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Program Experience and Its Regulatory Implications: A Case Study of Utility Lighting Efficiency Programs

Authors

Krause, F.
Vine, E.
Gandhi, S.

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F. Krause, E. Vine, and S. Gandhi

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Florentin Krause, Edward Vine, Sunita Gandhi

Energy Analysis Program
Applied Science Division
Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley, California 94720

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EXECUTIVE SUMMARY

In this report, we review the experience of utilities with a variety of lighting efficiency program designs, as illustrated by a dozen recent utility programs for residential, commercial, and industrial customers. This experience is then examined in terms of regulatory implications in the context of least-cost utility planning. The key questions explored in our report are as follows:

- How effectively are current utility programs mobilizing the technical potential of lighting efficiency resources?
- How does the program-based cost of lighting efficiency differ from the technology-based costs used in technical potential studies?
- What program designs appear to be most effective in reaching participants?
- What are the trade-offs between maximizing participation rates and per-customer savings and minimizing program costs?

In addition to these program evaluation questions, we also explore regulatory implications of lighting program experience:

- Could lighting programs offer resources substantial enough to defer the construction of power plants?
- What measures could be taken by regulatory commissions to ensure and facilitate further utility program improvements?

Detailed descriptions for the examined programs are compiled in appendices. The main body of the report analyzes these data in terms of the following parameters:

- range of sponsored efficiency technologies
- effectiveness of program designs in achieving high participation rates and cumulative penetrations;
- the impact of financial and other incentive levels on participation rates;
- persistence and take-back issues;
- unit costs of lighting efficiency resources and their cost-effectiveness under various least-cost tests;
- and free rider problems and their impact on lighting efficiency resource costs.

The principal findings of the report can be summarized as follows:

- In our sample, the total resource cost (utility incentive payments and administrative costs plus customer costs) of utility lighting efficiency programs ranged from about 0.7 ¢/kWh to about 3 ¢/kWh of electricity saved. These costs are less than typical short-run marginal costs.
- The administrative cost of running lighting efficiency programs was on the order of 0.1-0.8 ¢/kWh. Relative to the total resource cost without administration, program

administration costs bring an increase of typically about 10-30 percent. As program designs are improved these costs could be lowered further.

- Aggressive program designs that include free provision and/or installation of lightbulbs and personal contact with customers achieved large monthly participation rates. The cumulative penetration fraction (the number of eligible customers who participated) of these programs reached as much as fifty percent or more within a few months of operation.
- Conventional rebate programs appear to be reasonably effective for large commercial customers only. Even there, personal contact from utility representatives may be required to increase participation. For most customer classes, direct customer contact and free provision of full service packages (audits, hardware, redesign and installation) proved most effective.
- Aggressive program designs require larger outlays by the utility but do not necessarily drive up the unit cost of savings. In the programs we analyzed, higher per-customer savings ensured that costs per unit of electricity saved remained low.
- Significant improvements could be made in the range and choice of sponsored lighting efficiency technologies. Most programs mobilized less than one-tenth of the technically available per-customer savings. In residential sector programs, better bulb selection could make screw-in fluorescents suitable for a larger number of fixtures. In the commercial sector, optimized packages based on electronic ballasts, efficient lamps, and specular reflectors should receive more attention. Also, daylighting and occupancy control technologies should be more widely included in future programs.
- More sophisticated technological packages that offer greater per-customer savings will place greater demands on the technical and lighting design expertise of lighting program staff. Utility and subcontractor training programs will need to be expanded to meet these demands.
- A number of the program approaches described in the sample of this study were successfully tested on a pilot scale only. While more testing of these approaches is needed on a large scale there is strong reason to believe that the above findings can be generalized.

The current and potential future contribution of lighting efficiency programs to the nation's needs for electricity resources can be characterized as follows:

- The total annual impact of lighting efficiency programs on national power requirements as of the end of 1989 is small, measured at most in hundreds of MW of baseload equivalent. The lighting programs studied in this report had contributed an estimated 10 MW of baseload equivalent by the end of 1988. Peak savings were significantly larger.
- If present programs were improved on the basis of the lessons learned so far and implemented on a national scale they could possibly free the output equivalent of 5-20 GW of baseload capacity in the U.S. They would likely also have a significant indirect savings effect, due to program spill-over into the lighting equipment market.

For regulatory commissions wishing to promote a more complete mobilization of lighting efficiency resources, the following actions suggest themselves:

- Utilities need to be given appropriate regulatory rate-of-return rewards for pursuing lighting efficiency resources more aggressively.
- Commissions should encourage utilities to experiment with more advanced technology packages in their lighting programs and to use their market-creating powers to help stimulate broader commercial availability of efficient lighting technologies at a lower price.
- Regulatory commissions should consider establishing a process in which utility staff, regulators, and technical experts would review options for improving technology choices and other aspects of program designs.
- Commissions should encourage more widespread experimenting with different program designs. The more aggressive approaches found in some of the more innovative pilot programs should be tested and implemented on a system-wide and state-wide basis.
- To improve the cost data on lighting efficiency programs, commissions should consider requiring the reporting of total resource costs, i.e. both utility costs and the costs borne by the customer. Also, reporting of utility administrative costs should be standardized.

I. INTRODUCTION

This report takes an approach to utility demand-side program experience that differs from previous work in both focus and methodology. The assessment of program experience is limited to one specific end-use of electricity, i.e. lighting. Program approaches of a limited number of exemplary or illustrative programs are described and analyzed in depth. And the lessons learned about how to conduct effective programs are reviewed in terms of the implications for the evolving practice of least-cost utility planning (LCUP).

1. Program evaluation in the context of least-cost planning

During the early- to mid-1980s, the larger policy context for evaluation studies of demand-side management programs was predominantly provided by the goal of moderating energy use to help customers adjust to higher energy prices. More recently, utility demand-side programs have become part of efforts to improve efficient capital allocation in the delivery of electrical services. This report approaches program evaluation with the specific vantage point of integrating demand-side programs into utility least-cost resource planning.

Least-cost utility planning (LCUP) seeks to integrate conventional and unconventional electricity resources to provide energy services at least cost to society and ratepayers. It represents both a new approach to resource planning and a new regulatory approach. A key element in LCUP is the integration of so-called demand-side resources, i.e. electricity resources that can be freed from current or planned uses through investments on the customer side of the meter.

Past studies have found that market barriers and inefficiencies have created a large backlog of opportunities for such demand-side investments.[1] The cost-effectiveness of these resources to all ratepayers and to society often far surpass those of supply-side investments. These cost-effective demand-side resources could thus constitute a major component of utility resource plans. A number of states have actively encouraged utilities to develop efficiency and load management (E&LM) programs to balance their resource plans. Utilities, in turn, have conducted several hundred programs so far, and had spent an estimated 3 billion dollars on demand-side resources by 1986 (IRRC 1987).

Nevertheless, utility initiatives to mobilize these resources have been disappointing in the regulatory experience of most states (Wiel 1989). Regulators had hoped for a greater contribution from demand-side resources in utility resource plans than has been forthcoming so far. The major reason for this experience to date is regulatory in nature. The National Association of Utility Regulatory Commissioners (NARUC) has identified inadvertent regulatory disincentives for utility-sponsored demand-side investments, and is developing proposals to provide corrective incentives that would decouple profits and kWh sales or even institute a profit reward for utility demand-side management (DSM) activities (NARUC 1988, Moskovitz 1989).

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[1] For a summary of these findings, see e.g. NARUC's Handbook on Least Cost Utility Planning (NARUC 1989).

In addition to this fundamental barrier, utility programs, and for that matter, all demand-side efficiency programs, must address a number of practical difficulties that are more related to the nature of demand-side resources than to regulatory issues. They include both questions of program design and delivery of technology choice. Overcoming these difficulties involves experimenting and experience. Most utilities are still finding themselves at the beginning or in the middle of their learning curves.

Both factors in combination explain why the demand-side resources mobilized in actual utility programs are often far smaller than the technically available potentials estimated in studies that construct supply curves (plots and tabulations of available resources as a function of costs) for these demand-side resources.[2] Several factors contribute to this gap between achieved and technical potential:

- Not all commercially available technologies that could be utilized are sponsored in utility programs.
- Implementing cost-effective demand-side technologies through utility programs adds indirect program-related costs. Depending on their magnitude, these costs could reduce cost-effective resource potentials to less than those estimated in technical potentials studies.
- Not all customers that could benefit from demand-side investments are reached and participate in the programs.
- Some customers may utilize end-use devices with significantly lower intensity than average customers, and the peculiarities of some sites may cause much larger than average installation costs, making the program efficiency measures possibly too expensive for some installations.
- If the cost-effectiveness criteria and perspectives used by the utility and its regulators differ from the total resource cost perspective typically used in supply curve studies, this can limit the range of measures eligible for sponsorship in utility demand-side management programs.

Among the first least-cost planning analyses to use the supply-curve concept and explicitly consider program administrative costs and participation rates were the resource planning activities of the Northwest Power Planning Council and the Michigan Electricity Options Study (MEOS 1987, Krause et al. 1987). These studies had to rely on a limited body of detailed evaluations of individual programs, and on an even more limited body of studies that had extracted generalizable cost and participation parameters as a function of program design.

Since then, more program experience has become available. At the same time, a number of regulatory commissions and utilities have moved to competitive bidding procedures for resource acquisition, including the acquisition of demand-side resources. An unresolved question is whether conventional utility-sponsored and -operated programs or demand-side programs offered by private bidders would ensure a more complete and cost-effective mobilization of

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[2] The concept of supply curves for demand-side resources is introduced in Meier (1983). For a detailed supply curve exploration of technical and achievable demand-side efficiency potentials, see Krause et al. (1987).

demand-side resources. Again, this question cannot be answered without a better understanding of the quantitative and qualitative results achieved by utility programs.

Finally, proposals that would provide regulatory profit incentives for utility demand-side investments magnify the need for detailed evaluations of program experience. Such evaluations could address measurement issues raised by these incentives proposals. They can also help guide future utility experimentation with improved program designs.

2. Program surveys versus in-depth analysis

Program experience has been analyzed in two major ways: one is the compilation of program data and results in the form of comprehensive surveys or databases (EPRI 1988, IRRC 1987). Here, the NORDAX project of New England utilities (NORDAX 1988) goes a significant step further in that it develops a consistent reporting and data development protocol for a large number of programs.

Comprehensive surveys have provided valuable insights into the volume and direction of utility DSM activity, but they do not provide the detailed information needed for extracting more than broad generalizations about the "lessons learned." A second, complementary category of evaluation is the in-depth analysis of individual programs. In-depth process and impact analyses are needed to reliably translate specific program features, circumstances, and histories into guidelines for future program experimentation and lessons learned.

An inherent limitation of such in-depth studies is that they do not necessarily capture all pertinent program experience and do not provide a statistical sample. The unique value of samples of such more in-depth investigation is based on the proposition that many of the implementation problems and solutions found in a particular utility program are transferable, i.e., they would apply to utilities elsewhere, were they to run a comparable program. From this perspective, a sufficiently detailed understanding of how individual programs were run is essential.

While a growing number of individual programs have been described and evaluated, much less work has been done so far to assemble, analyze, and interpret this body of experience in terms of its relevance for utility least-cost planning and LCUP regulation. This deficit takes several forms:

- Analyses of lessons learned have emphasized the impact of customer attributes (customer classes and subclasses) on program success, but have not sufficiently disaggregated program experience *by technology and end use*. Due to the great diversity of end-use technology attributes, customer acceptance criteria, wholesale and retail markets, and industry and trade ally structures, program experiences made with one type of efficiency technology or in one type of end-use are not necessarily transferable to other technologies and end-uses.

  For example, refrigerator rebate programs must take into account many attributes other than energy efficiency that influence customer choice, such as color and features. In water heater programs, by contrast, features play a minor role. Instead, the retail and servicing industries are key, since replacement of this appliance often occurs on an emergency basis.

- The cross-cutting customer-oriented outlook of many past assessments of lessons learned has distracted focus from the impact on program success of *technological choices* and the underlying *cost-benefit assessments* at the stage of program conceptualization and initial design. Utility program evaluations to date have mainly addressed how alternative forms of program *delivery* fare within the cost-effectiveness framework chosen by the utility and/or its regulators. But these frameworks for initial cost-effectiveness assessments can greatly influence the basket of efficiency technologies that would appear worth sponsoring for individual end-uses.

  For example, a particular efficiency technology may be cost-effective against avoided costs of six cents per kWh, but not against short-run marginal costs of three cents per kWh. Depending on the planning horizon used in the overall least-cost exercise, a different technology basket would result.

  Technology choices, in turn, can influence the acceptance of the program by customers. For example, lighting programs face a choice of sponsoring non-tunable efficient core coil or electronic ballasts, or tunable electronic ballasts. Depending on which technology is sponsored, very different efficiency potentials and occupant benefits become available. Tunable ballasts can be integrated with daylighting controls and with task- and user-oriented controls for individual fixtures. The savings from these control options can be as large or larger than those from changes in lamp technology (Piette et al. 1989, Lovins and Sardinsky 1988).

The best program designs will fall far short of realizing available potentials if technological synergisms are not sufficiently understood and exploited. In general, past program evaluations have insufficiently integrated technological knowledge and experimentation with marketing and behavioral knowledge and experimentation. While some end-uses are inherently more complex than lighting, where a relatively limited number of highly standardized technologies are being applied, this observation would seem applicable to program evaluations in general.

3. Scope of this report: Illustrative study of lighting program experience

In this study, we limit our analysis to the area of lighting efficiency retrofit programs in buildings. We compromise between in-depth analysis and comprehensiveness by examining several but not all lighting efficiency programs. The choice of lighting as an area of program experience evaluation reflects a number of factors:

- According to technical analyses, recently commercialized efficient lighting technologies represent one of the lowest-cost demand-side resources available (Piette et al. 1989, Lovins & Sardinsky 1988, Krause et al. 1987).
- In recognition of this fact, a growing number of utilities have made lighting efficiency programs part of their demand-side management (DSM) plans, and some state regulatory commissions have mandated that utilities conduct such programs.
- The transferability of local program experience can be expected to be high. New, more efficient lighting technologies are being produced and distributed by a mature

national supplier industry, and are thus available to any utility. The patterns of lighting use differ only moderately from region to region within the country.

Key questions

The key questions to be explored in our discussion are as follows:

- How effectively are current utility programs mobilizing the technical potential of lighting efficiency resources?
- How does the program-based cost of lighting efficiency differ from the technology-based costs used in technical potential studies?
- What program designs appear to be most effective in reaching participants?
- What are the trade-offs between maximizing participation rates and per-customer savings and minimizing program costs?

In addition to these program evaluation questions, we also explore regulatory implications of lighting program experience:

- Could lighting programs offer resources substantial enough to defer the construction of power plants?
- What measures could be taken by regulatory commissions to ensure and facilitate further utility program improvements?

A question that is not addressed in this report but should be considered for future research is the following:

- What, if anything, does the experience with lighting programs suggest about the relative effectiveness and cost of utility-run programs, versus programs run by energy service companies in a bidding context?

Research on this question must await the accumulation of more program experience with demand-side bidding.

Analytic approach.

The selection of lighting programs for analysis in this study was based on the availability of reasonably comprehensive program data and aimed at covering programs with diverse designs and participation results. A checklist for information gathering covering about two dozen program design and program impact parameters was developed, based on review of existing evaluations and surveys. An initial list of candidate programs for in-depth analysis was identified from available surveys and individual contacts. The accessibility of program data was verified through review of existing utility or consultant evaluations, and through telephone contacts with utility personnel and evaluation researchers. This was followed by sending our information gathering questionnaire to the utility program manager in question, and/or by interviewing utility staff, contractors, and other practitioners. Program data and experience were written up and submitted to the practitioners for review.

The program data and experience summaries are found in the Appendix to this report. These appendices provide much detail on particular programs. In some cases, they include such useful data as compilations of operating hours for lighting systems in different building categories and subsectors, and statistics on the reasons for non-participation.

The body of our report below presents a synthesizing analysis of this experience, including summary tabulations. In these discussions, we also include two recent analyses of lighting programs that became available after our data collection had been completed (Clinton and Goett 1989, Wolfe and McAllister 1989).

II. OVERVIEW OF LIGHTING PROGRAMS

Table 1 lists the twelve lighting efficiency programs discussed in this report. All but two are further described in the Appendix. Programs were conducted between 1985 and 1988, with some still ongoing. The programs cover pilot-scale and full-scale, community-scale and larger service territories, and municipal, publicly-owned, and investor-owned utilities. Programs targeted both industrial, commercial, and residential customers, and both small and large commercial customers. Program incentive designs include information only, free direct installation, customer rebates, shared savings (leasing), and dealer incentives. Program outreach methods include door-to-door canvassing, on-site audits, personal contact, direct mail, use of trade allies and lighting manufacturers, and advertising campaigns.

Utility program expenditures ranged from less than $100,000 for the smallest municipal program to more than $4 million, and electricity savings from less than 1 GWh to 16 GWh. Peak demand savings were up to several megawatts per program. By the end of 1988, the twelve programs saved electricity equivalent to the output of about 10 MW of baseload capacity.

Program 1: NEES direct installation

This program was a pilot-scale program aimed at small commercial and industrial customers. It exemplifies an aggressive delivery approach. The utility paid all auditing, equipment, and installation costs.

Program 2: Sacramento Municipal Utility District

This program began as a pilot program and tested an aggressive delivery approach based on free provision of lamps and door-to-door canvassing of small commercial customers, including on-the-spot installation of some lighting efficiency measures.

Program 3: Austin Municipal Utility

This program began as a pilot program and was subject to a significant effort by the utility to assess program impacts and improve process evaluation. It was an audit and rebate program aimed at commercial customers.

Program 4: NEES Customer Rebate

This program was a pilot-scale program in NEES's Rhode Island territory to test the relative effectiveness of customer rebates compared to direct installation. It covered commercial and industrial customers at large.

Program 5: City of Palo Alto

This customer rebate program began as a pilot program and was aimed at large commercial and industrial customers. The utility used consultant services to evaluate and improve the program.

Program 6: NEES dealer-incentive

This full-scale dealer incentive program was aimed at commercial and industrial customers at large. It was launched system-wide to test whether it could deliver greater savings more cheaply

Table 1: Overview of reviewed lighting programs

Program Sponsor	Program Type and Scale		Program Duration	Evaluation by	Targeted Customer Class	Program Cost (million $)	Estimated Savings	
							GWh/yr	MW peak
1. NEES Massachusetts	Direct Installation	Pilot	Aug. 1985-Dec. 1986	Utility staff	Small C&I (< 100 kW)	2.20	5.90	1.90
2. SMUD	Direct Installation	Pilot/ Full-Scale	Jul. 1986-Oct. 1987	Utility staff	Small Commercial	0.62	3.73	1.30
3. Austin Mun. Utility	Customer Rebate	Pilot/ Full-Scale	Apr. 1984-Sept. 1986+	Consultant/ Utility staff	Commercial	0.69	4.84	3.4-4.0
4. NEES Rhode Island	Customer Rebate	Pilot	Jan. 1985-Jun. 1987	Utility staff	Commercial & Industrial	0.40	5.40	1.20
5. City of Palo Alto	Customer Rebate	Pilot/ Full-Scale	Jan. 1985-present	Consultant/ Utility staff	Large C&I (> 500 kW)	n.a.		2.48
6. NEES system-wide	Dealer Rebate	Full-Scale	Jul. 1987-present	Utility staff	All Commercial & Industrial	1.90	9.00	2.40
7. Niagara Mohawk	Info/ Rebates	Pilot	1988/89	Consultant/ Utility Staff	All Commercial & sm Industrial			
8. BPA/ Clark PUD	Incentives $/kWh saved	Pilot	1985-88	Consultant/ Utility staff	Industrial (medium & small)	0.90	3.45	3.24
9. SCE	Direct Installation	Full-Scale	Jun. 1985-present	Utility staff	Low-Income Residential	2.3	16	7
10. NYSEG	Customer Rebate	Pilot	Fall 1982-Spring 1983	Utility staff	Residential			
11. Traer Mun. Utility	Direct Installation	Pilot/ Full-scale	February-Apr. 1987	Utility staff	Residential & Commercial	0.20 (resid.)	0.55	
12. Taunton Mun. Utility	Shared Savings	Pilot/ Full-Scale	Spring 1988-present	Utility staff	Residential	0.08	1.5	

by giving rebates to dealers and letting them and contractors market sponsored lighting efficiency measures.

Program 7: Niagara Mohawk

This pilot program tested information and several levels of rebates to attempt to find out how lighting efficiency measures could be delivered at the lowest cost to the utility. It served commercial and small industrial customers.

Program 8: Clark PUD

This pilot program was aimed at small and medium sized industrial customers, and tested an aggressive delivery approach under the special conditions in that sector. It offered financial audits and installation services. Incentives to customers were provided on a simplified shared savings basis, with the customer paying an amount equivalent to the estimated first year's energy savings only.

Program 9: Southern California Edison

This full-scale program serviced low-income residential customers on a system-wide basis. It used an aggressive delivery mechanism of free installations and community-based organizations (CBOs) to penetrate this difficult-to-reach sector.

Program 10: New York State Electricity and Gas

This pilot program was one of the first, if not the first, of residential customer rebate programs for efficient lightbulbs. It tested various levels of rebates and provides a useful historical marker for the evolution of program approaches since 1982.

Program 11: Traer Municipal Utility

This small community-wide program was an aggressive program conducted in a small community with the goal of fast penetration. A free lightbulb exchange was conducted on two days to convert incandescents in most households to more efficient bulbs.

Program 12: Taunton Municipal Utility

This small community-wide program tested the use of leasing-based shared savings arrangements for application in residential lightbulb conversion. While not as aggressive as direct installation, this type of program allows the utility to retain part of the savings that would otherwise accrue entirely to the customer. This approach reduces lost revenues from efficiency programs, and can actually reduce revenue requirements and improve utility earnings (NARUC 1989).

III. PROGRAM EFFECTIVENESS IN MOBILIZING LIGHTING EFFICIENCY RESOURCES

The total lighting efficiency resource available to a utility is proportional to the number of customers and the unit savings achieved per average customer. As already mentioned above, the magnitude of the available resource has an upper limit, the *technical potential* based on installation of the full menu of cost-effective technical options in all facilities where they can be applied. Actual utility programs will realize less than the technical potential because not all customers participate, because not all available technologies are being applied, and because technology options are not always combined in optimal fashion to exploit synergistic effects.

It is therefore of interest to understand what fraction of the technical potential was realized and could be realized in lighting efficiency programs. The assessment of this *achieved fraction* involves two basic parameters: the choice of technologies sponsored, which is one of the major determinants of per-customer savings, and the annual participation rates and cumulative penetrations achieved.

Demand-side resources can be represented by a supply curve. This supply-curve shows how much electricity or power can be saved at what unit price, based on engineering analyses of available technology options. When plotted, the horizontal axis measures the amount of power, and the vertical axis the cost of power. This kind of supply curve allows the determination of the overall efficiency resource that can be cost-effectively mobilized. This cost-effective fraction is a function of the avoided costs of generating electricity or peak power.

In this section, we are concerned with the horizontal axis in the supply curve, which measures the magnitude of the lighting efficiency resource. The vertical axis, i.e., the unit cost of kWh savings from lighting efficiency programs, is dealt with in a subsequent section below.

1. Technologies sponsored and per-customer savings

The range of technologies sponsored by the above programs is shown in Table 2. In interpreting this table, one must keep in mind that a number of the pilot programs were designed more to test program delivery approaches than to promote the full range of technical options. Also, several lighting programs targeted residential customers only, thus ruling out applications of commercial sector technologies. Nevertheless, an evaluation of the technologies sponsored is useful.

When carefully combined and installed, the full range of measures listed in Table 2 can save as much as 65-90 percent of typical baseline lighting electricity consumptions while delivering approximately the same lumen output and lighting quality (Piette et al. 1989, Lovins and Sardinsky 1988). For residential applications, compact fluorescents are the most important option. For commercial applications, improved fluorescent lamps, ballasts, fixture systems and daylighting controls are the most widely applicable options. In the industrial sector, HID lamps can find wide application. We briefly review the utilization of technology options in the residential and commercial sector.

Residential programs:

Several programs sponsored the installation of screw-in compact fluorescents in place of incandescents. Only one program sponsored the low unit savings "Econowatt" incandescents, and did so as a complement to the screw-in fluorescents, not instead of that option. This swap to fluorescents yields large (typically 65-85 percent) electricity savings per installation. Thus, the degree to which efficiency potentials are realized in screw-in fluorescent programs depends mainly on the number of lighting fixtures converted per dwelling.

Among the programs reviewed, there were major differences in the number of fixtures converted. At one extreme, the NYSEG pilot program of 1982, which sponsored the older, large diameter circlite lamps, found that only one fixture could be changed over in the average household and that 30 percent of these fixtures had already been fitted with fluorescents. This survey result illustrates the importance of product improvements by both lamp and fixture manufacturers to overcome fitting problems. The newer compact screw-in fluorescents have begun to provide the technological basis for greatly expanded residential lighting retrofits.

The Taunton program and the SCE low income program were able to deliver about four lamps per household using the integral-type screw-in fluorescent. Both programs helped overcome a number of fixture fitting problems by also supplying special lampshade extension bars that could be installed on the new, somewhat larger lamps. Whereas in the SCE program, installations were partially guided by utility program representatives, the Taunton residents chose installations on their own using only written guidelines.

A much greater and faster penetration was achieved in the Traer program, which sponsored both integral screw-in fluorescents, modular fluorescents, and 55 W "low-wattage" incandescents to replace 60 W bulbs. A well- designed fitting and exchange program that involved a major lamp manufacturer further helped overcome placement problems. A detailed survey of existing lamp sizes and types preceded the program, and this may have also helped achieve better matching. The greater lamp selection and the assistance in choosing the best technology in each application paid off in greater penetrations per dwelling. As a result, an average of 19 screw-in fluorescents, equivalent to converting about half the fixtures in the average Traer home, were placed in each household (The persistence of these installations remains to be evaluated).

It is widely believed that only a small number of residential incandescents have sufficient operating hours to make compact fluorescents cost-effective. If this were correct, the Traer program would have gone overboard, sponsoring bulbs in fixtures where they don't pay. But as shown in a detailed analysis of the cost of conserved energy from residential compact fluorescent applications (Krause et al. 1987), compact fluorescents bought at wholesale prices (as done by utilities) are cost-effective against 6 cents/kWh in fixtures with operating hours of as little as 100 hours/yr (3 percent discount rate, see Figure 1) to 200 hours/yr (7 percent discount rate).

With an eye toward future program designs, it is worth observing what technologies were not sponsored in these lighting programs. One is combined compact fluorescents and fixtures designed for specific applications, such as bathrooms and porch lights (hard-wired). Several such products are on the market. Also, the above programs did not make use of the expanded range of lumen outputs and applications now available from "quad"-type modular screw-in fluorescents. Another lamp technology not sponsored in these programs were low-wattage HID

Table 2: Technologies sponsored in utility lighting retrofit programs

Sponsored technologies	Typical Savings(%)	Program number 1	2	3	4	5	6	7	8	9	10	11	12
(1) Replace incandescents:		•	•	•	•	•	•	—	•	•	•	•	•
(a) with lower-watt energy saving lamps	8-10	–		–	–	√				–	–	√	–
(b) with screw-in fluorescent lamps	40-85	√	√	√	√	√	√			√	√	√	√
circlite				√						–	√	–	–
integral (SL) type				√						√	–	√	√
modular (PL) type				√						–	–	√	–
Hard-wired fixture replacement		–	–	√	–	√	√			–	–		–
(c) with HID lamp-ballast systems	65-85	√	-	√	√	√	√		√	–	–	√	–
(2) Replace standard fluorescents		•	•	•	•	•	•	•	•	*	*	•	*
(a) w. more efficient fluorescent lamps		√	–	√	–	√	√	–	–			√	
40 W F40 T-12/LW	(5-10)			√									
Tristimulus lamps	10-15			–									
(b) w. 34W F40 T-12 lamps	10-15	√	√	√	√	√	√	√	–			√	
(c) with T-8 lamp-ballast system	20-30	–	–	–	–	–	–	–	–			–	
(d) with HID lamp-ballast system	20-30	√	–	√	√	√	√	–	√			√	
(3) Replace standard ballast		•	—	•	—	•	•	—	—	*	*	—	*
(a) with efficient core-coil ballast	8-10	√		√		√	√						
(b) with electronic ballast	20-40	–		√		√	–						
dedicated	20-30			√		√							
tunable	25-40			–		–							
(4) Delamp/optical reflectors		•	—	•	—	•	•	—	—	—	—	—	—
(a) delamp	40-50	√				√	√						
(b) install efficient reflector	15-25					√	√						
(5) Install controls		—	—	•	—	•	—	—	—	—	—	—	—
Daylight dimming circuitry	15-25			–		√							
Occupancy controls	15-25			√		–							
(6) Any cost-effective measure	8-85	•	—	—	—	—	—	•	•	—	—	—	—

Notes:
For discussion of savings, see Piette et al. (1989), Lovins and Sardinsky (1988)
*measure not applicable for targeted customer class
•category of measures [any of (1) to (6)] was sponsored
√measure was sponsored
—measure category not applicable

lamps, which could be used for some applications in some dwellings. Other technologies not sponsored in these programs were occupancy sensor controls, photocell controls for porch lights, or photovoltaic-powered porch lights and pole lights. All of these would impact high-usage applications.

Commercial/industrial sector programs

In the commercial sector programs there is a clear discrepancy between the range of technical options available, the technologies sponsored, and the range of options actually installed. Most programs ended up mainly promoting energy-saving 34W lamps.[3] The more efficient T-8 lamps, which involve retrofits of matching ballasts, were not implemented. Tristimulus lamps that do not just reduce wattage as the 34W lamps do, but also increase lumen output per watt (efficacy) also have not received sufficient attention in past programs. Furthermore, most programs did not implement the high-savings options, notably combined lamp-ballast retrofits, combined delamping-lamp-ballast-reflector retrofits, and lighting control-daylight dimming-tunable electronic ballast retrofits. Dedicated ballasts combined with T-8 lamps could provide large, up to about 40-50 percent savings per fixture (Piette et al. 1989, Lovins and Sardinsky 1988). Of the high-savings options, typically only the conversion of incandescents to screw-in fluorescents was promoted.

At the time of this writing, a number of utilities have improved their range of sponsored technologies. For example, NEES added both electronic ballasts and daylighting and occupancy controls to its list of eligible products for dealer incentives (program 6). Taunton's commercial leasing program, which started in 1989, has been sponsoring electronic ballasts from the start.

Another important step in the direction of improving the general acceptance of new technologies among utilities and lighting professionals is the recent creation of several regional lighting technology demonstration centers jointly sponsored by utilities, manufacturers, and professional associations. These centers could also offer expanded training for installers and specifiers.

Factors involved in technology choice

These patterns of technology choice appear to be the result of a number of factors. Some are technological, others are related to issues of practical program implementation, and still others have a regulatory background:

- Some of the more potent lighting efficiency technologies have arrived in the market only recently. Tunable electronic ballasts which can bring large additional savings from daylight dimming and task tuning, had been offered by only one manufacturer in the past.
- In the case of electronic ballasts, some utilities have had concerns over the harmonics problems potentially generated by these units. Even though these concerns were not

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[3] These lamps are an energy-saving but not an efficiency technology: they somewhat reduce energy consumption by somewhat reducing lighting output, see Piette et al. 1989.

shared by all utilities and technical experts, they did cause hesitation in a number of cases.[4]

- Beyond issues of technical maturity and utility familiarity with new products, the experimental nature of many of the reviewed lighting programs must be considered another factor, as already mentioned above. In the early phases of program development, technological optimization will necessarily compete for staff attention with many other aspects of program design. For example, exchanging lamps is a faster and more straightforward operation than replacing hard-wired components. In the initial program phases, when utility staff had little experience with winning customer cooperation, more involved measures were often seen as a potential deterrent to participation.
- The technologically more sophisticated lighting efficiency packages often place much higher demands on program staff, auditors and installers. Conversations with practitioners suggest that training of utility and contractor personnel is in most cases insufficient to enable them to reliably specify retrofits that would optimize savings (Piette et al. 1989).
- In the view of some utility staff, the choice of only the most modest efficiency technologies, and seemingly technologically based concerns over the reliability of more advanced technologies, also reflect utility resistance to aggressive demand-side activities in absence of regulatory incentives that would compensate for potential impacts on utility profits.

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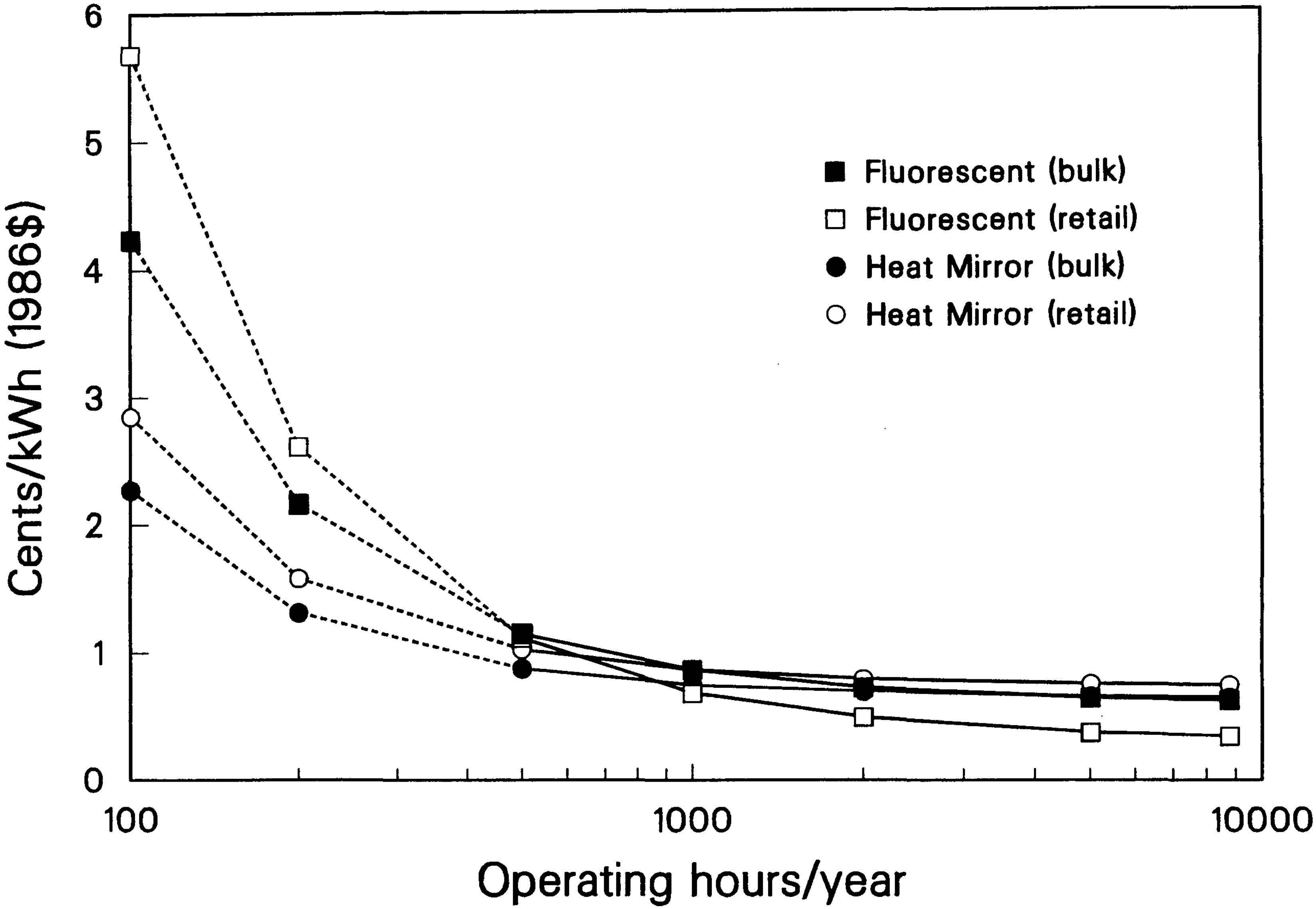
[4] An example for such initial hesitation was found in the NEES programs. NEES currently specifies a 20 percent harmonics limit for elegible ballasts. Other experts argue that there is no hard and fast rule for limiting harmonics, and that higher harmonics could be tolerated. Recently, at least one manufacturer has made these concerns a mute point by offering ballasts with low (10 percent or less) harmonics.

Figure 1

Cost of Conserved Energy for Improved Lightbulbs



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Also, incentives for trade-allies, contractors and customers to make use of high-savings technical packages were insufficient in most programs.

An important role also accrues to utility-manufacturer cooperation. As the Traer experience suggests, this could lead to significantly greater conversion rates per customer. Larger-scale programs could conceivably enlist both lamp and fixture manufacturers to expand the range of products for various applications and further reduce fitting problems. Such utility-manufacturer cooperation could also speed the commercialization of new products such as dimmable compact fluorescents, which would again expand applicability.

2. Participation rates and cumulative penetrations

Participation rates

The data in Table 3 show that program participation rates, expressed in terms of the average percentage of total eligible customers participating per month, varied by an order of magnitude among the different programs.[5] The interpretation of some of participation data, including those in Table 3, is not as straightforward as it might seem:

- First, the participation rates reported by the utilities or implied by their data do not necessarily reflect the relative effectiveness of alternative program designs in terms of motivating demand-side investments: high participation rates were not the dominant program objective in all programs. Different utilities may deploy one and the same program design with different intensity depending on their loadshaping goals.
- Second, many of the program data shown in Table 3 reflect experience in pilot programs. Just how the same program approaches might fare when applied system-wide is not clear in these cases.
- Third, participation rate calculations can easily contain important errors. When calculated on the basis of the most easily accessible utility statistic, i.e. the number of accounts in the targeted rate class, results are easily distorted by the fact that many customers in the commercial and industrial sectors have multiple accounts, including limited use accounts. The number of available customers, and therefore, potential participants, is thus less than the number of accounts.
- Fourth, not all programs managed to reach the total number of customers targeted by the program. This right away reduces the maximum participation rate that could be theoretically achieved for the target group as a whole to less than 100 percent.
- Finally, if participation rates are to measure the effectiveness of programs, they should be based on the total number of customers found eligible for the program *after audits have been performed.* Customers that are disqualified by the utility on account of audits should be excluded from the calculation of such participation rates.

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[5] In view of the fact that a number of programs did not operate a full year, the average monthly (rather than annual) participation rate is chosen as a basis of comparison.

Table 3: Participation rates by programs

Program	Number of Targeted customers	Program type	Preinstallatio audit required	Period evaluated (months)	Participation rate (ave) %/month	Participation fraction (%) cumulative
1. NEES Massachusetts	2263	Direct installation	Yes	17	2	34 [55]
2. SMUD	18000	Direct installation	Yes	6	4.2	25 [58]
3. Austin Munic. Utility	[461 audits in 1987-88]	Direct mail/Rebate	No	12	[2.6 f. audited customers]	
4. NEES Rhode Island	18000	Direct mail/Rebate	Yes	12	0.2	2.4
5. Palo Alto		Direct contact/rebate	No	36		
Demand-metered	750				0.5	19
other comml.	1750				0.2	6
6. NEES system-wide	70000	Dealer incentive	No	9	0.3	2.8
7. Niagara Mohawk	7500	Direct mail/ Rebates/Direct contact	No	6	1.2	7
8. BPA/	207	Direct mail		12	0.25	3
Clark PUD	180	Direct contact	Yes	36	0.3	10
9. SCE	700 000	Direct installation	No	40	0.7	26
10. NYSEG	13 300	Direct mail/Rebates	No	3	0.7	2
11. Traer				2		
residential	926	Direct contact/ Lamp exchange	No		28.5	57
commercial	117				17.5	35
12. Taunton Munic. Utility	19000	Direct mail/Leasing	No	18	0.3	5.5

Notes:
Numbers in [] refer to fractions based on customers actually contacted and found eligible after audits, see text
See Appendices for further details

Only in two of the programs reviewed here were data available to quantify these differences (NEES, see Appendix A and SMUD, see Appendix B).

Based on the total customers in the targeted rate class in the SMUD program, the cumulative participation rate was 25 percent. Based on the total customers that were actually informed about the program and contacted, this number was 47 percent. In the case of the door-to-door canvassing outreach used in this program, the difference was due in part to people that were not present when utility representatives stopped by, in part because utility representatives encountered language problems, etc. Thus, this difference in the two participation indices says something about the effectiveness of the initial program outreach (whether by mail, door-to-door canvassing, telephone, etc.), not about the customer acceptance of the program. For example, in a significant number of cases, SMUD utility representatives canvassing small commercial customers had difficulty communicating the purpose of their visit to people whose command of English was insufficient (see Appendix B). Improved outreach could probably close much or most of this gap, and thus lead to a fuller mobilization of the demand-side resource. Of course, the cost of reaching these residual customers would be higher than the average cost of customer outreach in the program as run. (see below for further discussion of this point).

When participation is calculated on the basis of eligibility as determined through on-site audits, the cumulative participation rate of the SMUD program becomes 58 percent, more than twice the rate obtained from the total number of customers in the target group.

The NEES direct installation program (Appendix A) yields similar results; here the eligibility-based participation rate is 55 percent, compared to 34 percent for the target group as a whole.

This difference is related to the fraction of target group customer sites that were disqualified on economic and other grounds once the program had reached them. This disqualification fraction depends on a variety of factors, including customer lighting habits, site-specific variances in retrofit installation costs (e.g. due to excessive ceiling height or other accessibility problems), the technical analyses used in deriving savings estimates and costs, and the avoided-cost ceilings set by the utility. The overall cost-effectiveness assessments applied in the audits, in turn, depend on whether the total resource cost perspective, the utility cost perspective, or other perspectives are used (see NARUC 1989 for a detailed discussion of the issues involved; see Section IV below for discussion of cost- effectiveness).

With these caveats in mind, some important conclusions can be drawn from the data in Table 3:

- A number of utility lighting programs have been able to achieve substantial customer participation rates and penetration fractions within relatively short periods of time (measured in months).
- The programs with these higher participation rates have used a more comprehensive program design which offered free or almost free lighting hardware, personal contact with customers, one-stop services, and hands-off installation by utility personnel or utility-sponsored contractors. Perhaps with the exception of large commercial customers, the simple coupon/rebate approach used in many lighting and other utility

programs seems to be less effective in soliciting customer participation in lighting retrofits.

The latter conclusion is borne out by correlating the participation rate data in Table 3 with the program design details provided in the appendices. For example, in the Palo Alto program, the assignment of a specific utility representative to each of the larger commercial accounts was important in creating a good customer response. In the Traer program, the lightbulb exchange service, preceded by a survey customers were paid to participate in, proved key in achieving the very high lamp penetration. In the NEES Massachusetts program, the SMUD program, and the SCE program, free hardware and direct installation services were similarly successful.

Cumulative penetration fractions

A further large variation is observed in the cumulative penetrations that were achieved over the duration of the programs (Table 3). At least one program achieved more than 50 percent participation within a year, and several others reached cumulative penetration fractions between 10 and 50 percent. None achieved more than about 60 percent, even after adjustments for the above-mentioned issues of defining participants.

These data, and conversations with program staff suggest that the cost and effort required to bring additional customers into the program will increase disproportionately beyond certain thresholds. How steeply this rise in program administration costs would be, and what effect it would have on the cost-effectiveness of the additional demand-side resources that would be mobilized, is difficult to predict in the absence of data. All that can be said is that lighting efficiency resources are relatively inexpensive, so that some amount of higher-cost outreach would seem feasible. In so far as a significant portion of the slow adopters are low income customers, such higher costs would possibly be justified on account of equity considerations (see Section IV below for a discussion of costs).

The data in Table 3 suggest that the upper limit for the point of diminishing returns from utility lighting programs might be a 50-60 percent cumulative penetration. In the estimation of SMUD program staff, a 70 percent maximum penetration could be achieved in direct installation programs before the costs of further recruitment become excessive (NEOS 1989). In general, the limit can be expected to depend on the type of program and the kind of technology offered. If the program is designed to achieve high annual participation rates, the threshold would likely be higher than in a program that uses a more lackadaisical approach. The less effective programs may never reach such a threshold.

Spill-over effects

The fact that customer groups are not behaviorally homogeneous means that utilities face inherent limitations in implementing the full technical potential of a demand-side resource, at least directly. However, if utility programs can realize a large (e.g. 50 percent) cumulative penetration quickly, and at sufficient scale, this partial penetration could still be sufficient to create a shift in the lighting technology market towards more energy-efficient products.

Technology "laggards" and other non-participants would adopt the new technology gradually through the influence of this shifting market rather than in direct response to utility programs. This indirect spill-over would still have the effect of making non-participants adopt efficiency technologies earlier than they would have otherwise.

From all this, a promising low-cost strategy for utility lighting programs would be to give the market a sufficient push through comprehensive programs designed for rapid, large-scale penetration of the more easily reached customer groups, and then let the spill-over effect in the market complete the process. Once an efficiency technology has reached a market share of 30-50 percent or so, it will also be easy to complete broad-scale adoption through government efficiency standards.

Of course, the portion of the demand-side resource potential that is delivered through direct customer participation and the portion that comes about as a spill-over effect of the utility program are not of the same quality from a planning point of view. While customer participation in the utility program could deliver a significant portion of the demand-side resource potential in a predictable manner and over the near-term, the realization of the remaining potential through indirect market influences would be much less predictable, and would be realized only in the longer-term. On the other hand, the costs of this portion of the demand-side resource to the utility would be zero.

3. Impact of incentive levels on participation rates

Two of the reviewed programs (NYSEG and Niagara Mohawk) explicitly tested for impacts of alternative rebate levels. In the NYSEG pilot program, customers seemed to respond to higher rebates with higher participation rates. In the Niagara Mohawk program, customer response seemed to be more or less neutral to rebate levels. In interpreting these findings, it may be significant that the customer class and technologies sponsored in each program were different. The NYSEG program focused on residential customers. These customers were faced with a large jump in first cost when switching from incandescents to screw-in fluorescents. In this context, a positive influence on participation rates from higher rebates might be expected.

In the case of the Niagara Mohawk program, the most widely adopted energy-saving technology was fluorescent tubes with lower wattage. The cost of the standard equipment and the efficiency equipment, though differing by a factor of two, were both of the same order of magnitude and low in absolute terms. This might dampen the impact of rebate levels.

If one moves away from the narrow interpretation of program incentives in terms of rebates and includes indirect customer costs that were reduced by the program, the level of economic incentive provided to the customer seems to again have a significant effect. In a sense, the difference in participation rates between programs that relied mainly on direct mail and rebates and programs that relied on personal contact and direct installation illustrates this point; in the latter programs, customers received not only free lamps and other lighting hardware replacements, but also free installation labor, and reduced transaction costs in researching energy- and money-saving options that would be suitable to their specific buildings and circumstances.

In the Clark PUD industrial lighting program, program staff often succeeded in obtaining customer participation once they were offered a complete redesign of their lighting system as part of the retrofit. Also, the survey data from Palo Alto's program show that in the absence of audits, many customers believe that in their building, all efficiency options have already been installed, for example, because the buildings are relatively new.

In general, rebate programs did not fare well compared to programs that offered more comprehensive assistance to customers. Even for large commercial customers, where rebates are relatively more effective, high penetration rates were only achieved where utility representatives were assigned to personally liaise with each larger customer. In the Palo Alto program, this led to a 40 percent participation rate among the largest commercial customers.

These broad ranges of services greatly reduced indirect customer costs that are often summarized under "hassle factor." Of course, this "hand-holding" also increases the absolute program cost to the utility (though not necessarily the cost per unit of energy saved, see Section IV below).

An interesting finding in this context is that the leasing of screw-in fluorescents in the Taunton program was quite successful, considering that no promotional campaigns were run beyond the first month. The Taunton experience shows that at least in some cases, customers could be quite willing to share the economic rent from an efficiency investment with the utility that helped them undertake the investment. As discussed elsewhere (NARUC 1989), such shared-savings arrangements could help address utility concerns over lost revenues and rate impacts from DSM programs.

At the same time, the SCE experience suggests that low-income households are unwilling to bear any portion of the increased first cost of more efficient lamps. A shared-savings approach would thus still have to be supplemented by special low-income programs to achieve maximum penetration. Similarly, the Clark PUD industrial program was unable to solicit participation by a number of firms despite the fact that the program effectively provided more than 85 percent of the first cost of the installation.

These experiences suggest that for residential and small- to medium-sized commercial customers, but possibly also for many small- to medium-sized industrial customers, a completely free initial service is important in order to get large participation rates, at least in the initial phases of program activity. In this context, it will be interesting to see how applications of the Taunton leasing approach will fare in the commercial and industrial sector.

4. Persistence and take-back issues

Persistence issues refer to the possibility that customers replace the program-sponsored measures with conventional equipment of lower efficiency, either during or at the end of the useful life of the hardware involved. Persistence concerns are less important in some lighting retrofits than in others. A number of programs tried to assure some degree of persistence by disabling removed lamps and ballasts. In the Clark County PUD program, the capacitors and ballasts removed by the program were collected and disposed of as toxic waste due to concerns over the PCB they contain. In some commercial programs, labeling of converted fixtures is used, and the rebate agreement with the customer stipulates that no reinstallation of removed lamps or changes to inefficient hardware are made for a specified period. Nevertheless, some uncertainty exists as to the persistance of the simpler lamp swaps. Periodic checks should be conducted over time.

Perhaps one of the most effective insurances against reconversion to inefficient hardware is that the new, energy efficient equipment is in many cases very long-lived. For example, efficient electronic ballasts are expected to last more than ten years even when operated for four thousand hours per year or more (Piette et al. 1989). Efficient reflectors have an even longer lifetime. In the residential sector, compact fluorescents typically will last 5-15 years. In the industrial program of Clark PUD, incandescents were replaced by metal halide and high pressure sodium lamps with lifetimes of about 15 years.

This long lifetime helps ensure persistence in two ways: over the life cycle of currently installed efficiency options, products can be expected to improve further and achieve a higher market share; and where the new product has a significantly longer lifetime than the original equipment, as in the case of incandescent to compact fluorescent conversions, the very tangible benefit of this extended lifetime creates customer satisfaction. This can be expected to lower the barriers to compact fluorescent replacement purchases in later years.

A method of ensuring persistence through program design is illustrated by the Taunton residential program. Here, customers are guaranteed the free replacement of their compact fluorescents should they ever fail or burn out.

Overall, then, the persistence of hardware conversions in lighting programs must be rated high. At the same time, more follow-up research is needed to better quantify the persistence of savings over the replacement cycle.

The *take-back effect* in lighting programs - an increase in lighting hours or illumination levels or both, apparently in response to the use of more efficient equipment - takes several forms: one is when customers feel, or find out through audits, that the lighting levels they have been using are insufficient or sub-standard, and request an upgrade of lighting levels. This phenomenon has been reported in many programs. It often represents an opportunity for winning participants by addressing these quality concerns along with offering the monetary savings from more efficient equipment. For example, the Clark PUD program found that lighting levels in the industrial facilities it served were generally substandard. The program used audit findings and customer dissatisfaction with existing lighting systems to market its assistance. On average, lighting levels increased by 36 percent.[6]

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[6] Due to the large efficiency differences between existing incandescent and mercury vapor lamps and the new metal halide and high pressure sodium lamps replacing them, average electricity savings (based on constant operating hours) were still about 50 percent relative to pre-installation consumption.

Similarly, program experience shows that in many buildings, a significant fraction of burned out lamps is in place at any one time. Building-wide installation of more efficient lamps will then bring less of a reduction in lighting electricity use than calculated, though the lumen levels for which the building was originally designed will be delivered with the predicted savings in electricity. For example, submetering experiments in buildings retrofitted in Austin, Texas, showed that predicted and measured savings agreed well if the number of burned out bulbs were taken into account (Gettings and MacDonald 1989).

Another possibility for take-back to occur is that the sense of having energy-saving lighting systems could induce a more careless attitude, resulting in more lights left on for longer hours. This latter effect has not been measured in any of the programs we examined, and could be a worthwhile research project.

The technical nature of one class of retrofit options, i.e. lighting controls, provides more or less inherent insurance against take-back. Occupancy controls, daylight dimming, photocell sensors for porch lights, and other central lighting control systems can provide energy savings by eliminating both already existing and possible future bad habits or carelessness at the light switch.

IV. COMPARISON OF TOTAL RESOURCE COSTS AND UTILITY COSTS

1. Methodological and conceptual issues

The cost-effectiveness issue arises both in the conceptualization of programs, and in their evaluation. When a program is planned, utility managers typically use engineering estimates of the cost and magnitude of savings to select demand-side measures for sponsorship. This initial estimation must account for projected program costs, for the impact of free riders on the unit cost of the demand-side resource, and for the customer portion of the demand-side investment. The latter two points relate to the choice of cost/benefit test perspectives used for assessing cost-effectiveness. Further assumptions must be made about the unit avoided costs to the utility. These may vary depending on the time horizon chosen, and involve a number of other complexities (NARUC 1989).

When programs are evaluated in terms of their costs and cost-effectiveness, it is vitally important to use the proper cost/benefit perspective. In the past, many analyses used the utility cost perspective (equivalent to the all-ratepayer perspective) in describing the unit cost of demand-side resources. This perspective neglects the portion of the demand-side investment which is paid for by the customer. Because of this neglect, the utility cost of a demand-side resource is an insufficient basis for determining the economic efficiency of demand-side programs. To test for economic efficiency in the neoclassical or societal sense, these cost portions must be captured. In the standard practice tests for utility demand-side programs, this perspective is only provided by the total resource cost test or societal test (NARUC 1989).

A key question in evaluating utility program experience, then, is how the costs incurred by the utility, and the unit costs (in ¢/kWh or $/kW) which can be derived from them, relate to the total resource cost.

A second question is how the total resource cost differs when demand-side measures are implemented through a utility program as opposed to independent action by economically rational consumers without the help of a utility program.

In addressing this latter question, it is helpful to introduce the concept of *technology cost*. The technology cost (in ¢/kWh saved) is the cost of demand-side measures as calculated in engineering-economic analyses, where savings estimates are correlated with first costs for equipment, installation, etc. and with maintenance costs over the life of the measure.

In the absence of programs, the first costs paid by consumers reflect prevailing wholesale or retail prices available to each customer type within their particular local and business environments. In many cases, utility programs can help reduce the technology cost through bulk purchases and other economies of scale. For the moment, we ignore those feedbacks and observe that the technology cost is a simple approximation to the total resource cost, since first costs are not split between customer and utility.

Program-based total resource costs versus technology costs

The technology cost is not exactly the same as the total resource cost because it neglects any transaction costs due to market and information barriers. Economically rational customers are faced with often significant indirect costs, such as finding information or negotiating with building owners to get measures installed. These transaction costs in the case of individual action are, however, difficult to quantify in monetary terms, and are in any event strongly shaped by market barriers that utility programs aim to lower or eliminate.[7]

When a demand-side investment is made through participation in a utility program, most or all of these transaction costs are now borne by the utility. Some "hassle factor" and transaction costs for the customer will remain, but the cost for most of these transactional aspects will show up as utility program administration costs. (These administrative costs exclude incentive payments, which are merely a transfer payment in the total resource cost perspective, see NARUC 1989). These utility program administrative costs are, as a rule, substantially lower on a ¢/kWh basis than the indirect costs would be in the case of individual customer action, due to the market-facilitating powers and economies of scale provided by a utility program.

A better approximation for calculating the total resource cost of demand-side measures than the technology cost alone is the technology cost plus the program administrative cost. This *program-based total resource cost* can then be used as an input into the cost-benefit test.

The same technology cost plus administrative cost formulation is useful in giving meaning to the costs of demand-side resources as found in supply curve studies. With few recent exceptions (e.g. Krause et al. 1988), these studies calculated only technology costs, i.e., they underestimated total resource costs by the indirect or administrative costs a utility must incur in order to mobilize these potentials.

The calculation of program-based total resource costs as the sum of technology costs and program administrative costs entails a further subtlety. As noted above, technology costs, notably the price of hardware and of other first-cost components, are themselves influenced by the manner in which demand-side resources are acquired. Utilities can purchase many demand-side measures at favorable wholesale prices that are not generally available to the average customer acting as an individual market participant. Thus, program-based total resource costs are not necessarily higher than technology costs as seen by the customer implementing the demand-side measure individually: The technology price advantage of program-based implementation may offset part or all of the added administrative costs.

Calculation of program administrative costs

The above discussion shows that key data for assessing program-based total resource costs are the administrative costs incurred by utilities. Here, the challenge is to translate the absolute administrative costs (in thousands of $) as tallied by utility program managers into *per unit* administrative costs (in ¢/kWh), which can then be related to the technology costs (again expressed in ¢/kWh). The ratio of the two then reveals the degree to which the costs of demand-side resources as calculated in engineering-economic analyses change when implemented through utility programs.

Past analyses have almost universally failed to provide such a consistent total resource cost based assessment (Berry 1989). Most often, program administrative costs are reported in absolute terms, and are compared to the total utility costs in absolute terms. It should be noted that

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[7] See the NARUC least-cost planning handbook for a more detailed discussion of this issue (NARUC 1989).

ratios and percentages calculated in this manner are flawed when used in evaluating program-based cost-effectiveness, and are not identical or comparable to the ratios and percentages calculated in this report. The two major shortcomings of the conventional accounting are:

- Utility costs are not identical with total resource costs. Often, they are substantially lower because customers pay for part of the measure. In certain cases where the more efficient equipment has a longer life, utility costs can be significantly higher than technology costs. An example for this counter-intuitive outcome is provided by compact fluorescents (see below). Therefore, correlating administrative costs with utility costs does not provide a reliable basis for determining economic cost-effectiveness. In the usual case, where utility costs are smaller than total resource costs (see below), percentage correlations of administrative costs with utility costs will overestimate the importance of administrative costs.
- High administrative costs in absolute terms do not necessarily mean that the program is less efficient or less cost-effective. Higher administrative costs could be associated with more aggressive program outreach, which tend to result in greater participation rates and/or greater per-customer savings. It is the *unit cost* of program administration (in ¢/kWh) that is important.

Technology cost versus utility cost

The relationship between technology costs and utility costs can best be explored by starting from the simplest situation. If utilities pay for the full cost of demand-side measures and pay the same price as economically rational customers buying the measure on their own, utility costs will be higher than technology costs in proportion to program-related indirect costs.

There are several complexities that influence the relationship between utility costs and technology costs. Ordered by rising ratios of utility costs to technology costs, the following cases could apply:

- In many instances, utility incentives payments to program participants cover significantly less than the technology cost. Utilities and their ratepayers can therefore acquire demand-side resources at costs that are significantly less than technology cost, even after program costs are factored in (see below). Utilities also can buy equipment at bulk purchase prices that are significantly (up to 50 percent or more) lower than prices available to individual customers.
- On the other hand, if utilities pay full or close to full technology costs in incentives and incur significant administrative costs in addition, the total utility costs could end up being higher than technology costs.
- In still other cases, utility incentives alone provide *more than* the technology cost. This is common in lighting programs. In some programs, the lamp rebate alone was higher than the full technology cost[8] In other cases, utilities provide not just a rebate

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[8] For example, the dealer rebate program of NEES originally provided incentives for compact fluorescents in excess of wholesale costs. In principle, this could be a sound way of spurning dealers to market such lamps aggressively to their customers. NEES has since then reduced incentives for compact fluorescents to a dealer rebate of $12.

for the *extra* first cost of efficient lamps over standard lamps but pay for the *entire* lamp replacement. Another case is when utilities provide installation labor in addition to hardware, as in several of the programs reviewed here. In these cases, utility costs could be significantly higher than technology costs, since the technology costs for efficiency improvements are typically calculated on the basis of extra first costs that do not include installation costs.[9]

- Another case where utility costs are higher than technology costs is in the case of efficiency measures whose lifetime is greater than that of existing equipment. Here, the benefit of avoided replacements of standard equipment accrues to the customer. This can make the technology cost significantly lower than utility costs. Examples are delamping, which saves future lamp and ballast replacements, and the conversion of incandescents to screw-in fluorescents, which can typically avoid 10-13 bulb replacements over the life of the fluorescent. The net present value of these avoided replacements can make the technology cost negative (Lovins and Sardinsky 1988, Piette et al. 1989), while utility costs would always be positive. In this special case of negative technology costs, program-based total resource costs could be negative or positive, but would always be smaller than utility costs.

2. Technology costs and utility costs in lighting programs

Table 4 shows cost data for the lighting programs reviewed in this report. The table shows the percentage of customer first costs and installation costs paid for by the utility, the total absolute costs of the utility program, the administrative costs of the program both in absolute dollars and as a fraction of total utility expenditures, and the technology and utility costs per unit of energy saved. The derivation of these figures involves several assumptions and both utility and non-utility data sources which are explained below.

As in other research (Berry 1989), we found significant differences in the way in which utilities account for administrative costs. These differences include both the range of expenditures included, and the assignment of these expenditures to individual subcategories. The figures shown in Table 4 are those reported by the utility and may not always include all administrative costs. In the accounting used in the table administrative costs include all costs except those for installation and incentives payments to the customers, i.e. all costs for processing rebates, pre- and post-inspections, marketing, program planning, process evaluation and surveys, etc. Uncertainties are also significant where the lighting program was part of a larger program and crude allocations of staff time and on-site audit and installation costs were made by utility program staff. We used the estimates provided by utility program managers without attempting to normalize them.

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[9] The technology cost is defined as the cost of installing a measure at the time when existing equipment needs to be replaced anyway. If the installation cost and lifetime of an efficiency measure is the same as that of existing systems, no installation labor costs are included in the technology cost. In other cases, a pro-rated value for both capital and labor must be included (see Piette et al. 1989).

A second complication was that data on utility incentives payments were readily available, while data on customer costs were often not reported. This reflects, in part, the utilities' emphasis on the all-ratepayer cost perspective rather than the total resource cost perspective. Where utilities provide free equipment, customer costs are, of course, not an issue. In other cases, the determination of total resource costs was built into the program procedure. For example, the Clark PUD program had contractors bid on proposed installations and then used these bids to calculate what portion would be paid for as an incentive.

In other rebate programs, it is often difficult to accurately pinpoint the prices customers are charged in the market. To do this, comprehensive surveys of wholesale and retail prices in the utility's service territory would need to be undertaken. Wholesalers and retailers treat their pricing practices as confidential. Instead of formal surveys, utilities typically used informal checks with a few distributors to determine typical market prices for the technologies they would rebate. These typical market prices were then used to set rebates, but were not directly reported. Rebate payments were sometimes given both in absolute figures and expressed as approximate percentages of market prices, from which assumed prices can be inferred. To allow for a consistent comparison, we calculated the technology costs in Table 4 on the basis of data developed in recent lighting technology assessments (Krause et al. 1987, Piette et al. 1989, Lovins and Sardinsky 1988).

A few comments should explain the figures in Table 4. With the exception of the NYSEG program, customer costs in residential programs were zero, because lightbulbs were provided by the utility. We therefore calculated the technology costs in Table 4 on the basis of the prices paid for the lightbulbs by the utility. For most residential programs sponsoring compact fluorescents, Table 4 shows a technology cost of 0.8-1.0 ¢/kWh. This reflects the cost of conserved energy as calculated in Krause et al. (1987), based on a wholesale cost of $10 per bulb, and assuming at least 500 operating hours per year (see Figure 1).[10] Actual prices paid by utilities were sometimes lower (see, e.g. Appendix I).

For some commercial programs, costs of conserved energy had been calculated by utility staff using the utility cost perspective. Here, we estimated the total resource cost based on the data given in Piette et al. (1989). For most commercial and industrial programs, we were unable to calculate the exact technology cost applicable to the program because the program sponsored a large number of measures under varying operating hours. To give an indication of the orders of magnitude involved, we show the range of technology cost for the most common measure in those programs, i.e. replacing 40W fluorescent tubes with 34 W versions. A recent technology assessment study found that the technology cost of conserved energy for this measure is about 0.5-2.0 ¢/kWh, assuming a range of 3000 to 4500 operating hours per year and a typical range of prices (Piette et al. 1989). As discussed in detail there other measures are somewhat more expensive, while still other options are considerably less expensive. For lack of detailed data, we

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[10] Figure 1 shows the technology costs for a 3 percent real discount rate. The calculations in Table 4 show data for a seven percent real discount rate. The costs of conserved energy for this investment behave in anti-intuitive ways, due to the present-value calculation for the string of replaced incandescents during the life of the compact fluorescents. For this reason, the bulk purchase assumption leads to slightly higher costs of conserved energy than the retail price assumption.

Table 4: Lighting program costs

Program Sponsor	Utility payments Fraction of extra first cost %	Fraction of installation %	Absolute costs Utility costs incl. incentives $K	Administrative costs excl. installation $K	share of tota	Costs per kWh saved Technology cost ¢/kWh	Utility Costs ¢/kWh	Admin. Costs excl. install. ¢/kWh
1. NEES Massachusetts	100+	100	2300	700	0.30	<0-2.0	2.3	0.5
2. SMUD	100+	100	197	38	0.19	<0-0.8	2.2	0.4
3. Austin Munic. Utility	30-100+	0	686	< 200	<0.29	<0-2.0	1.8	<0.5
4. NEES Rhode Island	30-100+	0	400	n.a.	n.a.	<0-2.0	0.9	n.a.
5. City of Palo Alto	~50	0	n.a	n.a	n.a	<0-2.0	n.a.	n.a
6. NEES system-wide	50 to 100+	0	1070	147	0.14	<0-2.0	0.7-1.7	0.1-0.2
7. Niagara Mohawk	50-100	0	n.a.	n.a.	n.a.	0.5-0.8	n.a.	n.a.
8. BPA/ Clark PUD	87	87	958	199	0.21	2.5	2.9	0.3
9. SCE	100	100	2500	250	0.10	0.1-0.3	2.5	0.3
10. NYSEG	10-100	0	>11	9.5	>0.85	0.5-1.0	>3.5	>3

11. Traer Mun. Utility	100	0	200	20	0.10	0.5-1.0	2	0.2
12. Taunton Munic. Utility	100	0	80	25	0.31	0.5-1.0	2.5	0.8

Notes:

(1) Utility costs include incentives, administration and installation where provided.
(2) Program cost in 1985 dollars. Administration costs include detailed energy audits for non-lighting measures. Utility unit costs as calculated by Nadel (1988).
(3) Program costs in 1986 dollars. Technology cost based on incandescent-to-compact fluorescent conversions (<0¢/kWh when installation labor costs are counted), and on 34W lamps replacing 40W lamps (0.8 ¢/kWh), see Piette et al. (1989).
(4) Program costs in1985 dollars. Utility cost per kWh based on SRC (1987).
(5) Program costs in1987 dollars. Utility cost per kWh from Nadel (1988).
(6) Complete cost data not available
(7) Program costs in 1987 dollars. Utility unit cost data from Nadel (1988).
(8) Technology cost data from Piette et al. (1989).
(9) Program costs in current 1986-88 dollars. Costs per kWh from Wolfe and McAllister (1989). Technology cost data include some installation costs.
(10) Program costs in current 1986-89 dollars. Technology costs based on Krause et al. (1987), adjusted for lamp price of $6. Utility cost per kWh calculated from cost of conserved energy for lamp without saved incandescents, and scaled to reflect program overhead and installation costs. Program cost data from Lane (1989).
(11) Program costs in 1982/83 dollars. Technology cost calculated by authors, based on prices and savings given by Dobish et al. (1983). Utility cost per kWh calculated as in (9).
(12) Program costs in 1987 dollars. Technology costs from Krause et al. (1987). Utility cost per kWh calculated as in (9).
(13) Program costs in 1988 dollars. Technology costs from Krause et al. (1987). Utility costs per kWh as calculated by Desmond (1989).

assume that on a weighted average basis, the multi-measure programs have a technology cost of at most about 2 ¢/kWh.

The lower end of the technology cost range for these commercial and industrial programs is given by the cost of converting incandescents to screw-in fluorescents. In the case of residential programs, the technology cost of switching to screw-in fluorescents is shown as a positive figure because no customer labor costs are involved (see Figure 1 and the discussion above). In the case of the commercial and industrial programs that sponsored such conversions, negative technology costs apply when installation labor costs are counted (Lovins and Sardinsky 1988, Piette et al. 1989). Inclusion of demand-charge savings from lighting retrofits can also lead to negative costs in these sectors (Piette et al. 1989). Where compact fluorescent retrofits are the dominant measure, its negative technology costs could cancel positive costs for other measures installed as part of the program package. In Table 4, we therefore give a range of less than 0 to 2 ¢/kWh for the technology cost of these programs. In order to provide self-consistent definition of technology costs and utility administrative costs, we excluded the cost of installation from the program cost data.

The following general observations can be made:

- The lighting programs reviewed generally provided most or all of the extra first costs of lighting measures, and in a few cases, the entire lighting hardware and installation.
- Utility costs per unit of energy saved were generally larger than technology costs. This is due to the significant incentives provided by the programs, and due to the fact that many programs sponsored measures such as compact fluorescent conversions with avoided replacement benefits that reduce the technology cost as seen by the customer below the first cost of the measure.
- In absolute terms, costs to the utility ranged from 0.7 ¢/kWh to 3.5 ¢/kWh. Ignoring the NYSEG outlier, the range is 0.7-2.9 ¢/kWh. This is significantly less than short-run marginal costs in most utility systems.
- The administrative costs per unit of energy saved ranged from 0.1 ¢/kWh to 0.8 ¢/kWh for all but one very small pilot program, which is an outlier.
- Demand-side lighting resources in the commercial sector may cost utilities somewhat less than residential resources, but the sample of programs reviewed in this report is not sufficient to generalize this pattern.

These cost figures must be seen as indicative of the level of skill in program delivery achieved by utilities in their initial lighting programs, many of which were pilot programs. More large-scale application of the various pilot program designs may change costs, and so will experience. A number of practitioners already reported specific means of reducing the administrative and other utility costs of future programs. For example, the leasing program pioneered by the Taunton municipal utility is now being replicated by the municipal utility of Burlington, ME with about half the administrative budget (Desmond 1989). The NEES One-Stop-Shop program in Massachusetts was burdened by the high cost of doing a complete building audit, rather than just performing a walk-through audit as other programs did. And this and some other programs had significant free rider fractions that could be reduced (see below).

3. Trade-offs between program costs and program participation rates and savings

These findings, and the generally high financial incentive levels offered by the reviewed programs, suggest that utilities still have room for reducing both the all-ratepayer costs for incentives and the administrative costs of programs. As a quantitative illustration, Nadel (1988) estimates that in the case of NEES's dealer incentives program, utility costs could be reduced by 60 percent (from 1.7 to 0.7 ¢/kWh, both values shown in Table 4) if free rider fractions were pared back.[11] The company also had been paying incentives for compact fluorescents that were in excess of wholesale costs. This incentive has been pared back to about 100 percent of wholesale costs in recent program revisions.

This "moving target" aspect of the cost of programs makes it difficult to arrive at conclusive statements about the relationship between high participation rates and the unit cost of program administration. Clearly, higher participation rates are associated with higher incentive levels, and therefore, higher unit costs for incentives, as already discussed in Section III.3.

However, from a societal perspective, it is the total resource cost that is of interest. Assuming the same technologies are being sponsored, the program-based total resource cost of more aggressive approaches can increase only if administrative costs rise per unit of energy saved. Such a rise could come about if the unit cost of administration increases more than the unit savings per customer.

The data in Table 4 provide some insight into this question. The administrative costs in the last column exclude payments for installation labor, since this cost is paid either way from a societal perspective. With this accounting, the per-kWh administrative costs for such aggressive programs as the NEES direct installation program, the SMUD direct installation program, the SCE direct installation program, or the Traer lightbulb exchange program appear not substantially higher than they are for some of the rebate programs, and are in fact lower in some cases. While the sample of programs is too limited to make more precise statements about trends in comparative costs, it seems that aggressive programs do not raise per-unit administrative costs significantly.

4. Impact of free riders.

Problems of free rider measurement.

The utility costs per kWh saved as reported in Table 4 do not reflect free rider fractions except where utility program staff included them in their own calculations, as in the case of the NEES programs. A detailed discussion of the free rider issue in the LCUP context can be found in Krause (1989). As pointed out there, utilities have generally relied on customer surveys to determine free riders. These surveys, which give free rider fractions of anywhere from less than 20 to 80 percent, are unfortunately unreliable, principally due to significant self-response bias

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[11] NEES ended up reducing free riders by imposing pre-inspection requirements. At the same time, the company significantly increased rebate levels to strengthen incentives for participation by those that did not yet use energy-saving lamps (see below). These changes increased per-customer savings but also meant that the projected downward correction of the utility's unit costs to 0.7 ¢/kWh was not achieved.

(ibid.). The derivations of free rider fractions in utility DSM program evaluations are also conceptually inadequate, due to the difficulty of measuring spill-over effects of the program on non-participants, and the inability to distinguish partial free riders from others.

As suggested in Krause (1989), a reasonable order-of-magnitude for probable free rider fractions can be obtained from the share in total sales and the market penetration rates of utility sponsored technologies as observed before the program began. The combination of both pre-program sales shares and pre-program penetration rates is important here, since the market-based trend has to be captured. Programs that rapidly achieve large changes in penetrations will have inherently low free rider fractions. Pre-installation audits also have proven successful in reducing free rider fractions substantially.

It should be noted that the impact of free riders on the cost-effectiveness of programs as seen from the total resource cost or societal perspective is inherently limited: only the additional administrative costs incurred in servicing free riders is a real cost to society. Thus, if program administrative costs are 0.4 ¢/kWh energy saved in a program without free riders, they would double in a program with a 50 percent free rider fraction. The total resource cost would increase by 0.4 ¢/kWh over what they would be without any free riders.

On the other hand, the impact of free riders on the *utility cost* of demand-side resources can be significant. Here, going from a zero to a fifty percent free rider fraction will double not only the administrative portion, but the entire unit cost.

Free riders in lighting efficiency programs

A significant number of lighting efficiency technologies have both very low market *shares* and penetration *rates* at this time. These include some of the most potent measures, such as screw-in fluorescents, specular reflectors, electronic ballasts, and various controls. None of these technologies are experiencing rapid market-driven adoption yet. Lighting programs emphasizing these technologies can be assumed to have small or negligible free rider fractions, particularly if they achieve high participation rates. In our sample, all residential programs certainly fall into this category. Consistent with this first-principles perspective, NEES reports free rider fractions of five percent for compact fluorescents, ten percent for HID retrofits, and 17 percent for reflectors in its dealer incentive program.

Note however, that large regional and customer class differences can exist in the saturation of even the more widely accepted technologies. For example, SMUD found that energy-saving 34W fluorescents had a low (less than 5 percent) saturation among their small commercial customers. This pattern was partly attributed to the level of utility rates, which had been less than 4 ¢/kWh until recently.

Another category of lighting programs where free rider fractions are lowered are programs in which a pre-installation audit was conducted and/or the utility had the measure directly installed through its program staff. This was the case in most of the commercial and industrial programs in this sample. Audits help reduce free riders in two ways: those customers that were already using the sponsored lighting products but were simply hoping to receive utility payments for replacements of these, were eliminated from the program. Of the remaining audited participants, some would have installed the sponsored technologies anyway, in proportion to prevailing market penetration trends. But even then, they might not have done so as extensively as they did once they had the audit information. Thus, some of these participants became only "partial" free riders.

The greatest free rider problems were probably encountered in the dealer incentives program of NEES and in the direct-mail/rebate program of Niagara Mohawk. In both cases, no pre-installation inspection was performed, and the technologies mainly implemented had already significant (30-50 percent) market shares.[12] But even in these programs, the impact of free riders on utility costs per unit of energy saved were still modest in absolute ¢/kWh terms, because the technology cost of the sponsored lighting efficiency measures were low, and/or the program paid only a fraction of these costs.

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[12] The second-year process evaluation of NEES's dealer incentive program still found an estimated 65 percent free rider fraction for 34W lamp purchases. In response, NEES instituted a pre-inspection requirement in 1989.

V. REGULATORY IMPLICATIONS OF LIGHTING PROGRAM EXPERIENCE

1. Could lighting programs defer power plants?

Compared to the typical output of a 1000 MW central station (5000 GWh per year), the annual energy savings achieved in our sample of lighting programs, at about 1-20 GWh (Table 1), is miniscule. Though a number of utilities have recently added lighting efficiency resources in the range of tens of MW to their resource plans, the contribution from lighting efficiency programs so far is small. This finding reflects, in part, the fact that full-scale lighting programs have not been widely implemented. It is informative to calculate the approximate impact from future lighting programs if present program experience were replicated on a large scale. Such an estimate is shown in Table 5.

Total U.S. electricity consumption for lighting is estimated to be about 450 billion kWh (Piette et al. 1989), but neither its total value nor its sectoral composition is well-known. U.S. electricity consumption for lighting in the commercial sector is estimated to be about 200-250 billion kWh per year, equivalent to the output of 40 to 50 large baseload power plants.[13] Indirect consumption in air conditioners that remove heat added to the building by the lighting equipment accounts for approximately 25-40 percent of lighting use (Piette et al. 1989). Total residential consumption, at a typical lighting electricity consumption of about 1000 kWh annually per household is about 100 billion kWh, equivalent to the output of about 20 large power plants. All told, lighting in the U.S. may require the output of about one hundred 1 GW baseload power plants producing 5 TWh/yr each.

We also show in Table 5 the same data scaled down to a prototypical utility serving a population of 5 million inhabitants. Here, commercial lighting would consume, on average, the output of 0.9 baseload plants. If air conditioning loads are added, this figure would rise by 300 MW or more. Residential consumption in the same service territory would be equivalent to about 400 MW of baseload capacity. In total, residential, commercial, and industrial lighting would absorb the output of about 2000 MW of baseload capacity.

In the third column, we show the national and utility-scale savings that could be expected if the better programs within our sample were applied in all service territories. In the fourth column, we show for comparison what results might be expected if the lessons learned from the current generation of programs were applied, together with better technology packages and more aggressive program designs.

For residential lighting programs, we use a 25 percent participation fraction. This assumption reflects actual experience with a large-scale program, i.e. the SCE low-income program. In so far as this program addressed a particularly difficult-to-reach customer group, future programs might achieve higher penetration fractions on a large scale. In the optimistic case, we assume that a 50 percent penetration could be reached and that a larger fraction of fixtures will be converted in each household. These parameters are modeled more

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[13] We refer here to baseload power plant equivalents to convey electricity savings in simple terms. This should not distract from the fact that lighting programs save much larger peak demands, and in many cases, utilities have been implementing lighting efficiency programs because of these peak demand savings.

Table 5: Potential powerplant displacements from lighting programs, U.S. total and typical utility

	Current electricity use for lighting				Potential savings from scaled-up programs			
	Lighting electricity consumption, TWh		Baseload powerplant equivalent, GW		Best designs, this sample, GW		Improved programs aggressive, GW	
	National	Utility	National	Utility	National	Utility	National	Utility
Residential	100	2	20	0.4	2	0.040	6.0	0.12
Commercial								
direct	225	4.5	45	0.9	1.7	0.034	8.4	0.17
indirect (AC load)	75	1.5	15	0.3	0.6	0.011	2.8	0.06
Industrial	100	2	20	0.4	0.5	0.010	3.2	0.06
Total	**500**	**10**	**100**	**2.0**	**4.8**	**0.095**	**20.5**	**0.41**

Notes:

(1) Total lighting consumption and indirect ac loads based on data in Piette et al. (1989)
(2) Utility prototype based on 5 million customers using one 50th of US total
(3) Current sample designs assume 25% participation fraction and 40% per customer savings (residential), 25% and 15% (commercial), and 25% and 10% (industrial).
(4) Improved aggressive program designs assume 50% participation and 75% per customer savings (residential), 50% and 50% (commercial), and 40% and 40% (industrial).

on the basis of the Traer program. A modification of the SCE program or a program similar to that of Traer should be tested on a larger scale. In the optimistic case, residential programs would save about 120 MW of baseload equivalent in our prototypical utility, or about 6 GW nationally.

In the commercial sector, we assume a 25 percent penetration fraction and a 15 percent per-customer saving for programs representing the best present practice. A better combination of the lighting efficiency products already sponsored in existing commercial programs (see Table 2) could as much as triple per-customer savings there without exhausting the total potential (see Piette et al. 1989, Lovins & Sardinsky 1988). The achievable penetration rate for the more aggressive designs is assumed to be 50 percent, based on the direct installation experience in the NEES and SMUD programs. Together with air conditioning savings, total savings could be about 230 MW for our prototypical utility, or about 11 GW of baseload equivalent nationwide.

Assuming similar figures for the industrial sector (see Table 5, footnotes), the total saving from aggressive lighting programs in the prototypical service territory would be about 400 MW of baseload equivalent, and 20 GW nationally. This is four times more than the 100 MW and 5 GW respectively, that would be obtained if the more modest program designs and technology packages found in the present sample were implemented nationally. With proper regulatory incentives, these figures could possibly be realized within less than 10 years. Emerging technologies (Piette et al. 1989), spill over effects, and government efficiency standards could provide even larger savings over the time horizon of 10-20 years.

These crude, illustrative figures indicate that even in their present form, lighting programs could provide substantial resources if implemented on a large scale. At the same time, our analysis suggests that the contribution from lighting efficiency programs could be significantly larger if the technologies sponsored, notably those in commercial sector programs, were better geared toward achieving large per customer savings. The figures also show that savings from residential programs could be larger than is commonly believed.

2. Potential regulatory initiatives

Our review of lighting programs suggests that regulators who seek to fully mobilize low-cost lighting efficiency resources should

- encourage utilities to expand the kinds of technologies sponsored in their programs;
- encourage utilities to experiment more systematically with alternative program designs;
- work with utilities and technical experts to establish a common minimum framework for all utility lighting programs in the state;
- standardize the reporting practices for total resource costs, free rider treatments, and administrative costs.

These regulatory efforts could, for example, be implemented through a collaborative review process similar to the one recently used by the Rhode Island Least Cost Planning Committee (RILCPC 1988). In that process, the state's utilities, the regulatory commission, and the governor's office of energy assistance met with independent experts to define a range of lighting measures utilities might sponsor, and to identify program designs that would seem conducive to improved delivery of these technology packages.

Regulators could also encourage utilities to use their considerable market power and engage in negotiations with manufacturers and other trade allies. The national sales volume of some of the most attractive future technology options, such as more versatile compact fluorescents and tunable electronic ballasts, could be increased many fold if they were sponsored in just one or a few large service territories through aggressive coordinated programs.

A second conclusion from the analysis of our program sample is that utilities should be encouraged to do more systematic program design experimentation. While our sample provides a good range of approaches, systematic experiments with fundamentally different program designs by one and the same utility, using good process and impact evaluation procedures, appear to be few and far between. The NEES and Niagara Mohawk programs come to mind. But such experiments and ongoing evaluation will be vital in expanding programs to service-territory or state-wide scale.

Again, the Rhode Island least cost planning process illustrates one possible form in which regulatory agencies can help expand programs and improve program designs. In the Rhode Island process, utilities and state agencies defined a statewide lighting assessment and installation program, to be provided by all utilities within the state. It consisted of free lighting audits and direct installation services for a defined set of products.[14] Several other regions and states have recently instituted or are in the process of establishing collaborative processes aimed at improved utility programs, including Massachusetts and California. While these processes have not gone to the level of detailed attention that was given to lighting programs in Rhode Island, they might be expanded in some such fashion in the future.

A standardized accounting practice for programs should extend to the subcategories of administration costs, free rider treatments, customer portion of total resource costs, and the engineering cost estimates used for selecting eligible technologies. Both the NORDAX data acquisition format and the the California PUC's DSM manual (CPUC 1987) could be used as instructive precedents for such standardization.

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[14] One organization (RISE) collects audit information and provides field staff training and installation services for all the utilities statewide. Additional programs are being provided by the individual utilities. Incentives in each service territory are tailored to each individual utility's avoided costs.

VI. CONCLUSIONS AND RECOMMENDATIONS.

This concluding section summarizes both the lessons learned from the reviewed programs and the implications of this learning experience for regulatory commissions wishing to promote effective utility demand-side programs.

The lessons learned can be summarized as follows:

- Even though utilities are still learning to run optimized lighting programs, the first generation of programs is already capable of producing significant amounts of highly cost-effective demand-side resources.
- In our sample of first generation lighting efficiency programs, promoted technology options were not optimized for the goal of obtaining the maximum fraction of technical lighting efficiency potentials. Nevertheless, several programs were very successful at promoting high per-unit-savings options.
- Further improvements in technology selection can be made notably in the commercial sector, where integrated packages of electronic ballasts, lighting controls, high efficacy lamps, and specular reflectors should be emphasized in the future.
- In residential programs, the challenge is to convert more fixtures per household to high efficiency lamps. Here, improved modular screw-in fluorescents, as well as integrated lamp and fixture units for special applications, can ease the fitting problem and should receive greater emphasis in the future.
- Penetrations significantly in excess of about 50-70 percent appear to be difficult to achieve in the short-term, but the spill-over effects of converting most customers to the new technology (restocking of the wholesale-retail chain, changed manufacturer pricing strategies, word-of-mouth communication) could be substantial.
- The same spill-over effects could be important in assuring the persistence of lighting efficiency in future replacement cycles in the absence of utility programs.
- The programs reviewed here suggest that the size of the financial incentive *is* important in determining participation, at least in the case of some customer classes. At the same time, there is evidence that improved outreach design could lead to reductions in the size of financial incentives needed to bring about a given participation rate, and that such improvements could in some cases make customers indifferent to the magnitude of the incentive.
- Equally important as the size of the incentive is the form of the incentive. Utility rebate programs seem to be reasonably effective only for the larger commercial customers. For all other customers, direct customer contact and installation services seem to be an essential prerequisite to program success. Here, even a 100 percent rebate would not by itself lead to high participation rates. This is particularly true when that contact is combined with on-the-spot audits and installations, or with assistance in redesigning lighting systems. Where high participation rates are to be achieved, free hardware and installation services and door-to-door canvassing are particularly effective.

- While such aggressive program approaches will increase the utility cost per unit of energy saved, these costs appear to remain well within the typical range of short-run marginal costs. From a total resource cost perspective, there does not seem to be a substantial per-kWh cost difference between aggressive program approaches with higher costs per participant and less aggressive programs with lower absolute utility expenditures.
- Program administration costs are a relatively modest (10-30 percent) fraction of utility costs. As other research on DSM programs at large shows (Berry 1989), this finding confirms specifically for lighting the rule of thumb used by the Bonneville Power Administration in its program planning, which assumes a 20 percent administration cost relative to the technology cost. With the program improvements mentioned in Section IV above, and subject to successful scaling up of the pilot program approaches reviewed, this percentage could in time drop to even lower levels. Conversely, where successful programs have already achieved large penetration fractions, the administrative cost of further increases can be expected to rise significantly.
- For some lighting efficiency technologies, the utility cost of acquiring them is several times higher than the technology cost, due to longer lifetimes of efficient equipment compared to standard equipment. In these cases, these rules of thumb for administrative cost shares do not apply. Here it is important to know that in absolute terms, administrative costs were generally no more than 0.8 ¢/kWh, and typically about 0.3-0.5 ¢/kWh.
- Most of the examined lighting programs were relatively immune to free rider effects when they included pre-installation audits or sponsored technologies with low market shares and penetration rates. The free rider problem can be more significant in programs in which customers are induced to select only the most pedestrian changes, such as replacing 40W fluorescent tubes with 34W lamps. To the extent that future programs will rely on more aggressive technology packages, free rider effects would be further deemphasized.

In terms of the implications for regulatory approaches, the following conclusions and suggestions emerge:

- In evaluating whether utility lighting programs were successful, it is important to use the stated objectives of these programs as a yardstick. Not all programs reviewed had maximum penetration rates or maximum mobilization of technical potentials as their goal. Several of the programs were of a pilot character and aimed at testing specific delivery methods.
- The overall achievements of utility lighting efficiency programs to date fall far short of their potential. However, a look at specific programs shows that a number of utilities have been highly inventive and successful in the promotion of lighting efficiency. Scaling up and improving these approaches could lead to national savings of 5-20 GW.
- In so far as expanded future efforts may be planned by utilities or desired by regulatory commissions, our review suggests that utilities should be able to shape the

acquisition of lighting efficiency resources flexibly according to their own load-shaping and resource planning goals, as well as in response to regulatory and environmental targets. Utilities appear to have good control over the rate of lighting program participation, and therefore over the speed with which demand-side resources can be mobilized. This significant range of control applies to both the commercial and residential customer classes. In some programs penetration rates in excess of 50 percent were achieved in a matter of months.

- The program-based costs of lighting efficiency resources compare similarly favorably with utility short-run marginal costs as those calculated in technical potential studies, with the difference that utility costs of demand-side resources will always be greater than zero while technology costs can be negative. The data from the reviewed programs suggest that as a rule, lighting programs can satisfy both the total resource cost test and the utility cost test in standard LCUP cost-benefit practice over the entire range of practically encountered avoided costs, including short-run marginal costs. This should apply to both currently sponsored and more aggressive technology packages that provide larger savings: the technology cost for lighting efficiency varies little with the level of savings when larger savings are realized through optimized packages (Piette et al. 1989, Lovins and Sardinsky 1988).
- Utilities and regulatory commissions should consider taking active steps to ensure that future lighting programs end up delivering technology packages with greater per-unit savings, especially in the commercial sector. Here, better training of specifiers and contractors, as well as more aggressive utilization of utility market creating and negotiating leverage with manufacturers would seem important.
- Utilities and regulatory commissions should develop a consensus standardized accounting practice for the various program cost categories. Notably customer costs should be spelled out in order to allow a clear view of total resource costs. Such standardization would make the cost evaluations of utility programs more transparent and would remove uncertainties about the variances in reported costs. Such a standardized accounting practice should extend to the subcategories of administration costs, free rider treatments, and the engineering cost estimates used for selecting eligible technologies.

VII. REFERENCES

1. Berry, L. 1989: "The Administrative Cost of Energy Conservation Programs," Oak Ridge National Laboratory (ORNL), ORNL/CON-294, Oak Ridge, TN.

2. CPUC 1987: "Standard Practice Manual, Economic Analysis of Demand-Side Management," California Public Utilities Commission, Sacramento, CA.

3. Clinton, J. and A. Goett, 1989: "High Efficiency Fluorescent Lighting Program: An Experiment with Marketing Techniques To Reach Commercial and Small Industrial Customers," *Proceedings: 1989 Energy Program Evaluation Conference*, Argonne National Laboratory, Chicago, IL, p.93.

4. Desmond, J. 1989: Personal Communication, Energy Services and Marketing Administrator, Taunton Municipal Lighting Plant, Taunton, MA, April.

5. EPRI 1988: "A Compendium of Utility-Sponsored Energy Efficiency Rebate Programs," RP 2884-09, Electric Power Research Institute, Palo Alto, CA.

6. Gettings, M.B. and J.M. MacDonald 1989: "Expansion of Utility Services to Small Businesses," Oak Ridge National Laboratory Draft Report, ORNL, Oak Ridge, TN.

7. IRRC 1987: "Generating Energy Alternatives. Demand-Side Management and Renewables at America's Electric Utilities." D. Cougan, S. Williams, Investor Responsibility Research Center, Washington, DC.

8. Krause, F. *et al.* 1987: "Demand-Side Electricity Resources in Michigan's Residential Sector," Report to the Michigan Department of Commerce. Lawrence Berkeley Laboratory, LBL-23026, Berkeley, CA.

9. Krause, F. 1989: "Issues in Estimating Free Rider Fractions," in: *Demand-Side Management Strategies for the 90s. Proceedings: Fourth National Conference on Utility DSM Programs*, Volume 1. Electric Power Research Institute, EPRI CU-6367, Palo Alto, CA, p. 15, April.

10. Lovins, A.B.L., R. Sardinsky, *et al.* 1988: "The State of the Art: Lighting," Rocky Mountain Institute, Snowmass, CO, March.

11. Meier, A. 1983: "Supply Curves of Conserved Energy," Lawrence Berkeley Laboratory, LBL-14686, Berkeley, CA, May.

12. MEOS 1987: "Electricity Options for the State of Michigan, Final Report," Michigan Electricity Options Study (MEOS), Michigan Department of Commerce, Lansing, MI, October.

13. Moskovitz, David 1989: "Least Cost Planning and Utility Earnings," White Paper prepared for the NARUC Conservation Committee, National Association of Regulatory Utility Commissioners (NARUC), Washington, DC, July.

14. Nadel, S. 1988: "Utility Commercial/Industrial Lighting Incentive Programs: A Comparative Evaluation of Three Different Approaches Used by the New England Electric System," *Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings,*, Volume 6, American Council for An Energy Efficient Economy, Washington, DC.

15. NARUC 1988: "Statement of Position of the NARUC Energy Conservation Committee on Least Cost Planning Profitability," National Association of Regulatory Utility Commissioners (NARUC), Washington, DC, July 26.

16. NARUC 1989, *Least Cost Utility Planning. A Handbook for Utility Commissioners. Volume Two: The Demand-Side,* by F. Krause and J. Eto for National Association of Regulatory Utility Commissioners (NARUC), Washington, DC.

17. NEOS 1989: "Operating a Commercial Lamp Installation Program," NEOS Corporation, Lafayette, CA, prepared for Western Area Power Administration (WAPA), January.

18. NORDAX 1988: "Northeast Region Demand-Side Management Data Exchange," Project Management: Carol Sabo, New York State Electric and Gas (NYSEG). Edison Electric Institute, Washington, DC.

19. Palo Alto, City of, 1984: *Staff Report: Electric Incentives Program for Peak Demand Reduction*, Palo Alto, CA.

20. Piette, M., F. Krause, R. Verderber 1989: "Technology Assessment: Energy-Efficient Commercial Lighting," Lawrence Berkeley Laboratory, LBL-27032, Berkeley, CA September.

21 RILCPC 1988: "A Statewide Least-Cost Plan for Rhode Island," Draft final report on initial work prepared by Xenergy Inc. for Rhode Island Least Cost Planning Committee, October.

22. SCE 1986: *Energy Management Results*, Southern California Edison, Rosemead, NY, March 31.

23. Wiel, S. 1989: "Making Electric Efficiency Profitable," *Public Utilities Fortnightly*, July 6, p. 9.

24. Wolfe, P. and L. McAllister 1989: "The Industrial Lighting Incentive Program: Process and Impact Evaluation," in: *Proceedings: 1989 Energy Program Evaluation Conference*, Argonne National Laboratory, Chicago, IL, p. 99.

APPENDIX A

UTILITY:

New England Electric System (NEES)
25 Research Drive
Westborough, Mass. 01582
Tel: (617) 366-9011
Contact Person: Liz Hicks

PROGRAM TITLE:

Enterprise Zone Small C&I One-Stop-Shop Lighting Giveaway Program

PROGRAM STATUS AND DATES:

The Enterprise Zone Small C&I One-Stop-Shop Lighting Giveaway Program was a pilot program offered in 20 "Enterprise Zone" communities located in central and western Massachusetts for a 17-month period (August 1985 - December 1986).

SECTORS AND SUB-SECTORS SERVED:

Commercial and industrial sectors.

PROGRAM OBJECTIVE:

This program was one of three programs run by NEES to promote energy-efficient lighting among commercial and industrial customers within its service territory. Two of the programs were run as pilot programs, in order to experiment with different program approaches, and the third program is now being run thoughout the NEES service territory and is an attempt to combine some of the best features of the two pilot programs.

DESCRIPTION OF PROGRAM:

The Enterprise Zone consisted of 20 economically depressed communities where NEES offered a comprehensive series of pilot conservation programs for residential, small C&I, and large C&I customers. These programs ran from August 1985 to December 1986. This program was designed to promote high energy savings among eligible customers by making it as easy as possible for customers to participate.

Customers were provided free energy audits and free installation of lighting retrofit measures which passed a cost-effectiveness test. Contractors hired by the utility performed all the work -- all the customer had to do was agree. The utility provided a one-year warranty on all measures installed.

This program required the coordination of marketing, energy auditing, preparing work orders, purchasing materials, installing measures, inspecting completed jobs, and issuing payments. Due to the quantity of work involved, work was divided between utility staff and two outside contractors. Utility staff marketed the program, conducted energy audits, and prepared work orders in selected areas. The utility also arranged for bulk-purchase of materials and payment of all bills. One contractor was responsible for marketing, energy audits and work orders in the remaining areas. Another contractor was responsible for measure installation in all areas. This contractor coordinated all work orders and hired local electrical contractors to conduct actual installations.

Total eligible customers:

There were 2,263 eligible customers; these were small C&I customers: average annual electricity demand was less than 100 kW, or whose annual electricity use was less than 240,000 kWh.

Eligible lighting products and services:

Cost-effective measures were those for which material and labor costs were less than or equal to the value of energy savings to the utility over a ten-year period. At the time of program start-up, this value was estimated to be $0.36 per kWh saved in the first year (the net present value was $0.07/kWh for ten years). Measures covered by the program were: energy-efficient fluorescent tubes and ballasts, compact fluorescent lamps, and high pressure sodium and metal halide fixtures.

Information outreach to customers (marketing):

Marketing included two mailings to all eligible customers, telephone calls to all eligible customers and site visits to customers located in large towns. In addition, general publicity on the Enterprise Zone initiative increased customer awareness of the program.

Involvement of trade allies:

Installation::

Contractors worked under subcontract with the utility.

Rebate Mechanism:

Free Installation.

Rebate levels:

The utility covered 100% of equipment cost and 100% of audit and installation cost.

Impact of rebate levels on customer first cost:

Customers had zero first costs. Indirect, "hassle factor" costs were also reduced substantially.

Baseline data on lighting use:

Baseline data were obtained through on-site audits.

PROGRAM EXPERIENCE:

Program evaluation by utility:

Surveys of customers were conducted to estimate the number of "free riders" (see below) and customer satisfaction with the program. Over 90% of the participants were satisfied with the program.

Participation rate:

The participation rate was 34.2% (775 customers) over the first 17 months of the program. Audit requests were even higher: over 60% of the targeted customers requested free energy audits under the program. The majority of customers who received audits but did not have lighting measures installed had insufficient operating hours to pass the cost-effectiveness test.

Impact of rebate level on participation rates:

The "hands-off" approach of this program, i.e. full coverage of all customer costs is the main explanation for the very high participation role of the programs.

Socio-economic characteristics of participants:

Average annual electricity consumption for participating customers was 42,000 kWh/year, which was higher than average annual electricity consumption of all eligible customers.

Special problems:

"Free riders," program participants who would have purchased efficient products anyway even if an utility incentive program were not offered, were estimated from surveys. Free riders were estimated to represent approximately 12% of program participants.

The organization of the energy audit function had problems: there were initial delays delivering energy audits, and tracking of audit recipients, while adequate, could have been better. In addition, the audit devoted extensive time to non-lighting measures. A simple walk-thru lighting audit might have been more preferable than a full-scale energy audit.

There was some confusion and concern that the program would not replace lights with inadequate operating hours to pass the program's cost-effectiveness test.

PROGRAM COST-EFFECTIVENESS:

As part of all program evaluations, NEES analyzes the costs and benefits of each program using an in-house "least-cost" model. This model analyzes the present worth of each program's costs and benefits, where benefits are valued at NEES' avoided marginal energy and capacity costs. Outputs from the model include cost-benefit ratio and cost/kWh saved over the life of the program.

Program costs:

$2.2 million (in 1987 $)

Program savings:

Demand savings were estimated based on engineering data for the new equipment installed and the old equipment replaced. These estimates were adjusted to eliminate free riders (see above) from the savings estimates and to adjust for the fact that not all lights are on at the time of system peak (adjustment factors vary from product to product and are based on professional judgment, energy audit, and load research data). Energy savings were estimated based on demand savings and reported or estimated hours of operation of each participating customer.

Total program savings were estimated to be 1.9 MW and 5.9 GWh. Average annual savings per customer were estimated to be 2.4 kW per customer and 7,660 kWh per customer. The average percent kWh savings per customer was 13%.

Program cost-effectiveness:

The cost-benefit ratio was calculated to be 0.61. The cost/kWh was calculated as $0.023/kWh (in 1987 $).

REFERENCE:

Hicks, E, personal communications, 1988, New England Power Service, Westborough, MA.

Nadel, S., personal communications, 1988, New England Power Service, Westborough, MA.

Nadel, S., "Utility Commercial/Industrial Lighting Incentive Programs: A Comparative Evaluation of Three Different Approaches Used by the New England Electric System," *Proceedings of the ACEEE 1988 Summer Study on Energy Efficiency in Buildings*, Vol. 6, pp. 153-165, American Council for an Energy-Efficient Economy, Washington, D.C., 1988.

APPENDIX B

UTILITY

Sacramento Municipal Utility District (SMUD)
6507 4th Avenue, Suite 400
P.O. Box 15830
Sacramento, California 95852-1830
Tel: (916) 732-5435

PROGRAM TITLE:

Commercial Lamp Installation Program (CLIP)

PROGRAM STATUS AND DATES:

A pilot program was conducted from July 14 to Dec. 31, 1986. A large-scale program has operated since Jan. 1, 1987 as a follow-up to the pilot program. The program was ended December 31, 1988 as it was felt that the market was saturated.

SECTORS AND SUB-SECTORS SERVED:

All nonresidential customers with energy demand less than 30 kW (classified by SMUD as Rate 27 customers). Later, customers with a demand of 50 kW or less (Rate 47) were included.

PROGRAM OBJECTIVE:

The main objective of the program is the reduction in peak demand. The pilot program was designed to test the cost-effectiveness of replacing (free to the customer) standard incandescents with energy-efficient fluorescents. The objectives of the pilot program were the following:

- determination of customer acceptance of the program
- analysis of implementation of recommendations identified during a small commercial audit program prior to CLIP
- collection of detailed cost-benefit data
- comparison of penetration rates in the direct installation approach with more traditional rebate methods

DESCRIPTION OF PROGRAM:

SMUD has adopted an innovative approach to achieve their objective of reducing peak demand. In their direct installation program, the utility brings a number of energy-efficient fluorescent lamps to small customers, and if the customer agrees, SMUD installs the lamps at the time of their visit to the customer's premises. Any number of lamps up to one hundred F40 or fifty F96 lamps may be installed during the visit, at no cost to the customer. After the initial site visit, SMUD offers a 40% rebate for those customers wishing to change more of their incandescents to efficient fluorescents. This approach has yielded a high participation rate and enabled low-demand customers, who would otherwise not invest in these technologies, to save energy.

The Western Area Power Administration provided a grant of $30,000 to pay labor costs for the installation of the lamps during the initial phase of the program. The pilot project began in July 1986, and the first installations occurred in early August. By the end of the pilot program (December 31, 1986), more than 50,000 lamps had been installed in 1,300 small commercial customers' premises. Because the pilot program achieved more installations and savings than expected (e.g., the program's goal was 900 customers), the program continued as a large-scale program without programmatic changes.

In the current program, an energy auditor contacts small customers located in specified zip code areas. At the time of his visit, the auditor seeks permission to install lamps on the premises if the customer is interested. He makes sure the customer qualifies for the program and may disqualify customers based on program guidelines (see below). Some customers may not be interested in the program, may require time to think about the program, or may want to refer the request to another person in their organization not present at the time of the initial visit. For other customers, the auditor makes provisional arrangements to visit and install the lamps at a later time. The customers are informed a day before a two-person installation team plans to visit. From the time the customer makes a request, it takes 3 to 10 days before the installation work is carried out.

After the installation, information on the vendor, a customer satisfaction survey form, and material explaining the benefits of energy-efficient lamps are left with the customer. A sticker indicating the wattage of the lamp and the date of its installation is placed on each fixture to encourage the installation of similar energy-efficient lamps should natural replacement be required at a future date. This provision also helps the utility to keep track of future problems (e.g., premature lamp failures) and to correct these measures when necessary.

At the start of the program, 10% of the participating customers' premises were inspected to confirm reported installations and to check customer satisfaction. These inspections have been reduced to cover only 5% of the participants, since not many problems were generally found to be associated with the program. However, these inspections are carried out for all customers who approach the utility with problems.

By November 1987, almost all zip code areas had been covered. Not all premises were visited; however, the utility is planning to systematically cover those customers excluded in the initial search. For example, some customer were not contacted because they were not fluent in English. In the next phase of the program, the utility intends to visit those customers who have in the past shown little interest in the program. Since a majority of these customers were approached some time ago, SMUD feels these customers may have changed their minds, especially since a new rate structure was recently imposed, leading to high increases in the cost of electricity (electricity rates for Rate 27 customers (see above) have more than doubled over the existence of the program to an average of 6.85 cents/kWh in October 1987).

Total eligible customers:

In the SMUD service territory, there are 18,000 Rate 27 customers eligible for the program. These customers typically use less than 48,000 kWh/customer annually.

Eligible lighting products and services:

Two lamp types are eligible in the program:

- Four-foot (F-40) Energy Saving cool or warm white fluorescent lamps with 34 watts
- Eight-foot (F-96) Energy Saving cool white fluorescent lamps with 60 watts

A maximum of 100 F-40s or 50 F-96s, or a combination of these, are eligible for each customer.

No ballasts are replaced in the program. SMUD conducted a pilot program (MENU LAMP PROGRAM) in 1989 that included a greater choice of products, including energy-efficient incandescents of the PL and SL specification. A point system was used to allow customers to choose lamps up to the utility's per-customer incentive limit. The program did, however, not prove practical and was discontinued.

Eligibility criteria:

For a facility to be eligible, the following conditions must be met:

1. The customer must be a Rate 27 customer in the SMUD service territory, or a Rate 47 customer with a demand of less than 50 kW.

2. The fixtures must be not more than 12 feet above the floor. (The rationale for this criterion was that trained staff do not carry large enough ladders to install lamps over 12 feet).

3. The facility must have in place, and operating, standard F-40 and/or F-96 fluorescent lamps. No non-operating lamps are replaced.

4. The fixtures must be in a heated area.

5. The lights must normally be used during SMUD's summer peak period (1 pm to 9 pm).

6. Since only lamps are changed (and not the ballasts), the ballasts must be compatible with the new energy-saving lamps.

Also, some "shop" type lights may not be eligible, and only F-40 and F-96 energy-efficient fluorescent lamps are installed in existing fixtures.

SMUD requires participating customers to be responsible for existing equipment in the building and to comply with the following conditions:

- The customer agrees to hold SMUD harmless from all loss or damage arising from, or in any way connected with, existing conditions.
- SMUD will not be responsible for existing equipment problems, such as defective sockets, fixtures (including brittle or aging diffusers and lenses), and wiring.

Furthermore, the customer has certain responsibilities after the new lamps are installed:

- SMUD will not be responsible for lamp or ballast failures occurring more than 30 days after installation.
- The customer will be responsible for disposal of the old lamps disabled by the installers during the re-lamping process.

Information outreach to customers:

SMUD contacts customers without prior warning on an area-by-area basis, and offers to install energy-efficient lamps either at the same time or at a later date in order to give customers time to decide. Since 1986, SMUD also sends intermittently reminders in utility bills to Rate 27 customers. The reminders describe the program and the offer of free fluorescent lamps and request customers to contact SMUD. In response to this message. SMUD usually receives 40-50 calls per billing cycle (every 2 months). There is no other advertising for the program.

Involvement of trade allies:

A vendor supplies SMUD with energy-efficient lamps at a competitive rate. The vendor was selected after SMUD compared rates from alternative sources, including vendors providing lamps at state contract prices. The prices of the selected vendors are typically lower than state contract prices. SMUD did experience problems with previous vendors which did not supply F-96 lamps on time; however, the utility has not experienced such problems with their current vendor.

Impact of rebate levels on customer first cost:

The CLIP program has been designed to cover the total cost of both the lamps and installation. This is attractive to many customers who would otherwise have not taken steps to install energy-efficient measures such as those offered through CLIP. This is particularly true for small commercial customers who are the least likely to install such measures.

Baseline data on lighting use:

In 1985, 18,00 commercial customers were audited under the federally mandated Commercial Apartment Conservation Service (CACS) program. Including previous and subsequent audit programs, about 3000 small commercial customers have received audits so far. Currently, about 250-300 audits are added each year. The audit data has not been analyzed by SMUD; however, the data base is computerized and represents an excellent source of baseline data. The data base contains the following information:

1. Customer name and address
2. SIC classification of each customer (4 digit)
3. Building type
4. Own or leased property
5. Age of the building:
    - Prior to 1949
    - 1950-1959
    - 1960-1969
    - 1970-1974
    - 1975-1978

1979-1984
1985 onward

6. Square footage of the building

7. Percentage of the building that is air-conditioned

8. Type of air-conditioning:

   Central
   Wall unit (Number of units ___)
   Evaporation
   Multiple package
   None
   Unknown

9. Commercial or multifamily (Number of apartments ___)

10. Pacific Gas & Electric audit (Yes or No)

11. Electric water heater (Yes or No)

12. Number of electric water heaters

13. Total water heater kW

14. Maintenance services:

   Light
   HVAC
   Both
   None

15. Auditors initials; date of audit; length of audit

16. Rate category (47, 27, 47F or 27F)

17. Participation in other conservation programs:

   Lamp incentive
   Small commercial load management
   Energy awards
   Combination of first three programs
   Peak load reduction

None
Other

18. July demand (kW)

19. Annual electricity use (kWh)

20. Weekday hours of operation:

	LIGHTING		HVAC	
	Start	End	Start	End
SUMMER (June - Sep.)	___	___	___	___
WINTER (Oct. - May)	___	___	___	___

21. For each account, data were collected for the following lighting measures:

Delamping
Energy-saving fluorescents
Energy-saving incandescents
H.E.L. system
Daylighting
Lamp control
Other

For these measures (as well as for HVAC measures), the following data were collected during the audit and during the post-audit visit:

kW already realized (0% kW, 25%, 50%, 75%, or 100%)
%kW implemented per year
Total years to implement
kW savings
% kW @ 4 pm June-Sep.
% kW @ 6 pm June-Sep.
% kW @ 8 pm June-Sep.
Total annual kWh

22. Comments; contact person, telephone number and appointment time.

PROGRAM EXPERIENCE:

Program evaluation by utility:

Some post-installation inspections have been carried out by SMUD. Initially, 10% of the participating customers' premises were inspected for installation, and customers were interviewed to determine their satisfaction with the lamps and the program. Since no major problems were encountered, the percentage of customers covered was reduced to 5%, and these customers were usually those who approached the utility with installation problems. SMUD currently receives only 3 to 4 calls per week, compared to 70 to 80 installation jobs completed per week.

Approximately 4,500 customers have participated in this program, out of a total of 9,500 customers approached by SMUD since the inception of the program. Of the 9,500 customers approached by the utility, only 342 (less than 4%) had energy-saving lamps. At the time of their visit to the customers' premises, the auditor investigated the reasons for nonparticipation and for disqualification (based on the eligibility guidelines established by SMUD). In some cases, the lack of fluency in English resulted in nonparticipation. Other reasons for nonparticipation or nonqualification are shown in Table 1.

Moreover, 84 customers decided not to participate in the program after initially agreeing to participate.

Participation rate:

SMUD's CLIP program has achieved a high response rate: 47% (4,500 out of 9,500 customers approached). Since about 1200 of those approached were not eligible for the program (see above), the actual eligible population was approximately 8,300, increasing the response rate to 54%.

Over 75% (about 2900 out of 3700) of the nonparticipants did not participate because a decisionmaker was not available at the time of the installation team visit. SMUD has, therefore, decided to approach these customers a second time, in order to increase the response rate to the program. SMUD staff estimate that the ultimate response rate for the program could be 68 to 70 percent. The then remaining nonparticipant customers are considered to be geographically too dispersed to cost-effectively reach.

Impact of rebate level on participation rates:

Although not explicitly measured, the high participation rate most likely was due to the fact that the program was free to the customer. As mentioned previously, small-sized customers are less likely to convert to energy-efficient lighting on their own, especially if they have to pay the full or partial cost of the measure.

Table 1. Reasons for disqualification or non-participation*

Reason	Unable to Participate	Disqualified	Refused
Existing energy-saving lamp	8	487	1
Ceilings not accessible	2	23	1
Bulb colors not available	69	4	17
Incompatible system	10	74	1
Operating hours not at peak hours		213	
Exterior lamps/unconditioned space	34	1429	
Concern about ballast and lamp failure			2
Lighting maintenance contract	1	45	1
Fixtures over 12' high		14	
Other	668(language)	261	109
Inconvenient time	14	1	2
Decision maker not available	2928	81	
Lack of information			2
Not interested		3	428
Total number of responses	3736	2638	565

* The blanks in the table indicate an insignificant number of respondents, or no respondents.

Socioeconomic characteristics of participants:

All the customers were small commercial customers with energy demand less than 50 kW. No account was kept of the number and type of businesses and buildings affected by the program.

Impact of process evaluation on participation rates:

As problems surfaced, CLIP was flexible in making small improvements or changes to the program and in handling requests made by different customers. This type of flexibility allowed a larger number of customers to participate than would have been possible with a less flexible program.

Special problems:

No major complaints were encountered with the installations or the management of the program. The problems that did arise reflected the nonparticipation issues discussed previously. For example, there were some problems in convincing customers in at least one zip code area where businesses were run by minority groups and where language was a barrier. After a few attempts, these localities were not pursued by SMUD. Similarly, unconditioned space in buildings was not retrofitted. Since it was SMUD policy to not retrofit these areas, requests by certain customers had to be turned down.

Finally, a large proportion of the participants did not understand why their old lamps were disabled during the retrofit. Despite several warnings (in written material and during site visits), a large proportion of customers expressed surprise and anxiety over their disabled lamps. Once the installations had been carried out, no problems were encountered by customers over the disposal of the old lamps.

PROGRAM COST-EFFECTIVENESS:

The program was considered cost-effective, as shown in the following data on costs and savings.

Program costs:

Program costs for the first six months of the program (July 14 to Dec. 31, 1986), resulting in the installation of 54,362 lamps, are shown in Table 2:

Table 2. Program cost components.

Contract labor	$85,000
Staff time	30,000
Cost of lamps	72,635
Equipment	1,300
Provision of vehicles	6,000
Material replacement	828
Total cost	$196,567

These estimates indicate an approximate cost of $3.62 per installed lamp. No cost estimates have been made since the first six months. However, it is believed that the cost/installed lamp has remained the same over the period of the program. Since a total of 171,279 lamps have been exchanged during the program (up to October 1987), this would indicate an estimated total program cost of about $620,000.

Program savings:

For each site visited, an average of 40 lamps were swapped to the more efficient types. By the end of the first six months of the program, 54,362 lamps had been installed (F-40 and F-96 combined). Between this time and October 1987, another 116,917 lamps were installed. Thus, a total of 171,279 lamps have been swapped in the program so far. An average savings of 6 watts per F-40 lamp and 15 watts per F-96 lamp have been assumed in computing program savings.

The total savings in kW and kWh are shown in Table 3.

Table 3. Program savings.

Duration of Program	No. of F-40s	No. of F-96s	Total Program Savings kW	Total Program Savings kWh
Up to Dec. 1986	37,492	16,870	478	1,321,251
Jan. to Oct. 1987	103,417	13,500	823	2,409,000
Total	140,909	30,370	1,301	3,730,257

Thus, for the 4,219 participating customers, the savings were approximately 884 kWh per year and customer. These savings may represent as much as 10% of annual kWh usage for some customers.

Program cost-effectiveness:

The breakdown of costs and savings for the program (as of Oct. 1987) are shown in Table 4.

Table 4. Costs and savings from CLIP					
Period	Lamps installed	Number of jobs	Total savings kW	Total savings kWh	Total cost $
July-Dec. 1986	54,362	1,278	478	1,321,257	196,567
Jan.-Oct. 1987	116,917	2,941	823	2,409,000	422,759*
Program Total	171,279	4,219	1,301	3,730,257	619,326*

* The cost for the period Jan.-Oct. 1987 was estimated, assuming that the cost/installed lamp was the same between the first six months of the program and the period Jan. to Oct. 1987. As a result, the total cost of the program is an estimate.

Benefit-cost ratios were generated for the 1986 period of the SMUD program by using *Dsplanner*, a demand-side management program developed by Barakat, Howard, and Chamberlin. Two scenarios were developed. The first scenario assumed a three-year program, four-year lamp life, and 25% impact persisting through the year 2015. The second scenario was similar to the first, but excluded the 25% impact persistence. The benefit-cost ratios are shown in Table 5.

Table 5. Benefit-cost perspectives.

	Benefit-cost ratios	
Perspective	Scenario I	Scenario II
All ratepayers (societal)	3.08	2.55
- impact of revenue loss included	1.09	0.94
Participant	6.04	10.35
Utility	5.69	3.34

The benefit-cost ratios indicate that the SMUD program was highly cost-effective in three out of four tests. When lost revenue is included, the program was marginally cost-effective. CLIP would have have been shown to be more effective if unquantifiable benefits (e.g., improved customer relations) were included in the ratio.

REFERENCES

Coulam, B. 1988, personal communications, Sacramento Municipal Utility District, Sacramento, CA.

NEOS 1989: "Operating a Commercial Lamp Installation Program," NEOS Corporation, prepared for Western Area Power Administration (WAPA), Sacramento.

Petersen, R. 1989, personal communication, Sacramento Municipal Utility District, Energy Services Department, Sacramento.

APPENDIX C

UTILITY:

City of Austin
Resource Management Department and the Electric Utility Department
Municipal Building
Eighth at Colorado
P.O. Box 1088
Austin, Tx. 78767
Tel: (512)/499-2000

PROGRAM TITLE:

Commercial Lighting Program (superseded by the Commercial Energy Management Program)

PROGRAM STATUS AND DATES:

The Commercial Lighting Program (CLP) ran from April 1984 to September 1986. In October 1986, the Commercial Energy Management Program (CEMP) superseded CLP and continues to promote CLP measures and additional lighting, equipment, and weatherization.

Other programs implemented by Austin include the Appliance Efficiency Program, the Residential Loan Program, the Whole House Rebate Program, the Municipal Program, the Austin Energy Star, the Direct Weatherization Program, and the Residential Audit Program.

SECTORS AND SUB-SECTORS SERVED:

The commercial (nonresidential) sector.

PROGRAM OBJECTIVE:

The City of Austin has pursued an aggressive approach to achieve a reduction of 553 MW of electricity generation requirements by 1996. Thus, CLP's and CEMP's objective was to reduce system load and peak power requirements.

DESCRIPTION OF PROGRAM:

In 1982, the City of Austin decided to use conservation as the primary source of energy to reduce their need for new generating capacity. This decision was later promulgated through a series of energy conservation programs embodied in the Austin "Conservation Power Plant." A pilot test of CLP was conducted and showed significant savings in 1984. CLP was finally discontinued in September 1986, but the program's features were incorporated in CEMP the following month.

Until the summer of 1985, CLP was promoted under the acronym HELP. The installation of reflectors in fluorescent fixtures (SAVE) was added to the HELP program in the summer of 1985. The replacement of incandescent lamps with small fluorescent lamps (SWAP) was added to the HELP program in January 1986. All these options were promoted until August 1, 1986. CEMP included five options: lighting, air-conditioning, roof and window treatments, and electric motors. CEMP also provided commercial customers with a buyer's guide containing guidelines to help customers select appropriate vendors and products.

Under CLP, cash rebates were offered for the conversion of existing standard fluorescent lighting to reduced-wattage fluorescent lighting. Customer facilities were inspected to determine the number and types of lamps that would be suitable for the rebates. Qualifying customers were issued a certificate indicating the maximum rebate amount and the rules for participation. After the installation of the energy-efficient lamps, a final inspection was conducted to verify installation, old lamp disposal, and validity of receipts. One-half of the cost of the lamps was paid subject to certain maximum limits for each measure. CEMP works in a similar manner, but includes more options and offers rebates on total lighting system changes (in terms of $/kW saved).

Program design:

An essential element of the program design was the adoption of goals that were going to govern the content, planning, and direction of the program. These goals included:

1. Reduction of barriers to participation

   Programs should recognize the diversity of customer energy conservation needs, and programs should be designed to address the needs of special customers (e.g., high and low energy users, tenants, and the elderly). (For example, Austin's rate structure provides a lower rate for customers whose monthly consumption is less than 500 kWh. This rate is one of the lowest in the country for small users of electricity.)

2. Cost-effectiveness based on predictable demand and energy savings

   The majority of programs should rely on increasing the efficiency of energy use rather than a change in lifestyle or comfort. In achieving the goals of the program, focus should be on proven and sustainable methods. An accurate assessment of future savings and projected customer response levels to the programs needs to be made in the beginning of the program. Continuous program evaluation is also needed to determine whether the forecasted levels are achievable and cost-effective.

3. Cost-effectiveness for the customer and flexibility to both customers and the City

   Programs need to be cost-effective and flexible to permit and encourage customer innovation. When necessary, modifications should be made to the program. New concepts need to be tested and tried, as in the pilot testing of programs so that they can be fine-tuned and improved.

4. Quick delivery times

   Program results need to be delivered in the shortest possible time, so that legal and administrative measures can be resolved as soon as possible.

5. Ability to achieve reliable savings

   The assurance of savings from the program depends on using proven delivery mechanisms, some of which may be based on those used in conservation programs by other utilities.

6. Targeted savings

   Programs should be targeted to specific end uses (e.g., air-conditioning, which significantly contributes to Austin's peak demand).

7. Applicable to Austin

   Each program should be designed to be applicable to Austin's requirements and reflect Austin's energy usage characteristics and customer mix.

Total eligible customers:

All commercial customers (both non-demand and demand rate classes) were eligible to participate in the program. The commercial sector was broadly defined and included banks, hotels/motels, churches, schools/universities, hospitals, multifamily/group residences, retail/grocery/convenience stores, and state and federal buildings. The total number of commercial customers was 25,700 (the non-demand class was 20,400 and the demand class was 5,300).[*]

In CEMP, before a customer can qualify for a rebate, several steps need to be taken:

- The Resource Management Department is required to perform an energy audit of the facility prior to any installation.
- All work is to be performed in accordance with all applicable national, state, local and manufacturer codes and standards.

For lighting retrofits, additional eligibility criteria must be met:

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[*] Based on a personal communication from Eric Rothstein, City of Austin, Resources Department, March 15, 1989.

- Lighting must operate indoors for at least four consecutive hours between 1 pm and 9 pm, or operate outdoors for 24 hours per day as required by low ambient light levels and in accordance with the Illuminating Engineering Society (IES) standards.
- The retrofit must achieve a reduction in wattage. For the conversion of incandescent lighting to screw-in fluorescents, input wattage must be reduced by a minimum of 35 watts. For the conversion of hard-wired incandescent to fluorescents, input wattage must be reduced by a minimum of 40 watts and components must be attached permanently.

For lighting retrofits, customers must also agree with the following conditions:

- All removed lamps, ballasts and fixtures must be retained for final inspection by the Resource Management Department.
- Removed lamps, ballasts and fixtures must be properly disposed after inspection and cannot be re-used. Some older ballasts contain PCB's (classified as hazardous materials) and, therefore, must be disposed according to established City and County policies governing the disposal of hazardous waste materials.
- Replacement equipment must be Underwriting Laboratory (UL) or Electrical Testing Laboratories (ETL) listed.
- Equipment and installations must be inspected by the Resource Management Department to insure compliance with all CEMP guidelines and requirements.

Eligible lighting products and services:

Initially, rebates were offered for the conversion of existing standard fluorescent lighting to high efficiency lighting. When the program was transferred to the Resource Management Department, the program was expanded to include SAVE (replacing 4-foot troffer lamps with 2 lamps with reflectors) and SWAP (replacing incandescent lamps with small fluorescent lamps).

Since October 1986, a range of lighting options was included in CEMP:

Fluorescent relamping
Screw-in fluorescent
Hard-wired fluorescent retrofit
Hard-wired fixture replacements
Hard-wired exit sign retrofit
Energy-efficient ballasts
High performance ballasts
Optical reflectors
Occupancy sensors
Lighting system retrofits

Information outreach to customers:

All commercial customers are notified of the program by bill stuffers, newspaper advertisements, direct mail, and presentations to large organizations representing commercial building owners and tenants. City personnel also maintain contact with lighting distributors. Customers interested in the program may contact the Department to receive a rebate and incentive package containing a program application. Each customer is also assigned a Customer Representative who assists the customer through the program (e.g., filing the application, selecting options, inspecting the premises, and paying the rebate).

Involvement of trade allies:

In CEMP, customers are provided guidelines to select appropriate vendors and contractors. There was no direct trade-ally cooperation in the lighting program.

Rebate mechanism:

After receiving the application, the customer completes the forms and provides supporting documentation. Subsequently, a City representative visits the facility to confirm pre-installation conditions, issues a certificate outlining the results of the inspection (walk-through audit), and provides the order and details of procedures required to receive a rebate. The maximum rebate amount is also estimated. The actual payment is conditional on several factors, including the provision of receipts.

In order to qualify for the rebate, the following steps are required after the walk-through audit and after a rebate checklist has been sent by the City:

- filing a rebate application within a month after receiving the rebate checklist
- installing equipment within 60 days after receiving a "letter of intent" (indicating eligible rebate payments specific to the customer)
- final inspection after installation
- invoices and documentation (costs must be separated into material and labor costs)

After the final inspection is conducted, the rebate payment is sent 4 to 6 weeks later.

Rebate levels:

Initially, the rebate was one-half the cost of the lamp, subject to a maximum of $1.00 for a 3 or a 4-foot lamp and $1.50 for an 8-foot lamp. The SAVE option rebated 30% of the installed cost of the reflectors, up to a maximum of $22 per fixture. The SWAP option rebated 40% of the installed cost, up to $300 per peak kW reduced. In CEMP, the minimum rebate payment per application is $100, and the maximum amount is $150,000. The rebate payment for each item installed cannot exceed the material cost of the item. Subject to the rebate levels outlined above, Table 1 shows the rebates offered by Austin.

Table 1. Summary of Austin's lighting rebates.

Specification	Type	Rebate
Fluorescent Relamping		
LR-1000	F-30	$ 0.75/lamp
LR-2000	F-40	$ 0.75/lamp
LR-3000	F-40U	$ 1.00/lamp
LR-4000	F-96	$ 1.75/lamp
Incandescent to Fluorescent		
Screw-in Fluorescent		
LI-1010	Circular Fluorescents	$ 5.00/lamp
LI-1020	PL's	$5.00/lamp
LI-1030	Compact Fluorescents	$ 5.00/lamp
Hard-Wired Retrofits		
LI-2000	Hard-Wired Fluorescent Retrofits	$ 7.00/fixture
Hard-Wired Fixture Replacement		
LI-3010	Hard-Wired Fixture Replacement	$15.00/fixture
LI-3020	Hard-Wired Fixture Replacement	$25.00/fixture
Hard-Wired Exit Sign Retrofit		
LI-3040	Hard-Wired Exit Sign Retrofit	$ 6.00/fixture
Fluorescent Fixture Retrofits		
Energy Efficient Ballasts		
LF-1010	1-lamp Ballast-4ft.	$ 2.50/ballast
LF-1020	2-lamp Ballast-4ft.	$ 3.00/ballast
LF-1030	2-lamp Ballast-8ft.	$ 4.00/ballast
High Performance Ballasts		
LF-2010	2-lamp Ballast-4ft.	$ 6.00/ballast
LF-2020	3-lamp Ballast-4ft.	$ 9.00/ballast
LF-2030	4-lamp Ballast-4ft.	$12.00/ballast
LF-2040	2-lamp Ballast-8ft.	$ 7.00/ballast
Optical Reflectors		
LF-3010	2x4 Fixture	$22.00/fixture
LF-3020	Other Fixture	$11.00/fixture
Occupancy Sensors		
LC-1010	225-449w controlled	$ 8.00/sensor
LC-1020	Min. 450w controlled	$16.00/sensor
Lighting System Retrofits		
LS-1000	Incandescent/Low Voltage	$200/kW reduced
LS-2000	Fluorescent/HID	$200/kW reduced
LS-3000	HID/Fluorescent	$200/kW reduced
LS-4000	Fluorescent/Fluorescent	$200/kW reduced

Impact of rebate levels on customer first cost:

Depending on the bulk purchase price, the ratio of the rebate to the price paid is proportionately low or high. The rebate level represents generally 50% or more of the price for the efficient lighting equipment and $200/kW saved for retrofit changes.

Baseline data on lighting use:

In calculating peak demand savings, Synergic Resources Corporation (SRC, the contractor hired by the City of Austin to evaluate their conservation programs) developed diversity factors for commercial lighting use by building type (Limaye *et al.*, 1987). SRC attempted to account for the possible divergence between the time lights are operated and the time the utility experiences a peak in its system load. Thus, the utility diversity calculations are based on the coincidence of lighting operation hours with the annual utility peaks (which are usually in July or August). In contrast, customer diversity represents the percentage of the total lighting in use during the occupancy hours of a group or type of facilities.

In the absence of schedules for the lighting systems retrofitted by the program, building occupancy represented a good alternative for determining actual savings. However, building occupancy was not used in calculating customer diversity in the case when the target was common area lighting (e.g., for hallways, lobbies, stairways, and meeting areas) under the SWAP option, or when a vast majority of the installations were "RF, PL and other" lighting.

The percentage of lights on during occupancy and lighting schedules were developed for twelve categories of buildings. Some schedules were based on those used for developing the standards for new commercial construction proposed by the American Society for Heating and Refrigerating Engineers (ASHRAE, 1985), and some were based on field audits and surveys. Buildings were categorized by schedule. For each category of buildings, schedules were compared with the time of the utility's winter and summer peaks. Fully diversified demand impacts of the program were used to compute the impact of the program by building type. Because utility peaks were always experienced during weekdays, diversity factors were developed for weekdays. Utility diversity factors were calculated by determining the peak demand period for the utility in both summer and winter and then determining what part of actual savings coincided with the utility peak summer (4pm to 6pm) and winter periods. If an operation encompassed the entire utility peak period during a season, then its utility diversity approached 1 (or 100%).

Analysis of the summer months indicated the following:

- Utility diversity was 100% for the following building types:
  1. Hotels/motels and hospitals (where weekday occupancy was 100%)
  2. Food stores (where weekday occupancy was from 7am to 11pm)
  3. Fast food restaurants (open 7am to 12pm)

4. Restaurants (open 10am to 12pm)
5. Multifamily or group residences (open 24 hours)
6. Retail store or university (open 9am to 10pm)
7. Miscellaneous (open 8am to 6pm)

- For the above categories, the percentage of light that was on during occupancy (customer diversity) was 90% except for:
  1. Hotels/motels and hospitals (60%)
  2. Multifamily or group residences (50%)
  3. Miscellaneous (80%)

- For all of the above building types, the percentage of buildings conforming to the weekday occupancy schedules was 100% (i.e., all the buildings in each category operated for the hours shown). However, office buildings and some manufacturing buildings had different hours of operation:

  1. Weekday occupancy for office buildings:
     70% were occupied from 8am to 7pm
     25% were occupied from 8am to 5:30pm, and
     5% were occupied from 8am to 11pm.

     a. It was assumed that lights were on 90% during occupancy, so that the utility diversity for these buildings was 70%, 18.8%, and 5%, respectively.
     b. However, for 25% of the buildings open to 5:30pm, only 75% of their occupancy coincided with the utility peak (i.e., a utility diversity of 18.8%=25%*75%).

  2. Weekday occupancy for manufacturing buildings:
     70% were occupied from 8am to 6pm
     20% were occupied from 8am to 11pm, and
     10% were occupied 24 hours

     a. It was assumed that lights were on 75% during occupancy, and their time of operation coincided with 100% of the utility peak. Therefore, the utility diversity factors for the three categories were 70%, 20%, and 10% respectively.

- 100% of the warehouses were assumed to be occupied between 9am and 5:30pm. The coincidence with peak demand was 75%, and utility diversity was 75%.

- Schools and Churches had weekday occupancy schedules between 8am and 5pm (80% of the schools and 100% of the churches conformed to this schedule). For both building types, the percentage of time coinciding with utility peak was 50% (4 to 5pm). It was assumed that 30% of the lights were "on" for schools during occupancy and 10% for churches. Therefore, utility diversity was 40% for schools and 50% for churches.

Table 2 shows the coincident loads estimated for the winter months.

Table 2. Utility lighting diversity by building type for winter.

(a) Building Type	(b) Weekday Occupancy Schedule	(c) % of light ON During Occupancy -Customer Diversity Factor	(d) % of Bldg. Type Conforming to (b)	(e) % coincidence between Peak (6am to 12pm & 6-7pm) and Building Occupancy	(f) Utility Lighting Diversity Building Type (d)*(e)
Hotels/Motels Hospitals	24 hours	60%	100%	100%	100%
Office Bldgs.	8am-5:30pm	90%	25%	57%	14%
"	8am-7pm	90%	70%	71%	50%
"	8am-11pm	90%	5%	71%	4%
Food Stores	7am-11pm	90%	100%	86%	86%
Warehouse	9am-5.30pm	90%	100%	43%	43%
Restaurants (fast food)	7am-12pm	90%	100%	86%	86%
Restaurants	10am-12pm	90%	100%	43%	43%
Multi-family or Group residences	24 hours	50%	100%	100%	100%
Retail Store or University	9am-10pm	90%	100%	57%	57%
Manufacturing	8am-6pm	75%	70%	57%	39%
"	8am-11pm	75%	20%	71%	14%
"	24 hours	75%	10%	100%	10%
Schools	8am-5pm	70%	100%	57%	57%
Churches	8am-5pm	10%	100%	57%	57%
Miscellaneous	8am-6pm	80%	100%	57%	57%

Fully diversified demand savings (kW) were estimated by SRC in the following way:

Step 1: Customer Demand Savings (kW)=
Unit Demand Savings (kW) X Customer Diversity Factor

Step 2: Diversified Demand Savings (kW)=
Customer Demand Savings (kW) X Utility Diversity Factor

In calculating the overall impact of Austin's program, SRC adopted a 10-year scenario. This period was considered the minimum time plausible for which a measure was expected to remain in place to achieve a deferment in future base load capacity. SRC assumed a measure would last at least 10 years, regardless if some measures would require replacement during this period. In the case of replacement, it was also assumed that the new equipment would have at least the same efficiency as the measure replaced.

For each product type, Projected Diversified Demand Savings (kW)=

Diversified Demand Savings (kW) X Persistence Factor After 10 Years

Table 3 shows the assumptions used in calculating lifecycle costs of demand and supply-side options.

Table 3. Inputs and assumptions used for lifecycle cost analysis of demand and supply-side resources.

Demand-Side Programs**	Life (Years)	Discount* Rate (%)	Total Capital ($M(in $1987))	Energy (MWh)
Appliance Efficiency Program	15	8.25	9.665	624218
Commercial Lighting Program	6	8.25	.686	54882
Residential Loan Program	15	8.25	2.708	95411
Whole House Rebate	15	8.25	.107	3362
Municipal Program	10-15	8.25	.621	37531
Supply-Side Programs***	Life (Years)	Discount* Rate (%)	Total Capital ($/kW(in $1987))	Energy (GWh)
Combined Cycle, 200MW (Natural Gas)	30	8.25	643	26280
Fluidized Bed, 400MW (Coal)	30	8.25	247	73584
South Texas Project, 400MW (Nuclear)	30	8.25	1877	73590

* Based on Electric Utility Department assumptions for combined cycle and fluidized bed generation.

** Based on SRC Technical Audits, May 1987.

*** Information supplied from the Electric Utility Department, May 1987.

Energy use parameters were developed on the basis of a synthesis of standards for new commercial construction proposed by ASHRAE (1985). Assumptions were also made for the following variables:

- Wattage of standard and replacement lamps.
- Number of standard lamps removed from service since initial installation and number replaced for each type of low-wattage lamp.
- Number of low-wattage lamps out of service since initial installation.
- Operating hours of participating facility.

Using these assumptions, the following measures were calculated:

Diversified demand saving in kW =
per unit saving * number of lamps * the rating factor

Annual energy savings in kWh=
# of units * unit demand savings (kW) * rating factor * hours of operation per year

where rating factor = average kW/maximum load kW and is calculated over three time periods (average Weekday, average Saturday, and average Sunday):
rating factor = (Average Weekday % of full lighting load + Average Saturday % of full lighting load + Average Sunday % of full lighting load) * (Hours/Year) * (1 Year/8760 hours)

The estimates for rating factors and lighting hours for each customer type are shown in Table 4.

PROGRAM EXPERIENCE:

Program evaluation by utility:

The City of Austin has regularly monitored and evaluated its programs. Monthly program reports provide information on:

Table 4. Rating factors and annual lighting use.

	Rating Factor	Lighting Hours/Year*
Restaurant**	0.59	8760.0
Hotel/Motel, Hospital***	0.47	8760.0
Manufacturer**	0.42	5982.4
Retail**	0.39	4925.6
Hotel/Motel**	0.35	8760.0
Multi-Family****	0.34	8760.0
Office**	0.30	4925.6
Warehouse**	0.25	2954.3
School**	0.20	3290.0
Church****	0.13	2663.1

* This calculation was based on the following breakdown of the number of days (for weekdays, Saturdays, and Sundays) in one year for all groups except schools: Weekdays - 254 days, Saturdays - 52 days, and Sundays and Holidays - 59 days. For schools, the breakdown was: Weekdays - 202 days, Saturdays - 52 days, and Sundays - 111 days.

** ASHRAE, *Energy Efficient Design of New Non-Residential Buildings and New High-Rise Residential Buildings*, Public Draft Review of proposed national standard, ANSI/ASHRAE/IES 90.1P, pp. 9-13, June 10, 1985, Atlanta, Georgia.

*** The average of restaurant and hotel/motel building types was used.

**** SRC estimates were used.

Number of applications processed
Number of eligible products by product type
Number of installed products by product type
Incentive amount by product type
Projected kW reduction
Projected annual kWh reduction.

A consultant was appointed to verify the results of the lighting program obtained by the Resource Management Department (Limaye *et al.*, 1987). Energy and demand impacts were estimated for the program options between April 1984 and September 1986. A survey of past program participants was conducted by randomly selecting program participants of the HELP and SWAP programs (four of the 5 SAVE participants selected to be surveyed did not wish to be interviewed). A total of 34 customers were surveyed (18 HELP and 16 SWAP participants).

The primary focus of the survey was the verification of lamp installations reported by the Resource Management Department. In all cases, the number of lamps reported by the Resource Management Department was found to tally with the number of the new, efficient lamps in use. In 2 of the 18 HELP audits, more lamps had been changed to high-efficiency lamps than the quantity reported, which indicated that extra lamps may have been installed after the rebate payment. In each of the buildings visited, all spare lamps were found to be of the low-wattage high-efficiency type. Three of the 34 participants surveyed were concerned that the new lighting levels were not acceptable; however, no one reinstalled standard lamps.

Participation rate:

A total of 394 customers participated in CLP from April 1984 to September 1986. Thus, approximately 7% of the demand class participated in the program (assuming all the participating customers were in the demand class).

Impact of rebate level on participation rates:

The impact of the level of rebate on participation rates was not discussed.

Characteristics of participants:

The program is targeted to large commercial customers.

Impact of process evaluation on participation rates:

CEMP is expected to attract more customers than the initial program, partly due to the evaluations that were conducted on the earlier program.

Special problems:

No significant problems were encountered in the program.

PROGRAM COST-EFFECTIVENESS:

Program costs:

The Resource Management Department estimated a total expenditure of $686,156 for the duration of CLP. These costs are composed of direct program costs and indirect division costs and Conservation Fund expenses (Austin, 1985). For the pilot program (April 14, 1984 to Dec. 31, 1985), a detailed cost-breakdown was provided by the Resource Management Department and is shown in Table 5.

Table 5. Pilot program costs (April 1984 - Dec. 1985).

Rebates	
4-foot lamps	$130,075
8-foot lamps	$ 29,515
TOTAL REBATES	$159,590
Advertising	
Bill stuffers	$ 550
Brochures	$ 1,382
Newspapers, magazines, etc.	$ 5,067
Lighting stickers	$ 295
TOTAL ADVERTISING	$ 7,294
Administration	
Consumer Service Rep (292 hrs @ $14.56/hr)	$ 42,573
Supervisor (344 hrs @ $30.97/hr)	$ 10,654
Other (215 hrs @ $8.58/hr)	$ 1,845
Transportation	$ 3,800
TOTAL ADMINISTRATION	$ 58,872
Total Pilot Program	**$225,756**

Program savings:

In 1984, a total of 1,230 kW of savings was obtained by CLP. This was equivalent to 9% of the total savings obtained by the City of Austin in 1984 by all conservation measures (including the appliance efficiency program (12,000 kW) and the residential weatherization loan (500 kW) and commercial loan programs (230 kW)). The appliance efficiency program and CLP were the two most successful programs in saving energy. Moreover, it was estimated that in 1985 and 1986, a total of 3.7 MW of peak demand was saved by CLP, compared to 43.1 MW for all the rebate programs.

Estimated annualized savings for CLP are shown in Table 6.

Table 6. Program impact (April 1984 to Sept. 1986).

	Demand savings (kW)	Electricity savings (kWh)
Total for Summer	3408 to 3991*	4,841,671**
Total for Winter	2419	4,305,315**

* Includes an estimated 454 to 1037 kW of demand savings due to related reduced cooling requirements during the summer. If this amount is excluded from the estimates, the summer savings are estimated to be 2954 kW.

** Energy use savings (kWh) are for installations in place each year. Since some installations were not operating for at least one year at the time of the estimates, while other installations had been in place over two years, the total energy savings are equivalent to the program's annual potential.

The new CEMP is conservatively expected to yield 30% direct and indirect savings in commercial lighting energy use by large demand customers (Limaye *et al.*, 1987). Thus, the expected maximum savings from the lighting program are estimated to be 18 MW, of which about 10 MW is expected by 1995.

Projected demand savings for Austin's programs (from 1987 to 1995) are shown in Table 7.

Table 7. Projections of future impact of major existing programs (1987 through 1995).

Program	Demand Savings (MW)
Appliance Efficiency Program	23.9
Commercial Lighting Program (CEMP)	9.8
Residential Loan Program	19.7
Whole House Rebate Program	10.4
Municipal Program	2.8
Total	66.6

Program cost-effectiveness:

Based on the figures above, the cost to the utility for purchasing these savings in CLP ranged from \$172/kW to \$201/kW (\$686,156/3991 kW to \$686,156/3408 kW). SRC also estimated that CLP provided savings at 1.8 cents per kWh, and it cost the utility an average \$194/kW for purchasing these savings.

SRC estimated that CLP was the most cost-effective incentive program conducted by Austin (see Table 8). For example, the Appliance Efficiency Program provided savings at 3.1 ¢/kWh and \$607/kW and the Residential Loan Program cost 5.7 ¢/kWh and \$500/kW. In terms of lifecycle costs, CLP was the most cost-effective demand-side option. The lighting program and the municipal and appliance efficiency programs were also more cost-effective than any supply-side option (e.g., fluidized bed coal at 3.8 ¢/kWh, combined cycle natural gas at 6.9 ¢/kWh, and the South Texas nuclear project at 7.6 ¢/kWh).

In terms of capital costs, CLP was the least costly option (\$194/kW average), compared to supply-side options (\$274/kW for combined cycle natural gas, \$643/kW for fluidized bed coal, and \$1877/kW for the South Texas project (all figures in 1987\$)). Therefore, based on both lifecycle costs and capital costs, CLP was the most cost-effective option, followed by the appliance efficiency program. Both conservation programs provided the best overall options among the demand and supply alternatives.

Table 8. DSM program impact results.

Program Name	Period of Analysis	Number of Participants	Total Program Costs ($)	Peak Demand Savings (Summer kW)	$/kW	¢/kWh
Appliance	Jan-Dec85	21,992	5,377,828	10,874	495	
Efficiency	Jan-Sep86	13,655	4,286,850	5,030	852	3.12[a]
Program	Total program	48,960		33,600	607	3.10[b]
Commercial	Apr84-Sep86	394	686,156	3408-	172-	1.77
Lighting				3991	201	
Program	mid-pt			3,700[c]	194	1.80
Residential	Jan84-Sep85	1,449	1,177,974	2,503	471	5.71[d]
Loan Program	Total prog	2,697[e]		5,300	500	5.70[f]
Whole House Rebate	Jan-Dec86	36	107,197	198	542	6.14
Municipal Program	1986-1987	1	620,658	314	1,977	2.71[g]

[a] Average for 1985 and 1986 load reductions
[b] Average for 1985 and 1986 (downsizing savings not included)
[c] Mid-point of range
[d] Average for 1984 and 1985 Fiscal Years
[e] Total for 1985 and 1986 Fiscal Years
[f] Average for 1984 and 1985 Fiscal Years
[g] Projected for 1988

REFERENCE:

American Society for Heating and Refrigerating Engineers (ASHRAE), *Energy Efficient Design of New Non-Residential Buildings and New High-Rise Residential Buildings*, Public Review Draft of Proposed American National Standard, ANSI/ASHRAE/IES 90.1P, June 10, 1985, ASHRAE, Atlanta, Ga..

Austin, City of, Resource Management Department, *Historical Costs: Operating Budget and Conservation Fund, City of Austin*, Financial Years 1984 and 1985, Austin, Texas, 1985.

Limaye, D., R. Camera, C. McDonald, V. Kreitler, and S. Balakrishnan, *Technical Audits of Demand-Side Management Programs for the City of Austin, Vol. 3: Demand-Side Management Program Technical Audits and Reviews*, Synergic Resources Corporation, Bala Cynwyd, Penn., 1987.

Rothstein, Eric, Personal Communication, 1988, Resource Management Department, City of Austin, TX.

APPENDIX D

UTILITY:

New England Electric System (NEES)
25 Research Drive
Westborough, Mass. 01582
Tel: (617) 366-9011

PROGRAM TITLE:

Narragansett Electric Customer-Based Lighting Rebate Program

PROGRAM STATUS AND DATES:

The Narragansett Electric Customer-Based Lighting Rebate Program was a pilot program offered in the Rhode Island portion of the NEES service territory for a one-year period (July 1986 - June 1987).

SECTORS AND SUB-SECTORS SERVED:

Commercial and industrial sectors.

PROGRAM OBJECTIVE:

This program was one of three programs run by NEES to promote energy-efficient lighting among commercial and industrial customers within its service territory. Two of the programs were run as pilot programs, in order to experiment with different program approaches, and the third program is now being run thoughout the NEES service territory and is an attempt to combine some of the best features of the two pilot programs.

DESCRIPTION OF PROGRAM:

The Narragansett Electric Customer-Based Lighting Rebate Program provided rebates to C&I customers for the replacement of inefficient lighting products with more efficient lighting products. Steps in the program included: (1) a low-cost ($25) energy audit provided by a contractor to the utility, (2) purchase and installation by the customer of eligible products recommended by the audit, (3) submission of a simple rebate application by the customer, (4) verification of measure installation by the utility, and (5) payment of the rebate by the utility. Energy audits were handled as part of the utility's existing commercial and industrial energy audit program. Administration of rebate requests was handled by a program manager who checked and processed rebate applications. Verifications were done by utility field representatives.

Total eligible customers:

18,000 customers.

Eligible lighting products and services:

Measures covered by the program were energy-efficient fluorescent lamps, elliptical reflector lamps, screw-in fluorescent lamps, and high pressure sodium and metal halide fixtures.

Information outreach to customers (marketing):

Marketing included a mailing to all eligible customers, several additional targeted mailings, advertisements in newspapers, and telemarketing near the end of the program to all audit recipients who had yet to submit a rebate request.

Involvement of trade allies:

NEES contacted local lighting distributors to solicit their help in promoting programs.

Rebate Mechanism:

See program steps above.

Rebate levels:

Energy-efficient fluorescent lamps (rebate of $1-$2 per lamp depending on size), elliptical reflector lamps ($2/lamp), screw-in fluorescent lamps ($5/lamp), and conversion to high pressure sodium and metal halide fixtures ($20/fixture). The maximum rebate amount was $3,000 per customer.

Baseline data on lighting use:

None

PROGRAM EXPERIENCE:

Program evaluation by utility:

Surveys of customers were conducted to estimate the number of "free riders" (see below) and customer satisfaction with the program. Over 80% of the participants were satisfied with the program.

Participation rate:

2.4% (431 customers) over 12 months

Socio-economic characteristics of participants:

Average annual electricity consumption for participating customers was 494,000 kWh/year, which was higher than average annual electricity consumption of all eligible customers.

Special problems:

The only significant problems encountered were customer confusion with the rebate application package, initial delays in meeting demand for energy audits, and customers applying for rebates who did not receive an audit prior to the purchase of efficient lighting equipment. Dissatisfaction by customers was primarily linked to program restrictions such as ineligible products and the maximum rebate amount of $3,000 per customer. "Free riders," program participants who would have purchased efficient products anyway even if an utility incentive program were not offered, were estimated from surveys. Free riders were estimated to represent between 6% and 23% of program participants.

PROGRAM COST-EFFECTIVENESS:

As part of all program evaluations, NEES analyzes the costs and benefits of each program using an in-house "least-cost" model. This model analyzes the present worth of each program's costs and benefits, where benefits are valued at NEES' avoided marginal energy and capacity costs. Outputs from the model include cost-benefit ratio and cost/kWh saved over the life of the program.

Program costs:

$400,000 (in 1987 $)

Program savings:

Demand savings were estimated based on engineering data for the new equipment installed and the old equipment replaced. These estimates were adjusted to eliminate free riders (see above) from the savings estimates and to adjust for the fact that no all lights are on at the time of system peak (adjustment factors vary from product to product and are based on professional judgment, energy audit, and load research data). Energy savings were estimated based on demand savings and reported or estimated hours of operation of each participating customer.

Total program savings were estimated to be 1.2 MW and 5.4 GWh. Average annual savings per customer were estimated to be 2.8 kW per customer and 122,644 per kWh. The average percent kWh savings per customer was 2.6%.

Program cost-effectiveness:

The cost-benefit ratio was 0.27 (all-ratepayer perspective). The utility cost/kWh was $0.009/kWh (in 1987 $).

EVALUATION:

Comments on program approach:

This program was relatively simple to operate and operations generally proceeded smoothly. Compared to the other two NEES programs (see writeups), this program is the easiest to run, has a low proportion of free riders, and has a very good cost-benefit ratio. However, its participation rate was not as good as the other programs, and its percent savings per participating customer were small. This program appears to be well suited for utilities who are primarily concerned with program simplicity and cost-effectiveness and are not as concerned with achieving high participation rates or energy and demand savings.

This program could be improved by increasing attention to program marketing, expanding the list of eligible measures, simplifying application forms and procedures, and increasing the maximum rebate amount.

REFERENCE:

Nadel, S., "Utility Commercial/Industrial Lighting Incentive Programs: A Comparative Evaluation of Three Different Approaches Used by the New England Electric System," *Proceedings of the ACEEE 1988 Summer Study on Energy Efficiency in Buildings*, Vol. 6, pp. 153-165, American Council for an Energy-Efficient Economy, Washington, D.C., 1988.

Hicks, E. 1987, personal communication, New England Electric System.

APPENDIX E

UTILITY:

City of Palo Alto
P.O. Box 10250
Palo Alto, Ca. 94303
Tel: (415) 329-2439

PROGRAM TITLE:

PARTNERS Electric Incentive Program

PROGRAM STATUS:

The program started in January 1985. This review covers the period till 1987.

SECTORS AND SUB-SECTORS SERVED:

The program is targeted to nonresidential customers. Demand-metered customers, particularly those with an annual peak demand exceeding 500 kW, are the main target.

PROGRAM OBJECTIVE:

The main objective of the program is the reduction in peak demand. A goal of 14 MW reduction in peak demand is to be achieved during a four-year period beginning in Fiscal Year 1984/85.

DESCRIPTION OF PROGRAM:

Following a recommendation by the municipal utility in May 1984 to the Finance and Public Works Committee of the City Council of Palo Alto, the PARTNERS program came into existence.

The PARTNERS program offers rebates for lighting measures and other energy-saving measures, including: HVAC, window film and solar screen, energy-efficient motors, thermal energy storage, refrigeration measures (e.g., acrylic doors and plastic strip curtains), lighting and HVAC controls, and process-related measures.

Customers are informed of the program by a variety of mechanisms, including phone contact by utility employees. After the initial contact, an information package is sent to a customer. The package contains a list of program requirements, rebate levels applicable to each measure, benefits of retrofit, and an application form. The application requires the customer to provide a quantitative description of project needs and the total number of units (e.g., lamps, horsepower, or watts) to be replaced by the retrofit. Only projects that reduce peak demand between 12 to 6 pm from May 1 to October 31 are eligible. For some projects, a professional engineer is required to certify calculations.

Before an application is approved, a utility representative inspects the premises and checks the proposed measures as qualifying for the rebate. Measures are installed only after formal approval has been issued in writing. Depending on its complexity, the deadline for completion of projects ranges from three to twelve months. After the measures have been installed, another inspection is conducted, and after submitting invoices, the customer receives a rebate.

One utility staff member follows the project from beginning to end. This provision makes things easier for the customer who does not have to go to different people at the utility for different phases of the program.

Total eligible customers:

Palo Alto has approximately 24,000 residential and 2,500 nonresidential customers, and the latter are eligible for the program. The 750 nonresidential customers that are demand-metered form the target population for the program.

Eligible lighting products and services:

Until October 1987, PARTNERS offered rebates on retrofit systems only. Since November 1987, new construction projects are also eligible under the City's New Construction Program.

Lighting equipment installed through the PARTNERS program has varied by manufacturer and type. Products have included low-wattage incandescent bulbs, energy-saving fluorescent lamps (F-40 and F-96), screw-in fluorescents, electronic ballasts, and optical reflectors. If requested by a customer, the City will conduct a free audit of the customer's building.

Information outreach to customers:

Advertising for the program began in January 1985, preceding the implementation of the program by two months. A variety of methods have been used by the utility to advertise their program. The distinguishing feature of the program's outreach effort is to allocate a specific employee for each customer. Over a period of time, the utility representative collects information regarding each customer's facility and those responsible for deciding on retrofits. The person-to-person contact is regarded as primarily responsible for the high level of program participation obtained by the utility.

Other methods of advertising the program include direct mail, utility-sponsored workshops (attended by customers and vendors), promotion through professional organizations, and trade-ally cooperation.

Involvement of trade allies:

Trade-ally cooperation is used to promote the program to vendors so that they can inform customers about the program and assist them in selecting eligible projects. Upon request, customers are provided with a list of all vendors in the area and the type of product they offer. This approach encourages customers to "shop around" to find the "best deal" for their retrofit needs.

Rebate mechanism:

Applications are submitted between January 1 and October 31. After an application is submitted, an auditor conducts calculations for an acceptance letter that is sent to the customer for his or her signature. Depending on the complexity of the project, specific deadlines are assigned to the projects, ranging from 3 to 12 months. The utility conducts inspections before and after installation of the retrofit. Before a rebate request form is sent to the City Finance Department, the customer must submit itemized invoices. The customer is presented with a rebate, and the customer may choose to accept the rebate as credit on their account or as a separate check.

An audit is not required by the utility. However, if a customer requests an audit, City staff will conduct the audit (usually, a walk-through type) for the identification of potential projects eligible for the rebate.

A field staff person from the City follows each application from start to finish to simplify customer contact with the utility. Various staff have developed areas of technological expertise. As a result, they often consult with other staff members on projects not specifically assigned to them.

Rebate levels:

Rebate levels for each lighting product are specified as shown in Table 1. The customer may include the cost of installation as part of the project cost. The total rebate cannot exceed 50% of the total cost of the project. Thus, for example, where costs are twice the rebate offered on a particular product, the utility only pays the rebate amount.

Table 1. 1987 rebate levels for lighting projects.

	Lamp Replacements	
A01	Low Wattage Incandescents	$1/lamp
A02	Energy Saving Fluorescent Lamps, F-40	$1/lamp
A03	Energy Saving Fluorescent Lamps, F-96	$2/lamp
	Fixture Improvements	
A10	High Efficiency Ballast	$5/ballast
A11	Current Limiters	$5/unit
A12	Screw-in Fluorescent Lamp Conversions	$5/lamp
A13	Wire-in Fluorescent Lamp Conversions	$15/fixture
	Optical Reflectors/De-lamping	
A20	Optical Reflector, F-40 Lamps	$10/lamp removed
A21	Optical Reflector, F-96 Lamps	$15/lamp removed
A22	Lamp Removal, F-40 and F-96 Lamps	$2/lamp removed
A23	Fixture Modification, F-40 Lamps	$5/lamp removed
A24	Fixture Modification, F-96 Lamps	$7.50/lamp removed
	Other Lighting	
A30	Electronic Ballast	$250/kW reduced
A31	Fluorescent Conversions (>50 watts)	$250/kW reduced
A32	High Intensity Discharge	$250/kW reduced
A33	Other Lighting Improvements	$250/kW reduced

For "early installations" (e.g., for 1987, by June 1), customers receive a 25% bonus on their rebate. In this case, the maximum rebate is not allowed to exceed 60% of project costs. In the first year of the operation of the program, the early installation bonus was limited to 10%. This bonus was increased to 25% in the following two years, based on a recommendation from the evaluation conducted at the end of the first year of the program (BHC, 1985). In the fourth year of the program, the bonus was removed due to changes in the value to the utility of load reductions. The utility plans to introduce a different rate structure to their customers which would increase demand charges while decreasing energy consumption charges. Because the rate structure is aimed at lowering demand, rebate levels will be lowered and the early installation bonus eliminated.

Baseline data on lighting use:

As shown in Table 2, the largest percentage of peak demand in Palo Alto is lighting (41%): 72.4 MW for lighting, compared to a total electricity demand of 175 MW. Following lighting, the next two major end-users of peak demand are cooling (27%) and process power and heating (10% each).

Table 2. Energy demand by end use in the City of Palo Alto.*

End Use	Residential**	Commercial**	Industrial**	Total
Heating	-***	-	-	-
Ventilation	-	7.3	10.7	18.0
Cooling	-	19.3	28.7	48.0
Lighting	2.4	49.8	20.2	72.4
Process Power	-	-	19.1	19.1
Refrigeration	9.0	1.6	-	10.6
Water Heating	0.3	0.8	-	1.1
Clothes Dryers	0.9	-	-	0.9
Small Appliances	1.1	-	-	1.1
Cooking	0.7	-	-	0.7
Other	1.8	0.3	1.0	3.1
TOTAL	16.2	79.1	80.7	175.0

* Demand (MW) is coincident with the City's peak load.

** Residential sector includes single-family and multifamily dwellings.
Commercial sector includes offices, restaurants, retail stores, food stores, hospitals, hotel/motels, schools, and wholesale operations.
Industrial sector includes all major manufacturing companies.

*** A "-" indicates either minimal use, no data, or not applicable.

PROGRAM EXPERIENCE:

Program evaluation by utility:

A program evaluation was conducted at the end of the first year of PARTNERS (BHC, 1985). The objective of the evaluation was to obtain greater insight into the design and operation of the 1985 program and to identify possible modifications for the 1986 program. Data were collected by focus groups with program participants, nonparticipants, vendors, and consulting engineers, and a telephone survey.

A focus group was held with members of the City's staff responsible for program management. Impressions of the operation of the program, its strengths and weaknesses, areas of uncertainty, management and implementation problems, and possible program improvements were discussed. Findings from the focus group were used in preparing the telephone survey in order to confirm some of the issues raised in the focus group.

The objective of the telephone survey was to assess awareness of the program, customer response and understanding of the program, adequacy of the incentive level, and impact of the program on the City's energy management goals. Some questions also addressed the role of the vendors in supporting the program.

- Phone interviews were completed with 38 customers, out of 43 program participants who had submitted applications for the PARTNERS program by September 30, 1985.
- Interviews were completed with 67 nonparticipants, comprising all customers with a demand of 200 kW or greater and approximately 25% of manufacturing, office, and retail customers with a demand between 100-199 kW.
- Interviews were completed with 22 vendors chosen from a list of firms compiled by Palo Alto. These vendors had received program literature or had been present at a workshop organized by the City.
- Following the telephone survey, four focus group meetings were conducted with customers. These 90-minute sessions focused on (1) large industrial park-type customers, (2) office building managers, (3) small manufacturers and hospitals, and (4) large retail chain stores and industrial facilities. The first four focus groups were attended by 4-5 people per session and comprised people who had indicated interest in attending the focus group during the telephone survey. A fifth focus group was conducted and included the first focus groups, the City's technical staff, evaluation consultants, and customers interested in participating in the program. One of the objectives of the fifth focus group was to emphasize the attractiveness of the program for eligible projects, find ways to encourage customers to install a wider range of products, explore interest in demand reduction, and evaluate the level of customer knowledge.

Awareness of the program and participation rate:

A survey conducted at the end of the first year of the program indicated that awareness of the PARTNERS program was extremely high. More than 90% of the nonparticipants had read the brochures and 44% had discussed the program with other colleagues. Almost 20% of the nonparticipants followed the program in detail and surveyed the possible actions that they could take to participate in the program. However, not all the customers (e.g., 40% of the vendors) who were aware of the program knew that the program was designed to reduce the electricity peak demand during summer afternoons.

During the first three years of the program, about 19% (140) of the City's demand-metered customers (750) and 6% (100) of the City's non-demand-metered customers (1750) participated in this program by installing lighting retrofits. However, the program obtained nearly a 40% participation among its very large customers (more than 300 kW) (BHC, 1988). Since the beginning of the program, almost 75% (237 out of 322) of the participants in the program conducted lighting retrofits.

Impact of rebate level on participation rates:

The rebate levels in this program were meant to provide up to 50% of the initial cost of the project. Due to the presence of price differences for similar products manufactured by different companies (e.g., products A01-A03 and A10-A13 in Table 1), however, it is difficult to determine how much of the first cost of the product is recovered by each customer.

The $250 rebate offered in 1985-87 for each kW of lighting replaced for selected lighting retrofits (A30-A33 in Table 1) is high in comparison to other utilities offering similar retrofits (e.g., the Sacramento Municipal Utility District pays a rebate of $150/kW reduction, and other utilities typically provide $200/kW reduction). Thus, Palo Alto's favorable rates should have helped promote the high level of participation in the PARTNERS program. Although the direct impact of the rebate level on the participation rate has not been assessed, an early program evaluation indicated that program participants found the rebate level to be "more than ample" for most measures (BHC, 1985). Most customers also felt that the rebates focused their attention on energy management issues and increased the likelihood of installing retrofits earlier than planned without the incentive. Most customers indicated that their retrofits occurred 2 to 4 years earlier than planned.

Most customers did not accelerate their program to take advantage of the 10% "early bird bonus". This bonus was found to be more attractive to small customers and retail facilities; however, only a few of these customers have participated in the program. Thus, for the majority of participants, the role of bonuses or the actual size of the rebate may have had little impact on their participation.

Characteristics of participants:

Approximately 60% of all program participants (nonresidential customers) were demand-metered customer with a peak demand exceeding 500kW and a monthly usage exceeding 8,000 kWh. These customers account for about 60% of the utility's peak demand.

Impact of process evaluation on participation rates:

The impact of the process evaluation on participation rates was not measured.

Special problems:

Customer satisfaction with the program was high. No special complaints or problems were encountered by program participants. However, for the entire PARTNERS program, one of the most striking findings was the nonparticipants' disinterest in the program (Table 3).

Table 3. Reasons for not participating in PARTNERS.

Reason	% (N=58)
Appropriate energy measures already installed	26
No capital or budget available	24
Installation was not practical	19
No time available	10
Deadline was too short	10
Lacked knowledge of appropriate measures	9

Thus, survey findings show that some of the nonparticipants have already taken demand-reducing measures, others may believe they have done everything possible, and some may have moved into a new facility and, therefore, assumed there was little potential left. Such findings indicate that there may be limits to the expansion of the program. However, if facility managers are informed of the potential for saving energy and of specific measures that could be taken at their sites, then participation rates might be increased.

PROGRAM COST-EFFECTIVENESS:

Approximately $4.3 million was allocated to the project at its inception in Fiscal Year 1984-85.

However, in its first three years of existence, only between one-third and one-half of this amount was spent. As a result, realized savings lagged somewhat behind projected total savings (MW reductions in peak demand), and the program was extended.

Program costs:

The initial budget allocation for the first four years of the project was $4.3 million (City of Palo Alto, 1984). A complete breakdown of the expenditures for various components is not available, except for the rebate amounts. By November 1987, approximately $800,000 had been spent in rebates for the entire PARTNERS program and about $500,000 for lighting projects.

Program cost data for the installation and operation of lighting projects are not available. A breakdown of estimated costs and expenditures of the entire PARTNERS program is available (Staff Report, May 1984), but does not represent actual program expenditures.

Program savings:

Palo Alto has an annual peak demand of 185 MW and annual sales of approximately one billion kWh. For all projects installed by Nov. 1987, program savings for PARTNERS was 3770 kW (2481 kW reduction for lighting measures) and 11,705,000 kWh cumulatively. The reductions achieved in 1986/87 were valued at $1,000,000 (based on a 10-year lifecycle basis). Projects that are planned to be installed are estimated to contribute an additional 4680 kW and 10,965,000 kWh. The program has consistently obtained reductions of 1.5 MW per year.

As mentioned above, program savings are less than initial projections. It was hoped that 12.3 MW savings would be achieved by the end of 1987, instead of 3.8 MW. By the time projects already approved are installed, the 8.5 MW savings will represent 70% of the anticipated savings.

Program cost-effectiveness:

Benefits of the PARTNERS program were expected to be 3 to 4 times the total cost. The lighting component has been the most successful part of the program, both in terms of the total number of participants and kW savings. Table 4 provides an overview of PARTNERS costs and peak demand reductions by technology, showing rebate costs and energy savings up to Nov. 1987.

The peak reductions from lighting measures cost an average of 180 $/kW in incentives. Data on total resource costs were not provided.

Table 4. PARTNERS overview (Jan. 1985 to Nov. 1987).

	Number of Projects	Rebates	kW Reduced	Percent by kW	Percent by Project
Lighting	237	$444,584	2481	66	74
Windows	53	90,526	556	15	16
HVAC	7	53,414	194	5	2
Motors	9	28,694	156	4	3
TES	1	157,300	286	8	-
Others	15	14,123	98	2	5
TOTAL	322	$788,641	3772	100	100

EVALUATION:

The City conducted its only evaluation in 1985, at the end of the first year of the program (BHC, 1985). A number of the evaluation findings were implemented in the program, and these are summarized in Table 5.

The PARTNERS program by the City of Palo Alto is a well-planned and comprehensive program. The program has been very successful in attracting a large number of large commercial customers to adopt energy-efficient measure, including lighting. Program success from the standpoint of enhanced interaction between the utility and its largest customers has been exceptional These customers account for approximately 70% of the City's electric utility revenues. An important reason for the success of the program with this customer group was the assignment of individual account representatives marketing the program to individual customers. The City's experience has demonstrated that personal contact is a very important program feature.

A stronger emphasis on trade-ally cooperation could have benefitted the utility. The City could have solicited bids from vendors to obtain special bulk purchase rates for customers participating in the program. This cooperation might have made it easier for customers to purchase measures and also provide them with fixed costs (in contrast to shopping around for the best price from a variety of prices for identical products). The utility could have passed the reduced costs to customers or could have reduced the level of the rebate.

Table 5. New program features based on evaluation recommendations.

Recommendations (1985)	Program Features (1986)
Use vendors to promote program	Vendors workshop
Remove 3-month project completion deadline	Policy of granting extensions
10% bonus did not motivate customers	Increase bonus to 25%
Allow cost of in-house labor as part of project cost	In-house labor costs allowed
Information needed on energy-efficient motors and HVAC equipment, and thermal energy storage (TES)	Fact sheets developed on TES and evaporative cooling, seminar conducted on energy-efficient motors, and program newsletter
Provide case studies of what has worked for participants	Program newsletter
Allow cost of labor and feasibility studies as part of project costs	Eliminated material-only cost rule
Need for technical assistance for customers	Audits and audit services contracted with consultants

According to program evaluation data, most of the targeted customer population is aware of PARTNERS. However, a majority of nonparticipants indicated that no measures were left to install in their buildings. It appeared to be necessary to more effectively make customers aware of the remaining energy-efficiency opportunities that still existed in their buildings. The awareness problem was particularly true for middle-sized manufacturers and office buildings having a demand less than 300 kW. In response to these needs, audit services were provided through a contractor. Currently, all customers requesting an audit receive an audit free of charge.

The program evaluation indicated that many program participants and nonparticipants thought the program was not sufficiently flexible. For example, in some organizations, more time was needed than provided by the utility to process the program internally before final decisions could be made. In other cases, specific deadlines did not suit customers' budget cycles and planning schedules. In particular, larger customers required longer lead times to meet deadlines. The City since then has provided more flexibility in its program participation criteria and deadlines. It also has offered customers to negotiate special projects with the utility.

The City's low electricity rate was a deterrent for many commercial customers to invest in peak-reducing measures. The estimated monetary savings were not high enough compared to estimated costs (despite the rebate) and the inconvenience associated with the installing retrofits. However, the City was planning to change its rate structure by substantially increasing demand-meter charges, and it is hoped that these changes will induce large customers to install peak-related retrofits (even without an incentive).

REFERENCES

Barakat, Howard and Chamberlin, Inc. (BHC), *Evaluation of the Palo Alto Utilities Department Partners Electric Incentive Program*, Barakat, Howard and Chamberlin, Inc., Berkeley, Ca., 1985.

City of Palo Alto, *Staff Report: Electric Incentives Program for Peak Demand Reduction*, Palo Alto, Ca., (May) 1984.

Govea, Peter 1987, personal communication, Energy Service Specialist with the City of Palo Alto.

APPENDIX F

UTILITY:

New England Electric System (NEES)
25 Research Drive
Westborough, Mass. 01582
Tel: (617) 366-9011

PROGRAM TITLE:

System-Wide Dealer-Based C&I Lighting Rebate Program

PROGRAM STATUS AND DATES:

The System-Wide Dealer-Based C&I Lighting Rebate Program was a full-scale program in operation throughout the NEES service territory until the end of 1989, with a five month extension into 1990 to complete pre-approved projects; as of 1990, the program has been converted to a nearly identical customer rebate program.

SECTORS AND SUB-SECTORS SERVED:

Commercial and industrial sectors.

PROGRAM OBJECTIVE:

This program was one of three programs run by NEES to promote energy-efficient lighting among commercial and industrial customers within its service territory. Two of the programs were run as pilot programs, in order to experiment with different program approaches, and the third program is now being run thoughout the NEES service territory and is an attempt to combine some of the best features of the two pilot programs.

DESCRIPTION OF PROGRAM:

Under this program, dealers are given rebates for sales of lighting products of qualifying efficiency levels to C&I customers in the NEES service territory. The dealer-based rebates are designed to give dealers a strong incentive to promote energy-efficient lighting products to their customers. On a monthly basis, dealers provide basic information on customers and the products they purchased. Upon receipt of this information, the utility pays the rebate due, generally within one to two weeks.

Total eligible customers:

70,000 customers.

Eligible lighting products and services:

The program began by offering rebates for energy-efficient fluorescent lamps, fluorescent ballasts, and fluorescent fixtures containing both efficient lamps and ballasts. In December 1987, high intensity discharge (HID) lamps, compact fluorescent lamps, and fluorescent reflectors were added to the program. The HID and compact fluorescent programs were for energy-saving retrofits only and required preapproval by a utility representative. The other products required no preapproval, and, except for fluorescent reflectors, were eligible for installation in both existing and new buildings.

In the spring of 1989 lighting controls (aylight dimming, occupancy sensors, and current limiters) were added to the program. At the same time, the pre-inspection requirement was extended to all projects. Incentives for lamp/ballast/reflector applications were combined, incentives for hard-wired HID and compact fluorescent retrofits were increased, and caps were placed on screw-in retrofits of compact fluorescents in order to limit rebates to 100 percent of measure cost.

Information outreach to customers (marketing):

The program is primarily marketed to dealers. Each dealer receives regular mailings as well as periodic visits from a local utility representative. Customers learn about the program in three ways: (1) through their dealers, (2) through a brochure mailed to all C&I customers, and (3) through regular contact between customers and utility service representatives.

Involvement of trade allies:

Dealers (see above)

Rebate Mechanism:

Rebates are given to dealers, and dealers are not required to pass on rebates to customers. Survey data indicates that 79% of the dealers report that they pass on a proportion of the rebate to customers, and, on average, these dealers report that they pass on approximately 80% of the rebate.

Rebate levels:

The program began by offering rebates for energy-efficient fluorescent lamps (rebate of $0.80/lamp), fluorescent ballasts ($5/ballast), and fluorescent fixtures containing both efficient lamps and ballasts ($5-

$20/fixture, depending on fixture size). Rebate levels for these products were set so dealers could sell efficient products at approximately the same price as conventional products. In December 1987, high intensity discharge (HID) lamps, compact fluorescent lamps, and fluorescent reflectors were added to the program (typically rebates of $0.30/watt saved).

Impact of rebate levels on customer first cost:

The rebates lowered the cost of the energy-efficient products to match the first cost of conventional products.

Baseline data on lighting use:

None

PROGRAM EXPERIENCE:

Program evaluation by utility:

Surveys of customers were conducted to estimate the number of "free riders" (see below) and customer satisfaction with the program. Almost 90% of the dealers were satisfied with the program.

Participation rate:

The participation rate was 2.8% (1,972 customers) over the first 9 months of the program (it is expected to be 4% after one year). The number of participating dealers and the number of rebate requests submitted by each dealer continues to grow each month.

Socio-economic characteristics of participants:

Average annual electricity consumption for participating customers was 1,876,000 kWh/year, which was higher than average annual electricity consumption of all eligible customers.

Impact of process evaluation on participation rates:

"Free riders," program participants who would have purchased efficient products anyway even if an utility incentive program were not offered, were estimated from surveys. For the most popular measure, i.e. energy-saving fluorescent lamps, they were estimated to represent between 60% and 80% of program participants, though these figures are quite uncertain. This high proportion of free riders was anticipated at least for the start-up phase of the program, and was taken into account in the planning process.

In the second year of program operation, the free rider portion again appeared to be high (65 percent). This prompted the extension of pre-inspection requirements to all projects in the spring of 1989. At the same time, the rebate amounts for energy-saving lamps were increased to solicit more participation from customers who did not already use them.

While the majority of dealers in the service territory are participating in the program, a number of dealers only intermittently participate (participation varies depending on dealer work load, the size of the order, and the particular salesperson taking the order), and a few dealers are actively opposed to the program, saying it disrupts their operations.

PROGRAM COST-EFFECTIVENESS:

As part of all program evaluations, NEES analyzes the costs and benefits of each program using an in-house "least-cost" model. This model analyzes the present worth of each program's costs and benefits, where benefits are valued at NEES' avoided marginal energy and capacity costs. Outputs from the model include cost-benefit ratio and cost/kWh saved over the life of the program.

Program costs:

$1.9 million (in 1987 $) (costs for first nine months)

Program savings:

Demand savings were estimated based on engineering data for the new equipment installed and the old equipment replaced. These estimates were adjusted to eliminate free riders (see above) from the savings estimates and to adjust for the fact that not all lights are on at the time of system peak (adjustment factors vary from product to product and are based on professional judgment, energy audit, and load research data). Energy savings were estimated based on demand savings and reported or estimated hours of operation of each participating customer.

Total program savings were estimated to be 2.4 MW and 9.0 GWh. Average annual savings per customer were estimated to be 1.2 kW per customer and 4,554 per kWh. The average percent kWh savings per customer was 0.2%.

Program cost-effectiveness:

The cost-benefit ratio ranges from 0.21 (for predicted future program performance) to 0.50 (for actual performance during the program start-up period). The cost/kWh ranges from $0.007/kWh (for predicted future program performance) to $0.017 (for actual performance during the program start-up period).

REFERENCE:

Nadel, S., "Utility Commercial/Industrial Lighting Incentive Programs: A Comparative Evaluation of Three Different Approaches Used by the New England Electric System," *Proceedings of the ACEEE 1988 Summer Study on Energy Efficiency in Buildings*, Vol. 6, pp. 153-165,
American Council for an Energy-Efficient Economy, Washington, D.C., 1988.

Hicks, E. 1987, personal communication, New England Electric System.

APPENDIX G

UTILITY:

Niagara Mohawk Power Corporation
300 Erie Boulevard West
Syracuse, New York 13202

SYNOPSIS:

Niagara Mohawk conducted a pilot lighting efficiency program for commercial and industrial customers that combined within itself experiments with three promotional approaches: personal sales calls, direct mail solicitation, and promotion through lighting suppliers. The emphasis was on comparing alternative program designs, so the technologies sponsored were confined to the simplest measures, i.e. energy saving fluorescent lamps. No pre-inspection was required to obtain rebates.

The three promotional approaches were tested with five treatment groups in geographically isolated parts of the service territory and with a control group. Members of the direct mail group were segregated into three treatment groups by the kind of offer they received: information only, an approximately 50 percent rebate of extra first costs for the energy saving lamps, and an approximately 100 percent rebate. The other two treatment groups were those receiving in-person presentations by utility staff and a 100 percent rebate offer; and participating lighting product suppliers who were paid 50 percent of the average retail price differential between standard and energy-saving lamps.

The following tentative findings were obtained:

- Among the direct mail recipients, customers receiving only information appeared to show a statistically significant participation response relative to the control group.
- Under the specifics of this pilot program, direct mail offers that included the 50 or 100 percent rebate did not appear to prompt greater participation.
- An in-person representation appeared to have the greatest effect in terms of soliciting participation.

Interpretation of the findings from this pilot program was hampered by a number of inherent uncertainties. These were partly related to generic handicaps encountered in econometric sample experiments, such as the need to rely on post-program surveys of customer motivations. Also, trade ally cooperation could not really be fully taken advantage of without distorting the treatment designs of the experiment.

For a more detailed description of this program, see:

Clinton, J.M. and Goett, A.A. 1989: "High Efficiency Fluorescent Lighting Program: An Experiment with Marketing Techniques to Reach Commercial and Small Industrial Customers," in *Proceedings. 1989 Energy Program Evaluation Conference, Chicago, Argonne National Laboratory, August, pp. 93-98.*

APPENDIX H

UTILITY:

Clark Public Utility District
Bonneville Power Administration
Clark County, Washington

Clark PUD's Industrial Lighting Incentive Program was a three year pilot program developed by Portland Energy Conservation, Inc. (PECI) for the Bonneville Power Administration. It served high-bay industrial and warehouse facilities in Clark County, Washington.

PECI ran the program and trained contractors and manufacturers' representatives in program procedures. Clark PUD assisted with the initial marketing and provided electrical histories for participating firms. Subsequent marketing was done by six manufacturers' representatives and eight local contractors certified by PECI. The manufacturers' representatives performed lighting audits and designed the lighting systems. The local contractors installed the systems.

The new system design first went to the contractors, who bid for the work. The contractor then presented the package to PECI, who determined whether the installation met the cost-effectiveness test of 26 mills/kWh (based on the all-ratepayer perspective, i.e. excluding customer costs). PECI then drew up a contract with the customer specifying the share of the bid to be paid by the customer, and the incentive. Once accepted, the contractor completed the work and billed the customer for his agreed-upon share. The contractor then billed PECI for the remainder. The installations had to pass an inspection before payment. Customers provided PECI with quarterly energy use and operation reports for one year after installation.

The program resulted in 24 installations involving a total of 7200 hours of labor, with an average completion time of 32 days. In the average installation fixtures were reduced from 94 to 49, lighting levels were increased by 36 percent, and lighting loads reduced by 50 percent. A total of 3.24 GWh/yr of electricity were saved.

The total installation costs paid for by Bonneville wereabout $760 000, of which nine percent was for the disposal of PCB containing old equipment. Administration costs were another nine percent of the utility's program cost, or seven percent of total resource cost. When pre-program planning and development and evaluation were included, this fraction rose to sixteen percent and 14 percent, respectively. The total program cost was $900 000, equivalent to 26 mills/kWh on a levelized basis. Customer costs were $113 000, or about one eighth of total costs. On a levelized basis, they were 3.3 mills/kWh. The other 7/8th, which were paid for as an incentive were roughly equivalent to having the customer pass on to Bonneville the first year's energy savings. Total resource costs were $1013 000, equivalent to a levelized cost of 29.3 mills/kWh.

The installations achieved an average simple payback of nine years compared to a system life estimate of 15 years. In many instances, lighting was converted from incandescent to metal halide or high pressure sodium lamps, resulting in substantial savings from reduced maintenance costs. The annual cost of replacing burned out incandescent lights in industrial facilities was estimated to be $75 per year and fixture. For high-bay fixtures requiring special equipment to access, the cost would be even higher.

For further detail on this program see:

Wolfe, P. and L. McAllister 1989: "The Industrial Lighting Incentive Program: Process and Impact Evaluation," Portland Energy Conservation Inc., Portland Oregon. In: *Proceedings. 1989 Energy Program Evaluation Conference, Chicago, Argonne National Laboratory, August, pp. 99-105.*

APPENDIX I

UTILITY:

Southern California Edison
P.O. Box 800
2244 Walnut Grove Avenue
Rosemead, CA 91770
Tel: (818) 302-3196

PROGRAM TITLE:

Special Program for Customers with Special Needs: Common Area Rebate Program (CAR)

Sub-Program: Energy-Saving Relamping Program in the Low-Income Energy Assistance Program (LIEAP)

PROGRAM STATUS AND DATES:

Southern California Edison's (SCE) relamping program began in June 1985 when extra funding was made available from the U.S. Solar and Energy Conservation Bank. Since it first started, the program has been responsible for replacing bulbs in more than 100,000 homes.

SECTORS AND SUB-SECTORS SERVED:

Low-income customers (with provisions for non-English-speaking customers with low incomes), including both renters and homeowners.

PROGRAM OBJECTIVE:

The primary objective of SCE's program has been to assist low-income customers in achieving energy efficiency through energy management.

DESCRIPTION OF PROGRAM:

Eligible customers (see below) complete a form, and upon the receipt of this form, SCE sends a representative to visit these homes and provide customers with up to five new fluorescent lamps, replacing existing incandescent lamps. Customers do not have to pay for the energy-efficient lamps.

SCE has contracts with 15-20 community based service organizations and hires about 200 people (from these organizations and from outside) to promote and implement their program. These contractors are paid to visit low-income homes and to confirm the eligibility of these homes. In addition to marketing the program, the organizations conduct home energy audits, covering several end uses (e.g., heating and water heating), to determine cost-effective measures for retrofit. The results from each audit are placed in a computer simulation program to determine the energy-savings potential of each home. This evaluation indicates which cost-effective measures to implement in each home. In addition to relamping, other measures include: exchanging conventional water heaters for heat pump water heaters, replacing energy-intensive air-conditioners for evaporative coolers, and changing from central heating to room heating.

Customers are sent a copy of the energy recommendations based on their house audit and computer simulation. Measures are taken after an agreement has been reached between the customer and SCE. The majority of improvements recommended in the audit is paid by SCE.

Total eligible customers:

In order to qualify for the program, income levels of eligible applicants must be below 150% (or 200% for handicapped and senior citizens) of the poverty level, as defined by the poverty guidelines of the U.S. Department of Health and Human Services. The income levels vary by family size, as shown in Table 1.

Table 1. Income eligibility criterion.

Family Size	Handicapped or Senior Citizens[a]	Other[b]
	<200% PG[c]	<150% PG
1	$11,540	$8,655
2	$15,460	$11,595
3	$19,380	$14,535
4	$23,300	$17,475
5 or more	d	e

[a] Seniors are 60 years or older

[b] Customers other than Seniors or Handicapped

[c] PG = Poverty Guideline

[d] An additional $3,920 for each additional member

[e] An additional $2,940 for each additional member

Over 700,000 customers (equivalent to 21% of SCE's 3.3 million residential customers) are estimated to fall in the low-income category which would qualify them for participation in this program.

Eligible products and services:

The fluorescent liglht bulbs used by Edison have a lifetime of 9,000 hours and is intended to replace a 60-watt incandescent.

Information outreach to customers:

The relamping program has been promoted as part of a larger program, the Low-Income Energy Assistance Program (LIEAP). A wide range of methods has been used by SCE to promote the relamping program: flyers, presentations in cooperation with social service organizations, advertising in the print media, radio, and television, customer service representation, and trade ally cooperation. The personal experience of several hundred thousand customers has also promoted the program.

Incentive mechanism:

The relamping program is free to the customer. The lamps are provided at the time of the first visit, and there is no effort required by customers to obtain these lamps. Customers do have to spend the effort to contact SCE and fill out the appropriate form.

Incentive levels:

Eligible customers receive up to five free fluorescent lamps.

Baseline data on lighting use:

Information on the number of lamps used by program participants or in homes in the SCE service area has not been collected by SCE.

PROGRAM EXPERIENCE:

Program evaluation by utility:

SCE has recently conducted an evaluation of its program. A one-page survey on customer satisfaction examined how customers received their energy-efficient lamps from the contractors hired by SCE to perform the job. The survey asked about the number of "new" lamps installed in each home, whether the representative explained how to operate the new lamps efficiently and safely, the politeness of the representative, how effective the representative was in communicating energy conservation information to the customer, and the customer's level of satisfaction with the performance of the new light bulbs.

Participation rate:

Since the program began, a total of 15% of the eligible customes (more than 100,000 homes) have participated. Annually, about 45,000 homes benefit from SCE's program, corresponding to 7% of the eligible population each year.

An average of 162,000 bulbs (3.6 bulbs per home) have been replaced annually. A total of 350,000 lamps have been replaced since June 1985. In 1987, 199,000 light bulbs were installed.

Impact of incentive level on participation rates:

The lighting program is free to eligible participants and, therefore, has permitted many customers to participate. However, SCE found that only a few customers were willing to pay part of the cost for high-cost improvements. Other programs offering energy-saving measures requiring money from customers have not been as successful in terms of participation.

Socio-economic characteristics of participants:

All participants are low-income households.

Special problems:

According to SCE's recent customer satisfaction survey, customers have been very satisfied with the relamping program. There have been no complaints about the program.

PROGRAM COST-EFFECTIVENESS:

Program costs:

As a rough estimate, the relamping of an average of 3.6 bulbs per home cost SCE around $50 per home. This cost includes the cost of the lamps and the visit by the customer representative, but excludes the cost of the energy audit and other costs. It was not possible to estimate the other costs because the relamping program was part of LIEAP. In 1986/87, the cost of LIEAP was $7 million and in 1985/86 it was $4.2 million. Additionally, federal funding has accounted for $1.5 million each year. A total of 14 staff at SCE are working full-time on LIEAP. Based on rough estimates, the cost of providing 45,000 customers with an average of 3.6 fluorescent lamps per home is about $2.3 million per year.

Program savings:

SCE estimates that each replaced lamp will result in an average saving of 97 kWh annually. Relamping of 162,000 bulbs per year results in a total savings of 16 million kWh per year, and this amount corresponds roughly to 0.03% of SCE's total annual electricity production.

Program cost-effectiveness:

SCE's program is reported to be cost-effective.

NOTES AND REFERENCES:

(1) Lane, Dina 1988: Personal Communication, Energy Assistance Program Supervisor, Energy Management Division, SCE. Unpublished SCE material was also used in this writeup.

(2) SCE's *Energy Management Results*, March 31, 1986.

APPENDIX J

UTILITY:

New York State Electric & Gas Corporation
4500 Vestal Parkway East
Binghamton, New York 13902
Tel: (607) 729-2551

PROGRAM TITLE:

Residential Lighting Conservation Project (RLCP)

PROGRAM STATUS AND DATES:

The RLCP was a pilot project that ran from Nov. 1982 to Jan. 1983, and allowed customers of New York State Electric and Gas (NYSEG) to purchase energy-efficient (screw-base) fluorescent lamps to replace incandescent lights. During March and April 1983, a follow-up program was conducted.

SECTORS AND SUB-SECTORS SERVED:

NYSEG's residential customers.

PROGRAM OBJECTIVE:

The objective of the RLCP was to investigate the benefits of conservation to ratepayers and the utility.

DESCRIPTION OF PROGRAM:

Program summary:

In the initial program (Nov. 1982 - Jan. 1983), 326 customers installed one fluorescent. In the follow-up program (which provided some customers an $8 rebate), 3 customers bought one additional fluorescent and 17 bought two additional fluorescents. Thus, a total of 363 lamps was replaced in the programs initiated by NYSEG.

Total eligible customers:

A total of 13,294 customers (2% of all residential customers (604,273)) was selected for the program. The sample was stratified into three groups. The first group consisted of all (8,786) the residents of the

Mechaniville/Stillwater area. The second group of 508 customers was randomly selected from other service areas to receive refund coupons during personal visits by NYSEG staff. And the third group of 4,000 customers was randomly selected from the rest of NYSEG's customers to receive rebates through the mail.

Eligible products and services:

Any screw-base fluorescent light (e.g., 22W and 44W Circlites) to replace any incandescent light (e.g., 60, 75, or 100 wattage).

Information outreach to customers:

The program was primarily promoted by direct mail. About 4% (508) of the targeted 13,294 customers was visited personally by NYSEG representatives.

Involvement of trade allies:

There was no trade-ally cooperation or involvement.

Rebate mechanism:

The rebate was offered in the form of coupons that were refundable after the purchase of an energy-efficient fluorescent light. A customer was required to complete a survey questionnaire at the back of the refund coupon and to mail it to the utility along with a proof of purchase. Upon receipt of these items, NYSEG mailed a rebate check to the customer.

Rebate levels:

Each of the 508 customers visited on a personal basis received coupons worth $2. All the residents of the Mechanville/Stillwater area received $2 coupons in the mail. Of the remaining 4000 customers in the sample, 25% received $2 coupons, 25% received $4 coupons, 25% received $6 coupons, and 25% received $8 coupons.

Impact of rebate levels on customer first cost:

A $2 rebate reduced the cost of the fluorescent lamps by 7-40% (based on the prices paid by customers for their lamps as reported in the survey questionnaire, and on customer purchase receipts). For the 1000 customers receiving an $8 rebate, this rebate was sufficient to pay nearly the full cost of a fluorescent (the average cost of a 22-watt lamp was $8.44). For a 44-watt lamp, the $8 rebate was equivalent to 30-95% of the cost, while the $2 rebate was about 13% (the average cost of a 44-watt lamp was $15.48). The range of costs paid by customers for their lamps are shown in Table 1.

Table 1. Cost of lamps.

Price	Wattage of lamps	
Category	22 W	44 W
Lowest	$5.00	$8.49
Highest	$17.98	$27.29
Average	$8.44	$15.48

Baseline data on lighting use:

Data on lighting use were obtained by a survey at the time of the refund claim (for both the pilot and follow-up programs). The survey questionnaire was printed on the back of the refund coupon and was completed by customers at the time of their refund claim. Questions included the size of the bulb replaced and the typical hours of operation.

The survey results indicated that the lights replaced operated an average of 5.4 hours per day and 36.2 hours/week. Most of the lights replaced were located in the living room (49%). Almost one-half of the bulbs replaced were 100-watt incandescents, 26% were 60 watts, 21% were 75 watts, and the rest were "other" wattage. The majority of the "other" lights were replaced by 22-watt fluorescents (74%), while the remaining lights were replaced by 44-watt fluorescents. Three-quarters of the customers who accepted the rebate lived in single-family dwellings. The majority (80%) of the customers used their lights between 6 and 10 pm.

PROGRAM EXPERIENCE:

Program evaluation by utility:

NYSEG carried out several evaluation surveys prior to conducting the RLCP. As part of their Conservation Assessment Project (which began in 1980), NYSEG surveyed 1500 customers in 1982 with the objective of designing a suitable conservation program for lighting, refrigerators, and electric water heaters. These customers had previously requested NYSEG to conduct a residential energy audit. Thus, the survey was not representative of all residential customers in NYSEG's service area. However, the survey did indicate the potential of lighting retrofit programs. Also, the evaluation survey helped design the RLCP. Little evaluation has occurred since this survey.

The survey indicated that a large proportion of households was capable of converting at least one incandescent light to fluorescent. Most of these lights were located in interior rooms, such as the living room, family room, bedroom, and basement. The survey also raised several issues concerning lighting changes. The main concern (69% of the sample) was the unsuitable size and shape of the fixture or shade. Poor color rendition, improper light level, and customer preference were additional reasons given for the undesirability of changing lights. Also, 30% of the audited customers already used fluorescent lights in locations where conversion was deemed possible.

The majority of the incandescents that could be replaced were located in the living room (59%), and 62% of these lights were between 60 and 100 watts. Assuming 20-40 hours of use of these lights, an annual savings of 69 kWh was estimated for a 44-watt fluorescent replacing a 75 to 100-watt incandescent, and an annual savings of 48 kWh was estimated for a 22-watt fluorescent replacing a 25 to 60-watt incandescent.

One of the main conclusions of NYSEG's survey was that most (54%) of the audited households could replace only one incandescent bulb with a fluorescent; 13% were capable of exchanging two bulbs, 6% three bulbs, 2% four bulbs, and 1% five bulbs.

Participation rate:

The overall program had a response rate of 2% (326 out of 13,294 customers). The highest response rate (6%) occurred in the sample of 1000 customers offered the $8 rebate; the response rate was 5% for customers receiving the $6 rebate, 4% for the $4 rebate, and 2% for the $2 rebate. The lowest response rate (1%) occured for those customers offered the $2 rebate during personal visits by NYSEG members.

Impact of rebate level on participation rates:

The response rate increased as the size of the rebate increased. It was not clear, however, why personal visits to the 508 customers yielded a response lower than that obtained for the $2 rebate in general.

Socioeconomic characteristics of participants:

NYSEG's program was not targeted at a particular socioeconomic group. The results of the customer survey indicated, however, that 76% of those who accepted the offer lived in single-family detached dwellings (9% lived in single-family attached dwellings, 7% in apartments, and 6% in mobile homes). Very few renters participated in the program. Data on the distribution of dwelling types in the NYSEG service area were not available, so that the representativeness of the participants is unknown.

Impact of process evaluation on participation rates:

The objective of the follow-up program was to investigate the further acceptance of the rebate offer by customers who had indicated in the survey questionnaire that they would be willing to purchase additional fluorescent lamps if additional rebates were provided. The follow-up program was not designed to evaluate ways to increase response rates in future lighting programs, however, some of the findings from the follow-up program do contribute to this objective.

Seventy percent of the 319 customers of the Mechaniville/Stillwater area who accepted the initial offer of the $2 rebate responded to the follow-up program and survey. The majority (about 60%) indicated that they purchased the new lamps to reduce their electric bills and to save energy. Other factors influencing their decision, in order of importance, were: they wanted to take advantage of the refund offer, they wanted to receive the literature provided with the offer, they preferred fluorescent lights, and they were already planning to buy fluorescent lights.

Most (87%) of the customers who responded to the survey indicated that they were satisfied with the fluorescents. Almost 80% indicated they were considering the purchase of additional lamps, and most of these customers were considering installing 1 or 2 more lamps (average was 1.3 lamps). More than 70% of the customers were strongly in favor of NYSEG initiating the lighting program, while a few (1%) strongly disagreed.

Special problems:

NYSEG was satisfied with its program, but there were some complaints from customers. Besides difficulties encountered with wrong fixture sizes, customers complained that the new circle fluorescents shifted the weight of their lamps, making them unstable. Others complained that the lamps toppled over and broke the fluorescents, making them not usable. Other complaints included poor color rendition, unsuitable brightness level, and the strange shape and size of the new lamps.

The issue of free-riders was not directly addressed in the program. Therefore, it is not possible to say how many customers would have bought the more efficient lights without the rebate. In the follow-up survey, 12% indicated they were considering the purchase of these lamps anyway; the rebate facilitated their purchase of the efficient lamps. Despite the small size and unrepresentativeness of the sample, these findings do indicate that some customers would have bought the efficient lamps irrespective of the incentive program.

PROGRAM COST-EFFECTIVENESS:

NYSEG estimated the costs of a future full-fledged program, using penetration levels similar to those achieved in their pilot program for each program category. NYSEG assumed a higher response rate for a higher rebate level. Costs were calculated for mailing a program package to 605,732 residential customers and for providing rebates to participating customers. The costs shown below do not include NYSEG's personnel and material costs.

Program costs:

Initial costs included the following:

1. Refund packet set-up costs: $1,460 (fixed: does not change with size of project).
2. Preparation and posting of each offer: $0.50 per packet ($0.40 per packet to print, handle, fill, and sort; $0.10 per packet (bulk rate) to mail).
3. Handling of returned coupons set-up costs: $525 (fixed).
4. Processing of refund coupons and mailing of coupons: $1.73 per coupon ($1.56 to process and $0.17 to mail refund).
5. Refund amount: $2, $4, $6 or $8 per coupon, depending on the value of the coupon returned by each group of customers.

Fixed costs (irrespective of size of project) were $1985, and for a residential population of 605,732 NYSEG customers, the cost of sending the initial offer was $302,866 (for all refund amounts).

Other costs varied, depending on the size of the response and the value of the refund coupon. For example, for a $2 rebate and 1.6% response rate, the cost breakdown was the following:

1. Costs of sending the initial offer, plus fixed costs: $304,851 ($302,866 + $1985). These costs do not vary with rebate size or response rate.
2. Costs for sending out the refund (@ $1.73 per coupon): $16,767 ($1.73 x 9,692). These costs vary with response rate.
3. Total amount refunded: $19,384 ($2 x 9,692 customers). These costs vary with response rate and with size of refund.
4. Thus, the total cost of a $2 rebate program (assuming a 1.6% response rate) was estimated to be $341,002. For a $2 rebate, the cost of the rebate itself ($19,384) was 6% of the total costs.

Similar calculations for other rebate levels assuming different response rates were the following:

For $2 rebate and 1.7% response rate: Refund: $20,594; Total Cost: $343,259

For $4 rebate and 4.1% response rate: Refund: $99,340; Total Cost: $447,156

For $6 rebate and 4.8% response rate: Refund: $174,450; Total Cost: $529,601

For $8 rebate and 6.4% response rate: Refund: $310,136; Total Cost: $682,054

As shown above, the "rebate share," defined as the rebate's percentage of total costs, increases with higher rebates because of the higher response rate and higher rebate. For the $4 rebate, this percentage is 22%, for $6 this is 33%, and for $8 this is 46%.

In contrast, the "fixed costs share," defined as the fixed costs' percentage of total costs, decreases as the rebate level increases: 89% for the $2 rebate, 68% for the $4 rebate, 58% for the $6 rebate, and 45% for the $8 rebate. Thus, whatever the rebate amount, the fixed costs constitute at least 45% of the total costs. Moreover, the addition of other administrative costs (e.g., NYSEG personnel and materials not accounted for by NYSEG) will increase the minimum fixed-cost percentage to about 50%. The results of this analysis indicate that for a program to have lower processing and set-up costs, it is necessary to offer a higher rebate amount (which will also ensure a higher level of customer response).

Program savings:

For a total of 363 bulbs exchanged by NYSEG in their pilot program, an estimated total savings of 37.8 MWh were made possible. For a full-scale program and assuming one bulb exchange per household, NYSEG estimated an annual savings of 104.8 kWh per lamp (based on an average weekly savings of about 2 kWh per lamp) and 0.045 kW/customer of peak load reduction at 7pm (based on time-of-use data compiled from the program survey findings). The savings for each rebate level were the following:

For $2 rebate and 1.7% response rate: Customers: 10,297; Savings: 463 kW and 1,079 kWh

For $4 rebate and 4.1% response rate: Customers: 24,835; Savings: 1,118 kW and 2,603 kWh

For $6 rebate and 4.8% response rate: Customers: 29,075; Savings: 1,308 kW and 3,047 kWh

For $8 rebate and 6.4% response rate: Customers: 38,767; Savings: 1,745 kW and 4,063 kWh

At a rate of $0.075/kWh, the decrease in residential revenues due to conversion was estimated to be $80,934 for the $2 rebate, $195,203 for the $4 rebate, $228,530 for the $6 rebate, and $304,709 for the $8 rebate. Therefore, the savings from the program varied from 24% of the total costs for a $2 rebate program to 45% of the total costs for a $8 rebate program.

EVALUATION:

The following evaluation is based on our analysis of NYSEG's pilot program.

Comments on program approach:

The response to NYSEG's program could be improved if the following concerns are taken into account:

1. NYSEG's low response rate may have been a result of poor program timing: the program was conducted close to Christmas when most people receive excess mail and may easily ignore refund coupons (such as those sent by NYSEG). In the follow-up survey, several customers did not recall being sent rebate offers by NYSEG.

2. The lengthy process involved in the obtaining of the refund, compared with the value of the refund, may have affected the response rate. The refund coupons were not refundable at the time of purchase. The customer had to keep the coupon until they were able to purchase the efficient lights. The customer also had to keep the receipt of the purchase and to complete the survey questionnaire attached to the coupon before mailing these items for the refund. This procedure seems more appropriate when large purchases are made, as in the commercial sector. The value of the refund is generally too small for the residential sector.

3. The program could have benefited from trade-ally cooperation: for example, obtaining a bulk rate on the purchase of large quantities of lights, or agreement with certain retailers to provide rebates at the time of the purchase. This type of cooperation would have enabled the utility to either pass on the savings to their customers or to reduce the utility's overall costs.

   A review of the prices paid by the customers for their efficient lamps showed a wide cost range for the same lamps (between \$5 and \$18 for 22-watt fluorescents and between \$8.50 and \$27.30 for the 44-watt fluorescents). Thus, due to the varying refund amounts, not all customers received the same benefit from their purchase. The provision of efficient lamps by the utility would have ensured a common price for these products, in addition to bulk rate savings.

NOTES AND REFERENCES:

1. This program description was produced in consultation with Diane Dobish of the Market Research Department of NYSEG.

2. NYSEG, *Conservation Assessment Project: 1982 Residential Conservation Potential Survey.* Market Research Department, Customer Services, New York State Electric and Gas Corporation, May 1983.

3. NYSEG, *Residential Lighting Conservation Project: Final Report.* Market Research Department, Customer Services, New York State Electric and Gas Corporation, July 1983.

APPENDIX K

UTILITY:

Traer Municipal Utilities
649 Second Street
Traer, Iowa 50675
Tel: (319) 478-8760

PROGRAM TITLE:

The Great Traer Light Bulb Exchange

PROGRAM STATUS AND DATES:

This program occurred over two separate days when incandescent lights were exchanged for more energy-efficient lights. The first exchange occurred on February 28, 1987, and the second exchange occurred on March 24, 1987.

SECTORS AND SUB-SECTORS SERVED:

Residential and commercial sectors; and street lighting.

PROGRAM OBJECTIVE:

The main objective of this program was to obtain maximum penetration of energy-efficient lighting by the rapid conversion of existing lights in a small community in Iowa. The program also sought to:

- establish the maximum potential of energy-efficient lighting
- estimate the savings available from replacing in-place incandescent lighting with more energy-efficient lighting
- examine the cost-effectiveness of the program from utility and customer perspectives.

DESCRIPTION OF PROGRAM:

Program background:

In 1984, the Public Utilities Division of the Iowa Department of Commerce suggested that Iowa utilities demonstrate a program in energy-efficient lighting on a community-wide basis. At the same time, the

North American Philips Lighting Corporation became interested in sponsoring such a project. The Iowa Association of Municipal Utilities placed a notice in their newsletter requesting proposals from municipal utilities. Five utilities submitted applications; however, the utility initially selected decided not to participate. In August 1986, the Iowa Department of Commerce, the Philips company, and the Traer Municipal Utility jointly decided to proceed with Traer as the program sponsor.

Total eligible customers:

All 923 residential customers and 117 commercial customers in Traer were eligible for the program.

Eligible lighting products and services:

In the residential sector, approximately 50% of the incandescent lights were replaced by compact fluorescents (of the PL and SL specification by Philips). These fluorescent lights typically save about 75-80% of the energy of a conventional light for the same light output. When fixture size or design did not allow the use of these lights, low-wattage "Econowatt" incandescent lights were used. These lights save about 8-10% of the energy of a conventional light for the same light output. A variety of energy-efficient fluorescent lights were installed in the commercial sector. Mercury vapor street lights were replaced by low-pressure sodium lights.

Information outreach to customers:

The program advertised primarily by direct mail to customers of the municipal utility. Articles and advertisements in the local newspapers also publicized the program in Traer. In addition, a $5 incentive was offered for responding to a pre-program survey (see below).

Involvement of trade allies:

Trade ally cooperation was extremely important. Philips provided residential households with thousands of free bulbs, offered bulbs at bulk rate to Traer and commercial program participants, and substantially subsidized total program costs.

Rebate mechanism:

For residential customers, the rebate was essentially the cost of the energy-efficient bulb. In order to receive the new bulbs, households were required to exchange their existing incandescent bulbs. For the commercial sector, rebates were based on wholesale rates provided by Philips. Philips conducted an audit of each establishment's lighting use and potential for change. Based on this information, customers were sent estimates of how much the light exchange was expected to cost them. Commercial customers were required to have been audited as a condition of their participation in the program.

Rebate levels:

In the commercial sector, customers were offered wholesale prices for more efficient lights. A four-foot fluorescent light was provided for $1.00, and an eight-foot light was available for $2.12 (the latter was typically available at an $8 retail value). In contrast, residential customers did not have to pay for the energy-efficient lights, but they had to spend their time and effort in obtaining them. For street lights, funds were provided by the Traer Municipal Utility. The utility was able to reduce their costs by the subsequent sale (at $5 per light) of the mercury vapor lights that were removed.

Impact of rebate levels on customer first cost:

For residential customers, there was no first cost, except for their original investment in incandescent lights. For commercial customers, the lights were subsidized by 75% or more, compared to retail costs.

Baseline data on lighting use:

Prior to the exchange, the Traer Municipal Utility conducted a survey to investigate the existing saturation, use, and wattage of bulbs in the residential and commercial sectors. The response rate to the survey was 74% for the residential sector (683 households) and 76% for the commercial sector (89 customers). The survey provided useful baseline data on lighting energy use by providing information on type, number and wattage of bulbs, daily use (in hours) of bulbs, and estimated daily kWh used. Based on the survey findings, it was also possible to estimate the potential maximum number of bulbs that could be exchanged and, therefore, the total maximum expenditure required for the project. The results of the survey are shown in Tables 1 to 3.

Table 1. Residential baseline data.				
Type of Bulb	Wattage of Bulbs	No. of Bulbs	Hours Operated /bulb/day	kWh Used /day
Fluorescent				
	8	37	5.9	1.7
	14	55	1.8	1.4
	15	404	2.0	12.1
	30	78	1.8	4.2
	40	2,036	2.2	179.2
	72	33	2.7	6.4
	96	18	3.3	5.7
	Circlite	359	3.1	-
Subtotal		3,020		
Incandescent				
	15	127	1.3	2.5
	20	158	2.9	9.2
	25	751	1.4	26.3
	40	4,161	1.3	216.4
	50	59	1.8	5.3
	60	8,975	1.8	949.3
	75	2,894	1.6	347.3
	100	3,424	1.9	650.6
	150	204	1.8	55.1
	250	33	7.8	64.4
	300	50	1.0	15.0
Subtotal		20,836		
Three-way				
	50-100-150	929	2.5	-
	100-150-200	42	11.3	-
Subtotal		971		
Total		24,827		

Survey findings for the residential sector indicate that:

1. A total of 24,827 bulbs were used, with an average daily use of 1.8 hours per day per bulb (based on an estimated total of 44,293 bulb-hours per day at the time of the survey).
2. The majority (84%) of all light bulbs were standard incandescent bulbs. Approximately 12% were fluorescent bulbs (12% of these were circlites), and the rest (4%) were 3-way lights. Based on kWh usage, incandescent bulbs were also the most important, representing 90% of the kWh usage of all lights (excluding circlites and three-way lights).
3. Two-thirds of the standard fluorescent bulbs were 40 watts and operated for a reported total of 4,417 bulb-hours (average use was 2.2 hours per day per bulb). The 40-watt fluorescents, therefore, contributed to to a daily usage total of 212 kWh, and this amount was equivalent to 85% of the total kWh usage of all fluorescents (excluding circlites). The 359 circlites represented 12% of the total fluorescent lights, but the former were used for more hours each day (3.1 hours per day); the 1095 bulb-hours of their use represented 16% of all fluorescent bulb-time daily use. In decreasing saturation, fluorescents other than 40 watts were: 15 watts (13%), 30 watts (3%), 14 watts (2%), 8 watts (1%), 72 watts (1%), and 96 watts (1%).
4. The majority of incandescents were 60-watt bulbs forming 43% of all incandescents (excluding three-way lights). The 60-watt bulbs represented 36% (15,823 bulb-hours out of 44,293 bulb-hours) of total bulb-time per day for all bulbs.
5. Based on kWh usage, the 20,836 incandescents accounted for 2,325 kWh of use per day (an average of 112 kWh per bulb). Almost all (97%) of this kWh usage was accounted for by four incandescents: 60 watts (41%), 100 watts (28%), 75 watts (15%), and 40 watts (9%).
6. Incandescent bulbs were used for about 80% of the total time for which all lights were operated in homes. Fluorescent bulbs accounted for 16% of the time, and three-way lights for the rest of the time. Circlites, which were used for longer bulb-hours (3.1 hours each day), represented only 2% of the total hours for which lights were used.
7. The majority (96%) of the 971 three-way lights were 50-100-150 watts. The rest were 100-150-200 watts. The total use of these lights (2806 bulb-hours, averaging 3 hours/bulb/day) was a minor fraction (6%) of the total time for which all lights were used.

Table 2. Commercial baseline data.

Type of bulb	Code or Wattage of Bulbs	No. of Bulbs	Total Hours Operated/Day	Hours Used/Bulb /Day
Fluorescent				
	F-15	240	2,545	10.6
	F-20	31	372	12.0
	F-30	5	36	7.2
	F-40	2,214	20,807	9.4
	FL-40	312	2,282	7.3
	F-48	11	206	18.7
	F-60	24	496	20.7
	F-96	1,085	11,691	10.8
	Not coded	1,461	10,520	7.2
Subtotal		5,383	48,955	
Incandescent				
	15	87	607	7.0
	25	117	937	8.0
	40	629	7,881	12.5
	60	704	3,141	4.5
	75	192	681	3.5
	100	325	1,359	4.2
	150	201	870	4.3
	200	74	201	2.7
	300	76	47	0.6
	500	7	36	5.1
	Other	376		
Subtotal		2,701	15,760	
Total		8,084	64,715	

Survey findings for the commercial sector indicate that:

1. In contrast to the residential sector in which incandescent lights dominated, more than half the lights in the commercial sector were fluorescent bulbs (5,383 out of 8,084).
2. Similar to the residential sector, 40-watt fluorescents and 40 and 60-watt incandescents were the most common. On the other hand, other fluorescents, such as the F-96s, were more prominent in the commercial sector.

Table 3. Street and other lighting baseline data.

Type of Bulb	Wattage of Bulbs	No. of Bulbs
STREET LIGHTING		
Quartz	300	2
Mercury Vapor	400	4
Mercury Vapor	175	136
Fluorescent	4-85 per fixture	16
RENTAL		
Mercury Vapor	175	65
RURAL METERED		
Mercury Vapor	175	97
RURAL UNMETERED		
Mercury Vapor	175	5
Total		325

Survey findings for street lighting indicate that most lights are mercury vapor lamps.

There is another data source that will provide additional baseline information, as well as shed light on the degree of satisfaction of program participants with the new lights. In September 1988, the Iowa State Utilities Board conducted the Light Bulb Project Customer Survey. The survey included information on house size (square footage and number of rooms), house type, household size (number of occupants), customer demographics (age, occupation, education, and family income), and location of the new lights installed in the house. The survey also asked questions about the level of customer satisfaction with PL and SL-fluorescents that were exchanged in the program and with street lighting.

PROGRAM EXPERIENCE:

Program evaluation by utility:

Traer conducted a pre-program survey to evaluate the feasibility of the proposed program and to obtain baseline data on the number, type and wattage of lights in use. Based on the survey findings, it was also possible to estimate the potential maximum number of bulbs that could be exchanged and, therefore, the total maximum expenditure required for the project.

Presently, there have been no other surveys conducted on the program. However, Traer is currently planning a program evaluation survey to measure customer satisfaction and savings.[†]

The Iowa Utilities Board of the Department of Commerce is also planning to review electricity consumption data from the surveyed households to determine savings and demand changes.

Participation rate:

The pre-program survey yielded a high response rate. In the residential sector, 74% of the customers responded to the request to fill out information relating to their bulb use. A similar high response rate (76%) was obtained in the commercial sector.

The level of penetration obtained in the exchange was also high, although not as impressive as in the pre-program survey. In the residential sector, 57% (526) of the customers participated in the exchange, compared to 35% (41) in the commercial sector. A total of 23,840 bulbs were exchanged: 19,975 in the residential sector, 3,540 in commercial, and 325 in street lighting. Thus, residential customers acquired on the average 38 new bulbs, evenly divided between fluorescent and "Econowatt" incandescent bulbs.

Impact of rebate level on participation rates:

In the residential sector, the rebate was equivalent to obtaining a free bulb, a sufficient incentive for participating in the program. In the commercial sector, the large discount on the retail price of energy-efficient lights was also a good incentive to participate. The pre-program audit of commercial buildings,

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[†] Personal communication from Kent Holst, General Manager of Traer, August 1987.

the feasibility of switching to more efficient lights, and the presentation of an estimate of possible savings due to lighting changes also provided additional incentives for commercial customers to participate.

Socioeconomic characteristics of participants:

The socioeconomic characteristics of participants were not assessed.

Impact of process evaluation on participation rates

No program evaluations have been conducted.

Special problems:

Two problems are associated with this type of approach. The first problem concerns "free riders," those customers who would have installed energy-efficient lamps without the exchange program. Because of the ease in switching lamps and because of their cost-effectiveness, many residential and commercial customers are routinely investing in energy-efficient lamps without rebates. Thus, the program unnecessarily provided subsidies to some individuals.

Related to this problem is the problem of customers investing in energy-efficient lamps when the investment is not cost-effective. This condition exists where lighting use is infrequent.

Finally, although the program was generally considered "problem-free," there were some complaints pertaining to the program: e.g., light wattage was reported to be insufficient after exchanging bulbs, and some people expressed dislike for the color of the low-pressure sodium lights used in street lighting.

PROGRAM COST-EFFECTIVENESS:

Program costs:

The total program costs to the utility of the exchange for the residential customers and street lighting were in the region of $200,000. Most (90%) of the cost of the program was due to lights ($181,182). In arranging and carrying out the exchange, the Traer staff spent their time on the following activities:[†]

Table 4. Program activities.

Staff time	Activity
300 hours	previous to the bulb exchange
300 hours	first exchange (30 people @ 10 hours)
100 hours	second exchange (10 people @ 10 hours)
50 hours	tabulation of results
750 hours	program total

Thus, the total cost for staff time was $9,000 (750 hours @ $12 per hour) There were other expenditures for mailing of notices, printing of material, and handling costs, amounting to $10-$12,000. Other costs, such as computing, were not available. In summary, the total program cost of $200,000 consisted of $20,000 in administrative costs and $180,000 in lights.

Philips paid all the costs incurred in the commercial sector, and no estimates of these costs are available.

Program savings:

Philips estimated electricity savings to be approximately 550,000 kWh per year (23,840 lights were exchanged at an average of 23 kWh/bulb/year). These savings represent about 4% of total electricity sales (13,225,000 kWh). Using utility bill data, the Iowa Utilities Board is planning to calculate more accurately the electricity savings resulting from the program.

Program cost-effectiveness:

According to utility staff, the Traer program was very cost-effective.

EVALUATION:

Comments on program approach:

The high level of response obtained in Traer was due to the following features:

1. The letter sent to customers in the pre-program survey, requesting their participation in the program, was written very effectively, starting with: "Want to earn $5.00 in a project that could lead to permanent savings?" This letter, combined with the ease in claiming the $5 incentive for completing

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† Personal communication from Kent Holst, General Manager of Traer, August 1987.

the questionnaire (by simply taking the refund voucher to a bank) and the size of the incentive, helped promote customer acceptance of the program.

2. The ease with which residential customers could obtain their new bulbs and the relative minimal cost of the exchange helped increase participation. Participants also believed that the bulb exchange was going to reduce their electricity bill.

3. The motto "we all save money" and "everyone wins" engendered community spirit which created greater awareness of the program's objectives. The media promoted the community spirit and was very supportive of the program, as reflected in newspaper articles. There was an overwhelming feeling in the community that Traer should be selected as the host sponsor of the exchange and that this program would benefit both the utility and its customers.

The program, results indicate that each home installed an average of 19 fluorescent bulbs. However, these numbers may be misleading, since it is likely that customers swapped more lights than they would use immediately in existing fixtures. Traer should survey the residential participants and determine the extent of the use of the more efficient lights over time.

REFERENCES AND NOTES:

(1) *Energy Auditor & Retrofitter*, "Trends in Energy," May/June 1987.

(2) Holt, K. 1987: Personnel Communication, Traer Municipal Utility, Traer, Iowa.

(3) Craddock, T. 1987: Personal Communication, North American Philips Lighting Co., Somerset, NY.

APPENDIX L

UTILITY:

Taunton Municipal Lighting Plant
55 Weir St.
Taunton, Mass. 02780-0870
Tel: (508) 824-5844

PROGRAM TITLE:

SMARTLIGHT

PROGRAM STATUS AND DATES:

The program started in March 1988 and is scheduled to continue for at least five years.

SECTORS AND SUB-SECTORS SERVED:

Residential sector.

PROGRAM OBJECTIVE:

The main objective of this program is to market fluorescent lights in the residential market using an innovative delivery system.

DESCRIPTION OF PROGRAM:

Program background:

The utility leases a SMARTLIGHT (in this case, a Philips SL-18 light) to a residential customer for 20 cents per month. Should it ever burn out, the utility replaces it, for free. The program is structured so that a utility recovers the cost of its investment in equipment (SMARTLIGHTS) over a period of four years. All the benefits associated with demand and energy reductions are accrued to the utility. Customers are guaranteed to save at least $50.

The program was designed to overcome the barriers of standard lighting programs: high first cost, high consumer anxiety about lighting quality, high perceived risk towards savings, low product availability, low product awareness, and physical constraints.

Total eligible customers:

19,000 residential households

Eligible lighting products and services:

The SMARTLIGHT used in this program was the Philips SL-18 light that uses 18 watts to replace 75 watts, lasts 13 times longer than ordinary lightbulbs, and gives the same amount of light. Thus, each SMARTLIGHT conserves 570 kWh over its 10,000 hours useful life and reduces demand by 57 watts.

The program was conceived and developed in-house prior to choosing any specific company or product. The Philips product was selected after several manufacturers' products were tested.

Information outreach to customers:

A pre-program survey was conducted and program objectives were developed based on target group characteristics, brand/product-class characteristics, and product/target group purchase patterns. After setting advertising objectives, all concepts, copy, layout direction, and media strategy were developed. To help the customer determine whether a SMARTLIGHT would fit in existing fixtures, an actual size punch-out of the light was included as part of the mailer.

Initially, the SMARTLIGHT program was implemented through an aggressive marketing campaign. Radio ads and print ads were developed to build awareness of the program. The focus of the campaign was an attractive, self-explanatory direct mailer. A cable TV ad was produced, and there were several appearances on local cable and radio shows by utility personnel. Further reinforcement was provided through the customer newsletter, speaking engagements at various civic groups and promotion tie-ins with existing conservation programs. After the first month, propagation has been entirely by word of mouth.

Involvement of trade allies:

The trade ally involved was Philips Lighting Co., to the extent that they worked with their local distributors to provide special pricing and delivery to the utility. Taunton was able to purchase bulbs at a wholesale price of $12.

Delivery mechanism:

Customers fill out a card attached to a special direct mailer and send it back to the utility, postage paid. SMARTLIGHTS are then shipped directly to the customer's home. If they prefer, customers can stop at any office and pick them up right away. Customers can offer as many lamps as they want.

Customer contribution:

Customers paid 20 cents per month to lease the light; the retail cost is normally $18 to $25.

Baseline data on lighting use:

Baseline data on light bulb usage and wattage was provided as proprietary information by a manufacturer. Hourly usage was also estimated from several utility studies, indicating an average of 3.5 hours/day. This number can be deceiving, since usage is task specific. The utility was not looking to replace infrequently used lights in closets or spare rooms. In fact, this was discouraged in promotional literature.

PROGRAM EXPERIENCE:

Program evaluation by utility:

As noted previously, prior to implementation, a survey was conducted to estimate participation rates and penetration levels (lights/household), and identify target group demographics. The utility keeps track of the number of bulbs distributed to its residential customers; the distribution for the period March to December, 1988 is shown in Table 1.

Table 1. Distribution of light bulbs in Traer program.

Number of bulbs	Number of households	Percent of households	Total number of bulbs	Percent of bulbs
1	202	23%	202	5%
2	167	19	334	9
3	88	10	264	7
4	74	9	296	8
5	173	20	865	23
6	38	4	228	6
7	13	1	91	2
8	19	2	152	4
9	0	0	0	0
10	96	11	960	25
> 10	14	2	380	10
Sub-totals	884	100%	3772	100%
Returned & cancelled all bulbs	81	8%	530	12%
Totals	965		4302	

Key findings from this distribution of bulbs are:

1. About one-half of the households received 1-3 bulbs and another one-third received 4-5 bulbs. Over 10% of the households received 10 or more bulbs.
2. About 4300 bulbs were distributed to 965 households, for an average of 4 bulbs per household.
3. Almost 50% of the volume of lights went to customers who ordered in quantities of 5 or 10 lights.
4. Some bulbs (12%) were returned because 90% of the time these customers failed to use the punch-out to determine where the lights would fit. These bulbs were not exchanged, and the people returning these bulbs represented 8% of the households.

Participation rate:

Household penetration rates ranged from 3.5% to 6.8% in the cities and towns the utility serves. To date, penetration for the total eligible customer base is 5.2% (about 950 customers).

Impact of program design on participation rates:

The leasing approach was promoted to encourage participation rates; participation rates in the residential sector for rebate programs are usually very low.

Socioeconomic characteristics of participants:

Socioeconomic characteristics were collected on program participants. Low-income customers did not constitute a large proportion of program participants. However, the program has a strong appeal to fixed-income customers.

Impact of process evaluation on participation rates

Participation rates have been evaluated monthly as part of the program. The vast majority of customers signed up during the first several months, after which word-of-mouth steadily increased sign-ups.

Special problems:

There were no special problems experienced with this program at any point, and the program continues to operate smoothly.

PROGRAM COST-EFFECTIVENESS:

A spreadsheet program was designed to perform an aggregate analysis of estimated system costs and benefits.

Program costs:

The utility incurred costs of about $48,000 for 4,000 lamps and about $25,000 for program development and the initial, one-month promotional campaign. Because the leasing fee is incorporated in customers' bills, ongoing costs are minimal.

Program savings:

An estimated 1.5 GWh. of electricity has been saved so far.

Program cost-effectiveness:

In calculating the impact of the program, the analysis was subjected to the no-losers test. Program savings had to offset all program costs, including any lost revenues as a result of conservation. The SMARTLIGHT program passed the no-losers test. Therefore, the program ensured that non-participants did not subsidize the savings of others, and the effect of conservation is not expected to result in short-term rate increases.

Using very conservative estimates, the analysis projected a range for Internal Rate of Return (IRR) between 18 and 35%. The current estimate of the benefit/cost ratio, subject to the no-losers test and using only short-run marginal costs, was 1.08. This does not reflect any quantifiable savings associated with environmental benefits from conservation.

The utility estimates a two-year payback for the utility, on the basis of short-run marginal costs of 2.5 ¢/kW yr. The cost of savings to the utility, which in this case is the same as total resource costs, is estimated to be about 2.5 ¢/kWh.

EVALUATION:

Utility evaluation of program:

In addition to the economic attractiveness of the program, the utility felt that the following non-monetary benefits of the program were also very important:

- Improved cash flow
- Small magnitude of start-up
- Postive public relations reaction
- Low risk associated with success of program
- Increased customer participation levels
- No perceived customer health or safety issues
- Ease and convenience of service installation
- Conformance to building codes and standards
- Regulatory acceptance

The utility also felt that the distribution of lamps reflected an important aspect of the program. As mentioned above, almost 50% of the volume of lights went to customers who ordered in quantities of 5 or 10 lights. This is not because they need 5 or 10, but because certain customers are willing to risk and think in terms of an incremental $1 or $2 increase on their bill (i.e., $0.20 x 5 or 10 bulbs). This finding points to the importance of pricing as a strategy in designing demand-side management programs. For example, if customers are thinking in terms of $1 or $2, then a $.05 increase in the lease payment may produce a 20% decrease in volume (as reflected in the number of bulbs leased by customers ordering in quantities of 4 or 8). Thus, pricing as a marketing strategy should not have to reflect actual program costs but should reflect relative costs within an acceptable range.

Other

This program was given an award by the American Public Power Association (APPA).

NOTES AND REFERENCES:

Desmond, Joseph 1989: Personal communication, Energy Services and Marketing Administrator, Taunton Municipal Lighting Plant, April 5.

LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
INFORMATION RESOURCES DEPARTMENT
1 CYCLOTRON ROAD
BERKELEY, CALIFORNIA 94720