controls, such as low-NO_X burners, and the development of new power plant designs with lower NO_X emission rates. In 2006, about 980 coal-fired electricity generating units were affected by the NO_X program.

The law made it clear that if the rules were delayed, every source would have to meet a source-specific emission limit without the flexibility of trading.

Providing the flexibility for electric generating companies to choose the method of compliance appropriate for their circumstances within a more typical rate-based structure helped EPA and regulated sources gain experience with continuous monitoring equipment for NO_X emissions and provided a strong data foundation for later cap-and-trade programs for NO_X, including the Ozone Transport Commission's NO_X Budget Program (1999), the NO_X Budget Trading Program under the NO_X State Implementation Plan (SIP) Call (2003 and 2004), and CAIR (2009).

III. Lessons Learned from the Acid Rain Program

A. Good legislation makes program implementation easier by reducing uncertainty

The ARP benefited from good legislation. Environmental goals were set and established through a phased-in emission reduction approach. There were few legal challenges to the rules EPA issued and none delayed implementation of the cap-and-trade program. What little litigation did occur revolved around interpretations of statutory provisions that, in some instances, were overly complex or unclear.

In most cases the legislation provided clear, easy-to-understand, and easy-to-implement language. For instance, the allocations for the first phase of the SO_2 program were printed in the law, leaving no question about the approach or results. To ensure that the level of the cap was maintained through the allocation for the second phase, the legislation includes a ''ratchet'' provision that requires EPA to reduce each regulated source's allocation pro-rata if the various allocation formulas result in allocations greater than the cap. The law also made it clear that if the rules were delayed, every source would have to meet a source-specific emission limit without the flexibility of trading. This created the likelihood of very real costs associated with

delaying the environmental improvement promised by the legislation.[9]

B. Adaptability to new circumstances is essential

An important element of the legislation or other legal authority is the ability to adapt to new information, practices, or technology. EPA has made a number of changes to the program foundation since 1990. Most of the changes were intended to streamline the program; improve the quality of emission data; take advantage of advances in information technology and the Internet; minimize burden and costs for regulated sources, market participants, and EPA; and improve the environmental accountability and results of the program.

C. Flexibility streamlines decision-making and reduces costs

A key feature of the ARP is the different roles that EPA and regulated sources play compared to traditional command and control approaches. In the ARP the regulated source, which best understands its operation and business, has the flexibility to develop compliance strategies and make decisions on technologies, fuels, operational practices, and investments, and to change its approach as better methods become available, without needing government review and approval. The government is focused on setting the environmental goal. EPA collects and verifies emission data, tracks allowance transactions, assesses and enforces compliance, and publishes information about the program.

This flexibility to develop compliance strategies creates a continuous opportunity for regulated sources to seek customized, cost-effective approaches to control emissions. Emission sources are not forced to install technology that may not be appropriate for their configuration or business plan and the compliance strategies are not subject to complex review by EPA to determine if the decisions meet technical specifications or if pollution control equipment is operating properly. Because EPA does not review the compliance strategies, there is no uncertainty about regulatory approval.[10] The stringency and simplicity of the emission cap ensure that the environmental benefits will be achieved regardless of individual compliance strategies. The result is that built-in flexibility not only keeps costs low for sources that choose cost-effective compliance strategies, but it also minimizes the administrative costs of the program.

Flexibility has driven down the cost of reducing emissions by offering a wide range of emission control options and encouraging innovation.

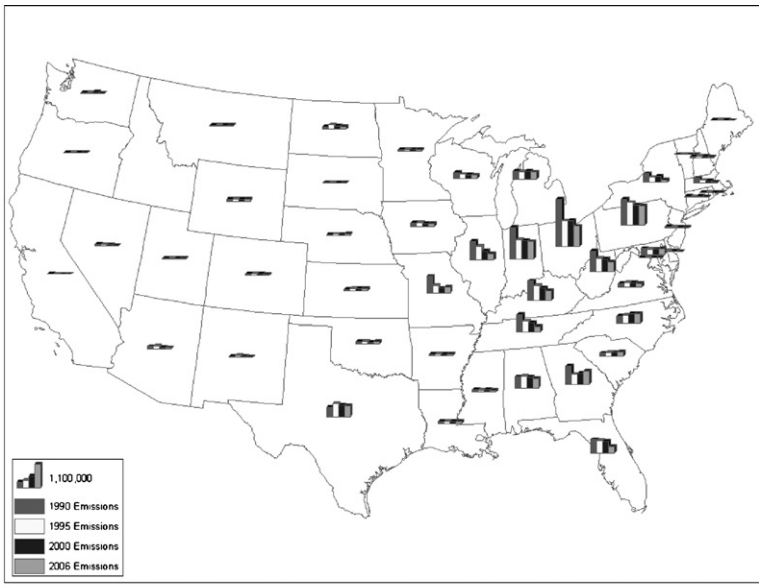
As part of its compliance strategy a regulated source may engage in allowance trading—buying or selling surplus allowances. Because of the cap, there is no need for EPA to review each transaction thereby reducing the time, transaction costs, and administrative costs to trade allowances. Parties to a trade can enter the transactions online using EPA's information system, allowing trades to be processed in less than one day; competition and market liquidity have driven down the costs of private transactions to less than 0.1 percent of the cost of an allowance,[11,12] and administering transactions of millions of allowances each year requires less than one full-time employee at EPA.

Flexibility has driven down the cost of reducing emissions by offering a wide range of emission control options and encouraging innovation. Competition among railroads shipping low-sulfur coal led to significant reductions in transport costs, a major component of coal cost; boiler adaptations and flexibility in the operation of flue gas desulfurization equipment (i.e., scrubbers) coupled with design and equipment advances increased the removal effectiveness from 90 to 95 and, more recently, 98 percent, and

 1040-6190/$–see front matter. Published by Elsevier Inc., doi:/10.1016/j.tej.2007.07.001

reduced the capital costs of the equipment by approximately 50 percent.[13] The effort to find ever cheaper emission reduction options also led to experimentation that improved the understanding and widespread use of fuel blending that reduced the cost of avoiding emissions.[14,15] Innovations in the fuels market also led to lower compliance costs as western producers of low-sulfur coal made major productivity gains to make their coal competitive in midwestern and eastern markets. In some cases, suppliers of relatively higher-sulfur coal started bundling allowances with coal to compensate buyers for the higher emissions and improve the competitiveness of their product. Bundling allowances not only made high-sulfur coal more attractive to fuel purchasers, but it enabled arbitrage between the fuels and allowance markets.[16] Other emission reduction options that competed to lower costs included installing or improving pollution controls, improving operating and/or combustion efficiencies, switching to cleaner fuels and/or cleaner combustion units, retiring or closing uneconomic facilities, and/or purchasing allowances from the allowance market. For many companies, these actions were combined across their fleet of fossil fuel units to meet load requirements and comply with the ARP in the most cost-effective manner.

The ARP also provides emission sources with temporal flexibility through banking, providing an incentive for sources to decrease emissions below allowable levels sooner than required, resulting in earlier human health and environmental benefits. Banking provides liquidity, a cushion for price volatility, and creates a safety mechanism for unforeseen market events. With the bank, allowances could go up in any given year (and have, in some cases) although the overall trend shows significant power industry reductions of SO_2. Over the five years of Phase I, regulated sources reduced emissions 11.62 million tons more than required and could use those banked allowances to cushion the effect of the declining cap in the second phase.



Source: EPA

Figure 3: Electric Power Sector SO_2 Emission Levels, 1990, 1995, 2000, 2006

Flexibility under the ARP has not adversely affected attainment of national ambient air quality standards. Independent analyses of the ARP demonstrate that trading has not led to increases in localized pollution, or ''hotspots.''[17,18] In fact, the greatest SO_2 emission reductions were achieved in the regions that had the highest SO_2 emissions prior to the program (**Figure 3**), acid deposition decreased (Figure 1), and environmental benefits were delivered in the areas where they were most critically needed.

D. Accountability is the prerequisite for flexibility

Cap-and-trade programs require rigorous and complete emissions data. EPA believes the emission data underlying the ARP, including SO_2, NO_X, and CO_2 emissions, is the most accurate and comprehensive emission data collected by EPA or any other government agency. To determine that regulated sources are in compliance, EPA requires monitoring, reporting, and

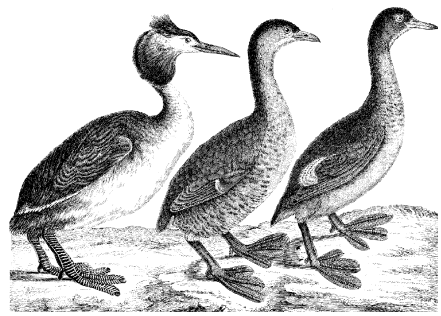
 1040-6190/$–see front matter. Published by Elsevier Inc., doi:/10.1016/j.tej.2007.07.001

verification of emissions to ensure that emissions data are complete, consistent, and account for every ton. The quality of emission monitoring plays an important role in determining the market efficiency, investor confidence, and ability to meet the emission reduction target.[19]

Regulated sources are required to measure and report hourly emission data with monitoring techniques that range from the more stringent continuous emission monitoring system (CEMS) and fuel-based analysis to the more flexible emission estimation methods, which are based on testing samples of flue gas from the stack. Coal-fired units are required to use CEMS for SO_2 emissions, while units that burn oil, gas, or other homogenous fuels have the flexibility to choose CEMS or fuel analysis methods for SO_2 and CO_2. Given the unpredictability of combustion NO_X emissions, most sources are required to measure NO_X with CEMS.

The more flexible measurement methods use environmentally conservative assumptions that overestimate actual emissions. This overestimation reflects any uncertainty in the methodology. Because the overestimated emissions must be offset with allowances, there is an incentive for regulated sources to use more accurate monitoring approaches. More importantly, more accurate monitoring approaches are focused where it matters most: on the largest emitters.

Emissions data are subjected to extensive, rigorous quality assurance (QA) checks by the regulated sources and EPA to ensure completeness and accuracy. Sources implement a mandatory and comprehensive on-site QA program where monitoring systems are subjected to daily calibration and a series of checks and tests, before



certification and submission of their quarterly electronic data reports to EPA. EPA audits the reported data through a several-step process,[20] and then supplements this audit process with separate ad hoc analyses and data cleanup surveys. The high-quality emission data provide the basis for ensuring compliance and assessing achievement of the emission reduction goal and contribute to the credibility of the allowance market.

E. Complexity and ambiguity increase costs and create uncertainty

The ARP has demonstrated that operating the program with simple, clear goals and rules saves time and money for both regulated sources and EPA. Moreover, the high compliance rate with the critical elements of the SO_2 and NO_X programs – greater than 99 percent – is due in large part to rules that are clear and easily enforced. In contrast, complexity often requires more decisions, debate, and information collection. Such a situation can create uncertainty and unnecessary burden that may lead to delays, opportunities foregone, and, ultimately, higher costs.

While simplicity was a key objective of the ARP, some areas of the program included unnecessary complexity. Some of these complexities were introduced in the political process as a way to gain support for the program. Two aspects of the program – allocation formulas and partial coverage of the electricity sector during Phase I – had the potential to increase uncertainty, program costs, and administrative burden, and may have benefited from greater simplicity.

Allowance distribution can be one of the most challenging aspects of developing a cap-and-trade program. The particular method for distributing allowances is generally not critical to the environmental success or total cost of the program, but can affect the distribution of economic impacts. Unlike ARP Phase I allocations which were specified in the legislation, Phase II allocations were more

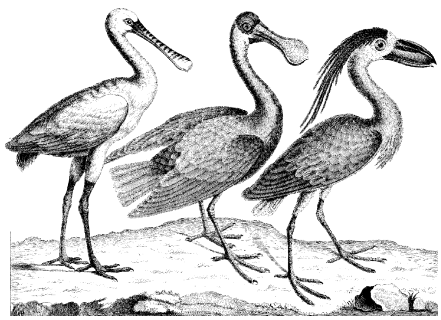
 1040-6190/$–see front matter. Published by Elsevier Inc., doi:/10.1016/j.tej.2007.07.001

complicated, with a number of different formulas. The complications of the allocation process led to litigation as regulated sources sought to force the EPA to use interpretations of the statute that would result in more allowances for the source. A simpler allocation process that minimized the number of formulas and established clearly defined data requirements may have enhanced certainty, lowered the administrative burden, and reduced or eliminated the litigation over allocations.

Because Phase I of the ARP covered only a subset of electricity generating units, there was a possibility of ''leakage''—shifting generation from a Phase I source to a source not required to participate in the ARP until Phase II. The electric power sector is interconnected, meaning sources could easily shift generation from one combustion unit to another. To address the possibility of leakage, the ARP includes a reduced utilization provision that requires a Phase I source that reduces utilization to demonstrate that the reduction was not offset by an increase at a non-Phase I source. Through this provision and the voluntary substitution provision several hundred more units, including some oil and gas units, were brought into Phase I. If the ARP had included all regulated sources in Phase I, there would have been no possibility of leakage and the complicated reduced utilization provision would not have been necessary.

F. Incentives need to be clear and strong to be effective

By their very nature, market-based programs provide incentives to seek opportunities to reduce compliance costs. While the ARP includes a number of incentive provisions to promote compliance or encourage certain activities, some were



insufficient to achieve their objective.

The penalty provisions for non-compliance reduce the need for traditional enforcement mechanisms and the courts, which could delay end-of-year compliance assessments, introduce market and environmental uncertainty, and increase costs. Excess emissions trigger clear, nonnegotiable, automatic penalties – allowances equal to the excess emissions are automatically deducted from the facility's account and a significant financial penalty is automatically due and payable. Other violations as well as excess emissions may result in supplemental civil and/or criminal penalties. Compliance is encouraged through the use of incentives, including progressively punitive provisions for missing monitoring data, reduced frequency for monitoring equipment quality assurance checks when superior test results are achieved, and clear consequences for cases of excess emissions.

The ARP also includes provisions to promote energy and resource efficiency. For example, the Conservation and Renewable Energy Reserve was created to provide allowances to energy efficiency and renewable energy projects. The program's features included a standard award formula, a pre-approved list of eligibility measures, and standardized measurement protocols.[21] However, it also required detailed information to verify the measures used to avoid emissions and to calculate the tons of emissions avoided. Ultimately the conservative award formula and low allowances prices provided an inadequate incentive to spur additional projects.

G. Information technology streamlines program operation and reduces administrative costs

For the ARP to operate with environmental integrity and public credibility, the EPA must collect, verify, maintain, and disseminate vast amounts of data. The most effective method available today to process and disseminate these data is an

 1040-6190/$–see front matter. Published by Elsevier Inc., doi:/10.1016/j.tej.2007.07.001

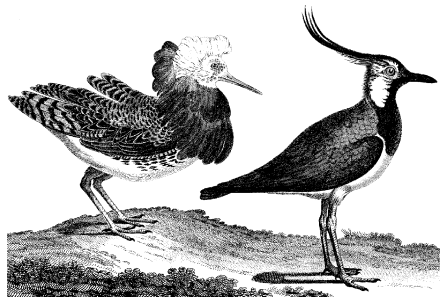
integrated information system. The advantages of using information systems go well beyond their ability to handle large amounts of data. Information systems provide increased data accuracy, reduced administrative time and cost, enhanced access, greater transparency, and improved consistency and comparability.[22]

The information system is a critical component of the ARP infrastructure. Without the systems in place to collect, process, maintain, and disseminate emission and allowance data, the program would require significantly greater resources and would not likely achieve the same level of accuracy or consistency. Due in part to the simplicity and clarity of the rules, EPA is able to take full advantage of information systems to operate the entire program with fewer than 50 EPA employees. Most of these staff are responsible for certifying and auditing monitoring equipment and data and providing compliance support to the regulated community.[23] The process of allowance transfers requires minimal EPA staff input with 98 percent of the transactions done online by market participants.

H. The government's role should be focused on ensuring the program achieves the environmental goal

One of the aims of the ARP was not only to achieve significant environmental outcomes and to do it at lower cost, but to change the way government and industry interact. As noted previously, the nature of a well-designed cap-and-trade program allows EPA to focus on results.

The EPA facilitates compliance by assisting regulated sources. This includes holding workshops



on the technical aspects of the ARP, including monitoring and reporting requirements, and working with sources one-on-one to help them understand the program's requirements and to assist with issues that could lead to non-compliance. EPA has staff dedicated to compliance support in specific regions of the country. These staff are available to answer questions about monitoring, reporting, and verification requirements. Because the goal of the program is complete compliance, EPA works with regulated sources to ensure they are complying with the provisions and requirements of the ARP.

I. Cap-and-trade policies complement programs intended to protect local air quality

Cap-and-trade programs work best on a regional or larger scale. By requiring significant reductions of regional pollution that is often transported across state boundaries, cap-and-trade programs may also, and often do, improve local air quality. However, eliminating high, localized concentrations of emissions is not their primary purpose. To protect local air quality, cap-and-trade programs should complement, not conflict with, state or local programs.

In the case of the ARP, regulated sources must comply with all applicable local, state, and other federal emission requirements, regardless of the number of allowances held. This means that local and state governments can impose additional source-specific emission limits as necessary to protect local air quality.

J. Transparency builds confidence and credibility

Public availability of data, or information transparency, is a vital feature of the ARP. The data EPA collects on SO_2, NO_X, and CO_2 emissions, official allowance transfers, and ecosystem indicators are publicly available on EPA's Web site. Transparency is important to a well-functioning cap-and-trade program, both in terms of its design, operation, and

assessment. Transparency of the design process promotes public acceptance and confidence in the cap-and-trade program. Publishing emission and allowance data also promotes confidence in the program and provides an additional level of scrutiny to verify enforcement and encourage compliance. Assessing and publicizing information about progress toward program goals demonstrates the achievements of the program as well as challenges that may need to be addressed.

K. Ongoing program assessment is critical

To analyze progress toward goals as well as any intended or unintended consequences or disbenefits, EPA regularly assesses the ARP. The results of the ARP have been dramatic and unprecedented. The program works and has reduced emissions earlier than required, attaining broad regional environmental and health benefits; costs have been one-third of what was anticipated and benefits are far greater than expected.

Ecological, health, and economic assessments indicate if the program is leading to improvements. However, despite the progress from the

Our experience clearly demonstrates that market-based cap-and-trade programs are effective.

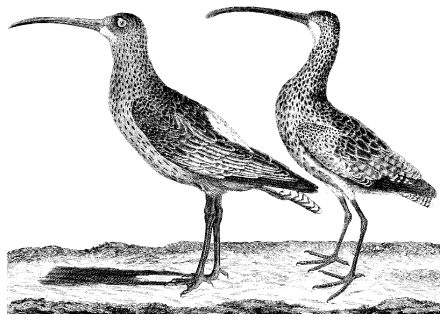
 1040-6190/$–see front matter. Published by Elsevier Inc., doi:/10.1016/j.tej.2007.07.001

ARP, recent scientific research shows the need for additional SO_2 and NO_X reductions to fully restore our environment, and further reduce the number of acidic lakes and streams in many regions of the country.[24] Some of these additional emission reductions will be achieved through implementation of regulations to address transport of ozone and fine particles, including CAIR; car and diesel rules affecting mobile sources; and state implementation plans to achieve National Ambient Air Quality Standards.

IV. Conclusions

The lessons from the ARP provide insight into how to effectively design and operate cap-and-trade programs. Key lessons from EPA's experience can help policymakers in the U.S. and abroad as they consider the implementation of cap-and-trade programs. The key lessons from the ARP are:

- Clear, comprehensive legislation makes it easier to implement the program and minimizes legal challenges that can introduce uncertainty, delays, and additional costs;
- A solid, but adaptable, program foundation is a substantial benefit, allowing room for new information, practices, and technologies;
- Flexibility in compliance approaches streamlines the decision-making process, fosters innovation, opens new compliance alternatives, and creates competition among emission reduction options, thereby reducing compliance costs—and lower costs make it possible to seek greater environmental protections where necessary;
- Accountability is a prerequisite for flexibility-regulated sources must be held accountable for accurately measuring and reporting all emissions, and complying with program requirements;



- Clear, simple rules are easier and less costly to implement; complexity may be required in some cases, but should be minimized whenever possible;
- Clear and strong incentives can encourage better monitoring and improve compliance with allowance holding requirements;
- Special provisions should be used sparingly and care should be taken to create sufficient incentive to achieve the objective;
- Information technology makes it possible to collect, quality assure, maintain, and disseminate large amounts of data and information with very low administrative expenses and burden;
- Regulators can create a cooperative relationship with industry by focusing on results and assisting regulated sources in complying with program requirements;
- Cap-and-trade programs can provide cost-effective, broad, regional reductions of air pollution and should complement efforts to attain and maintain local air quality;
- Transparency of data and program operation provide an additional level of scrutiny to verify enforcement and encourage compliance, and inform stakeholders, including the public, about the program and its results; and
- Assessment is an important tool to measure progress toward the goal of the program.

With more than 15 years of experience, the Acid Rain Program clearly demonstrates that market-based cap-and-trade programs are an effective means of achieving broad improvements in air quality by reducing emissions of regionally transported air pollutants and encouraging efficient solutions. For regional or larger-scale air pollution problems, experience suggests that a well-designed cap-and-trade program can be cost-effective, flexible, and easy to implement, with clear

benefits sustainable into the future.■

Endnotes:

1. For information about the results of the Acid Rain Program, see annual compliance reports at http://www.epa.gov/airmarkets/. For emission and allowance data, see Data and Maps at http://camddataandmaps.epa.gov. For environmental effects data like acid rain, see CASTNET at http://www.epa.gov/castnet/.

2. Benefit and cost estimates are in 2006 U.S. dollars.

3. Lauraine Chestnut and David Mills, *A Fresh Look at the Benefits and Costs of the U.S. Acid Rain Program*, J. Env'l. Mgmt., Nov. 2005.

4. *Id*.

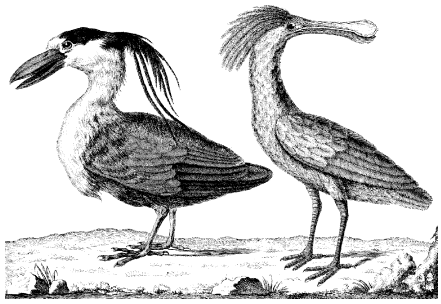
5. For additional assessments of the U.S. Acid Rain Program, see: Robert Stavins, *Lessons Learned from SO_2 Allowance Trading*, Choices, 20(1), 2005; Robert Stavins, *What Can We Learn From the Grand Policy Experiment? Lessons from SO_2 Allowance Trading*, J. Econ. Perspectives, Summer 1998; Chestnut and Mills, *supra* note 3; Denny Ellerman, Richard Schmalensee, Paul Joskow, Juan-Pablo Montero and Elizabeth Bailey, *Emissions Trading Under the U.S. Acid Rain Program: Evaluation of Compliance Costs and Allowance Market Performance*, MIT Center for Energy and Environmental Policy Research, Oct. 1997; Curtis Carlson, Dallas Burtraw, Maureen Cropper and Karen Palmer, *Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?*, J. Pol. Econ., Dec. 2000; and Environmental Law Institute, *Implementing an Emissions Cap and Allowance Trading System for Greenhouse Gases: Lessons from the Acid Rain Program*, Sept. 1997.

6. In Section 821 of the 1990 Clean Air Act Amendments, Congress required monitoring and reporting, and public availability, of CO_2 information from all sources regulated under Title IV of the Clean Air Act.

7. The penalty for excess emissions was set at $2,000 and is indexed to inflation each year.

8. The penalty for excess emissions was set at $2,000 and is indexed to inflation each year.

9. Brian McLean, *Testimony Before the House of Representatives Committee on Energy and Commerce Subcommittee on Energy and Air Quality*, March 29, 2007.



10. Joseph Kruger, *Companies and Regulators in Emissions Trading Programs*, Resources for the Future Discussion Paper 05-03, Feb. 2005.

11. Typical transaction costs are $0.50 per allowance in the SO_2 allowance market. Transaction costs for allowance swaps and loans in the SO_2 allowance market are even lower: $0.25 per allowance.

12. Personal communication with Gary Hart, ICAP-United, June 25, 2007.

13. Dallas Burtraw, *Cost Savings Sans Allowance Trades? Evaluating the SO_2 Emission Trading Program to Date*, Resources for the Future Discussion Paper 95-30-REV, Feb. 1996.

14. *Id*.

15. Generally, combustion boilers are designed for the characteristics of a specific type of coal. Deviations from those characteristics may not only affect the performance of the boiler, but may damage equipment. Because low-sulfur sub-bituminous coal from the West has some very different characteristics, combustion engineers used to believe that blending it with bituminous would cause problems in boilers designed for bituminous. The incentive for innovation under the ARP encouraged experiments that led to an improved understanding of the ability to successfully burn blended coals.

16. Denny Ellerman, Paul Joskow, Richard Schmalensee, Juan-Pablo Montero and Elizabeth Bailey, Markets for Clean Air: The U.S. Acid Rain Program (Cambridge, UK: Cambridge Univ. Press, 2000).

17. Carlson *et al.*, *supra* note 5.

18. Byron Swift, *Allowance Trading and Potential Hotspots: Good News From the Acid Rain Program*, Environmental Law Institute Environment Reporter, May 2000.

19. Joe Kruger and Christian Egenhofer, *Confidence Through Compliance in Emissions Trading Markets*, Centre for European Policy Studies (CEPS), April 2006.

20. John Schakenbach, Robert Vollaro and Reynaldo Forte, *Fundamentals of Successful Monitoring, Reporting, and Verification under a Cap and Trade Program*, J. Air & Waste Mgmt. Assn., Nov. 2006.

21. Jeremy Schreifels and Joe Kruger (eds.), *Tools of the Trade: A Guide to Designing andOperating a Cap and Trade Program for Pollution Control*, EPA430-B-03-002, June 2003.

22. Jinnan Wang, Jintian Yang, Stephanie Benkovic-Grumet, Jeremy Schreifels and Zhong Ma, *SO_2 Emissions Trading Program: A Feasibility Study for China*, China Environmental Science Press, 2002.

23. Brian McLean, *Testimony Before the House of Representatives Committee on Energy and Commerce Subcommittee on Energy and Air Quality*, March 29, 2007.

24. National Acid Precipitation Assessment Program Report to Congress: An Integrated Assessment, 2005.