The Quantification and Verification of Energy Savings for Acid Rain Compliance

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The enactment of Title IV of the Clean Air Act Amendments of 1990 provides both explicit and implicit incentives for utilities to use energy conservation as a means to reduce SO_2 emissions for acid rain compliance. By saving energy, utilities can earn or save valuable SO_2 emission allowances that can help reduce compliance costs. The Act provides three distinct incentives for saving energy: (1) bonus allowances from a special reserve for energy conservation and renewable energy generation; (2) benefits from reducing utilization of affected units with high SO_2 emission rates; and (3) benefits from system-wide emissions reductions due to conservation. The bonus allowances and reduced utilization benefits are available through application to the U.S. Environmental Protection Agency (EPA), and require a demonstration of energy savings by the utility; bonus allowances are also subject to strict eligibility requirements. By contrast, the benefits of system-wide emissions reductions are automatic and require no application or demonstration. The ability of conservation programs to reduce acid rain compliance costs increases the cost effectiveness of these programs. A method for incorporating the benefits into a Total Resource Cost Test is developed. EPA is developing Conservation Verification Protocols (CVP) for the bonus allowance and reduced utilization programs. The CVP will emphasize measured energy savings, but will permit the use of stipulated savings in some instances. Verification results certified by state regulators may be substituted for EPA's CVP in some circumstances. Case studies of the potential for utilities to reduce compliance costs by saving energy are also shown.

Introduction

The enactment of the Clean Air Act Amendments of 1990 (CAAA) has fundamentally altered the economics of energy efficiency investments for most of the electric utilities operating in the United States. Title IV of the CAAA, which sets forth requirements for reductions in total emissions of sulfur dioxide (SO_2) by electric power plants, provides both explicit and implicit incentives for utilities to use energy conservation as a means to reduce their costs of complying with the Act.

In particular, Title IV's adoption of a permanent ceiling on SO_2 emissions, coupled with an innovative emissions trading system, provides an unprecedented opportunity for utilities to take advantage of energy efficiency gains as a means of preventing pollution. In addition to reducing the cost of complying with the new acid rain provisions, energy conservation measures increase compliance flexibility and reduce emissions of other pollutants as well as SO_2.

Even where utilities do not take specific actions to use conservation as a compliance option, the new emissions limits for SO_2 increase the benefit/cost ratio for all demand-side management programs that reduce electricity consumption. Not only will the net benefits increase for programs that are already cost-effective, but some programs that previously did not appear cost-effective may now produce economic benefits by helping to reduce CAAA compliance costs. Moreover, utility programs to promote sales of energy, such as to improve load factor, are likely to prove more costly because they will tend to increase the cost of compliance with Title IV. The ability of utilities to take advantage of energy conservation as an SO_2 compliance option will vary greatly among utilities, as will the impact of the CAAA on the cost-effectiveness of their DSM programs.

Those provisions of the CAAA that provide explicit opportunities for utilities to use energy conservation technologies as a compliance option require quantification and verification of energy savings as a condition for the disbursal of these conservation-related benefits to utilities. The existence of these provisions of the CAAA underscores the urgency of developing generally accepted, standard techniques or approaches for verifying energy savings from DSM programs (Wiel 1990).

Energy Efficiency as an Acid Rain Compliance Option

Overview of Acid Rain Program

Under Title IV of the Clean Air Act Amendments of 1990, Congress authorized the U.S. Environmental Protection Agency (EPA) to establish the Acid Rain Program. The legislation sets as its primary goal the reduction of annual SO_2 emissions by 10 million tons below 1980 levels. To achieve these SO_2 reductions, the law requires a two-phased approach, involving the use of tradeable annual SO_2 emission allowances, and which gradually tightens the restrictions placed on fossil fuel-fired power plants.[1]

The proposed Acid Rain Program represents a dramatic departure from traditional command and control regulatory methods that establish specific, inflexible emissions limitations with which all affected sources must comply. Under the new system, affected utility units are being allocated allowances annually based on their historic fuel consumption and a specific emissions rate. Each allowance permits a unit to emit 1 ton of SO_2 during or after a specified year. Extra allowances freed up by reducing emissions below required levels may be sold or banked for use in future years. During Phase II of the Acid Rain Program, the Act sets a permanent ceiling on total yearly allowance allocations to utilities at 8.95 million allowances (i.e., 8.95 million tons of sulfur dioxide.)

Opportunities to Reduce Emission Through Conservation

The Clean Air Act Amendments of 1990 offer three different opportunities for utilities to use energy efficiency measures to comply with sulfur dioxide limits. These include (1) special bonus allowances that can be earned through conservation and renewable energy programs; (2) reduced utilization of high-emitting Phase I units; and (3) general system-wide emissions reductions after compliance deadlines. This section will discuss each of these strategies, which are summarized in Table 1.

Conservation and Renewable Energy Reserve. Probably the best known opportunity for using conservation to reduce SO_2 emissions is the Conservation and Renewable Energy Reserve ("the Reserve"), a special pool of allowances available to utilities that meet electric demands with either conservation or renewable energy resources. Congress established this Reserve to provide an early "jump start" to energy efficiency and renewable energy strategies for reducing emissions. To qualify for allowances from the Reserve, a number of eligibility requirements must be met, including the following:

- Least Cost Planning: All applicants must have an approved "least cost plan" for meeting future electric needs to ensure that the utility is considering the full range of both supply and demand-side options in meeting the power needs of ratepayers at lowest system cost. Under EPA's proposed regulations, states may, but are not required to, consider social and environmental costs in a utility's "lowest system cost."

- Net Income Neutrality: Investor-owned utilities (IOUs) must be subject to a rate-making process that permits them to make as much money on energy saved as on energy sold. EPA's proposed regulations don't mandate any one mechanism for achieving net income neutrality. Acceptable methods may include rate-making formulas that decouple profits from sales, lost revenue adjustments, and shared savings mechanisms. The U.S. Department of Energy will certify to EPA that the regulatory commission has implemented ratemaking that guarantees income neutrality.

- Other Requirements: EPA has proposed several additional criteria that conservation measures and programs must satisfy in order to qualify for allowances from the Reserve. Qualified measures must (1) be consistent with the utility's least cost plan, (2) be funded in whole or in part by the utility, (3) not increase the use of any other fuels (other than renewables, industrial waste heat, or industrial waste gases), and (4) not be programs that are solely informational or educational. In addition, allowances from the Reserve will be allocated for demand-side efficiency improvements only; supply-side (generation, transmission, and distribution) efficiency investments will not be eligible.

Once a utility meets the requirements described above, EPA will allocate allowances retrospectively from the Reserve based on verified conservation savings or renewable generation during a prior calendar year.[2] Utilities owning any Phase I generating capacity are eligible for bonus allowances based on conservation savings and renewable energy generation occurring during the first three years of the program (January 1, 1992--January 1, 1995); utilities owning Phase II units only are eligible from January 1, 1992 through January 1, 2000, or until the Reserve is depleted.

Table 1. Opportunities for Earning/Saving Allowances

Feature	CRER Bonus Allowances	Reduced Utilization	System-Wide Emission Reductions Through Conservation
Type of Efficiency Measures	Demand-Side Only	Demand- and Supply-Side	Demand- and Supply-Side
Emission Rate at Which Allowances Earned/Saved	.004 lbs/kwh (.4 lbs/mmBtu)	Emission Rate of Unit(s) with Reduced Utilization	Marginal Emission Rates of Units in the Utility System
How Many Allowances Available?	300,000	No Limit	No Limit
When Available?	Phase I and II Utilities: Beginning in 1993	Phase I Utilities: 1995-1999	Phase I Utilities: 1995 Onward
		Phase II Utilities: Not Applicable	Phase II Utilities: 2000 Onward
Verification of Savings Required?	Yes	Yes	No

The Reduced Utilization Provision. A lesser known part of the Act, the reduced utilization provision, creates an even greater opportunity to use conservation as a component of an acid rain compliance strategy for many Phase I utilities. In establishing the Acid Rain program, Congress recognized that during the first phase of the program, utilities might shift load (and emissions) "off-the-books" to units not regulated until the second phase of the program. To avoid this potential emissions shell game, the Act requires that during Phase I, a utility that reduces utilization at regulated units below a baseline level must either (1) account for the emissions consequences of the shift by bringing a Phase II unit into the program early, or (2) demonstrate that reductions in utilization resulted from energy conservation.[3]

The proposed reduced utilization conservation option may be particularly valuable to some utilities because it allows them to account for reduced utilization at Phase I units (and avoid retiring allowances) by receiving credit for system-wide energy savings. The provision has several unique features that set it apart from the Reserve program. First, all verified conservation savings may be credited toward reduced utilization at Phase I units. In other words, if the reduction in utilization below 1985-87 baseline levels at Phase I units is less than or equal to a utility's system-wide verified kWh savings, no further surrender of allowances is required. Second, with proper verification that savings persist, utilities may receive credit for conservation activities begun after the 1985-87 baseline years. Finally, unlike the Reserve, utilities may receive credit for supply-side efficiency improvements, either at their generating units or in their transmission and distribution systems.

For many utilities, the reduced utilization provision can free up many more allowances than the bonus allowance provision. The following simple example illustrates this point. Assume that the emission rate for a Phase I unit that reduces utilization is 4.0 lbs. SO_2/mmBtu (.04 lbs/kWh). At this emissions rate, a utility can save 10 allowances for every 500 MWh of verified energy savings. In contrast, the Reserve awards allowances based on an assumed emissions rate of 0.4 lbs. SO_2/mmBtu (or .004 lbs./kWh), and 500 MWh of energy savings would earn only one allowance.

System-Wide Emissions Reductions Through Conservation. The most widespread application of conservation to emissions reduction comes from a simple principle inherent in the Act: generating less electricity leads to system-wide reductions in emissions. Unlike the bonus allowance and reduced utilization provisions, credit for allowances freed up through conservation is automatic after Phase I and Phase II compliance deadlines; EPA does not require verification or other documentation of emissions reductions or energy savings from conservation programs. To the extent that conservation reduces generation at sulfur dioxide-emitting plants, a utility will simply have less monitored emissions and will be required to retire fewer allowances to cover these emissions.

As with the reduced utilization provision, the number of allowances saved by avoiding emissions system-wide ("nega-allowances") may be greater than allowances earned from the Reserve. The magnitude of emissions reductions for a given utility will depend on several factors, including the SO_2 emission rates of different generating units in the utility's system and power pool, the production costs and dispatch order of different units, and the types of DSM measures adopted. Avoided system-wide emissions are likely to be the greatest in Phase II of the acid rain program, when virtually all fossil fuel burning units will be subject to stringent emissions limitations.

The Benefits of Conservation

The benefits of using conservation in the acid rain program may be viewed from two different perspectives:

- First, how does energy efficiency help a utility comply with SO_2 emissions reduction targets?
- Second, how do the benefits of emission reductions from conservation improve the cost effectiveness of demand-side management programs?

Compliance Benefits. Conservation may play a variety of roles in a utility's acid rain compliance strategy (Centolella et al. 1988; Nixon and Neme 1989; Hobbs and Heslin 1990). For some utilities, it may fit into a least-cost compliance plan with other options, such as switching to lower sulfur fuels or co-firing with natural gas. Conservation reduces operating costs--through reduced low-sulfur fuel costs or reduced variable costs of scrubbers (Geller et al. 1987)--and increases flexibility--by providing, in effect, an allowance reserve margin. Conservation can also help preserve dispatching flexibility, which may allow systems with diverse incremental control costs to achieve low cost emissions reductions through unit commitment and dispatching procedures. In addition, conservation may be able to delay more costly compliance options such as the installation of scrubbers. Ultimately, utilities should explore the synergies between all compliance options to find the least-cost portfolio. But in order for energy conservation to make a maximum contribution, this must be done before commitments are made to other compliance strategies.

Conservation as a compliance strategy will become increasingly important after the year 2000, when utilities must stay within the 8.95 million ton cap on SO_2 emissions. Conservation programs will help utilities to meet customer demand for electricity without an increase in emissions. Unlike existing utility units that receive an automatic allocation of allowances, new units must "buy in" to the allowance system, i.e., they must cover their emissions with allowances allocated to other units or with purchased allowances.

Pollution prevention is an additional benefit from using conservation in a compliance strategy. Unlike the more conventional acid rain compliance options, energy efficiency reduces nitrogen oxides, air toxics, particulates, and carbon dioxide (CO_2), as well as SO_2. CO_2 reductions could prove to be an important consideration, should the U.S. sign a treaty calling for limits on greenhouse gas emissions. In addition, conservation programs reduce emissions without the solid waste disposal problems caused by scrubbers, or the land use issues associated with the production of fossil fuels.

Finally, avoiding a ton of SO_2 through conservation programs may be more cost effective than buying an allowance to cover that ton or reducing a ton of SO_2 through scrubbing or fuel switching. In fact, where a conservation program is already cost-effective, "nega-allowances" are created and emissions are reduced at no cost.

Conservation Cost-Effectiveness Benefits. In addition to looking at conservation as a component of a cost effective compliance strategy, utilities and commissions should consider the effects of "nega-allowances" on the cost-effectiveness of DSM programs. The allowance trading system contains an inherent incentive for utilities to undertake conservation measures since for each ton of SO_2 that a utility avoids emitting, one less allowance needs to be retired. Allowance prices will be set by the market, so utilities and commissions will be able to incorporate the benefits of avoided allowances when determining the cost effectiveness of conservation programs.

The monetary value of "nega-allowances" may affect DSM program cost effectiveness or design in several ways. In some cases, a program may become cost effective from the added value of nega-allowances. In other cases, the value of nega-allowances may prolong the cost effectiveness of existing programs, may increase the penetration level for a program, or may increase the rebate level offered by a conservation program.

Method to Quantify Energy Savings Benefits

We propose a simple method to quantify the cost effectiveness of energy conservation programs in the context of acid rain compliance. Our approach is to use a modified Total Resource Cost (TRC) test (Barakat and Chamberlin 1991) that accounts for nega-allowances. Previous uses of the TRC generally have not accounted for the avoided SO_2 emissions benefits of energy conservation. We expect these avoided emissions benefits to swing many submarginal conservation programs into the cost-effectiveness category. It should be noted that while our analysis ignores fuel switching, other applications can be adapted to include natural gas efficiency programs.

The mathematical form is:

$$TRC = \sum_{t=1995}^{N} UAC_t + Ac_t - UC_t - PC_t \,/\, (1+d)1-t \quad (1)$$

where

$$UAC_t = \sum_{i=1}^{I} (EN_{it} \times MC{:}E_{it}) + \sum_{i=1}^{I} (DN_{it} \times MC{:}D_{it}) \quad (2)$$

and:

UAC_t = Utility avoided energy supply costs in year t,
AC_t = Nega-allowance cost for avoided SO_2 emissions at affected units in year t,
UC_t = Utility program costs (including conservation verification) in year t,
PC_t = Participant costs in year t,
EN_{it} = Reduction in energy use in costing period i in year t,
DN_{it} = Reduction in demand in costing period i in year t,
$MC{:}E_{it}$ = Marginal cost of energy in costing period i in year t,
$MC{:}D_{it}$ = Marginal cost of demand in costing period i in year t.

In the case of the Reserve, the number of allowances earned is based on a formula described in 40 CFR 73 that assumes that energy efficiency programs offset SO_2 emissions of 0.4 pounds/million Btu, regardless of what is actually being offset. Thus:

$$AC_t = (0.000002 \times EN_t \times MC{:}A_t) \textit{ for } t = 1992 \textit{ through } 1999 \textit{ (or } 1994) \quad (3)$$

where:

MC:At = Marginal cost of allowances in year t.

Case Study Examples

To illustrate our method in the context of either acid rain compliance or least cost utility planning, we have developed two hypothetical case studies to analyze. One considers a large commercial lighting efficiency retrofit program for a large, high SO_2 emitting multi-state utility in the Southeastern U.S., and the other considers a somewhat more modest, industrial motor efficiency retrofit program for a large, high SO_2 emitting multi-state utility in the Midwest. Both case studies, however, rely on actual utility cost and benefit (including allowance) data, and production-cost modeling to account for dispatching procedures. The analyses are summarized in Tables 2 and 3. In the commercial lighting example, a conservation program that is already cost-effective becomes much more so when the nega-allowance benefits are considered. In the case of the industrial motors program, the nega-allowance benefits actually make the program cost effective. The program size (100 MW total peak reduction for commercial lighting and 10 MW for industrial motors, following a 5-year ramp up of 20% per year) is somewhat arbitrary, and does not necessarily represent the optimal cost-effective scale of either program.

The commercial lighting program results in net benefits exceeding net costs in each of the 10 years that we analyzed. The Net Present Value (NPV) of the TRC test (with a 10% discount rate) exceeds $90 million. When the nega-allowance benefits are not considered the NPV exceeds $83 million, so these benefits add a total of about $7 million to an already cost-effective energy conservation program. It is possible, therefore, that a larger program could be justified by the utility.

The industrial motors efficiency program does not appear to be cost-effective without the nega-allowance benefits. This is partly because the utility system's marginal operating costs are very low, due to excess capacity and the presence of many coal plants with low operating costs. Furthermore, there are also special industrial rates that approach the average system operating cost. Finally, this

Table 2. Southeastern Utility Commercial Lighting Program ($ Million Nominal)

Year	Avoided Energy Savings	Avoided Capacity Savings	Nega-Allowance Savings	Program Costs	Participant Costs	TRC
1995	4.728	0.8	0.107	3.234	2.0	0.402
1996	5.136	1.6	0.625	3.234	2.0	2.126
1997	6.893	2.4	0.870	3.234	2.0	4.929
1998	14.581	3.2	0.488	3.234	2.0	13.035
1999	17.593	4.0	0.956	3.234	2.0	17.315
2000	21.212	4.0	1.703	0	0	26.915
2001	20.329	4.0	1.487	0	0	25.816
2002	8.391	4.0	2.970	0	0	15.361
2003	11.227	4.0	2.446	0	0	17.672
2004	23.599	4.0	1.028	0	0	28.627
2005	25.790	4.0	1.364	0	0	31.153

Avoided Capacity	40 Per kW-Year	Rebate Level	$610
Allowances - Phase I	$300 each	NPV Savings	$90.537
Allowances - Phase II	$500 each	NPV Savings	$83.321
Participants	16,393	(No Nega-Allowances)	

Table 3. Midwestern Utility Industrial Motors Program ($ Million Nominal)

Year	Avoided Energy Savings	Avoided Capacity Savings	Nega-Allowance Savings	Program Costs	Participant Costs	TRC
1995	0.224	0.8	0.026	2.0	0.208	-1.878
1996	0.449	1.6	0.057	2.0	0.208	-1.542
1997	0.686	2.4	0.080	2.0	0.208	-1.203
1998	0.915	3.2	0.109	2.0	0.208	-0.863
1999	1.161	4.0	0.128	2.0	0.208	-0.519
2000	1.176	4.0	0.208	0	0	1.783
2001	1.183	4.0	0.207	0	0	1.790
2002	1.185	4.0	0.216	0	0	1.801
2003	1.182	4.0	0.216	0	0	1.798
2004	1.160	4.0	0.182	0	0	1.742
2005	1.165	4.0	0.183	0	0	1.748

Avoided Capacity	40 Per kW-Year	Rebate Level	$1250
Allowances - Phase I	$300 each	NPV Savings	$0.015
Allowances - Phase II	$500 each	NPV Savings	-$0.820
Participants	833	(No Nega-Allowances)	

particular industrial motors program also has very high program costs. Nonetheless, the nega-allowance benefits swing the NPV from -$820,423 to +$14,616. These benefits make this more modest energy conservation program a marginally cost-effective one.

Our results underscore that nega-allowance benefits of utility conservation programs can be significant and thus should be accounted for by utility planners. Moreover, these cost savings can be recycled back into the programs to increase customer rebate levels, participation rates, and thus improve the program impacts on load, energy use and emissions. Nega-allowance benefits will have an effect and should be considered at two stages by conservation analysts--at the resource screening level, and at the final plan integration stage. Of course, it is important that a production costing model is used that correctly accounts for the number of SO_2 emission allowances "freed up" in the utility system by the conservation programs. Conversely, load promotion or load management programs that do not actually reduce emissions should be debited for any increase in allowance requirements that may result from them.

Verification

Because of the allowance benefits available to electric utilities under Title IV of the Act discussed earlier, energy conservation savings must be verified by utilities in a timely manner. Indeed, verification results will typically be less accurate but more specific than general evaluation results of energy conservation programs (Keating 1991). EPA will be publishing federal Conservation Verification Protocols (CVP) later this year. Note that while this section represents EPA's current thinking on the CVP, EPA may change parts of this approach to reflect further analysis and public input. The following discussion summarizes key elements of our proposed approach.

EPA's proposed CVP will be similar to those in several states, such as protocols resulting from the California Collaborative, in that they will be flexible to allow the use of different measurement techniques in different conservation programs (California Collaborative Process 1990). Our proposed CVP will be different, however, in that they will generally not prespecify load impacts for specific measures. The reason for this is EPA's view that the allowances saved or earned by utilities through conservation programs must be based on verified savings for a previous year (not guarantees), which will increase the confidence of utility executives, government policymakers, and ratepayers in the cost effectiveness of these programs (Hirst 1990).

The proposed CVP will give preference toward measured energy savings in contrast to engineering estimates (Nadel and Keating 1991; Hirst 1992).[4] While end-use submetering of energy savings (along with associated analyses) can be an expensive and time-consuming task, EPA assumes that most utility energy conservation programs will involve some actual measurement as part of a savings evaluation plan. Utility expenditures on evaluation and verification will vary widely, though we expect that about 5-10% of the program costs will be dedicated to verification. Such expenditures may be inflated in the short run if a state decides to impose evaluation requirements beyond or more stringent than the CVP; over time, these costs will be lowered as utilities gain more experience in the evaluation and verification field.

One of the most difficult and controversial issues surrounding verification is the distinction between net and gross savings, and the treatment of free riders and free drivers (Hirst and Sabo 1991; RCG/Hagler, Bailly, 1991a). While states such as New York are moving toward uniform procedures for estimating and treating free riders, free drivers are more difficult to quantify. Moreover, some observers believe that the effects of free riders and free drivers may cancel each other out. Nevertheless, EPA also may require utilities to estimate the net energy savings of their conservation programs, so that they will not be credited for energy efficiency that would have occurred anyway. The protocols may allow flexibility, however, in how a utility arrives at its estimate of the net energy savings.

Strict verification of energy savings may not be required for certain measures where savings can be reliably estimated at a significantly lower cost. A small but growing list of conservation measures can be created where our confidence will be high that the energy savings of these technologies are well-documented in the literature, or in some cases should be discounted from literature values. Examples of such measures include refrigerator replacements, water heater insulation blankets, and exit signs. Additionally, for some measures, instantaneous or short-term metering may be acceptable as a proxy for first-year savings. EPA may establish a technical review committee to periodically update this list of energy savings.

Persistence of energy savings in conservation programs is another difficult and controversial issue. Ideally, a utility would want to monitor its program over time to determine the persistence of its conservation savings, but in some cases this may not be practical. The performance of many conservation measures typically drops off over time because of obsolescence and behavioral changes. To encourage utilities to directly verify savings persistence, EPA may offer the default option of using stipulated decay rates based on first-year savings (e.g., 80%, 70%, etc. in subsequent years). Similar stipulated efficiency decay rates may be available for the technologies on our stipulated savings list of conservation measures.

While EPA reserves the right to audit the verification claims of utilities under the proposed Conservation and Renewable Energy Reserve regulations, the utilities themselves have a vested interest in the validity of their results. As more states enact regulatory reforms such as lost revenue adjustments and shared savings mechanisms, significant ratepayer monies in addition to emission allowances will be at risk. Thus, verification provides a means for utilities to demonstrate the cost-effectiveness of their conservation programs for other reasons beyond acid rain compliance (Caner 1992). Our hope is that as conservation evaluation techniques improve, the need for independent auditors of verification results will be minimized.

Conclusions

The link between saving energy and acid rain compliance for electric utilities is important for two reasons. First, improvements in energy efficiency can help to reduce a utility's cost of complying with the Act. Second, the SO_2 emissions reduction benefits of saving energy make all conservation measures more cost effective and can even turn non-cost effective programs into viable ones. The extent to which utilities pursue energy savings as an acid rain compliance option may depend upon the policy of state regulators toward energy conservation. Special bonus allowances for energy conservation are available only to utilities that have implemented least cost planning and whose state regulators have taken measures to make conservation profitable. While the other (and generally more lucrative) conservation incentives under the Act are not subject to these eligibility requirements, utilities that lack such regulatory reforms from their commissions are not likely to aggressively pursue improvements in energy efficiency.

Least cost utility planning provides an ideal mechanism for state regulators to review and evaluate the acid rain compliance strategies proposed by their utilities. Indeed, the substantial compliance costs that many utilities may incur suggests that acid rain compliance should be a central issue in forthcoming reviews of utility resource plans in most states in the eastern United States.

Finally, the verification requirements associated with the conservation bonus allowance program and the reduced utilization provision could help to accelerate the current trend toward improved measurement and verification of energy savings by utilities. EPA's Conservation Verification Protocols as well as those developed in several states will further advance our ability to measure energy efficiency improvements more precisely, reliably, and cost effectively.

Acknowledgments

This paper was prepared at the Office of Atmospheric and Indoor Air Programs at EPA. We thank Dan York, Dave Schoengold, and Steve Brick of MSB Energy Associates Inc. for their assistance in preparing the case study examples, and Alan Meier of Lawrence Berkeley Laboratory for his assistance in preparing the Conservation Verification Protocols. The opinions, findings and conclusions expressed herein are solely those of the authors and do not necessarily reflect the views of EPA.

Endnotes

1. Phase I begins in 1995 and affects 110 mostly coal-burning electric utility plants located in 21 eastern and midwestern states. Phase II, which begins in the year 2000, tightens the annual emissions limits imposed on these large higher emitting plants and also sets restrictions on smaller and cleaner plants fired by coal, oil and natural gas. All existing utility units with an output capacity of 25 megawatts or greater and all new utility units will be affected by Phase II.

2. The Reserve allowance allocation will be derived from a simple and conservative formula specified in the Act. The calculation is based on an assumed rate at which SO_2 emissions will be avoided by the demand-side efficiency measures or renewable electricity generation (emissions for an average "clean" coal unit = .004 lbs. SO_2/ kWh). Our analytical method is most applicable to utilities with higher emissions.

3. Note that this is a simplified discussion of the reduced utilization provision. For a full description, see the proposed regulation at 56 FR, Dec. 3, 1991, pp. 63117-63121.

4. While engineering estimates are generally less accurate than measured energy savings, these estimates can be considerably improved by behavioral studies of a stratified sample. See, e.g., RCG/Hagler, Bailly (1991b).

References

Barakat and Chamberlin, Inc. 1991. *End-Use Technical Assessment Guide (End-Use TAG): Fundamentals and Methods.* EPRI CU-7222, Vol. 4, Palo Alto, California, Appendix A.

California Collaborative Process. 1990. *An Energy Efficiency Blueprint for California, Appendix A: Measurement Protocols for DSM Programs Eligible for Shareholder Incentives,* State of California.

Caner, P. 1992. "The Drive to Verify Energy Savings." *The Electricity Journal* 5(4):44-52.

Centolella, P. et al. 1988. *Clearing the Air: Using Energy Conservation to Reduce Acid Rain Compliance Costs in Ohio.* Ohio Office of the Consumers' Counsel, Columbus.

Geller, H.S., M.R. Ledbetter, E.L. Miller, and P.M. Miller. 1987. *Acid Rain and Electricity Conservation.* American Council for an Energy-Efficient Economy and the Energy Conservation Coalition, Washington, D.C.

Hirst, E. 1990. "Progress and Potential in Evaluating Energy Efficiency Programs." *Evaluation Review* 14(2):192-205.

Hirst, E. 1992. "The Role of Evaluation When Electric Utilities Get Financial Incentives for their DSM Programs." *Evaluation Review* 17(1):93-107.

Hirst, E., and C. Sabo. 1991. *Electric-Utility DSM Programs: Terminology and Reporting Forms.* ORNL/CON-337, Oak Ridge, Tennessee.

Hobbs, B.F. and J.S. Heslin. 1990. "Energy Conservation and Midwestern Utilities: Potential Impacts on SO_2 Emissions, Supply Costs, and Customer Value." *DSM and the Global Environment,* pp. 83-91. Synergic Resources Corp., Bala Cynwyd, PA.

Keating, K. 1991. "Evaluation vs. Verification." *Evaluation Exchange* 1(1):1-4.

Nadel, S.M., and K.M. Keating. 1991. "Engineering Estimates vs. Impact Evaluation Results: How do they Compare and Why?" *Energy Program Evaluation: Uses, Methods, and Results, Proceedings of the 1991 Conference,* pp. 24-33. National Energy Program Evaluation Conference, Chicago.

Nixon, L. and C. Neme. 1989. *An Efficient Approach to Reducing Acid Rain: The Environmental Benefits of Energy Conservation.* Center for Clean Air Policy, Washington, D.C.

RCG/Hagler, Bailly, Inc. 1991a. *Impact Evaluation of Demand-Side Management Programs: A Guide to Current Practice.* EPRI CU-7179, Vol. 1, Palo Alto, California.

RCG/Hagler, Bailly, Inc. 1991b. *Impact Evaluation of Demand-Side Management Programs: Case Studies and Applications.* EPRI CU-7179, Vol. 2, Palo Alto, California.

Wiel, S. 1990. "The Urgent Need for Verifying DSM Achievements." *Program Evaluation - Proceedings from the ACEEE 1990 Summer Study on Energy Efficiency in Buildings,* Volume 6, pp. 6.215-6.223. American Council for an Energy-Efficient Economy, Washington, D.C.