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

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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

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).

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

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.

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

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 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.

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

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.

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.

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

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 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.

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 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

[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.

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

[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.

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).

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

[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.

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.

[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.

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

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.

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.

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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.

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.

Program cost-effectiveness:

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

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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

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.

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

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.

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.

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	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.

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.

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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 conser-

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:

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

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.

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)

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%

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:

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.

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 8. DSM program impact results.						
Program Name	Period of Analysis	Number of Participants	Total Program Costs ($)	Peak Demand Savings (Summer kW)	$/kW	¢/kWh
Appliance Efficiency Program	Jan-Dec85 Jan-Sep86 Total program	21,992 13,655 48,960	5,377,828 4,286,850	10,874 5,030 33,600	495 852 607	3.12[a] 3.10[b]
Commercial Lighting Program	Apr84-Sep86 mid-pt	394	686,156	3408- 3991 3,700[c]	172- 201 194	1.77 1.80
Residential Loan Program	Jan84-Sep85 Total prog	1,449 2,697[e]	1,177,974	2,503 5,300	471 500	5.71[d] 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

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 $)

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 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.

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 pants 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.

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 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

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.

$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

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.

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

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

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

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.

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.

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:

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

PROGRAM TITLE:

The Great Tracr 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 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.

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.

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 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 Tracr staff spent their time on the following activities:[†]

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.

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	

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.