COMPREHENSIVE ASSESSMENT OF A CONSERVATION AND LOAD REDUCTION PROGRAM: RESULTS OF THE GENERAL PUBLIC UTILITIES CASE STUDY

Douglas Norland
The Alliance to Save Energy

ABSTRACT

This paper presents the major quantitative results from the Alliance's recent case study for General Public Utilities (GPU) assessing a comprehensive demand-side management (DSM) program. The purpose of the study was to assess what amount of resources GPU could devote to conservation and load reduction programs meeting a corporate goal of minimizing future revenue requirements.

Seventy-five conservation and load reduction options were analyzed across the residential, commercial, and industrial classes. Data gathered on these options included initial costs, energy and demand savings, and market penetrations. Data on GPU's end-use consumption and peak demand, marginal costs, average rates, and customer class investment cutoff criteria were also gathered. The data were used in a market penetration and equipment stock turnover model to simulate the incremental impacts of a cash rebate program -- operating at rebate levels from 10 to 90 percent of incremental option initial cost -- on option market penetrations, utility annual energy and peak demand forecasts, and utility revenues and costs.

Fifty-five of these options were found to be economic to society for GPU to promote in the cash rebate program. A rebate level of 90 percent was found to produce the greatest reduction in GPU's future revenue requirements. This program, if implemented and achieving the simulated load reductions, would save GPU $634 million in revenue requirements (in 1985 dollars). It would also achieve savings equivalent to the capacity and output of a 350 MW power plant operating at 52 percent capacity. All of this would be accomplished at an average program cost per kWh and kW saved of 2.4 cents and $124, respectively. The paper presents the program's results graphically including annual energy and winter peak demand impacts over time and by customer class.

The paper concludes with a discussion of the insights gained in the study, how GPU is using the information from the study, and the application and usefulness of such modeling in utility DSM and integrated resource planning.

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BACKGROUND AND DESIGN

Background

In 1984 General Public Utilities (GPU) asked the Alliance to assess, through a case study, the financial resources GPU should devote to conservation and load reduction programs to mimimize its future revenue requirements (or what is called applying the Utility benefit-cost test). GPU was interested in reducing its future revenue requirements to help alleviate its poor financial situation resulting from the Three Mile Island (TMI) nuclear power plant accident. Because of the accident GPU was experiencing substantial clean-up costs, lost revenues from TMI's being taken out of the ratebase, and high costs of purchased power.

Study Design

Working together, GPU and the Alliance set the study's scope. First, the study was restricted to GPU's two Pennsylvania subsidiaries -- Metropolitan Edison Company (MetEd) and the Pennsylvania Electric Company (Penelec) -- rather than also including its New Jersey subsidiary, which was under a different state's regulatory order to implement specific types of conservation programs. In 1984, the base year for this study, the customers of the two Pennsylvania subsidiaries consumed 18,324 GWh and demanded 3,270 MW at summer peak and 3,577 MW at winter peak.

Second, we decided to conduct a comprehensive analysis by modeling end-uses and technical options for the residential, commercial, and industrial classes. Most of the options affect the entire load shape, producing both energy and peak demand savings. We also concentrated solely on options that were, or were soon to be, commercially available and that had good documentation on their energy and demand savings.

Third, because it would be impossible to model and evaluate the many Demand-Side Management (DSM) programs that could be designed, we decided to model a generic program of rebates, searching for the rebate level at which GPU's future revenue requirements would be minimized.

Fourth, GPU desired to assure that societal costs would not rise due to any program they might implement. To assure this requires that the program meet what is called the Total Resource Cost test. At the same time, GPU decided not to apply the Ratepayer Impact Measure test[1] (though we calculated it) because its overiding concern was to reduce its financing requirements by reducing the rate of growth in its energy sales and peak demand.

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[1]See the forthcoming update of the "Standard Practice Manual for Economic Analysis of Demand-Side Management Programs," California Public Utilities Commission and California Energy Commission for definitions of the Utility, Total Resource Cost, and Ratepayer Impact Measure tests.

Data Inputs

Two types of data were required for this project: DSM technical option data and utility data. Because of the amount of data and assumptions involved in the case study, the data are only highlighted here.

DSM Option Data. Data on 75 DSM strategic conservation options were gathered for the three customer classes. Twenty-five options were identified for nine residential end-uses, 28 options for eight commercial end-uses, and 22 options for six industrial end-uses. The end-uses and number of options modeled are shown in Table I. The end-uses are listed according to their contribution to GPU's energy sales.

Table I. End-uses and number of technical options modeled for GPU by customer class.

Residential	Commercial	Industrial
Other & lighting (1)	Ventilation (3)	Motors (8)
Refrigeration (3)	Cooling (6)	Process heat (3)
Water heat (5)	Space heating (2)	Lighting (7)
Space heat (8)	Lighting (8)	Space heat & misc. (2)
Cooking (0)	Refrigeration (3)	Electrolytics (1)
Drying (1)	Water heating (3)	Refrigeration (1)
Freezer (3)	Miscellaneous (2)	
Window A/C (2)	Cooking (1)	
Central A/C (2)		

The options consisted of efficient appliances, lighting, and motors; insulation; motor controllers; energy management systems; and cooling, refrigeration, and process heating alternatives.

For each option, we recorded information on initial cost, useful life, current and expected long-term market penetration, percent of customers the option applies to, year of market introduction, and savings for energy (on- and off-peak and by season) and demand (diversified and non-diversified summer and winter peaks). This data was obtained from GPU, secondary sources, and an earlier Alliance case study with Arkansas Power & Light Company.[2]

Utility Data. We collected data on the subsidiaries' marginal energy and capacity costs, average class rates, discount rates (utility and consumers), energy and demand forecasts, and class energy and demand end-uses.

GPU's planning assumptions estimated the level of the subsidiaries' marginal generation costs to be 4.0 cents/kWh on-peak and 2.5 to 3.0 cents/kWh off-peak, growing at nominal annual rates of 6.3 percent for MetEd and 5.7 percent for Penelec. For comparison to GPU's marginal energy costs, average class rates used for energy were 9.0 cents/kWh for residential, 6.2 cents/kWh for commercial, and 4.8 cents/kWh for industrial. Demand rates used for commercial were $9.00/kW per month and for industrial, $7.20/kW per month. Marginal capacity costs are represented by costs of the Pennsylvania-Maryland-New Jersey (PJM) Power Pool, which sells capacity under a complex formula estimated by GPU for the project to equal $36.00/kW at summer peak and $19.00/kW at winter peak.

[2]Utility Promotion of Investment in Energy Efficiency: Engineering, Legal, and Economic Analyses, Alliance to Save Energy (August 1983).

Overall, GPU is a utility characterized by low load growth, nearly equal summer and winter peaks (the winter is larger), a shortage of generation capacity, and average levels of marginal energy and peak capacity costs. Technical options that dampen the growth in both seasonal peaks and electricity consumption year around and that possess low costs of conserved energy and demand are ideal ones for GPU to pursue.

DSM Program Design

The design of the program for GPU was kept simple. We modeled a program of rebates to customers investing in DSM options that contributed to the achievement of GPU's stated conservation and load management program goal: minimize future revenue requirements without raising societal costs of acquiring energy services.

To meet this goal required the application of two constraints in setting rebate values for DSM options. First, to ensure minimization of future revenue requirements, rebate values must be constrained to be less than or equal to the present value of the DSM option's avoided cost savings evaluated at the utility's cost of money. Otherwise, the utility will spend more money paying out an incentive than the costs it saves by not producing electricity it otherwise would have, thereby losing money and increasing its revenue requirements (through the vehicle of a rate request). Second, to ensure that societal costs for obtaining equivalent energy services did not rise, rebates were offered only on DSM options economical to society. Such options were evaluated on a Net Present Value (NPV) basis using the yield on long-term U.S. government securities as a proxy for a risk-free rate -- which equaled 7.5 percent at the time of our analysis.

Rebate values were calculated as a percentage of the option's initial cost. By initial cost we mean the differential in cost between purchasing a high-efficiency versus standard-efficiency product, such as fluorescent lighting. Where no efficiency options exist for a product, such as an adjustable frequency motor drive, the full purchase cost is the initial cost.

To determine the amount of resources GPU could devote to strategic conservation to minimize future revenue requirements, we evaluated alternative rebate values from 10 percent to 90 percent of the option's initial cost in 10 percent increments. Rebates were held to this range because (a) the parameter in the market penetration model that determined the rate of adoption of an option (and that was adjusted for the rebate) became indeterminate at rebate values equal to, or greater than, 100 percent of option initial cost and (b) there is little utility program experience involving the offering of very high rebates from which to construct a model or to compare results.

Applying the initial cost constraint to DSM options often imposed a more severe constraint than applying the marginal cost constraint. This occurred because the value of the option's initial costs were often far below the value of the option's energy and demand savings. In this situation, paying rebates equal to or higher than 100 percent of option initial cost could be done and still reduce revenue requirements.

THE GPU STUDY: RESULTS

The results of the GPU case-study analysis are presented in two parts: (1) Conservation Opportunity and (2) Program Analyses.

Conservation Opportunity--Over Time

Conservation Opportunity--Over Time shows the maximum impact on GPU's load curves from consumer investment in all energy efficiency options economic according to their financial criteria for making investments. These maximum savings we call Conservation Opportunity-Customer, or COc. Consumers acting on their own will naturally capture some portion of the opportunity in either case.

Figures 1 and 2 show the magnitude of COc for annual energy and winter peak demand (the larger peak) for GPU. In the figures two load curves are:

1. ULceu -- the constant efficiency and utilization reference curve. This curve is drawn as a reference in our approach. It shows the amount of electric sales or peak demand that would have occurred if, in our approach, the efficiencies and use of all electricity-using devices and processes were held constant (or "frozen") at 1985 levels.

2. ULcocb -- the utility load assuming investment in all options economic to individual consumers. The "coc" stands for conservation opportunity-customer. The "b" designates before rebate program.

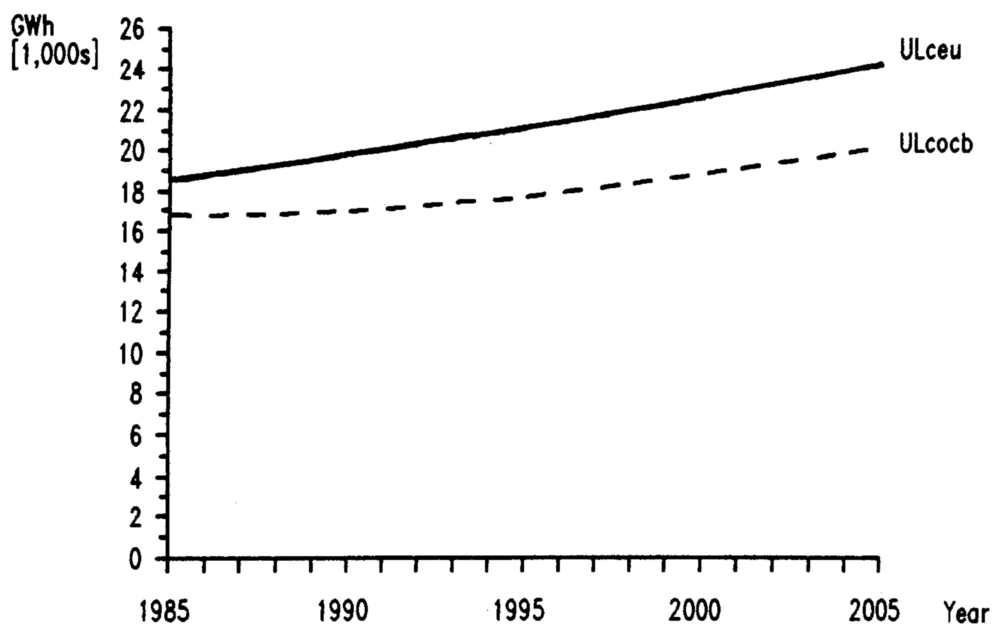

Figure 1. Conservation opportunity: annual energy (1985-2005).

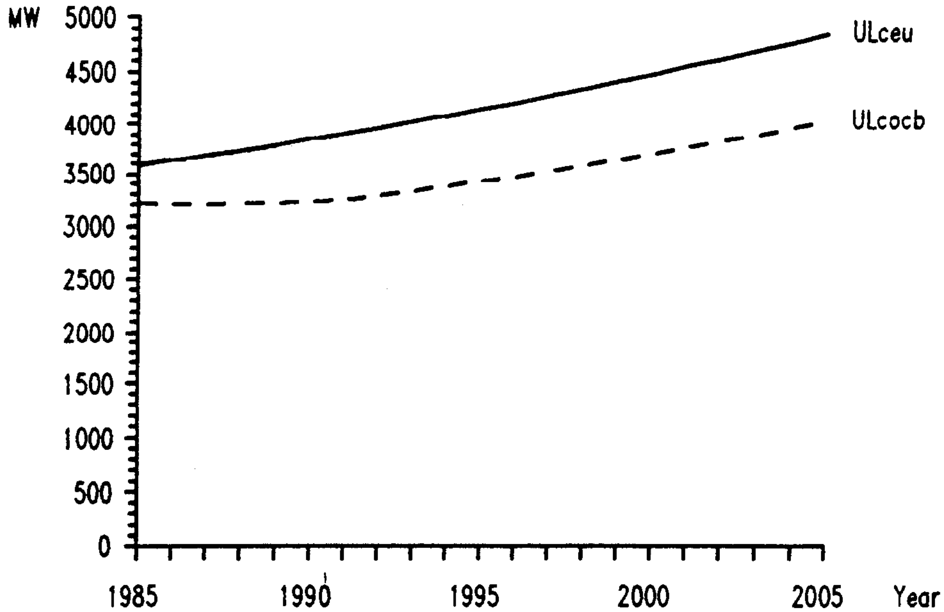

Figure 2. Conservation opportunity: winter peak demand (1985-2005).

Ulceu minus ULcocb equals COc. Looking at the numbers for the year 2005, we find COc for annual energy is 4,055 GWh. This opportunity is 17 percent of the constant efficiency and utilization reference projection. For winter peak demand, the opportunity for load reduction is 818 MW (also 17 percent of ULceu).

Our estimates show substantial conservation opportunities exist that could be captured, in part, through new GPU DSM programs. The paper next presents the results of our analysis of the generic DSM rebate program examined over the alternative rebate levels.

Program Analyses

Benefit-Cost Test. We analyzed the impacts and program cost-effectiveness of rebate programs with rebate levels ranging from 10 to 90 percent (in 10 point increments) of device initial cost. Of the 75 options evaluated, rebates were offered on 55 options -- options economic to society on a NPV basis. The rebate program was assumed to last for twenty years with benefits and costs being evaluated for thirty years.

Initially, a market penetration curve was calibrated for each option assuming no rebate program. Then, for each rebate level new penetration curves were estimated, translated into load curve and utility revenue and cost impacts, and evaluated for cost-effectiveness. Figure 3 shows the results for the Utility Test for each rebate level where the test was calculated at GPU's cost of capital of 14.0 percent. We found that the "optimal" rebate level (given GPU's corporate goal and the 10 to 90 percent range modeled) for each customer class is 90 percent. At this level GPU would achieve the greatest reduction in revenue requirements, $634 million (in 1985 dollars).

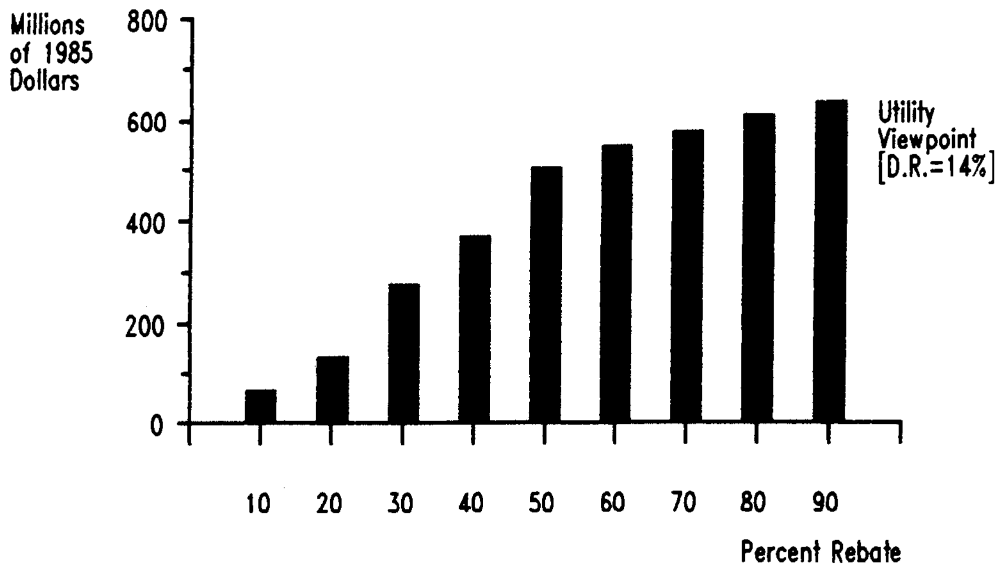

Figure 3. Utility cost-effectiveness test results: alternative rebate levels (10 to 90 percent in ten point increments).

Load Curve Impacts. The impacts of the 90 percent rebate program on our forecasts of GPU's energy and peak load curves are shown in Figures 4 and 5. In the figures, ULforb is the Alliance forecast before the program (also called our base case), and ULforp is the Alliance forecast with the program. The change in the Alliance forecast resulting from the rebate program is the difference between ULforb and ULforp. These figures are followed by Figures 6 and 7, which show the rebate program impacts (ULforb - ULforp) for annual energy and winter peak broken out by customer class.

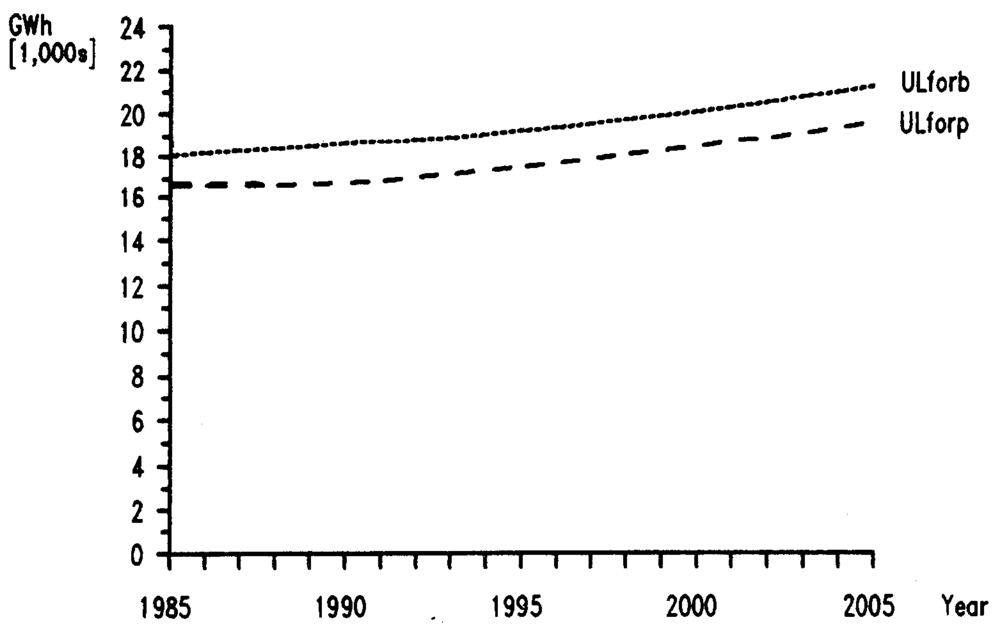

Figure 4. GPU 90 percent rebate program impacts on annual energy: 1985-2005.

In Figure 4, the effect of the rebate program is to raise the amount of savings from customer investment by 1,400 to 1,700 GWh a year. In examining the individual customer classes (Figure 6), the bulk of the energy savings come from the residential and commercial classes (about 75 percent in 1985, rising to 90 percent in 1995 and beyond).

The impact of the rebate program on the Alliance base case forecast for winter peak (Figure 5) ranges in most years from 350 to 425 MW per year. Overall, the residential sector accounts for approximately 60 percent of the winter peak savings from the early 1990s to 2005 with the commercial and industrial sectors accounting for 30 percent and 10 percent, respectively.

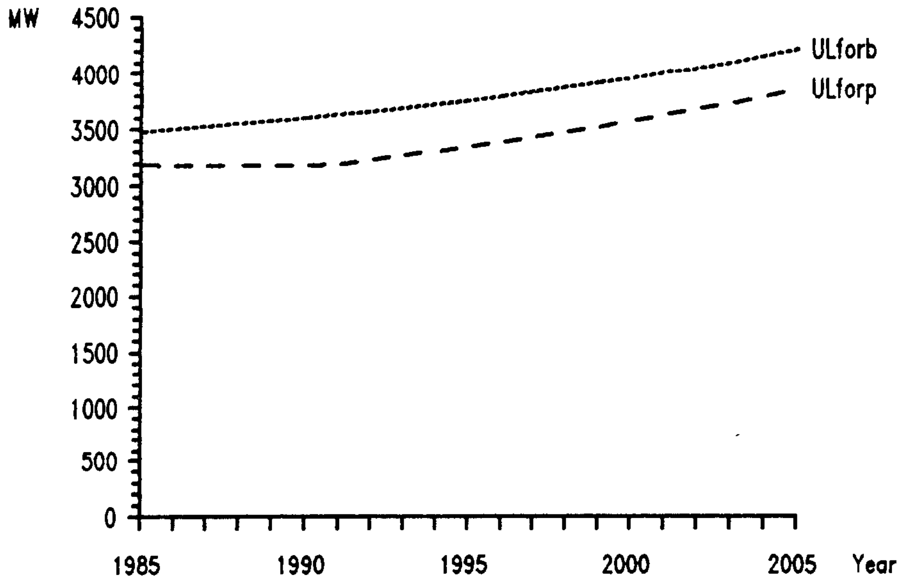

Figure 5. GPU 90 percent rebate program impacts on winter peak demand: 1985-2005.

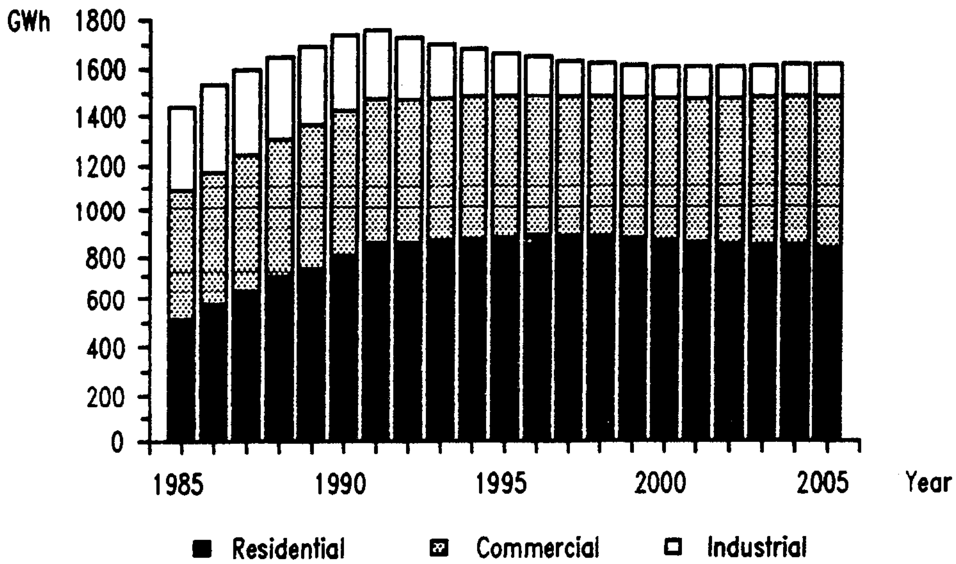

Figure 6. GPU 90 percent rebate program induced impacts on annual energy by customer class: 1985-2005.

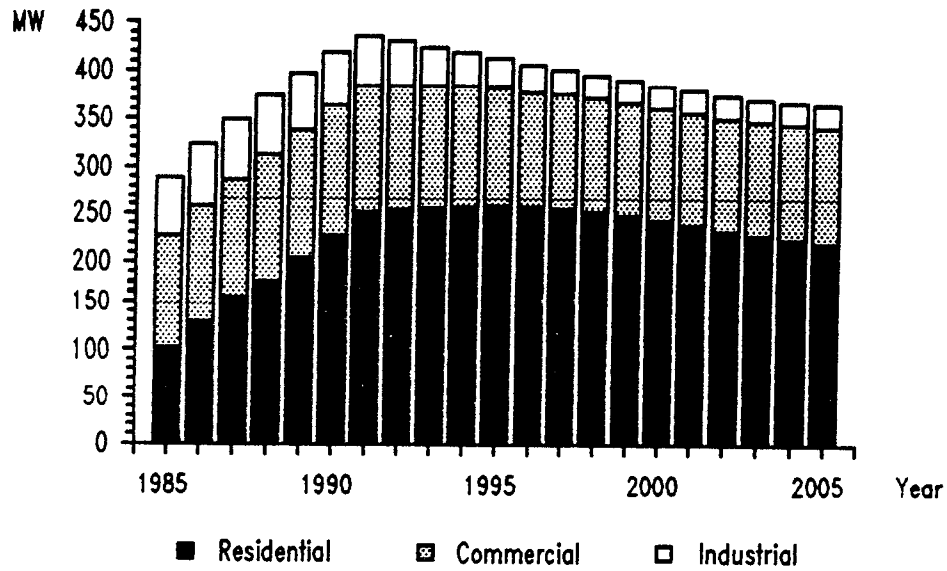

Figure 7. GPU 90 percent rebate program impacts on winter peak demand by customer class: 1985-2005.

Both energy and winter peak demand savings for the residential class come from lighting, efficient appliances (refrigerators, freezers, and water heaters), and ceiling insulation. Commercial savings result from efficient lighting and HVAC opportunities. Industrial savings are dominated by motor (adjustable frequency drives) and lighting options. Although the industrial class accounts for about 40 percent of GPU's energy sales and 30 percent of its winter peak demand, its conservation and load management savings opportunities are proportionately smaller because of the dominance of motors used in continuous process situations already are of high efficiency and high load factor.

These total impacts on GPU's load curves can be interpreted using a simple analogy. The impact is virtually the same as the capacity and output of a 350 MW power plant operating at 52 percent capacity. In other words, our DSM program that best meets GPU's objective (given the range of rebate levels analyzed) could be described as a 350 MW conservation power plant. This size demand reduction also can be translated into a delay in the construction schedule for new capacity. At GPU's projected growth in winter peak demand (the higher of the two peaks), the 350 MW savings would translate into a ten year delay.

The impacts of these savings would also reduce the annual growth rates in annual energy and winter peak demand over the 20 year planning horizon for GPU in the following manner: energy from 1.24 to 0.88 (a 29 percent reduction) and winter peak demand from 1.03 to 0.63 (39 percent).

GPU Revenue and Cost Impacts. The impacts of the rebate program on the present values of GPU's revenues and costs required to calculate the Utility test are shown in Table II. The fuel savings benefits of the program dominate the cash flow changes, and are the primary reason the test shows substantial net benefits.

Table II. GPU 90 percent rebate program: benefits and costs (millions of 1985 dollars).

	Benefits*		Costs		Net Benefits	
Class	Fuel	Capacity	Admin.	Rebates	Dollars	% Of Total
R	311.6	99.3	9.7	104.5	296.7	46.8
C	256.8	106.8	9.1	118.6	235.9	37.2
I	101.7	30.1	2.6	27.6	101.6	16.0
ALL	670.1	236.2	21.4	250.7	634.2	100.0

*Does not include transmission savings, which were not quantified in the study.

Capacity savings were quantified at $19/kW/year for a kW of winter peak savings. This number represents the current value of the transfer price for capacity for the PJM Power Pool[3] that is used by GPU in their demand and supply option analyses.

The capacity savings benefits, however, are -- in the view of the Alliance -- understated. Like GPU, the Alliance prefers to evaluate strategic conservation and load reduction programs by evaluating short-term savings in terms of marginal fuel costs and power pool or holding company capacity charges. But for longer-term savings, we prefer to evaluate savings based on the levelized cost of constructing and operating a base load plant, as do some other utilities, and as we did in the AP&L study. We believe such an approach to evaluating the benefits to GPU of the DSM program would show even larger net benefits to GPU's customers.

The Cost Of The Program To GPU

The cost to GPU of the rebate program producing the greatest reduction in revenue requirements is $272 million, of which $21 million is for administrative costs and $251 million is for rebate payments (all in 1985 dollars). This, therefore, is our answer to GPU's question of how much resources they could devote to strategic conservation programs. This cost is less than that of constructing a comparable power plant (estimated at $525 million for 350 MW at $1500 per kW). It, however, covers the cost of operation (which is not reflected in the power plant construction cost). It also is recoverable immediately (assuming expensing), produces immediate net benefits, and reduces revenue requirements on a net basis rather than increasing them.

On a program basis the levelized cost of a kWh saved is 2.4 cents and for a kW of winter peak, $34. The energy costs are very competitive with GPU's marginal costs of generation, lying below GPU's lowest cost of 2.5 cents/kWh for winter off-peak generation. While the capacity cost is higher than the PJM capacity charge, one has to keep in mind that the PJM capacity charge reflects the cost of peaking units, which have a very low initial capital cost compared to the unit cost of base load capacity but inefficiently convert fossil fuel to electricity compared to base load units. The use of a peaking unit's levelized cost as the proxy for marginal capacity costs is fine in the short term, but, as mentioned above, it understates such costs in the long term when base load capacity needs to be built. We estimate the marginal cost of just constructing base load capacity to range from $124 to $184 per kW on a levelized basis in 1985 dollars. Thus, the rebate program's cost per kW saved is a real bargain when compared to the marginal costs associated with new base load capacity.

[3]The full capacity transfer price equals $55/kW of which $18 is allocated to the winter and $36 to the summer. The $55 is a reasonable proxy for the levelized cost of a kW of combustion turbine capacity.

In examining the individual customer classes, the residential class accounts for the bulk of the revenue requirements reduction. The present value to the utility of the savings in revenue requirements for each class is $297 million for residential, $236 million for commercial, and $101 million for industrial. The residential class accounts for 47 percent of the program net benefits with a benefit/cost ratio of 3.6. The industrial class has the highest benefit/cost ratio (4.3) but accounts for the smallest portion of net benefits (16 percent). The commercial sector has the lowest benefit/cost ratio with a value of 2.8.

CONCLUSIONS

As a result of the GPU study, the Alliance estimates that about 70 percent of the opportunity for electricity efficiency savings economic to society in 1995 will not be captured through consumer and business investment under normal market place conditions. Barriers to investment such as lack of capital, information, and motivation inhibit reaching the full potential for energy and demand savings. Without utility or state programs and policies encouraging more investment in electricity efficiency options, society will end up consuming more electricity than necessary at a higher overall cost compared to the efficient alternatives.

In the case of the GPU study, we concluded that a comprehensive, vigorously promoted program of cash rebates could result in capturing about one-half to two-thirds of the efficiency gains that otherwise would go unrealized. These energy and demand savings could be obtained on average for about one-half the cost of traditional supply alternatives. While investments in efficiency are economic and should be pursued, they are not the panacea some claim them to be. For example, we estimate that the impact of our rebate program could reduce GPU's peak load growth rate by one-third (in percent and percentage points) from what it would otherwise be. The program, therefore, cannot result in the elimination of the need for acquiring traditional supply resources.

GPU has found the study very useful in documenting the number of conservation and load reduction options and their impacts on load. In the last year of the study GPU's cost and resource circumstances changed dramatically. As a result of new base load capacity availabilty from the PJM pool, of which GPU is a member, GPU's marginal generation costs dropped by one-third (the results in this paper reflect the new costs), and GPU received substantial offers of co-generation capacity. GPU is now using the study's results to reassess their integrated resource plan and document the opportunity for DSM program savings to the Pennsylvania PSC in light of these new conditions.

In making such resource acquisition decisions, we believe modeling approachs (like ours) to evaluating demand-side management options meets the needs of managers in today's environment. Simple approachs that incorporate explicit information and assumptions on technical option performance and market penetration (both before and after DSM program implementation) are the most useful in integrated resource planning.