Using DSM to Help Meet Clean Air Act Requirements: A Case Study

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Under the Clean Air Act Amendments (CAAA) of 1990, utilities must substantially reduce their SO_2 emissions. These requirements particularly affect a band of utilities in the midwest and mid-Atlantic regions stretching from West Virginia to Illinois. PSI Energy, the largest electric utility in Indiana, is an example of a heavily impacted utility; by 2000, PSI must reduce SO_2 emissions by 70 percent or acquire emission allowances in lieu of these reductions. PSI already has an extensive set of DSM programs. For this project PSI worked with ACEEE to develop an enhanced set of DSM programs, and to explore how these enhanced programs affect PSI's CAAA compliance plans. Preliminary results of the analysis indicate that the suggested program enhancements increase energy savings by between 55 to 125 percent of existing PSI DSM programs. These existing and enhanced DSM programs can contribute about 4 to 5 percent of the emissions reductions PSI needs in 2000. Given the large emission reduction PSI needs, DSM has only a modest impact on PSI's compliance plan. DSM does provide added flexibility for meeting CAAA requirements and DSM does help to reduce the customer bill impacts of CAAA compliance. Also, factoring avoided CAAA costs into DSM cost-benefit calculations can have a significant impact on the cost-effectiveness of some DSM programs.

Introduction

PSI Energy

PSI Energy (formerly Public Service of Indiana) is the largest electric utility in the State of Indiana and serves over 610,000 homes, farms, and businesses including approximately 1.9 million people in north central, central and southern Indiana. Its service area spans 22,000 square miles and includes portions of 69 of the State's 92 counties.

PSI Energy is a summer peaking electric utility. The 1993 summer peak load was 5,110 MW. The winter of 1994 peak load was 4,937 MW which occurred during the coldest weather recorded in the state. Installed resources are 6,100 MW with ninety four percent being coal fired. Load growth, after a period of stagnation throughout the eighties has increased significantly in the nineties. Load forecasts are presently calling for 2.5 to 3 percent growth over the next ten years.

The availability of low cost, high sulfur coal has kept rate levels low. The average price per kilowatt-hour was $0.045/Kwh in 1991. However, expected costs of new power plants and environmental compliance costs associated with the Clean Air Act Amendments are expected to add $1.5 billion dollars in capital investment over the next ten years. This upward cost pressure has driven PSI Energy to look seriously at all viable options to minimize this expense.

PSI Energy is currently working with The Cincinnati Gas & Electric company to form a new company, CINergy. CINergy will serve approximately 1.3 million electric customers and 400,000 gas customers in a 25,000 square mile area spanning three states. Based on owned generating capacity of 11,000 megawatts, CINergy will be the thirteenth largest investor owned electric utility in the United States.

Clean Air Act Amendments

The Clean Air Act Amendments of 1990 (CAAA) included several provisions which promote the continued development and implementation of DSM programs, but by far the most important of these are the Title IV Acid Rain Provisions. These provisions call for major reductions of

sulfur dioxide (SO_2) emissions from fossil powered utility boilers in two phases–Phase I which covers the 111 plants with the highest SO_2 emissions and Phase II which covers most remaining plants. For the first time a market based approach is being used.

SO_2 emission allowances were established with each allowance representing the right to emit one ton of SO_2 in the year in which it occurs or any year after. Factored on a historical baseline, utilities are allocated emission allowances, and each affected utility is required to develop compliance plans to reduce their SO_2 emissions to match the allowances they receive from the Environmental Protection Agency (EPA), or buy allowances from utilities that over comply and have an excess of allowances to sell on the open market.

In order to promote energy efficiency, Congress also established a pool of conservation bonus allowances available to utilities with sources that could qualify by reduction of generation during the period from 1992 until the utility has an affected unit, 1995 for Phase I utilities and 2000 for Phase II. In addition, a pool of bonus allowances was also established for the use of renewable energy sources.

The Clean Air Act and Coal Belt Utilities

The Clean Air Act Amendments affect nearly all utilities throughout the country, but have a particularly strong impact on "coal belt" utilities in the midwest and mid-Atlantic regions. Of the 110 plants regulated under Phase I, approximately two thirds come from the states of Illinois, Indiana, Kentucky, Ohio, Missouri, Pennsylvania, Tennessee, and West Virginia. Phase II requirements also have a strong impact on these states; out of the sulfur dioxide reductions scheduled under Phase II, approximately 80 percent will come from these eight states. As a result, utilities in this region have been scrambling since the bill's passage to develop plans to bring their generating plants into compliance. Nationwide, expenditures of approximately $2 billion or more have been projected by 2005, of which approximately half will come from this eight state region (ICF 1994).

PSI'S Present Phase I & II CAAA Compliance Plans

Under requirements of the CAAA, PSI Energy will be required to reduce SO_2 emissions 34 percent from 1990 levels by 1995, and by approximately 70 percent from 1990 levels by the year 2000 or acquire allowances in lieu of those reductions. Based on PSI's current load forecast, to achieve these reductions will require emissions reductions of 175,000 tons of SO_2 in 1995 and 360,000 tons in 2000. For compliance on its four Phase One plants and 15 units, PSI Energy has planned to use an array of compliance options. One of its largest units will retrofit a scrubber which will remove 92 percent of the SO_2 from that unit, The company will also reduce the sulfur content in the coal burned at all of the other Phase I units to the extent that can be accomplished with existing particulate control equipment. These steps are by far the greatest portion of PSI Energy's compliance.

The ACEEE Acid Rain and Electricity Conservation Study

During the debate leading to the passage of the Clean Air Act Amendments, ACEEE conducted a study on the potential role of energy-efficiency measures in helping to address sulfur dioxide emissions in the midwest. The study concluded that accelerated energy conservation efforts could directly reduce electric utility sulfur dioxide emissions by 7-11 percent by 2000. More importantly, the study found that an accelerated conservation program could reduce regional expenditures for sulfur dioxide control by 25 percent or more (because the last 10 percent or so of emissions reductions was particularly expensive), and that savings in consumer bills from energy conservation (resulting from reduced energy use and reduced need for new power plants) would more than offset bill increases associated with emissions reductions (Geller et al. 1987). However, this study was based on mid- 1980s data for the entire region, which are not necessarily representative of utility-specific situations in the 1990s. To address these limitations, in 1991, ACEEE proposed to PSI that the two organizations work together to assess the potential role of demand-side management programs in helping PSI to meet its Clean Air Act obligations, an offer which PSI accepted.

The PSI/ACEEE Study

The PSI/ACEEE study was designed to build upon PSI's existing demand-side management (DSM) and Clean Air Act implementation plans. For the study, PSI's existing programs and plans were used as a base. ACEEE, with extensive PSI input, then worked to develop new or enhanced DSM programs that complemented PSI's existing programs and resulted in additional cost-effective energy savings. The emissions impacts of these programs were then analyzed based on year by year emissions factors developed from a load dispatch analysis on PSI's system. Finally, the financial implications of these two scenarios were assessed from the utility and consumer perspectives. The methodology and results for each of these steps are discussed in subsequent sections of this paper.

DSM at PSI

Current Programs

As part of a demand-side management (DSM) settlement agreement agreed to by PSI and groups representing PSI Energy's customers, PSI Energy has been implementing twelve DSM programs. The agreement provides for the recovery of implementation costs, the recovery of lost revenues, and a shareholder incentive to encourage performance. The result is an aggressive set of energy efficiency program that put PSI Energy at the forefront of Midwest utilities in DSM.

DSM programs are considered important not only for the cost savings to the utility, but also for the value created for customers through reduced bills, the value energy efficiency produces for customers, and the environmental benefits that accrue through reduced use. It is from these environmental benefits that PSI Energy expressed interest in developing additional efficiency programs that can mitigate the impacts of the Clean Air Act Amendments. This is particularly important considering the impact the act is expected to have on PSI Energy's capital investment. As a result, PSI's DSM programs include a significant focus on energy savings because energy savings allow PSI to reduce the amount of coal burned in its power plants. PSI does offer some load management programs, but since these primarily defer natural gas use, PSI does not offer as many load management programs as some utilities.

Table 1 lists these current programs; programs that are expected to produce 266 megawatts of summer peak demand reduction and 1070 gigawatt-hours of energy reduction in 1999.

Table 2 provides a comparison of the expected demand and energy impacts and the cost effectiveness of the programs from different perspectives. This set of programs is very diverse, encompassing both PSI's Present Phase I and II CAAA Compliance Plans.

Possible Expanded DSM Offerings

In developing recommendations for expanded DSM programs for PSI, four general concepts were followed: (1) influence purchases that are already happening in the market, thereby addressing *lost opportunity* resources; (2) promote market transformation where possible; (3) address major efficiency opportunities and customer segments not addressed by PSI's current programs; and (4) limit retrofit programs primarily to customer segments that might be underserved by other programs. Each of these concepts, and the programs they lead to, are discussed in the paragraphs below. The programs that emerged from this process are summarized in Table 3.

During periods of new construction, remodeling and equipment replacement, customers are spending substantial amounts of money to purchase energy consuming equipment. By providing incentives to help cover the incremental cost difference between standard-efficiency equipment and high-efficiency equipment, utilities can encourage customers to save energy at modest cost. If efficient equipment is not purchased at this time, *lost opportunities are* created because it will often be technically or financially difficult to upgrade equipment later on a retrofit basis. In an effort to take advantage of these market-driven opportunities to improve equipment and facilities, new or enhanced programs were developed for residential new construction, commercial new construction, industrial new construction, commercial remodeling, commercial planned HVAC change-outs, residential water heaters and residential clothes washers.

Some utilities are developing long-term strategies to transform the market so that efficient equipment or practices are the norm and utility incentives are no longer needed. These strategies often use utility programs to help leverage government actions, such as adoption of improved building codes or equipment efficiency standards. A market transformation approach has the potential to increase participation rates (because once a market is transformed, participation rates are near 100 percent) while reducing costs per kWh saved (because once transformation is complete, incentives are no longer needed) (Nadel and Geller 1994). Several of the proposed PSI programs seek to advance market transformation including the residential, commercial, and industrial new construction programs, equipment replacement programs for clothes washers, water heaters, ballasts, and commercial HVAC equipment, and the retailer-based compact fluorescent lamp program.

As noted in the previous section, PSI has an extensive array of DSM programs. However, some efficiency measures and customer segments are not fully covered by PSI's existing programs. For example, existing residential programs do not address residential appliances, some new construction efficiency measures (e.g., sealing ducts), and efficiency measures unique to farms. Existing commercial programs do not cover equipment replacement, commercial building design and remodeling. Existing industrial programs do not fully address process efficiency improvements or small facilities, and do not provide prescriptive incentives for customers who want to avoid the complications of applying for customized incentives. To address each of these limitations, new or enhanced programs were developed.

Table 1. Summary of Current PSI Energy DSM Programs

Residential Water Heating	A direct installation program for electric water heating customers that promotes installation of energy efficient water heating measures. Participants are also eligible for reduced price compact fluorescent lights.
Residential Smart $aver Home	An efficiency program targeted toward the new construction and existing home markets. The program promotes high efficiency building construction and the installation of high efficiency air conditioners and heat pumps.
Residential Storage Water Heater	Encourages customers to install oversized water heaters with lock-out devices to shift usage from peak to off-peak periods.
Residential Appliance Cycling	Provides bill credits to customers who allow PSI to cycle air conditioners and water heaters.
Residential Seal-Up	Provides the same measures as the water heating program and also includes blower door tests to detect leakage sites and the installation of caulking, weather-stripping, outlet gaskets and door sweeps to reduce leakage.
Residential Low Income	Designed to enhance delivery of government supported low-income weatherization through the addition of measures found in other PSI Energy residential programs.
Commercial Custom Energy Audits	Provides a comprehensive energy audit that identifies cost effective energy efficiency measures. Incentives are offered to partially offset installation cost. Also provides incentives for more efficient equipment in new construction.
Small Commercial Direct Lighting	A direct installation program for small commercial customers. Measures include: T8 lamps, electric ballasts, exit signs and compact fluorescent lights.
Industrial Customized Audit	PSI Energy provides a comprehensive energy audit. Incentives are offered to partially offset the installation cost.
C&I Time of Use Rates	A rate program that encourages customers to shift use from high-cost on peak periods to lower cost off-peak periods. Current design is a three season, three period rate.
C&I Curtailable Rates	Participants are provided bill credits based upon a mutually agreed upon level of interrupted load. Credit varies with notification period and seasons.
Planergy Water Link Cooperative	A five megawatt load shed cooperative comprised of water and waste water treatment plants.

Finally, because previous studies have found that retrofit installations are often more expensive than pursuing lost opportunity measures (see for example Katz et al. 1989), proposals for new or expanded retrofit programs were primarily limited to customer segments that might be underserved by other programs. Serving all customer segments is important because DSM programs often lead to modest rate increases but significant bill reductions for participating customers due to lower energy use. By offering programs for all customer segments, everyone has an opportunity to reduce their bills. Programs that serve potentially underserved customer segments are

Table 2. PSI Energy Demand-Side Management Project Impacts of Existing Programs

Program	Utility Cost Ratio[a]	Total Resource Cost Ratio	Peak Demand MW Reduction (2010)	Annual Energy GWh Reduction (2010)
Residential Water Heating	1.49	1.34	3.5	51.0
Residential Smart $aver	1.30	1.25	50.5	510.7
Residential Storage Water Heater	1.27	0.88	13.9	17.7
Residential Appliance Cycling	1.15	1.86	7.2	2.1
Residential Seal-Up	1.37	1.28	3.9	88.6
Residential Low Income	1.32	1.35	0.7	11.1
Commercial Custom Energy Audits	1.52	1.17	82.7	326.5
Small Commercial Direct Lighting	1.48	2.52	13.1	80.9
Industrial Customized Audit	2.93	1.50	100.7	730.0
C&I Time of Use Rates	1.12	1.67	10.4	4.3
C&I Curtailable Rates	1.13	3.84	21.2	7.5
Planergy Load Shed Cooperative	1.01	1.01	0.0	0.0
Total	1.54	1.31	307.8 MW	1830.4 GWh
Forecast Retail Load without DSM			4,939 MW	38,751 GWh
DSM as % of Forecast			6.2%	4.7%
Levelized Rate Impact (twenty year)			0.75 mils	

(a) Benefit cost ratio using the revenue requirements or utility cost (UC) test evaluated over twenty years.

programs for residential and farm customers and small commercial and industrial customers. The one exception to this guideline are that enhanced retrofit programs are proposed for the industrial sector, in part because there is a chance this customer segment may be underserved by existing programs and in part because industrial retrofit programs generally have low costs per kWh saved, making them highly cost-effective (Jordan and Nadel 1993).

In developing input assumptions for the particular programs, there was substantial debate between PSI and ACEEE about the specific assumptions to use. In most cases the two organizations agreed to a single set of common assumptions. For four programs there was a difference in opinion as to the participation level that could ultimately be achieved. For these four programs two scenarios were run-an optimistic and a conservative scenario. As a result of these differences, savings from the more optimistic package of programs are approximately 54 percent higher in energy savings than the more conservative package of programs in 2000.

For three of the programs, differences were relatively minor and stem largely from the fact that PSI caps incentives at 60 percent measure cost while in some cases ACEEE believes higher incentives are justified. For one of the programs, the HVAC retirement program, differences were more substantial. PSI program staff believe that most of the savings that can be achieved from existing commercial buildings are captured by PSI's existing audit and incentive program and hence they project very little additional savings from the HVAC retirement program. ACEEE on the other hand believes that savings from PSI's audit and incentive program are relatively modest (participating customers reduce their energy use by about 5 percent) and that substantial savings are available in the long-term through a program that emphasizes HVAC system optimization at the time of HVAC equipment replacement and also includes comprehensive lighting retrofits that allow the new HVAC system to be downsized substantially. Approximately 75 percent of the difference between the conservative and optimistic scenarios is due to differences over this one program.

Table 3. Summary of Proposed New/Enhanced DSM Programs

Residential Sector	
Second Refrigerator Turn-in	Encourages customers to turn in under-used second refrigerators and includes environmentally-safe disposal.
Compact Fluorescent Lamp Manufacturers' Cost Credits	Promotes availability of affordable CFLs in local retail stores by providing cost credits direct to manufacturers.
Heat Pump Water Heater	Seeks to establish local market for HPWH through use of incentives and work with trade allies—targets new construction and equipment replacement markets.
Clothes Washers	Provides incentives for purchase of horizontal-axis and high-spin speed clothes washers.
Farm Efficiency	Provides technical assistance and incentives to farmers to improve lighting, heating, ventilation, grain drying, watering, food handling, and food storage.
Enhanced Smart $aver	Adds duct sealing to new construction program.
Commercial Sector	
Equipment Replacement	Works with trade allies to provide incentives for purchase of high-efficiency ballasts, motors, HVAC and refrigeration systems.
HVAC	Encourages building owners with HVAC systems that are about to fail to install new, efficient systems and at the same time improve lighting systems so that HVAC systems can be downsized.
Remodeling	Encourages efficient lighting designs at time of tenant build-out or tenant changes.
Enhanced New Construction	Adds technical assistance, a systems perspective, and expanded marketing to existing PSI program.
Industrial Sector	
New Construction	Encourages factory and process-line designers to improve the efficiency of their though expert technical assistance and incentives.
Small Industrial	Extension of existing small commercial program into the industrial market, with an emphasis on the high-and-low-bay lighting systems common in the industrial sector.
Enhanced Efficiency Improvement	Expansion of existing retrofit program—includes expert technical assistance and addition of prescriptive components for fans, pumps, air compressors and ASD's.

While Tables 1 and 3 show a total of 25 programs, in actual operation, many of these programs are or will be offered as part of a package of DSM services targeted to particular customer segments. Thus, to most individual customers and trade allies, it will appear that PSI offers a single program that contains several program components.

The combined impacts of the programs listed in Table 3 are substantial. By 2010, the peak year of the DSM impacts, these additional DSM programs are estimated to save 832 GWh in the conservative case and 1906 GWh in the optimistic case. The benefit cost ratios vary from 1.2 to 3.3 using the UC test for the conservative case. For the optimistic case the UC ratio varies from 1.3 to 3.4. These results are summarized in Table 4.

Table 4. PSI Energy Demand-Side Management Projected Impacts of ACEEE Programs

Program	Optimistic Assumptions				Conservative Assumptions			
	Utility Cost Ratio	Total Resource Cost Ratio	Peak Demand MW Reduction (2010)	Annual Energy GWh Reduction (2010)	Utility Cost Ratio	Total Resource Cost Ratio	Peak Demand MW Reduction (2010)	Annual Energy GWh Reduction (2010)
2ND Refrig. Turn-in	1.28	1.28	0.00	0.00	1.28	1.28	0.00	0.00
CF Coupon Program	2.13	1.63	0.07	7.2	2.13	1.63	0.07	7.2
Heat Pump/Water Heater	1.67	1.19	6.82	89.1	1.67	1.19	6.80	89.1
Clothes Washer Rebate	1.71	1.53	1.40	9.3	1.71	1.53	1.40	9.3
Farm Efficiency	1.30	0.98	0.01	0.08	1.18	0.89	0.01	0.04
Enhanced S$ - Duct Seal	3.27	2.70	1.94	14.3	3.27	2.70	1.94	14.3
Commercial Equipment Replacement	1.48	1.60	28.58	114.5	2.30	1.52	19.49	78.1
Commercial HVAC Retirement Upgrade	2.93	2.44	210.84	844.8	2.60	2.18	10.54	42.2
Commercial Remodeling - Lighting	2.74	2.31	37.46	150.1	2.91	2.07	7.36	29.5
Commercial New Construction	3.44	3.86	19.51	78.2	3.44	3.86	19.52	78.2
Industrial New Construction	1.71	1.71	38.68	290.5	2.43	1.81	23.44	176.1
Small Industrial Direct Installation	1.93	1.62	1.61	12.1	1.93	1.62	1.61	12.1
Enhanced Industrial Efficiency	2.99	9.10	39.40	296	3.01	8.81	39.40	296
Total ACEEE Programs	3.01	2.33	386.30	1906.00	2.55	2.55	131.59	832.10
Forecast Load without ACEEE			4,939 MW	38,751 GWh			4,939 MW	38,751 GWh
ACEEE as % of Forecast			7.80%	4.92%			2.66%	2.15%
Levelized Rate Impact (twenty year)			2.0 Mills				1.1 Mills	

Emission Impacts of Expanded DSM

Methodology

PSI Energy uses detailed production dispatch models to determine the level of fuel burn and hence SO_2 production by its power plants. Emission levels are determined by running these models with and without the DSM programs. Emission levels and production costs are determined by the difference between the two cases. The emission levels are converted to emission allowances and applied to a forecast of allowance prices.

The forecast values for these emission prices is quite variable. Initial forecasts made in 1992 were substantially higher than that at the present. The most recent forecast, and those values used in this analysis, range from 1995 level of $155 and rising at a 6.8 percent rate over the next ten years. The emission levels used in this analysis are based on the PSI current DSM case. A more precise level of emission that reflects the additional production dispatch effects will be made available during the Summer Study in late summer.

These avoided emission allowance benefits are included in the cost effectiveness tests used by PSI Energy to screen and evaluate the cost effectiveness of its DSM programs. The cost effectiveness tests reflect the standards in the California Standard Practice manual and include the utility cost (UC), total resource cost (TRC) and rate impact measure tests (RIM). All benefit/cost ratios presented in this paper include the financial value of these allowances.

Results

PSI Energy's base case demand-side management programs reduce SO_2 emissions by an estimated 22,500 tons in 2000, peaking at 24,900 tons in 2002 before gradually declining to 14,400 tons in 2013 as DSM measures wear out (see Figure 1). The enhanced programs developed by ACEEE increase SO_2 emissions reductions by 7,220 - 13,400 tons in 2000 (the range captures the difference between the conservative and optimistic scenarios), peaking at 10,000-21,600 in 2005, and gradually declining to 5,600 - 14,400 tons in 2013. Combining PSI's existing programs with ACEEE's conservative scenario, total SO_2 reductions in 2000 are 29,765 tons, which represents about 4 percent of the emissions reductions needed by PSI in that year. Under the conservative scenario, the total package of programs is projected to save 1476 GWh in 2000, which represents 6 percent of PSI's load forecast for 2000 before accounting for the effects of PSI's DSM programs. Thus emissions reductions, on a percentage basis, are less than energy reductions. This appears to be the case because the emission factors used in the analysis are based on PSI's existing DSM programs which emphasize savings during peak and intermediate periods. An analysis based on emission factors derived for the ACEEE programs will be presented at the conference. This analysis should show slightly higher emission allowances than presented here.

PSI is presently developing a new optimized CAAA compliance plan-results of this analysis are not yet available. However, a range of possible impacts can be estimated by assuming that DSM either defers emissions allowance purchases (which provides a low-end estimate of cost savings) or scrubbers (which provides a high-end estimate of cost savings). In all likelihood, the correct answer lies between these two extremes.

If only emissions allowance purchases are deferred, based on forecasted emissions allowance prices developed for PSI by a contractor, PSI's existing DSM programs over a 20-year period will save $29 million (1994$) in emissions allowances. The ACEEE programs will save an additional $16-27 million. These emissions allowance savings represent 12 percent of the total projected benefits of DSM. These results suggest that emissions allowance benefits can substantially alter the cost effectiveness and hence the level of DSM programs a utility affected by the CAAA may cost effectively undertake. However, these emissions allowance benefits represent only a small portion of PSI's CAAA compliance costs, which are projected to be $0.6-1.2 billion, approximately 4-7 percent using the conservative scenario.

If only scrubbers are deferred, based on an average scrubber cost of $400 per ton of SO_2 removed annually, PSI's existing DSM programs will reduce CAAA compliance costs by $60 million over 20 years, and the ACEEE programs will save an additional $45-90 million. Such a scenario accounts for a much more significant share (17 percent) of PSI's estimated CAAA compliance costs.

Another advantage of DSM is that it helps ameliorate the bill impacts of CAAA compliance. PSI estimates that in 2000, CAAA will cost a typical customer $180 annually. DSM programs, by reducing energy use and hence energy bills for the average customer, reduce these impacts by $100 under the ACEEE conservative scenario.

Conclusions

There are many reasons for undertaking energy efficiency DSM programs. This analysis suggest that complying with the CAAA is one of them. Incorporating these benefits into the DSM screening process may increase the penetration of cost effective DSM programs. It also suggests that as a stand alone strategy, DSM programs are insufficient

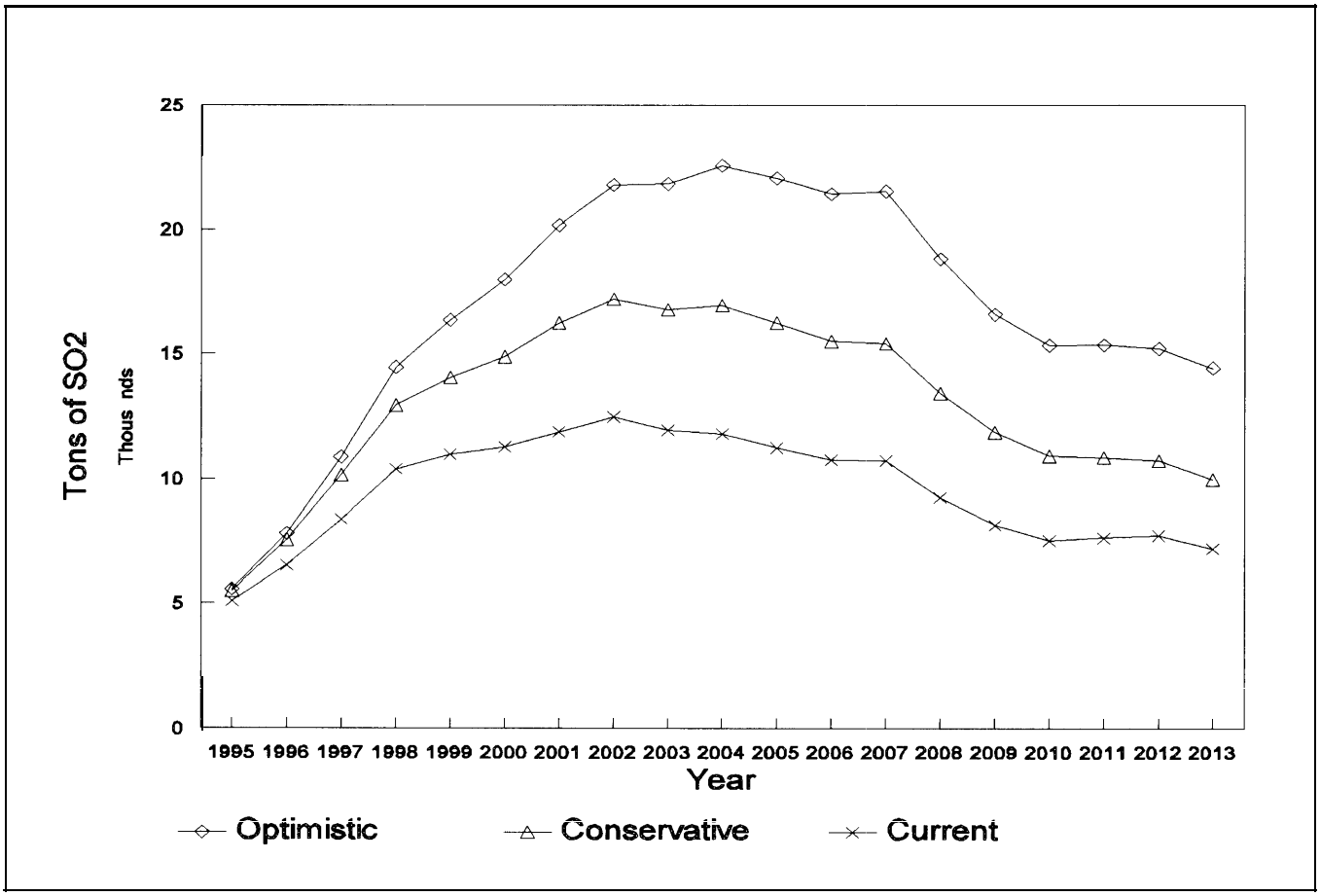

Figure 1. PSI Energy - Emission Reductions from DSM

to meet compliance. However, what DSM does provide is the added flexibility of an additional tool to meet future long term environmental regulations. DSM programs also help reduce the customer bill impacts of CAAA compliance.

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