Shooting in the Dark: Making Residential Lighting Programs Work

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Many electric utilities depend heavily on lighting savings in their residential DSM efforts. However, obtaining cost-effective energy savings from efficient lighting is one of the least understood aspects of residential DSM programs. There are substantial questions regarding customer acceptance and long-term marketing, as well as a series of installation and technical issues.

This paper reviews the lighting programs of several New England utilities which are part of collaborative DSM efforts. The programs attempt to remove barriers to customer participation. The utilities have tried a variety of program strategies over several years, including catalogs, direct installation, broad-based promotions, give-aways, retail rebates, and direct mail promotions.

Several evaluations and detailed field reviews have been conducted of these programs in the past year. This paper synthesizes the results of that learning. Primary topics of discussion include: short- and long-term marketing issues and goals; improving customer acceptance of high-efficiency lighting options; technical issues such as lumen equivalency and lamp life; and installation issues regarding the product characteristics.

Introduction

As part of long-term, collaborative efforts to capture electricity savings, utilities in New England are offering aggressive DSM programs. One component of the diverse types of residential programs is an effort to capture lighting savings, primarily by the use of compact fluorescent lamps.

In the realities of DSM, compact fluorescents must provide a reliable source of electricity savings that helps to defer or avoid electricity generation investments. Depending on the type of program operated, this means that either the customer must be convinced to purchase and install the product initially, despite the differences (e.g. size, cost) from standard incandescents, or that the customer must at least continue to use and/or replace lamps installed by the utility. Over the long-term, DSM utilities would like to encourage a transformation of the marketplace, so that customers routinely purchase high-efficiency lighting with little or no subsidy from the utility. A necessary condition for this to occur is that customers be convinced that the benefits of compact fluorescent lamps outweigh the costs and complications of the initial purchase. Although a reduction in product costs is likely to be needed as part of this transformation, customers must also learn to recognize the product benefits and understand the basic differences between compact fluorescents and standard light bulbs in technical characteristics and applications.

In the three New England utilities discussed in this paper, energy-efficient lighting is incorporated in a variety of DSM programs. Ultimately, there are two primary ways for the utility to get the customer to install energy-efficient lighting in all cost-effective applications; either send a trained professional to the customer's residence to install the lamps, or educate and encourage the customer to purchase and install the appropriate products themselves. In either case, unless a hardwired fixture is replaced, the utility is dependent on the customer to continue to keep the product installed.

Lighting Program Issues

The customer's satisfaction with the product's performance is key to the success of energy-efficient lighting programs. Customer acceptance is dependent on (1) the customer liking the product sufficiently to keep it installed, and (2) the customer replacing the lamp with a similar replacement when it fails. To prevent removals, the energy-efficient lamp choice must perform well. To encourage repurchase, the customer must also be aware of the benefits of the product, and the customer's perceived

value of benefits, such as energy savings, bulb life, and color rendition, must exceed the customer's costs, including financial costs and any inconvenience.

Customer Contact - Marketing/Installation Strategies

For most customers, utility DSM programs represent the initial customer contact with compact fluorescents, and the quality of the information and products presented are key to later satisfaction levels and perhaps the purchase of additional bulbs. There are four basic types of marketing/ installation programs that have typically been used; direct installation, catalog sales, retail sales, and special promotions.

Direct installation programs are programs where the utility (or its contractors) enters a customer's house and installs the appropriate types of compact fluorescents in applicable locations (e.g. correct light levels, burn-times, fit). Because there is a significant cost of getting to the customer's house, the lighting measures are frequently "piggy-backed" with other services, such as space heating, appliance, or water heating measures. At Boston Edison, lighting measures are directly installed as part of electric space heat programs for both single family and multi-family, a (now discontinued) electric water heater efficiency program, a state-mandated energy audit program, and through Energy Fitness, a program targeted to lower income neighborhoods that is primarily a lighting program. Similar programs are operated at New England Electric System and Northeast Utilities.

The advantage of direct installation is that a trained installer works with the customer to determine their lighting needs and an optimizing installation strategy, as well as providing education about the products. If the job is done correctly, all cost-effective installations will have been made, with the right products installed in the right applications. A variation on this approach (that is no longer used in the utilities discussed) is where the installer, while at the customer's residence (for a space heat program, for example) simply leaves the lamps on the kitchen table, briefly explaining their benefits. This is the equivalent of leading a horse to water, but not letting him drink. Given that the primary expenses of such a program are to get to the customer's door and purchase the products, not taking the one or two minutes to determine the best applications and products is likely to be a waste of resources.

The potential disadvantages of direct installation are the cost of providing the service (assuming it is not piggy-backed with another service), the limited number of customers such programs can reach annually, and the dependence on the installer to bring the right products, make the correct installation decisions, and understand the customer's needs. Anecdotal evidence from field reviews at several utilities have shown that programs that emphasize lighting tend to offer a wider array of products and pay more attention to lighting than programs that primarily are oriented to capturing space heat savings, where lighting is considered secondary. Typically this difference is not designed into the program, but results from the emphasis of the contractor completing the work.

Additionally, all three utilities offer **catalog programs**. The catalogs offer an array of products at discount prices. Customers who want compact fluorescents and have some idea of the types of products that they need, can place orders through the catalogs. Some customers place a small order initially, followed by an additional order when they better understand the products and the installation guidelines. Catalogs can reach a broad spectrum of customers and offer a wide product range, but the customers must be able to properly select and install products for their applications from written information and/or assistance over the telephone. Catalogs do tend to contain a variety of quality educational materials, in part to help the customer's select appropriate products.

To this point, Northeast Utilities' catalog program is the most successful effort of the collaborative utilities, with over 300,000 pieces of lighting equipment sold in about one year, however, while 98% of the participants installed at least some of the products purchased, about one-third of the total products purchased have not been installed (Bourget 1991b). Boston Edison's catalog has not been nearly as successful as other promotional strategies that they have used, possibly due to the lack of a strong marketing campaign and/or too much technical information. New England Electric had a fairly good response to initial catalog mailings, with about 2% of customers ordering bulbs.

Promotional programs include special offers that promote perhaps only one type of bulb. This type of program is easier for customers to understand, as the amount of information provided regarding the various types of energy-efficient lighting products is limited. The price to the customers is highly subsidized so that the customer is not risking much money to try the new technology. In several occasions, most notably the Lions Club related programs operated at Central Maine Power and Boston Edison, the risk is further reduced by having most of the customer cost contribution used to support charitable causes.

Promotional programs can serve as introductory offers to initially expose customers to these new and different lighting products, but they are limited in that more specialized products are not carried. The limited product range means that customers may not be able to fit the bulbs in some otherwise good applications due to incorrect light level, or physical or aesthetic constraints. Thus, this program approach will not result in all cost-effective installations being completed, something that the direct installation programs could do routinely and that is possible in a catalog or even a retail approach, if these approaches have a broad selection of products. Also, the customer may incorrectly perceive that compact fluorescents cannot be fitted into some fixtures, especially if the bulb promoted is larger or has a cover. Evaluations of the Lions Club programs at both Central Maine Power and Boston Edison have indicated that about one-third of the lamps purchased were not installed (Mulholland 1991 and Sabo 1991).

A recent promotional approach by Boston Edison attempts to overcome some of the problems of promotional programs by offering a "starter pack" of three different bulbs plus a replacement harp for table lamps, all at the attractive price of $10.00. Initial sales results have been impressive, exceeding the annual goal in the first three months of the year.

Retail support programs (e.g. mail-in rebates, instant rebates) offer another avenue to customer awareness and purchase. At the retail level, the daunting first cost of compact fluorescents is readily apparent, and the selection is usually limited. Retailers need products to sell at a specified rate (product turn), or the store is not as profitable. The education values of other approaches may not be presented as well in a typical retail setting. If utilities are subsidizing the purchase of the lamps, there is also a need to assure that the lamps are being purchased by the utility's customers. Most regular light bulbs are purchased at retailers, and despite the initial barriers, many people believe that compact fluorescent lamps must ultimately be sold primarily through this traditional marketing mechanism.

The New England utilities initially did not promote retail sales heavily, but Boston Edison did have a mail-in rebate as part of their program. More recently, Boston Edison has initiated an instant rebate retail program, where the customer receives their rebate at the store as part of the sales transaction. Instant rebates avoid the problem of the high initial cost of the bulbs, but complicate data tracking and verification that the purchaser is the utility's customer. Boston Edison has also found that the retail marketing mechanism does not work very well for special product promotions, because the retailer does not want to restrict promotional items to only some (i.e the utility's) customers.

Technical Issues - How Complicated Can a Light Bulb Be?

Compact fluorescents have a variety of characteristics that are different from standard incandescent lamps. The common positive characteristics are dominated by the energy savings and the extended lifetimes. Other characteristics vary substantially depending on the type of ballast, the appearance and/or size of the product, and other characteristics that determine where a lamp might fit and what types of applications it is best suited for. There are a wide variety of compact fluorescents on the market at the current time, and additional products are being developed on a nearly continuous basis.

Unfortunately, the complexities presented by compact fluorescents do not end with the more obvious fit, aesthetic, and safety considerations. A basic problem has been matching lighting levels of incandescent and compact fluorescent lamps. Customers either require or are accustomed to a certain amount of light from a given fixture. Program guidelines typically promote the installation of compact fluorescents in fixtures that are used most frequently, so it is likely that the customer will be aware of any lighting level changes.

Manufacturer-stated lumen levels are based on defined operating characteristics and are rated at their initial lumen output. All lamps produce lower light levels over time. Fluorescent lamps deteriorate more than incandescent lamps do, although this deterioration occurs over a longer period of time. An incandescent lamp and a fluorescent lamp that are rated at the same initial lumens will produce substantially different amounts of light by the end of their life.

To more accurately compare products, the mean lumen output can be used. Based on discussions with several manufacturers, a reasonable estimate of the mean lumens for incandescents are 91% of their initial lumens, and the mean lumens for compact fluorescent lamps are 84% of the initial lumens. The practical application of this is that a 900 initial lumen compact fluorescent does not fully replace a 900 initial lumen incandescent lamp. While the difference may be small, it may also be noticeable.

Further reductions in light levels may occur in enclosed fixtures or other installations where heat can build up in the compact fluorescent tube. Testing is not complete, but it appears that heat build-up in enclosed or partially

enclosed fixtures can reduce the light levels of some compact fluorescents by 8% to 20%, depending on the installation. Lamps installed with the base down, as in a table lamp, can also suffer light depreciation due to the build up of heat. Some additional research is needed in this area before field application guidance can be developed.

Two additional factors that can also mean that what you see isn't necessarily what you get are light color and ballast factors. The human eye sees better under certain types of light sources. This is not necessarily bad news for compact fluorescents, as triphosphor coated fluorescents compare favorably to incandescents. Perhaps more of a concern is that lamps with separable bulb and ballast may be rated for lumen output with a reference ballast in place at the factory, and the reference ballast may perform better than the ballast that comes in the box you buy, resulting in lower than rated light output. The practical application of this information has not yet been fully formulated.

Most programs encourage replacement of a certain size of incandescent with a compact fluorescent rated at similar initial lumens. It can already be difficult to find good replacements based on this standard for some fixtures. However, the inclusion of the use of mean lumens, and possible corrections for lumen depreciation caused by heat build-up, ballast factors, and color temperature further complicates the decision. Manufacturers are working to improve the performance of products, but currently, if program participants say that the compact fluorescents don't put out as much light as their old style bulb, they may well be correct.

Another issue that may be relevant to cost-effectiveness testing is product life. Compact fluorescents have a rated lifetime of 9,000 to 10,000 hours. This lifetime is based on the average hours of burn time resulting from testing a series of 3 hour on-time cycles. In practice, the lifetime of compact fluorescents may vary substantially. Based on discussions with manufacturers, lamps that burn for 24 hours a day may last an average of nearly 20,000 hours. Lamps that experience a series of 1 hour cycles may last for only about 5,500 hours.

Finally, there are two issues that the customer may not see but that the utility might, power factor and harmonic distortion. The high levels of harmonic distortion created by some compact fluorescents can degrade the electric power supply below acceptable levels if they are placed on the system in sufficient quantities (Emanuel 1990). The New England Electric System does not include bulbs with high levels of harmonic distortion within their programs. At this point, they not offer electronically-ballasted compact fluorescents within their programs due to this concern. Poor power factor means that the system electricity savings in total power consumption is less than the real power savings at the customer's billing meter. These problems are solvable, and indeed have been solved in Europe, but they continue to cause uncertainty about the system benefits of compact fluorescents in some utilities.

It's 1995, Do You Know Where Your Light Bulbs Are?

There are two major uncertainties regarding the energy savings produced by the retrofit of energy-efficient lighting in residences. The first is how long the bulbs are actually used on an annual or average daily basis, and the second is whether the bulbs remain in use over their lifetime in similar applications.

In direct installation programs, there is usually specific guidance given regarding the minimum average daily burn-time where installation of the bulbs is appropriate. In the Boston Edison Energy Fitness Program, which uses a 2 hour average daily minimum burn-time, installers were able to fit an average of 6.5 lamps. In Northeast Utilities Neighborhood Program, which uses a 4 hour minimum burn-time, 4.9 bulbs were installed per residence (Cowell 1992). The establishment of which lights are burning for how long in a residence is subjective in these programs and, to date, light loggers have not been used by these utilities to establish better baselines for energy savings estimates. A telephone survey of 401 participants in the Northeast Utilities Program indicated that the average daily use of the compact fluorescents installed was 5.6 hours (Bourget Research 1991a).

Evaluations of these collaborative lighting programs are currently being finalized, and some data is available to estimate energy savings from billing information and other data. Boston Edison has conducted process and impact evaluations of only one of the direct installation programs to this point. The WattBusters Program was targeted to customers with electric water heaters, but also included a lighting component. In the first year of the program, the contractor simply gave several tungsten-halogen light bulbs to the customer, while in the second year, compact fluorescents were installed along with some additional hot water savings measures. Over 90% of program participants received a water heater tank wrap and/or energy-efficient light bulbs. Savings from an impact evaluation of billing data for 210 participants indicated that the program net savings were 250 kWh per participant annually for the initial program, and 601 kWh for the refined program (Decision Research 1992).

Northeast Utilities estimated energy savings for their Neighborhood Program based on survey responses that estimated burn-times and data regarding the wattage of the original and the replacement bulb. Based on this information, they estimate a program net average savings of 519 kWh per participant annually (Bourget Research, 1991a).

It might be expected that direct installation programs would produce higher annual lighting energy savings than retail, catalog, and promotional programs, due to the focus on only installing in high use fixtures and the use of trained personnel with a full range of lamps and installation hardware. However, surveyed participants in Northeast Utilities catalog sales program reported that they had purchased an average of 10.7 lighting products, of which 6.85 products were installed, at an average daily use of 4.5 hours (Bourget Research 1991b). With the larger number of products, when pre- and post-wattages were compared, the estimated annual program energy savings were higher than the Neighborhood Program at 630 kWh per participant. A primary contributing factor to the number of products installed (and therefore the engineering savings estimates) is likely to be that the Neighborhood Program is targeted to lower income neighborhoods, where smaller house sizes may mean fewer installation opportunities, and that a 4 hour minimum burn-time criteria is used in the Neighborhood Program, which also restricts installations.

Equally important in developing reliable energy savings is the persistence of savings. Boston Edison (Decision Research, 1992) has estimated that approximately 9% of the light bulbs installed through the WattBusters Programs had been removed or were never installed, with the primary reasons being either that the bulbs were never received, were not appropriate for the installation, or burned out. This information was based on site visits and telephone surveys completed an average of more than one year after program participation.

The direct installation Neighborhood Program at Northeast Utilities was also evaluated for product retention. They found that 98% of products were still in place 4 months after installation. For products that were removed, the primary reasons were either that the lamp was not bright enough, it burned out or did not fit properly.

At the most basic level, customers or installers may substitute compact fluorescents for incandescents rated at a higher lumen level. In the evaluation of a promotional program at Central Maine Power, 38% of customers used a 15 watt compact fluorescent to replace a 75 watt or 100 watt incandescent, when the initial lumen level comparison would suggest replacing no more than a 60 watt lamp (Sabo 1991). Not surprisingly, almost the same number of customers mentioned that the compact fluorescents were not as bright. Fortunately, only 3% of customers thought that the lower light levels were a problem.

New England Electric's first direct installation program did not fare as well. A large percentage of customers (about 30%) believed that the compact fluorescent were not as bright as the bulbs that were replaced (Applied Management Sciences 1990). Subsequent site visits found that nearly 25% of the bulbs had been removed, primarily 11 and 9 watt lamps and that installation crews had experienced shortages of larger wattage bulbs during the program. An internal review at New England Electric System indicated that all four contractors being used to deliver a direct installation program were routinely degrading light levels based on the labeled initial lumens. The customers were almost certainly correct, light levels had been reduced. The lesson learned is that installation crews must have a reasonable selection of bulbs, and that customers do pay attention to light levels.

Continued Development

Compact fluorescents are a product with a substantial number of technical complexities and market barriers to overcome before they are a fully integrated component of the lighting market. For utilities that are interested in capturing DSM resources now, and in helping to promote the development of the products and the marketplace, there are at least two important considerations for the deployment of lighting in their DSM programs. First, it is necessary to introduce customers to the products, and to educate the customers regarding the product characteristics. Second, it is important to install the appropriate products in the right applications to help assure customer satisfaction, and create and maintain energy savings.

To accomplish the first goal, any of the marketing mechanisms discussed before can be satisfactory, but catalogs and promotional programs are likely to reach the largest audience in the shortest time. Boston Edison's packaging of three different bulbs in a $10.00 "starter kit" may be the most aggressive introductory offer yet developed in that it is low financial risk to the customer, is likely to contain products that will fit in various fixtures, and gives the customer some idea of the diversity of products available. Participants in Northeast Utilities' catalog program, which features a wide variety of products, sometimes tend to make their own starter kits, often with assistance from the person taking their order by telephone.

The evaluation of Northeast Utilities catalog program indicates that participants were more than twice as likely to buy energy-efficient lighting in the next year compared to non-participants (45% versus 20% - Bourget, 1991b). This was similar to responses to the same question asked of participants in the direct installation program (46% versus 18%, Bourget, 1991a). Thus, it appears that both types of programs are successful in encouraging the future purchase of compact fluorescents. Comparable data are not yet available on the promotional programs.

To accomplish the second goal, of assuring that the right products are installed, it is probably necessary to give some additional help to both customers and professional installers to assure that the products installed are the best for the particular application. The range of technical issues that compact fluorescent lamps raise, and the sheer numbers of available options, may mean that creative ways to make complex decisions into simple choices need to be developed.

Boston Edison is currently developing a decision chart to assist both customers and installers. The objective of the decision chart is to make the selection of appropriate lamps simple, while ensuring that current technical and installation knowledge is incorporated in the decision framework. In final form, the information should fit on the back and front of one letter-size piece of paper, while replacing several other charts and types of product information.

In general form, the user scans across several columns on the chart to identify the type of fixture, the location and the current wattage of the incandescent bulb they would like to replace, and then the final column lists one or more appropriate choices for their particular application. The final appropriate choices would consider such factors as mean lumens, temperature related light level degradation, cold weather performance, and likely ability be properly fit the fixture and the application.

The final column in the chart includes the recommended replacement. This is really in two pieces. First, the customer or installer decides whether the light level from this particular fixture is critical to the tasks performed in that area of the house (critical use), or whether the light is really an area light, used to create ambiance, or a secondary source of light (general use). Most fixtures could perform either function, it depends on how the area is used and whether or not other light sources are present. Critical Use and General Use will need carefully worded definitions, but generally, critical use is synonymous with task lighting. The second part of this column is the actual recommendation for the lamp or lamps that would work for the specified fixture and the type of application. The lamps should be listed very specifically, i.e. brand name, size, type, and perhaps model number.

With the specificity of the recommendations, the customer can make a decision quite rapidly, and the choice of product will (1.) produce the amount of light needed and (2.) very likely fit properly. The chart has an additional advantage of indicating where the "holes" in fit occur, which would enable the utility to review the ability of their current selection of lamps to meet customer needs.

The invisible part of the chart is the analysis and judgement used to specify the recommended product(s) for particular applications. The analysis would include mean lumen output, temperature sensitivity in the particular fixture (e.g. enclosed versus unenclosed), ballast factors for component lamps, and (possibly) color temperature. Judgement factors would included light quality, size, appearance, operating temperature range, and other fit considerations.

The Lights Are On; Is Anybody Home?

The experiences in New England have emphasized the importance of a few basic lessons regarding the marketing and installation of compact fluorescent lamps. In summary, they are:

Customer education needs to be emphasized, no matter which type of marketing campaign is developed. Customers need to understand the advantages and differences of compact fluorescents, compared to both standard incandescents and other compact fluorescents.

Lighting programs need to carry a reasonable variety of lamps to fit different fixtures and different applications. (Additionally, installation accessories such as harp adapters and socket extenders are needed to assist some installations.) This is particularly important in direct installation programs.

Light levels are important to customers, and light levels that are lowered increase the risk that the customer will remove the new product.

The rated initial lumens for compact fluorescents are not a sufficient guide to assure that light levels are not reduced. Factors such as mean lumens, thermal degradation of light output, and ballast factors should be considered, especially for task lighting.

Utilities may want to work with manufacturers to improve power factors and reduce harmonic distortion in compact fluorescents, so that the power system receives the full benefit of the technology.

A final conclusion is that customers accept compact fluorescent technology. Customers like the energy and money savings, and those that have compact fluorescents in their homes are substantially more likely to consider purchasing additional compact fluorescents in the future.

When the customer can defeat the program goal with a twist of their wrist, utilities need to get the details right to make sure that the customer likes the product. Although there are still uncertainties regarding the amount and duration of energy savings generated by residential lighting DSM programs, it appears that more sophisticated marketing techniques, better products, and improved installation guidelines are increasing the level of customer satisfaction, which should also increase the level and persistence of energy savings.

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