Residential Lighting Technologies in the United States: An Assessment of Programs, Policies, and Practices

***Prepared for*:**

Delta-Montrose Electric Association

Prepared by:

Katherine Johnson on behalf of Intermountain Energy

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Table of Contents

Index of Tables

Index of Figures

Executive Summary

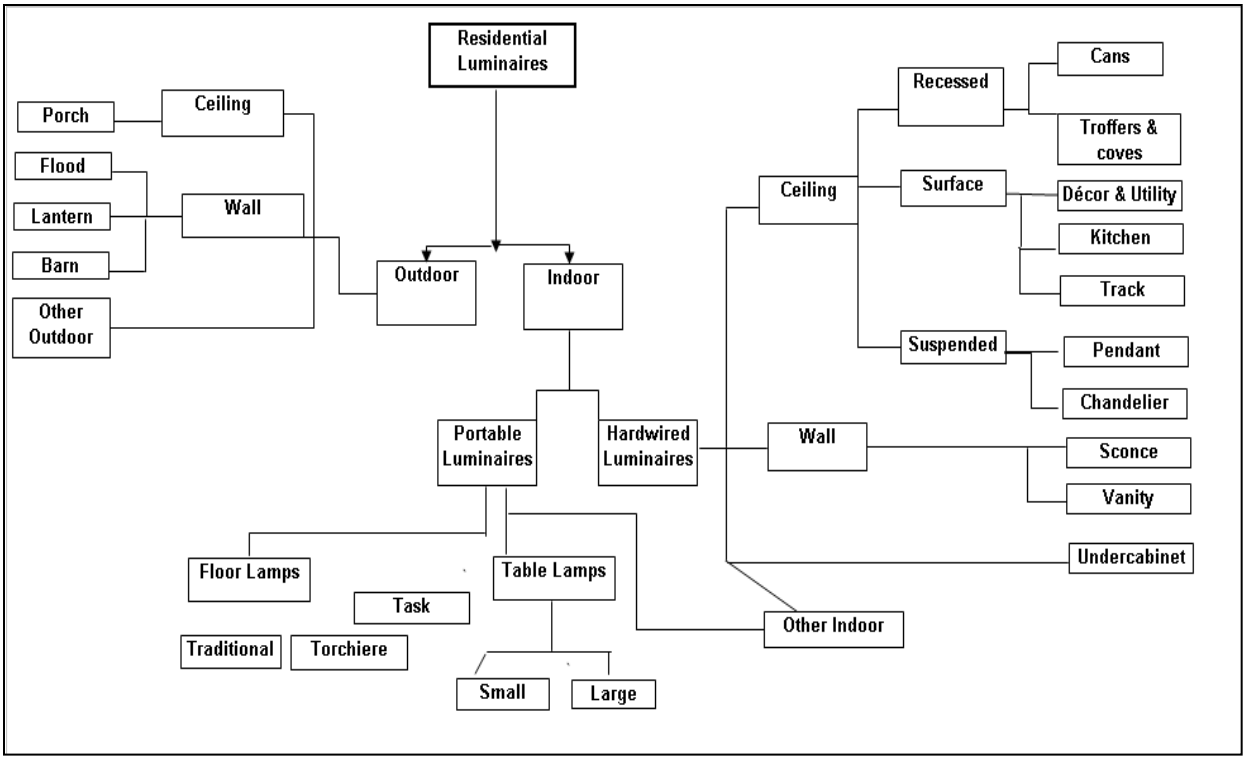
Residential lighting affects every household in the United States. New forms of energy efficient lighting have been available for more than two decades, yet customers have been slow to adopt these new types of lighting technologies.

To accelerate market acceptance and to encourage energy conservation, nearly 100 energy organizations have funded and delivered various programs targeting residential customers. The purpose of these programs is to encourage residential customers to switch from the traditional light bulb and instead purchase and install a Compact Fluorescent Light (CFL) or other energy efficient type of bulb or fixture.

The Intermountain Energy Team conducted a literature search to identify the major issues that DMEA should address when designing its own residential lighting program. The findings from this literature review will be used by the Intermountain Energy Team to:

- Develop baseline estimates and default assumptions for the Lighting Model;
- Determine which barriers to program implementation DMEA must specifically address in its own residential lighting program;
- Benefit from the "Lessons Learned" from other utility lighting programs, by identifying which strategies and tactics will be most appropriate for DMEA to model; and,
- Identify the best potential DMEA lighting partners.

Figure E-1 summarizes the breadth and depth of the residential lighting market, summarizing the various ways in which both lamps (light bulbs) and fixtures are used in US households.



Source: Figure 2-5-Residential Luminaires Flowchart, California Baseline, May 30, 1997, Heschong Mahone Group, p. 15

Figure E-1: Overview of the Residential Lighting Market

Major Findings

The literature review identified several major findings that will be helpful in guiding DMEA in designing and implementing its own residential lighting program. These findings are summarized next.

1. Even though energy efficient lighting has been available for more than two decades, standard incandescent bulbs are installed in 85 percent of all lighting fixtures in the U.S.

2. Residential lighting accounts for a significant portion of a household's total energy usage. Estimates vary among the national and regional studies, however, on average lighting accounts for 13 percent of residential energy use.

3. The average American home has approximately 41 lighting sockets in 21 fixtures. However, the critical issue is not how many lights are installed in a typical home, but rather the *frequency of use* by these lights. Siminovich and Mills (1995) reported that between 20 and 30 percent of all lighting sockets may account for as much as 70 to 80 percent of all lighting used in a home.

4. Significant barriers still remain to installing energy efficient technologies, such as CFLs and Halogen Infrared Reflecting (HIR) lamps. The high first cost of energy efficient lighting makes a whole-house energy lighting change-out costly.

5. Customers still rely on energy organizations to provide information and funding to promote the installation of energy efficient lighting and to determine the best applications for these technologies.

6. Utilities can achieve significant load reductions in winter-peaking hours due from residential lighting programs promoting CFL bulbs and hard-wired fixtures.

Recommended Strategies

The literature review also identified some recommended program strategies for DMEA to consider.

1. Winter-peaking utilities, such as DMEA, would benefit from a residential lighting program. However, impacts from these load reductions would have to be monitored closely in order to accurately track savings.

2. The most successful lighting strategy appears to be to target high use areas where bulbs are used for at least three hours per day. Targeting the most commonly used lights in a household would lead to the most significant energy savings at the lowest installed costs. These high use areas include kitchens, outdoor lights, torchieres, and task lighting.

3. Another potential strategy to increase installation rates of CFLs is to target them for replacement in “hard to reach” applications such as ceiling fixtures. These may be an effective second-tier strategy to maximize energy savings.

4. Effective lighting programs may be offered to residential customers in a variety of ways. DMEA should identify which approach would be most effective with its members and move forward with a pilot program.

5. DMEA should consider partnering with a lighting manufacturer, such as TCP, that offers a comprehensive product line designed to meet all residential customer lighting needs.

6. To reduce the administrative cost and overhead burden, DMEA may want to consider entering into third-party agreements with either lighting vendors and/or third-party administrators to implement the lighting program and fulfill member orders. These relationships would provide DMEA an opportunity to offer members lighting products at competitive prices, without taxing additional internal resources.

Next Steps

Before initiating a residential lighting program, DMEA needs to complete the following steps:

1. **Determine the lighting program's size and scope.**

   This includes identifying the most appropriate lamps to be included, the amount of funding available for a residential lighting program, and identifying appropriate deployment strategies, including potential partnership strategies. These issues will be developed in DMEA's Residential Lighting Implementation Plan, due to be completed by September 2004.

2. **Establish Budget/Set Aside Funds to Obligate**

   Next, DMEA needs to establish a budget to fully account for both the anticipated program and administrative costs and the amounts of funds required for initial program implementation. These estimated costs will be identified in the Implementation Plan.

3. **Develop a strategy for estimating load reductions attributable to the lighting program.**

   Since measuring actual savings from residential lighting reductions would be difficult, DMEA needs to develop a Lighting Savings Model to estimate these savings. This Lighting Savings Model will be completed by the end of July 2004.

4. **Identify benchmarks for effective program management and evaluation.**

   The Lighting Implementation Plan will identify the appropriate benchmarks for success, specifically installation rates, participation targets, and increases in member awareness of residential lighting technologies.

5. **Plan Marketing Campaign and Program Launch**

   The final step for DMEA is to develop and launch its marketing campaign. This campaign should target DMEA's high-use residential members. DMEA should use its existing promotional tactics, including radio spots, direct mail, and print ads, to generate program awareness regarding residential lighting applications for DMEA employees and members.

1. Introduction

Residential lighting affects every household in the United States. The light bulb greeted the Industrial Age and with the dawn of the Information Technology, lighting remains a critical application in residential homes. New forms of energy efficient lighting have been available for more than two decades, yet customers have been slow to adopt these new types of lighting technologies.

To accelerate market acceptance and to encourage energy conservation, nearly 100 energy organizations have funded and delivered various programs targeting residential customers. The purpose of these programs is to encourage residential customers to switch from the traditional light bulb and instead purchase and install a Compact Fluorescent Light (CFL) or other energy efficient type of bulb or fixture.

A literature review is a critical first step in program design. By gathering information from diverse sources, this report identified the following key issues:

- Current lighting technologies available;
- Current usage patterns;
- Lighting impacts in the residential market in both energy usage and costs;
- Challenges and opportunities for accelerating market acceptance of energy efficient lighting; and
- Overview of various residential lighting programs offered by energy providers.

The purpose of this report is to identify the major issues that DMEA should address when designing its own residential lighting program. The findings from this literature review will be used by the Intermountain Energy Team to:

- Develop baseline estimates and default assumptions for the Lighting Model;
- Determine which barriers to program implementation DMEA must specifically address in its own residential lighting program;
- Benefit from the “Lessons Learned” from other utility lighting programs, and identify which strategies and tactics will be most appropriate for DMEA to model; and,
- Identify the best potential DMEA lighting partners.

Report Methodology

The Intermountain Energy Team conducted a literature search of key trends in residential lighting market, including estimating load impacts, gathering information about residential lighting programs conducted at other cooperatives and utilities, and identifying emerging trends. The project team supplemented these findings with information gathered during in-person or telephone interviews with lighting experts, manufacturers and distributors.

The project team gathered information from the following types of sources:

- Energy efficient lighting resources from ENERGY STAR;
- Energy efficient lighting resources from the Department of Energy;
- Energy Federation Organization, a non-profit online distributor of energy efficient products
- Lighting Research Center, Troy, New York;
- American Lighting Association
- Energy Efficient Lighting Association
- Illuminating Engineering Society of North America
- International Association for Energy Efficient Lighting International Association of Lighting Designers
- International Association of Lighting Management Companies
- National Association of Independent Lighting Distributors
- National Council on Qualifications for the Lighting Professionals
- National Electrical Manufacturers Association
- TCP, Incorporated, a leading manufacturer of energy efficient lighting technologies
- In-house staff interview with Steve Metheny;
- Review of the local prices of standard and energy efficient lamps in the greater Delta-Montrose area.

These findings were augmented with additional web searches on specific lighting topics such as utility lighting programs and emerging technologies. The Intermountain team also reviewed materials prepared by the Electric Power Research Institute (EPRI), E Source, and the Cooperative Research Network (CRN), made available through DMEA's affiliation with these associations.

The results of this literature review have been divided into four major categories:

- An assessment of the current lighting technologies, in terms of its size and scope, discussed in Section 2
- An assessment of current lighting impacts and costs in the residential market which is discussed in Section 3
- A summary of emerging trends, challenges, and opportunities provided in Section 4.
- Section 5 summarizes the types of lighting programs offered by utilities and energy organizations across the United States.
- Key findings, conclusions, and recommendations from this literature review are summarized in Section 6.

2. Residential Lighting Technologies

The residential lighting market is dominated by incandescent light bulbs, referred to as "lamps" in the industry nomenclature. The Department of Energy's (DOE) Energy Information Administration (EIA) estimates that there are 3 billion lighting fixtures in the United States.[1]

Incandescent lamps, the kind invented by Thomas Edison, still dominate the residential lighting market. Various sources reviewed in this literature survey suggest that incandescent lamps are installed in 85 percent of all lighting fixtures in American households (Rubinstein, et al, 1998; Jennings, et al, 1997).

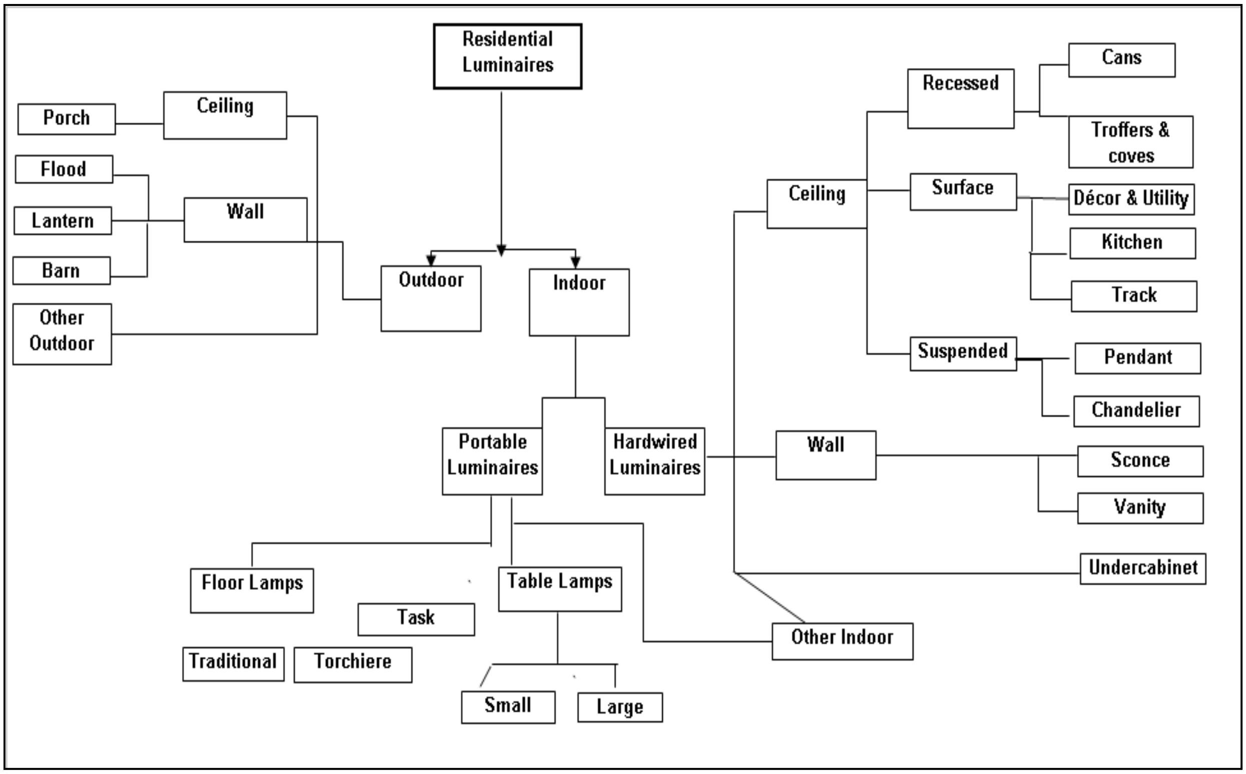
Types of Residential Lights in the United States

The residential light bulb or lamp has changed in both form and function since it was introduced a century ago. Residential lighting goes beyond illuminating a dark surface and is now used in a number of ways including:

- *Ambient lighting*- described as general illumination used in a home.
- *Indirect lighting*- which uses ceiling lights to push the light upwards and reduces glare.
- *Wall Washing*- which illuminates a vertical surface to a uniform brightness. This lighting is used to accentuate features of a home, such as a fireplace or entry way.
- *Accent lighting or highlighting*- which focus light directly on a particular object. Accent lighting is used to create dramatic effects and highly artwork.
- *Task lighting*- which provides supplemental lighting for specific applications such as reading, sewing, or other close work. (Leslie & Conway, Lighting Research Center, 1996).

Figure 1 illustrates the types of lamps that are used to fulfill these various lighting applications.

[1] US Census Bureau data obtained from www.census.gov for July 1998, July 1999, and July 2000.



Source: Figure 2-5-Residential Luminaires Flowchart, California Baseline, May 30, 1997, Heschong Mahone Group, p. 15

Figure 1: Summary of Residential Lighting Technologies in the US

Lighting used in residential applications is either incandescent or fluorescent. However, two new lighting technologies have become popular in residential applications recently—portable lamps or torchieres and Light Emitting Diodes (LEDs).

Incandescent Light Bulbs

Incandescent lamps are the least expensive to buy. However, they have the shortest life span of all lamp types, and use the highest amounts of energy, so they are actually the most expensive lamp to operate. Incandescent lamps are grouped into three common types:

- Standard incandescent (A-Type Lamps);
- Tungsten halogen; and,
- Reflector lamps

The A-Lamp

The incandescent bulb is the major lighting technology used in American homes, as Table 1 shows. It is also the least energy efficient.

Table 1: Medium Screw-Based Lamp Shares Based on Normalized Lamp Life -2001

Lamp Type	*Average Lamp Live (hours)*	*Relative Life of Lamp (years)*	*US Share*
Incandescent	**875**	**1**	**98.10%**
Compact Fluorescent	**10,000**	**11.43**	**1.30%**
Halogen	**2750**	**3.14**	**0.60%**

Source: Fields, Harcharik, & Pulliam, 2002

The incandescent light bulb is small, inexpensive, produces a color and quality of light that most customers find pleasing, but lasts 875 hours. A key measure of light quality is the lumens per watt output, which measures the brightness produced by the lamp. In actuality, a 100-Watt incandescent lamp is not nearly as bright compared to a fluorescent lamp. Using the lumens per watt (l/W) criterion, the 100-Watt lamp produces only 17 l/W while a compared to a fluorescent lamp which produces 50 to 70 l/W (Rubenstein et al, 1998).

Halogen Lamps

Halogen lights were first invented in the 1960s and were improved significantly in the 1980s. The halogen infrared reflecting (HIR) lamp nearly doubles the effectiveness of the standard incandescent lamp. In 1988, a General Electric engineer wrote (McGowan 1988):

> The IRF [infrared reflecting film] development, which represents one of the largest one-time improvements in the history of incandescent lighting, has moved incandescent lamp efficacy into the discharge lamp range. The challenge now is to apply the technology to general lighting service lamps at a cost low enough to be utilized in the billions of existing incandescent sockets. (Rubenstein et al, 2002).

The halogen infrared reflecting lamp represents a major advancement in incandescent lighting technology. Lamp engineers created a more efficient lamp by encapsulating the incandescing filament in a specially-formed quartz capsule onto which a multilayer coating has been deposited. The multi-layer coating allows visible light to pass but wasted heat (infrared radiation) is reflected back onto the filament. This reflected heat warms the filament, thus reducing the need to supply electrical power and improving lamp efficiency. For example, an HIR lamp, built to produce the same amount of light and with the same lifetime as a standard 60-Watt incandescent lamp, would have a brightness level of 26 l/W, compared to 15 l/W for the standard incandescent lamp (LBNL 1995 and Rubenstein et al, 1998).

Reflector Lamps

Reflector lamps (Type R) are designed to spread light evenly over specific areas. They are used indoors for floodlighting, spotlighting, and down lighting. Parabolic aluminized reflectors (Type PAR) are used for outdoor floodlighting, while the ellipsoidal reflector (Type ER) focuses light in recessed fixtures. ER lamps are twice as energy efficient compared to the PAR lamps for recessed fixtures. (DOE/GO-10095-056, 1995)

Fluorescent Lamps

Fluorescent lamps are lit by an electric current conducted through mercury and inert gases. Fluorescent lighting, used primarily indoors for ambient and task lighting, are three to four times as efficient compared to standard incandescent lamps. Fluorescent lamps have a much longer operating lifetime compared to standard incandescent lamps as well. However, fluorescent lights require ballasts to control their operation, which raises their overall initial cost (DOE/GO, 1995).

Tube Fluorescent

These lamps are the second most popular type of lamp after the A-type incandescent. The most common types are 40-W, 4-Foot and 75-W, 8-Foot lamps. These lamps are used for ambient lighting in large outdoor areas (DOE/GO, 1995).

Compact Fluorescent Lights (CFLs)

Compact Fluorescent Lights (CFL) revolutionized energy-efficient lighting since its introduction in the 1980s. CFLs are miniature versions of full-sized fluorescents which allow them to be used instead of incandescent light bulbs.

CFLs come in many shapes and sizes. Some are CFLS are just lamps while others are incorporated into energy efficient fixtures. These fixtures use either a “core and coil” ballasts or “electronic” ballasts. Core and coil ballasts are less expensive, slightly heavier, and take a few seconds to light. Electronic ballasts, which are lighter and more expensive, start the lamp instantly and run quietly.

Some CFLs are sold with bulb and ballast as a unit while others are sold as two pieces with replaceable bulbs. The two-piece CFLs are called “modular.” The one-piece units are less expensive initially, but the entire unit must be replaced when the bulb burns out. In contrast, only the CFL bulb needs to be replaced in a modular unit (Eartheasy.com)

Table 2: Comparison of Average Light Levels of Incandescent and Fluorescent Lamps

Incandescent Watts	CFL Range	Lumen Range
60	**13 - 18**	890
75	**18 - 22**	1210
100	**23 - 28**	1750
150	30 - 38	2780

Source: Eartheasy.com ©2000-2004

Torchieres

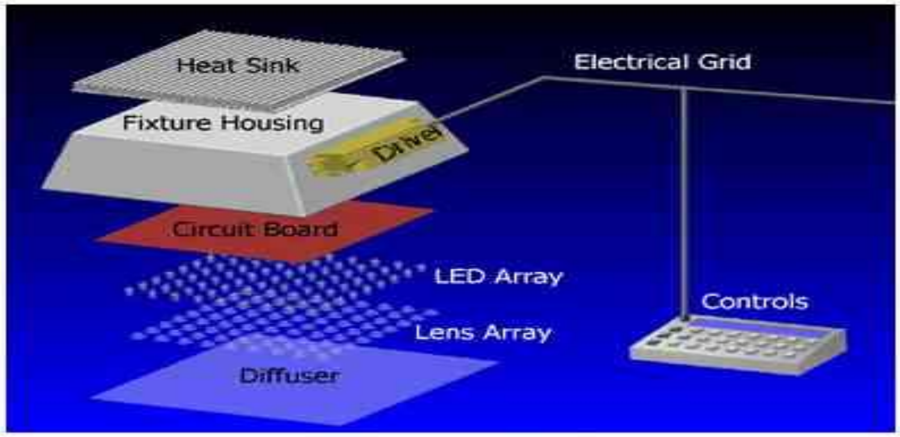
A torchiere is an indirect floor lamp that sends its light upwards (Leslie & Conway, 1996). These free-standing fixtures have become more popular in recent years as the need for more indirect lighting has increased in residential homes. Torchieres are also referred to as “portable” fixtures, since these lamps can be moved around a home. Torchieres use either incandescent, halogen, or CFL lamps.

The halogen torchiere floor lamp is popular with many Americans because of its appearance, light distribution, availability, and low cost. It provides an economical source of reflected indirect lighting as an alternative to conventional direct lighting sources such as table lamps and ceiling fixtures. However, the halogen torchiere lamp requires a significant amount of electricity to run. Moreover, the bulbs operate at extremely high temperature levels, creating a potential fire hazard. To address these safety and energy concerns, the CFL torchiere was introduced to the US market in 1998. **(**Ihrig, Titus, & Ziermer, 2002)

LEDs Lights

LEDs (Light Emitting Diodes) are small, solid light bulbs which are extremely energy-efficient. Until recently, LEDs were limited to single-bulb use in applications such as miniature train sets, instrument panels, electronics, pen lights and strings of outdoor Christmas lights.

LEDs have a light source, a ballast called a driver, and a luminaire in which the light is enclosed and provides optical control of the emitted light and thermal control of the overall system. These elements are shown in Figure 2 (Lighting Research Center, 2004).



Source: Lighting Research Center, 2004

Figure 2: LED Lighting System Anatomy

LED bulbs up to last ten times longer than CFLs and more than 100 times longer than typical incandescent bulbs. Since LEDs do not have a filament, they are less likely to be broken or damaged compared to an incandescent bulb. The LED also bulbs do not cause heat build-up, producing 3.4 btu's/hour, compared to 85 btu's/hour for incandescent bulbs.

Since these bulbs last for years, there are significant savings in both energy and maintenance costs. Most LEDs are installed in commercial applications such as traffic lights and exit signs, reducing electric costs by as much as 80 percent. (Easylights.com, 2004).

Recent improvements in manufacturing have lowered the cost of LEDs, which has expanded their application. The bulbs are now available in clusters, from 2 to 36 bulbs, and are popular especially for battery powered items such as flashlights and headlamps. LEDs are also available in arrays which fit standard AC and DC receptacles, lamps, recessed and track lights. (Easylights.com, 2004).

LED colors

LEDs come in a variety of colors which makes them especially suited to task-specific applications. The material used in the semi conducting element of an LED determines its color. The two main types of LEDs presently used for lighting systems are aluminum gallium indium phosphide (AlGaInP) alloys for red, orange and yellow LEDs; and indium gallium nitride (InGaN) alloys for green, blue and white LEDs. Slight changes in the composition of these alloys alter the color of the emitted light (Rensselaer Polytechnic Institute, 2004).

Most residential use relies on the white LED. Blue is a popular LED color because it is easy on the eyes. The elderly report that they can read under the blue light for hours without eyestrain, compared to severe eyestrain in less than 30 minutes with incandescent lighting. (Easylights.com, 2004)

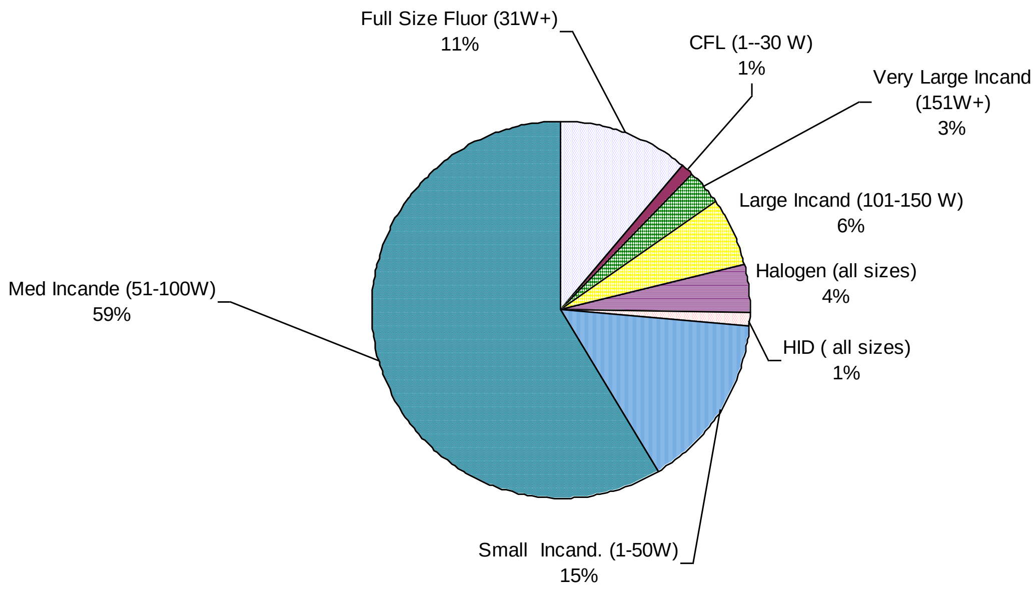
Limitations to LEDs

Although the cost of LEDs is declining, these lights are still relatively expensive compared to other lighting options. For example, a single AC bulb (17 LED) replacing a 25-Watt incandescent costs about $40.00.

LEDs have limited applications. Since they are focused lights, they are best suited for task lighting, such as reading lights, desk lamps, nightlights, and spotlights. LEDs are also popular in signage and decorative and accent lighting. LEDs are also starting to be used in unusual residential task lighting including individual shelf lighting for refrigerators (Lighting Research Center Interview, 2004).

Sales and Installation Rates for Residential Lamps

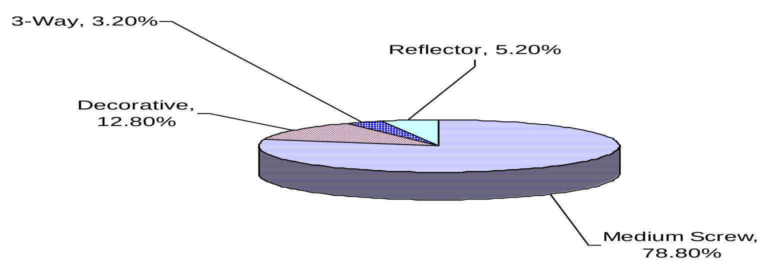
This literature review identified a number of significant studies that estimated overall installation and sales rates for various lighting technologies across the United States. One of the most comprehensive analyses was prepared as part of the California Baseline Study completed in 1997 by Heschong-Mahone.



Source: Heschong-Mahone, 1997

Figure 3: Installation Rates of Residential Lamps in California

According to the US Census figures, sales of total lamps in the United States were $2.03 billion in 2001. Incandescent lamps accounted for the majority of these sales ($1.3 billion) while the fluorescent lamps comprised the remainder, as illustrated in the following figures.

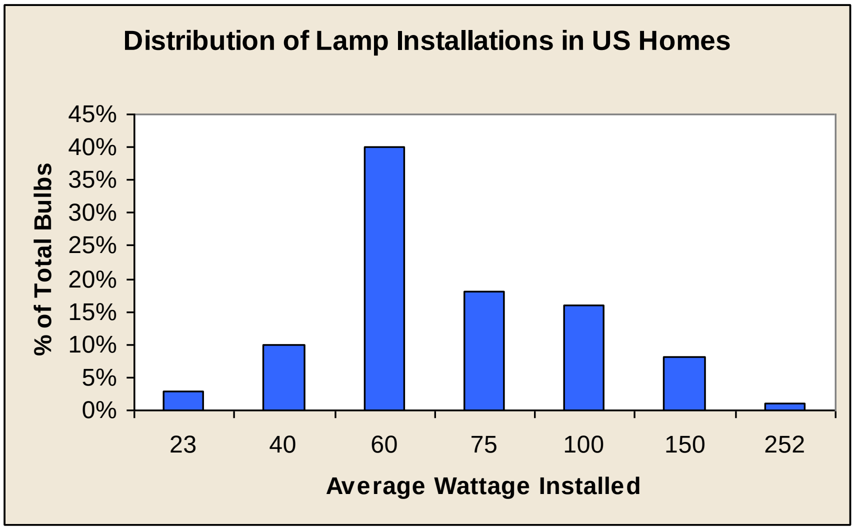


Source: Fields, Harcharik, & Pulliam, 2002

Figure 4: Percentage of Sales of Incandescent Lamp Sales by Type in the US- 2001

Figure 4 illustrates that most of the incandescent lamps sold in the United States are the Standard A-lamps, with the specialty and decorative bulbs comprising the rest.

Exploring this issue even future, Figure 5 illustrates that most incandescent A-lamps installed are 60-Watts, suggesting that this is the predominant lamp type in the United (Rubinstein et al, 1998).



Source, Rubinstein et al, 1998.
Figure 5: Distribution of Incandescent Bulbs by Wattage

Sales of CFL lamps still lag significantly behind sales of incandescents, even though most American knows about this technology. According to an EIA study, 49 percent of Americans knew about CFLs, but less than 10 percent ((8.9%) have actually installed them in their homes (EIA, 1993).

However this finding varies regionally. The California Residential Baseline Study found significantly higher installation rates of CFLs in California compared to the national results. As Table 3 illustrates, more than three-quarters of all California households had at least one CFL installed.

Table 3: Fluorescent Lamp Saturations in California

All Fluorescents	**Percent of Households with Lamp**	Avg # lamps per household
All Fluorescents	**77%**	5.2
Empty 0 Wattage	**6%**	0.1
CFL 1-19 Watts	**20%**	0.4
CFL 20-30 Watts	**27%**	0.6
CFL 31+ Watts	66%	4

Source: Heschong-Mahone, 1997

3. Energy Usage And Costs

Residential lighting represents a significant percentage of energy usage in the United States. The literature review revealed a variety of estimates of residential energy usage reported in national and regional studies. These estimates varied considerably from a low of 4.9 percent to as much as 20 percent, depending upon the scope and breadth of the study. On average, residential lighting accounts for approximately 13 percent of the total energy use in the United States. In the absence of more specific data, this 13 percent appears to be a reasonable baseline assumption for DMEA to consider in its lighting program design. Table 4 summarizes the estimates found in these reports.

Table 4: Summary of Studies on Residential Lighting Energy Usage

Data Source	Percent of Lighting in Total Household Energy Use
EIA, 1993	9%
Lighting Research Center, 1996	6-20%
Jennings et al, 1997	10-20%
California Baseline Study, 1997	28%
EPA, 2004	10-15%
Northwest Power Planning Council, 1991	4.90%
Leslie, Conway, 1993	10%
Average of All Studies	13%

Jennings et al (1997) estimated that American homes use about 138 billion kilowatt-hour (kWh) annually for lighting. This amounts to an annual energy cost of $11 billion, at an average of 8 cents per kWh.

However, regional variations in usage patterns make it difficult to pinpoint residential lighting usage. For example, the California Baseline Study found significantly higher energy consumption attributable to lighting. This variation was based on the unique characteristics of the California energy market, which does not have a significant electric load (Heschong-Mahone, 1997).

Table 5 summarizes the various estimates these of energy consumption directly attributable to residential lighting. While, the typical American home uses 1,200 kWh annually for residential lighting applications, lighting usage varies geographically. According to estimates completed by the EIA, lighting usage is highest in the Midwest and lowest in the Northeast and West.

Table 5: Estimated Annual kWh Consumption Attributed to Lighting

Data Source & Year	Geographic Region	Annual kWh
EIA, 1993	Northeast	815
EIA, 1993	South	992
EIA, 1993	Midwest	1030
EIA, 1993	West	856
Northwest Power Planning Council, 1991	Northwest	710
Eugene W&E 1996	WA	1,002
Pacific, 1996	WA	765
PGE, 1996	WA	1,573
Peninsula, 1996	WA	2,502
Port Angeles, 1996	WA	1,059
Snohomish, 1996	WA	1,690
Tacoma, 1996	WA	1,014
California Baseline, 1997	CA	2026
National Average		1,233

For example, Tacoma Public Utilities completed a comprehensive residential baseline study in 1996 that examined the operating characteristics and locations of lamps and fixtures in the Pacific Northwest. These surveys gathered information from seven utilities in the Pacific Northwest, as shown in Table 5. This lighting study suggested that lighting accounted for slightly higher annual consumption, 1,800 kWh, compared to the national average of 1,233 kWh.

But the Tacoma Public Utilities Study did find that lighting usage was fairly consistent regardless of other variables, such as square footage, number of occupants, or daytime occupancy. This finding suggests that lighting usage appears to be fairly consistent across the entire residential population in a particular region, suggesting that lighting provides an opportunity to reduce load (Tribwell & Lerman, 1996).

In comparison, the average home in DMEA's service territory consumes 9,261.5[2] kWh per year. Of course annual consumption varies depending upon the type of equipment installed. If lighting accounts for approximately 13 percent of the total annual residential load, then the average DMEA member would consume 1,203 kWh annually which is very close to the national average illustrated in Table 5.

Number of Sockets

Another way to examine the breadth and scope of the residential lighting is to examine the locations and concentrations of the lamps and fixtures in the United States. Table 6 summarizes these estimates. According to these studies, the average American home has

[2] Average home kWh from the DMEA Residential Load Profiling Study In Support of Policy Line Changes, Quantum Consulting, September 2003, p. 2.

approximately 41 lighting sockets in 21 fixtures. On average, 1.5 bulbs are installed in these sockets. This finding illustrates the potential costs that homeowners incur by installing lamps in each of these fixtures. For example, the average price of an incandescent bulb is 75 cents the average price of a CFL in the Delta-Montrose is approximately $5.00. Installing lamps in a typical DMEA's member home would then cost approximately $30.00 for incandescent bulbs compared with nearly $150.00 to purchase the same number of CFLs.

Table 6: Summary of Literature Review Estimates for Average Number of Sockets and Fixtures in US Homes

Data Source and Year	Geographic Region	Average Number of Sockets	Average Number of Fixtures	Average Sockets/ Fixture
EIA, 1993	National	33.81	21	1.61
OPC/Kates, 2003	MA	58	39	1.5
Grey's Harbour PUD	WA	30.63	30.63	1.45
Tacoma PUD, 1994	WA	48.06	29.6	1.6
SCE, 1993	CA	34.9	21	1.66
California Baseline, 1997	CA	42.9	26.2	1.64
National Average		41.38	27.91	1.58

Typical Locations and Hours of Use

Americans install lighting everywhere in their homes. However, the critical issue is not how many lights are installed in a typical home, but rather the *frequency of use* by these lights. Some lights in high traffic locations are used much more intensely compared to other lights that may be used more rarely.

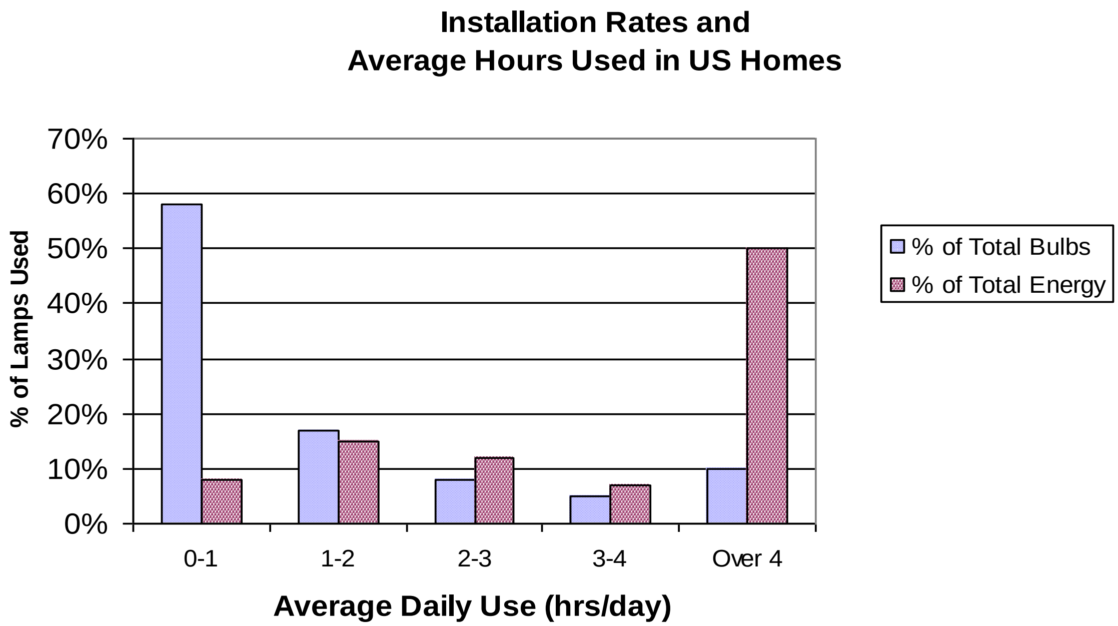
The literature search revealed several interesting findings regarding lighting locations and hours of use in US homes. For example, the EIA RECS Survey (1993) revealed that 87 percent of all residential lights used 15 minutes or longer are incandescent. This study also indicated that while incandescent bulbs are used most frequently, Americans tend to leave fluorescent lights on for longer periods of time. The study found that fluorescent lamps, which account for 13 percent of the total lighting market, tend to be left on for at least an hour per day (EIA RECS Survey, 1993).

These findings were further supported in the California Baseline Study results, as shown in Table 7. Note that both fluorescent and High Intensity Discharge (HID) lights tend to be left on for much longer periods compared to incandescent lamps. This may be partly due to the high installation rates of HID lights installed outdoors.

Table 7: Summary of Average Use and Wattage by Lamp Type

	Avg Hours Per Day	Avg Watts/Lamp
Overall Average	**2.33**	**58**
Incandescent	**2.22**	**62**
Halogen	**2.66**	**145**
Fluorescent	**3.1**	**37**
HID	**8.81**	**72**

Source: Heschong-Mahone, 1997



Source: Rubinstein et al, 1998.

Figure 6: Average Daily Use by Hours of Use and Energy Consumed

These findings all reinforce the conclusion reached by Siminovich and Mills (1995) in which they reported that "a relatively small number of sockets in homes, between 20 percent and 30 percent, may account as much as 70 to 80 percent of all lighting used in a home."

Since lighting tends to be concentrated in a few locations in a typical home, it is therefore important to identify these "high traffic" locations. The top six applications for residential lighting were outdoor fixtures, wall-mounted, kitchen, bathroom, and dining room lights. These six locations account for up nearly 50 percent of all lighting energy use, suggesting that if utilities target these "high use areas," they will be able to reduce their lighting load significantly (Heschong-Mahone, 1997). Table 8 shows that these findings are consistent across all the studies examined in this lighting review.

Table 8: Comparison of Average Hours Used Per Day by Room Type

Room	California Baseline Study, 1997	Tacoma Public Utilities Study, 1996	EIA National Study, 1993	Average Hrs/Day
Bedroom	1.4	1.2	1.6	1.40
Bathroom	2	1.7	1.8	1.83
Den	2	NA	3.2	2.60
Hall	2.2	NA		2.20
Garage	2.3	NA		2.30
Living	2.6	3.1	3.4	3.03
Utility	2.6	NA		2.60
Yard	3.1	3.44		3.27
Kitchen/ Dining	3.4	3.9	3.8	3.70

‘

Hours of Use During Peak Demand

Residential lighting is viewed as an attractive load shaving strategy since it accounts for a fairly significant portion of the total household’s energy use. Moreover, residential lamps are typically used during peak hours, offering many utilities the opportunity to reduce peak load consumption by switching residential customers from standard to compact fluorescent lamps.

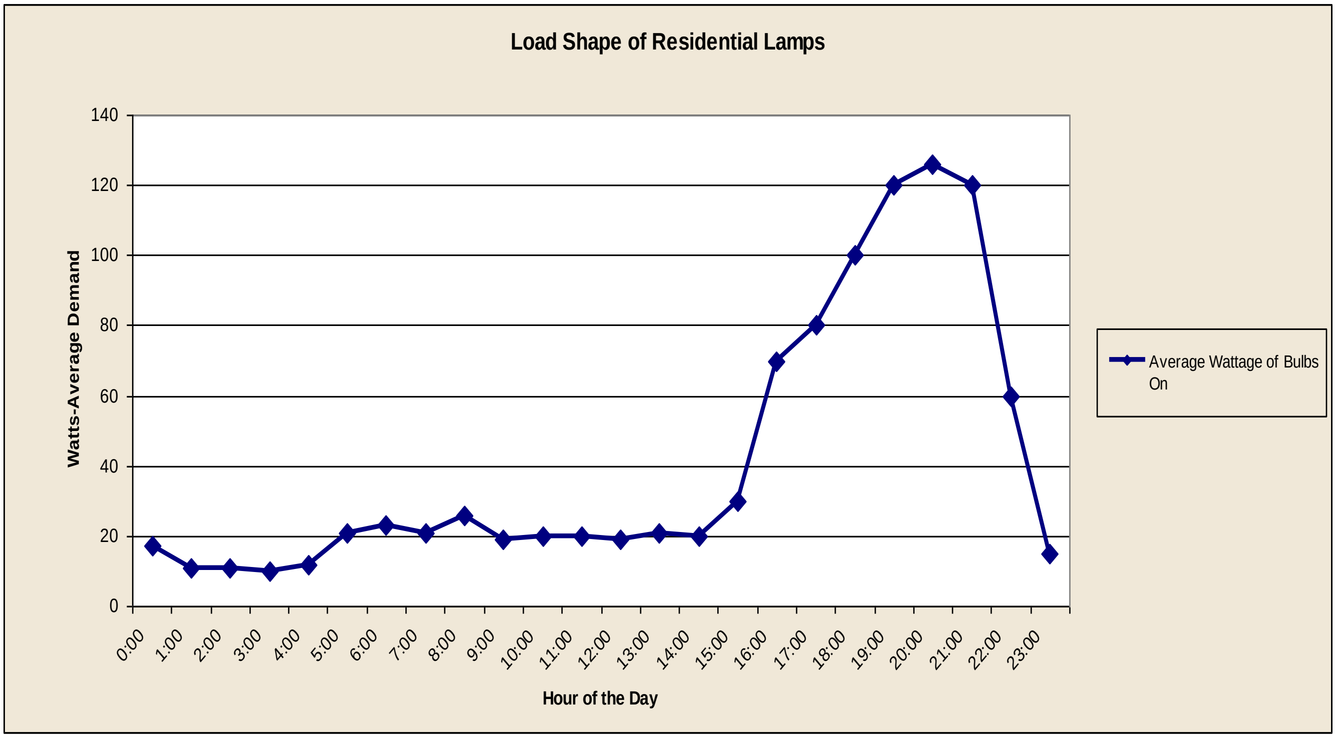
The time of day that the lamps are on is an especially important consideration when developing an estimate of true lighting impacts for utilities, such as DMEA. The next table illustrates the variations in lighting usage patterns depending upon the hour of the day. For example, lamps in the kitchen tend to be turned on mostly at night, while lamps in the bathrooms are used more frequently during the morning hours as shown in Table 9.

Table 9: Percent of Lamps Turned On By Hour of the Day

Time of Day	Living Room	Office/Den	Din/Kitchen	Bedrooms	Hallways	Bathrooms
0:00	8%	0%	0%	0%	0%	0%
1:00	5%	0%	0%	0%	0%	0%
2:00	5%	0%	0%	5%	0%	0%
3:00	1%	0%	0%	5%	0%	0%
4:00	1%	0%	0%	7%	0%	2%
5:00	1%	0%	0%	10%	1%	10%
6:00	2%	5%	3%	10%	1%	12%
7:00	3%	6%	3%	8%	1%	12%
8:00	3%	7%	3%	7%	1%	12%
9:00	3%	8%	3%	5%	2%	11%
10:00	3%	9%	3%	5%	3%	10%
11:00	3%	10%	3%	3%	5%	10%
12:00	3%	10%	3%	3%	5%	9%
13:00	3%	10%	3%	3%	2%	8%
14:00	5%	10%	3%	3%	3%	7%
15:00	10%	10%	3%	3%	3%	7%
16:00	12%	11%	5%	10%	3%	7%
17:00	20%	20%	10%	12%	10%	7%
18:00	40%	30%	15%	15%	18%	10%
19:00	55%	45%	15%	23%	17%	11%
20:00	55%	48%	15%	27%	17%	11%
21:00	51%	45%	12%	25%	15%	9%
22:00	30%	38%	11%	17%	10%	5%
23:00	20%	20%	10%	12%	10%	2%

Source: Heschong-Mahone Group, 1997

Figure 7 illustrates the typical residential lighting pattern based on information gathered from several California studies. As this figure shows, lighting usage is heaviest in the evening hours, which coincides with peak hour demand for many utilities such as DMEA. The DMEA Lighting Model will compare these hours of use against the peak load times for both DMEA and Tri-State to determine the potential avoided costs that would occur as a result of reductions in the residential lighting load. This analysis will focus especially on potential lighting load reductions during late afternoon and evening hours.



Source: Heschong-Mahone Group, 1997

Figure 7: Load Shape of Residential Fixtures

This load shape will be an integral part of DMEA's Lighting Model. It will help to identify the likely usage characteristics for lighting behavior among DMEA members. The time of day average Wattages will be used to develop estimates of the lighting load during the typical day, and also during peak load times.

Seasonality of Lighting Load

Electric lighting loads also vary seasonally with the day length. A study of metered lighting and other miscellaneous end-use in a large sub-metered sample of homes in the Northwestern U.S. by Pacific Northwest Laboratories (PNL) demonstrated a 40 percent variation from a high in December to a low in June (Pratt et al., 1993). Moreover, the PNL research clearly identified lighting loads associated with holiday use being much greater in the month of December. Similarly, a Bonneville study showed 30 percent greater lighting energy use in winter versus summer months (Tribwell and Lerman, 1996).

These seasonal variations will be important considerations in developing the default assumptions for DMEA's Lighting Model. The average Wattage by hour, as shown in Figure 8, will also be compared to the average kW used by DMEA members, based on the RLP study. This study found that the average DMEA member uses 1.96 kW during the winter months, and 1.02 kW during the summer months[3]. These kW assumptions will

[3] Residential Load Profiling Study, p. 4.

be adjusted accordingly to reflect seasonal nature of lighting usage. For example, since lighting usage increases by 30 percent in the winter, the "average" kW usages will be adjusted. Similiarily, the kW during the summer months will be adjusted downward by 30 percent to reflect the longer daylight hours during the Colorado summer.

Average Lighting Use for Torchieres

Information about lighting usage is relatively limited regarding torchieres. A study conducted by Sacramento Municipal Utility District (SMUD) and Lawrence Berkeley National Laboratory (LBNL) in 2000 monitored torchiere usage in 60 households. The household's halogen torchiere was monitored for one month, and then it was replaced with CFL torchiere that was monitored for one month (Ihrig et al, 2002).
This study found that there were significant opportunities for energy savings. Replacing a halogen lamp with a CFL lamp cut energy usage by 85 percent (Lindeleaf, 2002).

Another study (Caldwell 2000) analyzed actual hours that torchieres were used, based on self-reported survey data from turn-in events in Pacific Gas & Electric's (PG&E) service territory. In this study, torchieres were used about was about 4.5 hours/day, or 31.5 hours/week.

Average Lighting Use for CFLs

The EPA's Lighting Supplement data show that less than one percent of all lights used 15 minutes or more per day are compact fluorescent bulbs.

Average Hours of Use for LEDs

The most common application for LEDs in the residential market is Christmas lights. According to an analysis conducted by Seattle City Light, using LEDs rather than standard holiday lights would save a resident approximately $100.00 over a five-year period. Table 10 compares the cost to light an eight-foot tree for five years, five hours per day, 30 days per year at City Light's second block residential rate of 8.66 cents per kWh.

Table 10: Comparison Costs to Operate LEDS During the Holiday Season

Light Type	Purchase Cost	Electricity Costs	Total 5-year Cost
Standard C-7	**$55 .00**	**$87.00**	$142.00
Mini Lights	**$18.00**	**$26.00**	$44.00
LED Lights	$30 .00	$1.00	$31.00

Source: Seattle City Light Website

Operating Cost Comparisons

The costs to operate residential lamps are based on three factors: initial cost, light produced in terms of lumen output, and operating life. Table 11 compares these factors in based on the default average of 8 cents per kWh. As this table shows, cost and lamp life have an almost inverted relationship.

This table illustrates a number of interesting cost comparisons between standard and energy efficient lamps.

- Lamps #1 (60-Watt traditional incandescent) and #2 (13-Watt compact fluorescent produce the same amount of light, yet the compact fluorescent lamp costs 25 percent less than the operating cost of the incandescent lamp.

- Lamp #3 (60-Watt incandescent lamp with halogen) produces more light than either lamp #1 or lamp #2. It also has longer life than normal incandescent lamps, but produces less light than either lamp #4 (23-Watt compact fluorescent) or lamp #5 (26-Watt compact fluorescent).

- Lamps #6 (40-Watt traditional incandescent) and lamp #7 (40-Watt fluorescent lamp) use the same amount of power, but the fluorescent lamp produces six times more light for the same electrical cost (Durda, 2004).

Table 11: Cost Comparisons of Commonly Installed Residential Lamps

Lamp Example	Lamp Type	Power Consumed Per Lamp	Light Produced (in Lumens)	Average Initial Cost	Average Life Per Lamp	Power Cost per 24 hours of use (Assuming $0.08 US per /KWH)	Cost to Own and Operate for 20,000 hours
#1	Incandescent	60 Watts	800	$0.60	1,000 Hours	$0.12	(20 lamps X $0.60) + $96 power = $108.00
#2	Compact Fluorescent Warm White	13 Watts	800	$4.00	10,000 Hours	$0.03	(2 lamps X $4.00)+$20.80 power = $28.80
#3	Incandescent Halogen	60 Watts	1,080	$3.00	3,000 Hours	$0.12	(6.67 lamps X $3.00) + $96 power = $116.00
#4	Compact Fluorescent Warm White	23 Watts	1,400	$4.50	10,000 Hours	$0.04	(2 lamps X $4.50) +$36.80 power = $45.80
#5	Compact Fluorescent Warm White (2700K/82CRI)	26 Watts	1,580	$4.95	10,000 Hours	$0.05	(2 lamps X $4.95) +$41.67 power = $51.57
#6	Incandescent	40 Watts	490	$0.60	1,000 Hours	$0.08	(20 lamps X $0.60) + $64 power = $76.00
#7	4 Foot Fluorescent Warm White	40 Watts	3,200	$4.00	20,000 Hours	$0.08	(1 lamp X $4.00) + $64 power = $68.00

Source: Copyright 2002,2004 Frank Durda IV, All Rights Reserved.http://nemesis.lonestar.org

These cost comparisons reinforce the importance of developing an effective lighting strategy to promote energy efficient lighting technologies. Yet, tremendous barriers remain, which are discussed more fully in the next section.

4. Challenges and Opportunities Offered by Residential Energy Efficient Lighting Technologies

The previous sections described the size and scope of the US residential lighting market. Residential lighting presents a tremendous opportunity for significant and lasting energy savings. However, significant barriers still exist that must be addressed in order to realize that potential. This section focuses on the major barriers to widespread adoption of energy efficient lighting technologies and describes a strategy for realizing this savings potential.

Current Barriers to Energy Efficient Technologies

CFLs are the most widespread energy efficient lighting technology, but these lamps are still disliked by most residential customers. So, the largest barrier to installation remains the lighting technology itself.

The literature review identified several common barriers to CFLs. Unless these barriers are eliminated by improving the technology, CFLs will continue to stay on the fringes in residential lighting applications, just as they have been for the past two decades. Table 12 summarizes the most commonly cited barriers to market acceptance of CFLs.

Table 12: Summary of Market Barriers to CFLs from Literature Review

Market Barrier	Research Study Supporting that Finding		
	EPRI, 1994	Rubinstein, 1998	Kates, et al, 2003
First cost too high.	**X**	**X**	X
Do not fit in existing fixture	**X**	**X**	X
Poor Appearance/Ugly Lamp	**X**	**X**	X
Not versatile: Do not work in some applications including dimmers	**X**	**X**	X
Customer resistance and confusion	**X**		X
Perceived as dangerous if broken	X		

First Cost

As Table 12 shows, initial purchase price remains a major barrier to CFL installations. Even though the average price of CFLs has declined in the past few years, the cost of a CFL bulb is still significantly higher compared to standard incandescent bulbs.

A pricing survey conducted in four Montrose-area locations found that CFL bulbs are consistently priced at 10 times higher than the standard efficiency counterpart. While some incandescent bulbs marketed as “energy misers” are more expensive than a standard bulb, on average, CFLs are significantly more expensive per bulb compared to standard incandescent bulbs.

While these prices can be justified when looking at the "lifetime" or payback of a CFL compared to a standard bulb, however as the EPRI research found, "Few customers have experienced noticeable differences in their utility bills as a result of installing CFLs."

Therefore the price-value argument is a difficult one to make for CFLs compared to other energy efficient technologies, where the energy savings are more noticeable. According to Rubinstein (1998), the first-cost barrier effectively eliminates approximately 25 percent of all available lighting sockets (applications).

Even more alarming is that the prevalence of lighting rebate programs has further diluted the value of CFLs to the residential customer. The EPRI report found that "with very few exceptions, CFLs were installed as a direct result of utility programs which offered direct monetary incentives." This finding suggests that without utility subsidies, CFLs are unlikely to be routinely installed in most residential lighting applications.

Installation Cost Comparisons

Figure 8 illustrates the average retail price differences between standard and energy efficient lamps. These average retail prices were based on the prices found in three area stores in the Montrose, Colorado area.

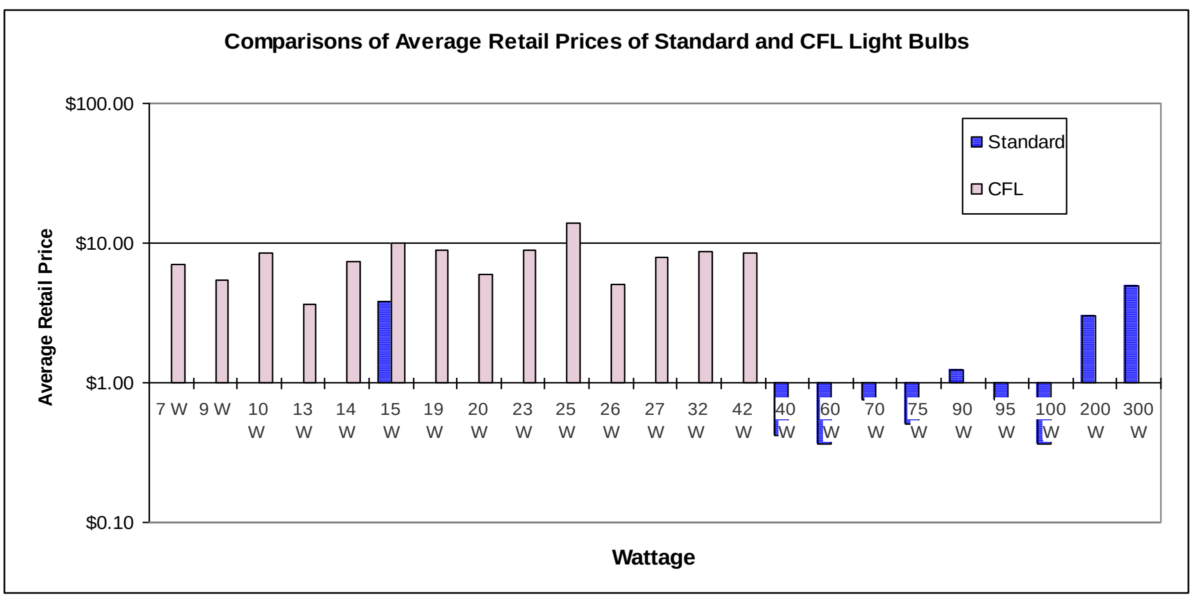


Figure 8: Average Retail Price Differences Between Standard and CFL light bulbs in DMEA's Service Territory

Product Availability

Another major barrier facing DMEA members is the availability of energy efficient lamps. Although three stores in the Montrose, Colorado area offer some energy efficient light bulbs, the overall selection is limited. Given the diverse range of lighting needs in typical homes, it is important therefore to provide customers with a diverse array of energy efficient product offerings.

Fit

CFLs are also not a good fit in many existing fixtures. This poor fit is either due to the interference with the ballast shroud on the fixture cover or because the lamp is too long for the fixture (Rubinstein, 1998). This barrier is estimated to exclude 50 percent of all lighting sockets in the US, according to Rubinstein (1998).

Poor Appearance/Ugly Bulb

CFL bulbs are viewed by many customers as “ugly” because they have an odd shape that tends not to fit well in the current fixtures. While there have been significant improvements in the overall bulb design by some leading manufacturers, such as TCP, few customers have seen these new more aesthetically-appealing bulbs. This was illustrated in the EPRI focus group where respondents said that CFLs were “not as nice looking” as regular lighting.

Poor Versatility

CFLs are also not as versatile as standard incandescent lamps. The literature review found that in all three studies on CFL perceptions, these lamps were not viewed as a comparable replacement to standard bulbs. This was especially true in applications that required either decorative or specialty bulbs, or required instant on capability (Kates, et al, 2003; Rubinstein et al, 1998).

For example, CFLs may require a full minute to reach 90 percent of its brightness when first energized and usually at least ten seconds before reaching 50 percent of full brightness. This makes CFLs unsuitable for applications such as bathrooms or bedrooms, where instant on is required. Thus, many residential customers have returned to incandescent lamps because the CFLs were unsuited to their needs (Rubinstein, 1998).

Similarly, CFLs are not good replacements in dimmer applications. Most of residential dimming controls are designed for incandescent lamps and will not work properly with CFLS. This lack of versatility is estimated to exclude 30 percent of all lighting sockets in the US, according to Rubinstein (1998).

Customer Resistance and Confusion

Another major barrier to CFL installations is the continued lack of understanding and appreciation for this lighting technology. Kates et al found that customers are unwilling to replace a current working bulb or fixture with an energy efficient model. Given the high price point differential, this will be a difficult barrier to overcome.

Moreover, the EPRI study in 1994 found that despite the ongoing educational programs funded by both manufacturers and energy organizations, customers are still unclear about finding the best place for CFL installations. In the absence of a clear and beneficial change-out strategy, the customer elects to stay with the status quo.

Disposal Concerns

Customers first raised these concerns in 1994 during the EPRI focus groups, yet they remain relevant today. If the CFL breaks, there are valid worries about how to properly clean up and dispose of the bulb in a safe manner. Unless this information is provided to customers either via the manufacturers and/or the utilities, the concern over environmental safety may trump the concern for lighting savings, especially if lighting savings are **not** immediately apparent to residential customers.

The next section focuses on the savings potential that could be achieved, if these barriers to CFLs were reduced.

Savings Potential

Residential lighting accounts for an enormous amount of energy used in residential applications. The rising consumption rates coupled with constraints on the electric supply has led a number of organizations to evaluate the potential energy reductions that could result from an increase in energy efficient lighting installations in the U.S. This section summarizes two different analyses of the energy savings potential available through increased installation rates of energy efficient lights.

The first analysis was prepared by the Energy Information Administration as part of its comprehensive residential baseline study initiated in 1993 and published in 1996. The second study was prepared by a group of researchers at Lawrence Berkeley National Laboratory (LBNL) led by Francis Rubinstein and published in 1998. As both these analyses show, the potential savings that could result from energy efficient lighting installations is overwhelming.

Given the relatively high initial cost of CFLs compared to incandescent bulbs, it is cost-prohibitive to expect the average residential homeowner to change out all existing bulbs in the home with CFLs. Therefore, recommendations from these energy researchers focus instead on a partial replacement strategy. Several reports in the literature review recommended focusing on the high use lighting sockets as key to achieving these lasting savings. As Rubinstein et al (1998) defines it,

1. *Low-use* sockets *(<3* hr/day) represent 70 percent of the sockets in the home and account for 33percent of all household lighting energy.

2. *High-use* sockets *(>3* hr/day) consume 67 percent of all lighting energy in household but represent only 30 percent of the total number of sockets.

EIA Study

Table 13 summarizes the EIA's basic assumptions used to calculate the potential impact of energy savings from energy efficient lighting technologies.

Table 13: Summary of Lighting Savings Payback for Three Bulb Types

		Bulb Type					
Lamp Parameter	Unit	Incandescent		HIR		**Compact Florescent**	
		EIA Study	LBNL Study	EIA Study	LBNL Study	EIA	**LBNL Study**
Unit Cost	$	$0.75	$0.75	NA	$3.50	$22.00	**$15.00**
Power	Watts	75	60	NA	43	26	**15**
Lamp Life	Hr/lamp	750	1,000	NA	3,000	10,000	**6,000**
Hours/Day	**Hrs**	**6.7**	**6**	**NA**	**6**	**6.7**	**6**

The EIA analysis shows that a compact fluorescent bulb would last 4.1 years compared to the average lifespan of an incandescent bulb of 3.5 months. The following figure illustrates the savings that accrue over the expected life span of a compact fluorescent bulb. This figure includes the cost of repeatedly replacing the incandescent bulb at an electric rate of 10 cents per kWh, the closest calculation to DMEA's current rates.

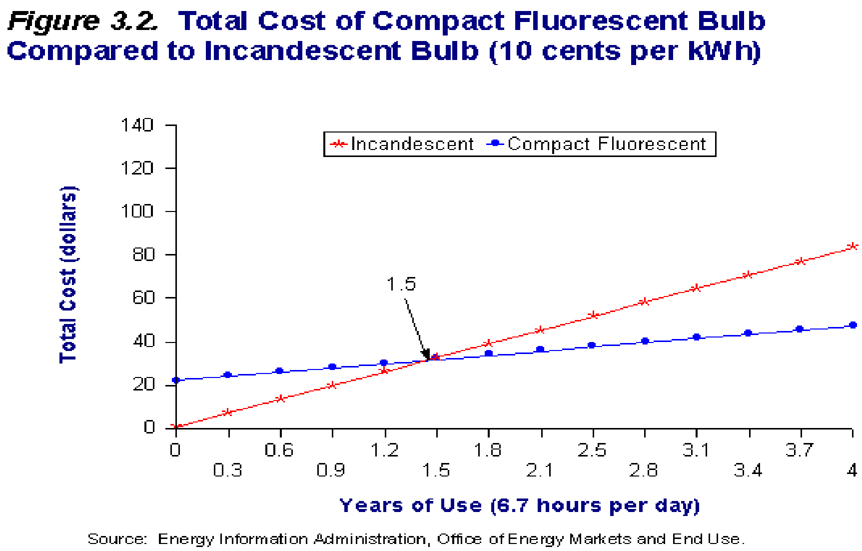


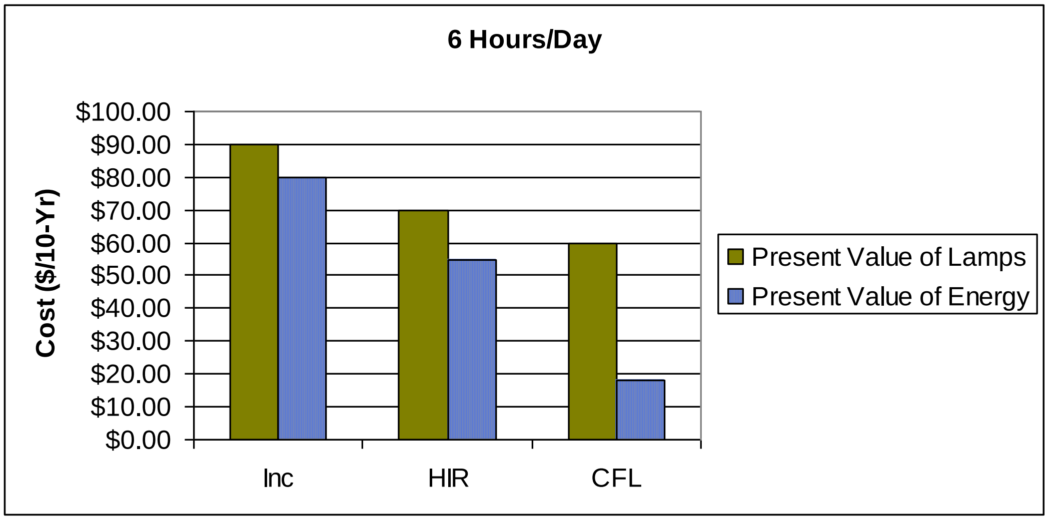
Figure 9: EIA's Comparison of CFL and Incandescent Cost and Operating Life

EIA's estimates suggest that the potential aggregate savings from replacing all incandescent bulbs used more than 4 hours per day is 31.7 billion kWh annually. This assumes that the average incandescent bulb of 75 Watts is replaced by a 26-Watt compact fluorescent bulb. Thirty-eight percent of this savings, or 12 billion kWh, would come from replacing the 44.1 million bulbs used 12 or more hours per day and 62 percent, or 19.7 billion kWh, would result from replacing the 196.6 million lights used 4 to 12 hours per day. These potential energy savings are 35 percent of the electricity used for lighting in 1993 (91 billion kWh (EIA, 1993).

LBNL Results

LBNL also conducted a life cycle economic analysis comparing standard incandescent, HIR, and CFL prices, lifetimes, and paybacks. These assumptions were based on an analysis of 10 years, with a discount rate of 10 percent, and an energy cost of 10 cents/kWh.

Using the life cycle cost equations from Clear (1996), the LBNL analysis found that CFLs and halogen infrared reflecting lamp (HIR) are most cost effective when used in long-burning applications. This study found that the HIR lamp is more cost-effective than either a standard incandescent lamp or CFL for shorter burning hours (< 3 hr/day), while CFLs are the most cost-effective in applications used more than three hours per day.



Source: Rubinstein et al (1998).

Figure 10: Comparison of the Present Value of Lamp Types Based on a 6-Hour Burn Time

Energy Impacts

Both studies also estimated the national impacts that would be achieved, if US households adopted energy efficient lighting at higher rates. The LBNL study focused on calculating the energy savings from HIR change-outs while the EIA estimated energy savings from replacing standard incandescent bulbs with CFLs. Table 14 summarizes these findings.

Table 14: Estimated Aggregate Annual Savings

Data Source	Estimated Energy Savings	Estimated Dollar Savings
EIA, 1993	**31.7 billion kWh**	$3 billion/year
LBNL, 2002	13.5 TWh/year	$2 billion/year

To realize these savings, more than 100 energy organizations have implemented a variety of lighting program strategies to encourage residential customers to move from standard to energy efficient lighting. The next section summarizes these program strategies and outcomes.

5. Summary of Utility Program Offerings

Electric utilities have been offering residential energy efficient lighting programs to their customers for more than a decade. The table on the next several pages summarizes all currently available information regarding residential lighting programs offered by energy organizations throughout the United States.

The review of residential lighting programs revealed several major findings regarding the current types of lighting programs offered in the United States.

- Lighting programs vary significantly in terms of the size, scope, and delivery method used to influence the residential market.

There is no one "Model Lighting Program" in the United States. Depending upon the needs of the energy organization, a residential lighting program may be relatively small, targeting only a select group of customers, or may be fairly comprehensive encompassing thousands of retailers at a state or regional level.

- Not all lighting programs target CFLs.

While CFLs are the most common lighting technology targeted, other-related lighting technologies are often included in a residential lighting program. For example, some energy organizations target all lighting technologies, including CFLs, fixtures, ceiling fans, and stand-alone fixtures (torchieres). Other energy organizations may instead choose to just target fixtures and torchieres as a way to develop a more lasting effect on energy efficiency in their areas. In general, the larger the program, the more technologies would be included.

- Not all lighting programs are offered by utilities.

In fact, few lighting programs are offered by large Investor-Owned Utilities (IOUs), and if they offer these programs, chances are these programs are administered by a third-party. The large state and regional programs are often overseen, either directly or indirectly, by a non-profit organization, a state energy agency, or a third-party contractor. In general, large lighting programs are administered by outside experts. Furthermore, some smaller municipal and Rural Electric Cooperative (REC) utilities are beginning to outsource their lighting programs to third-party contractors. This provides the utility with a mechanism for controlling costs while reducing the administrative burden to the utility with limited staff resources.

- Rebates remain the most popular program delivery method, but not all rebates go directly to the customer.

In general, the CFL market has been flooded with rebates. However, rebates are not a sustainable program delivery mechanism. To induce customers to purchase CFLs and other energy efficient products, without specifically teaching them to look for rebates, several energy organizations have begun providing funding directly to the manufacturers rather than to the customers. This "upstream" rebate program has been relatively successful in the California lighting programs, however, like other financial incentives, these rebates do not lead to lasting market change.

- Lighting program costs and kWh and KW savings are not easily tracked.

Of the 69 lighting programs reviewed in this study, fewer than half provide detailed information regarding program costs and actual reductions in kWh and peak demand reductions in kW. This information was provided when it was available; however, this information is not reported at a national level in any consistent format.

Tracking lighting program costs and savings is also difficult because lighting program budgets and the resulting energy reductions are often included as part of an organization's overall energy conservation results. The information provided in the following tables was gathered from a variety of sources including company websites, a rebate database, state utility commission websites and reports, and national and regional assessments of residential lighting programs.

The rest of this section supports these five critical findings regarding residential lighting programs in the United States. It also provides examples of typical lighting programs used by various organizations to illustrate the diversity of lighting programs in the United States.

As Table 15 shows, the size and scope of lighting programs offered to residential customers in the United States vary considerably. Moreover, these lighting programs also vary in both the delivery method as well as the targeted equipment. Figure 11 displays the distribution of energy organizations offering lighting programs in the residential market. This table also illustrates that 87 percent of all lighting programs are offered by some type of electric utility, while the remainders are offered either through state-run programs or non-profit organizations providing these programs on a regional basis. However, utility lighting programs seem to be the most prevalent among municipal and rural electric cooperatives, rather than Investor-Owned Utilities (IOUs).

Table 15: Summary of US Residential Lighting Programs

					Estimated Savings		*Targeted Equipment*				
Utility	*State(s):*	*Utility Type:*	*Population*	*Budget*	*kWh*	*kW*	*CFLs*	*Fix-tures*	*Torch-ieres*	Ceiling Fans	Delivery Method
Alameda Power & Telecom	CA	Municipal	29,300				X				Mail-In Rebates
Alliant Energy	IA	Investor Owned Utility	1,300,000	NA	NA	NA	X				Mail-In Rebates
Aquilla	MO	Investor Owned Utility	446,000	NA	NA	NA	X	X	X	X	Rebates: Mfg Buy Down
Austin Utilities	MN	Municipal	11,500	NA	NA	NA	X				Mail-In Rebates
Blachly-Lane Electric Cooperative	OR	Rural Electric Cooperative	3,400	NA	NA	NA	X				Mail-In Rebates
Black Hills Electric Cooperative	SD	Rural Electric Cooperative	5,900	NA	NA	NA		X	X	X	Other-Low Interest Loans for Lighting Fixtures
Bonneville Power Administration	WA, OR, ID, MD	Municipal	8,000,000	$2,500,000	74 MW	NA	X	X			Utility rebates
Bryan Texas Utilities	TX	Municipal	66,000	NA	NA	NA	X				Other-Third Party Sales
Burlington Electric Department	VT	Municipal	16,000	NA	NA	NA	X				Other- Leases CFL bulbs to customers
Central Maine Power	ME	Investor Owned Utility	34,000	NA	81 MW	5,100	X				Third-Party Sales
Chicopee Electric Light	MA	Municipal	54,000	NA	NA	NA	X	X	X	X	Third-Party Sales
City of Anaheim	CA	Municipal	330,000	$330,000	NA	NA	X			X	Mail-In Rebates
City of Davis	CA	Municipal	60,300	NA	NA	NA	X				Targeted Giveaway
City of Mountain Lake	MN	Municipal	2,000	NA	NA	NA	X				Mail-In Rebates
City of Pasadena	CA	Municipal	136,000	NA	NA	NA				X	Mail-In Rebates
City of Redding	CA	Municipal	85,700	NA	NA	NA		X			Mail-In Rebates
City of Riverside	CA	Municipal	44,000	NA	NA	NA	X	X		X	Mail-In Rebates

Clallam County Public Utility District	WA	Municipal	9,000	NA	NA	NA	X	X	X		Mail-In Rebates
Commonwealth Edison	IL	Investor Owned Utility	3,200,000	$60,000	NA	NA	X	X	X	X	Education
Concord Municipal Light Plant	MA	Municipal	17,000	NA	NA	NA	X				Mail-In Rebates
Connecticut Light & Power	CT	Investor Owned Utility	1,200,000	NA	NA	NA	X	X	X		Mail-In Rebates
Dakota Electric Association	MN	Rural Electric Cooperative	92,000	NA	NA	NA	X				Mail-In Rebates
Efficiency Maine	ME	Municipal	1,274,000	$2,500,000	NA	NA	X	X	X	X	Instant Rebates
Efficiency Vermont	VT	State Agency	28,872	NA	NA	NA	X	X	X	X	Instant Coupons
Energy Trust of Oregon	OR	State Agency	3,472,000	NA	NA	NA	X				Targeted Giveaways
Grant County Public Utility District	WA	Municipal	40,000	NA	NA	NA	X				Education
Imperial Irrigation District	CA	Municipal	100,000						X		Mail-In Rebates: Education
Jefferson Utilities	WI	Municipal	6,000	NA	NA	NA	X				Targeted Giveaway
Jo-Carroll Energy	IL	Rural Electric Cooperative	6,200	NA	NA	NA		X			Mail-In Rebates
Kennebunk Light and Power District	ME	Municipal	NA	NA	NA	NA	X				Mail-In Rebates
Kootenai Electric Cooperative	ID	Rural Electric Cooperative	17,000					X			Mail-In Rebates: Education
Linn County Rural Electric Cooperative	IA	Rural Electric Cooperative	19,000	NA	NA	NA	X				Mail-In Rebates
Long Island Power Authority	NY	Municipal	1,000,000	$2,000,000	NA	NA	X	X	X	X	Instant Rebates
Los Angeles Department of Water and Power	CA	Municipal	1,300,000	$3,000,000	17MW	NA	X	X		X	Mail-In Rebates
Madison Gas & Electric	IL	Investor Owned Utility	128,000	NA	NA	NA	X	X			Education
Maquoketa Valley Electric Cooperative	IA	Rural Electric Cooperative	14,000	NA	NA	NA	X	X			Mail-In Rebates

Marshfield Electric and Water Dept.	WI	Municipal	11500	NA	NA	NA	X	X			Rebates
Midwest Energy Efficiency Alliance	OH, O, IL, MN	Non-profit Corporation	3,000,000	$400,000	51MW	NA	X				Instant Rebates
Minnesota Department of Commerce	MN	State Agency	4,900,000	$7,000	NA	NA	X	X			Education; Instant Rebates
Minnesota Power	MN, WI	Investor Owned Utility	133,000				X				Mail-In Rebates
Modern Electric Water Company	WA	Municipal	195,626	NA	NA	NA	X	X			Mail-In Rebates
Muscatine Power & Water	IA	Municipal	8,600	$2,000	NA	NA	X				Mail-In Rebates
National Grid	MA, RI, CT, VT, NH	Investor Owned Utility	3,200,000				X	X	X	X	Instant Coupons; Education
New Hampshire Rural Electric Cooperative	NH	Rural Electric Cooperative	75,000				X	X	X	X	Third-Party Sales
New York State Energy Research & Development Authority	NY	State Energy Agency	17,000,000	$3,600,000	NA	NA		X			Education
Northeast Energy Efficiency Alliance	OR, WA, ID, MT	Non-profit Corporation	11,000,000	$1,813,500	NA	NA	X	X	X	X	Education
Northeast Energy Efficiency Partnerships	MA, RI, CT, VT, NH	Non-profit Corporation	6,500,000	$20,000,000	NA	NA	X	X	X	X	Instant Rebates
NorthWestern Energy	MT, SD, NE	Investor Owned Utility	600,000	NA	NA	NA			X		Mail-In Rebates
Osage Municipal Utility	IA	Municipal	3,800	NA	NA	NA	X	X			Mail-In Rebates
Pacific Gas & Electric	CA	Investor Owned Utility	1,300,000	$21,000,000	536,939, 370	140,598	X	X	X		Instant Rebates
Port Angeles Public Works and Utilities	WA	Municipal	9,000	NA	NA	NA	X	X			Mail-In Rebates
Puget Sound Energy	WA	Investor Owned Utility	800,000	NA	1,500,000	NA	X	X			Rebates to Builders: Mail-In Rebates
Rochester Public Utilities	MN	Municipal	42,000	NA	NA	NA	X				Mail-In Rebates
Rock County Electric Cooperative	WI	Rural Electric Cooperative	152,700	NA	NA	NA	X				Mail-In Rebates

Sacramento Municipal Utility District	***CA***	***Municipal***	***468,000***	***$2,440,000***	***8,600,000***	***1,200***	***X***		***X***	***X***	***Mail-In Rebates***
San Diego Gas & Electric	CA	Investor Owned Utility	1,200,000	$1,500,000	NA	NA	X	X	X	X	Mfg Rebates & Targeted Giveaways
Seattle City of Light	WA	Investor Owned Utility	680,000	NA	150,000	NA	X				Targeted Giveaway
Sierra Pacific	NV	Investor Owned Utility	180,000	NA	NA	NA	X				Education
Silicon Valley Power	CA	Municipal	50,000				X	X		X	Mail-In Rebates
Snohomish County PUD	WA	Municipal	320,000	$1,650,000	NA	NA	X				Mfg Rebates: Mail In Rebates
Southern California Edison	CA	Investor Owned Utility	4,500,000	$1,800,000	25, 654, 471	4,767	X	X			Targeted Giveaway
Southern Minnesota Municipal Power Agency	MN	Municipal	92,000				X				Mail-in Rebates
Tennessee Valley EMC	TN	Rural Electric Cooperative	25,000	NA	NA	NA		X	X	X	Other- Part of New Constructio n Rebate
Unitil	NH	Investor Owned Utility	69,000	NA	NA	NA	X	X	X	X	Instant Rebates
Wakefield Municipal Gas & Light Department	MA	Municipal	24,404	NA	NA	NA	X	X	X	X	Mail-In Rebates
Wisconsin Energy Conservation Corp	WI	Non-profit Corporation	2,000,000	$2,400,000	NA	NA	X	X	X	X	Mail-In Rebates
Wisconsin Focus on Energy	WI	State Agency	118,000				X		X		Mail-In Rebates
Xcel Energy	MN	Investor Owned Utility	1,000,000	NA	NA	NA	X				Education

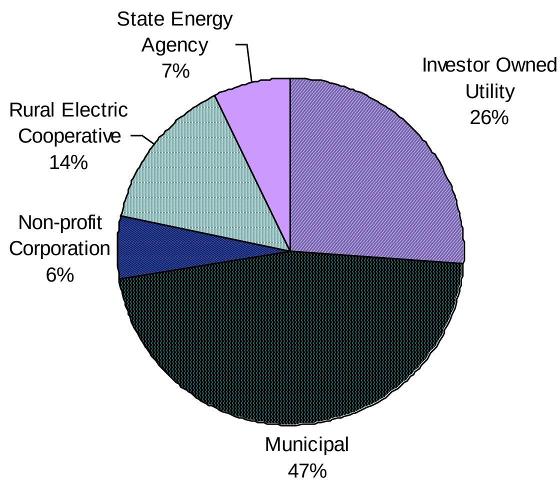


Figure 11: Types of Energy Organizations Offering Lighting Programs

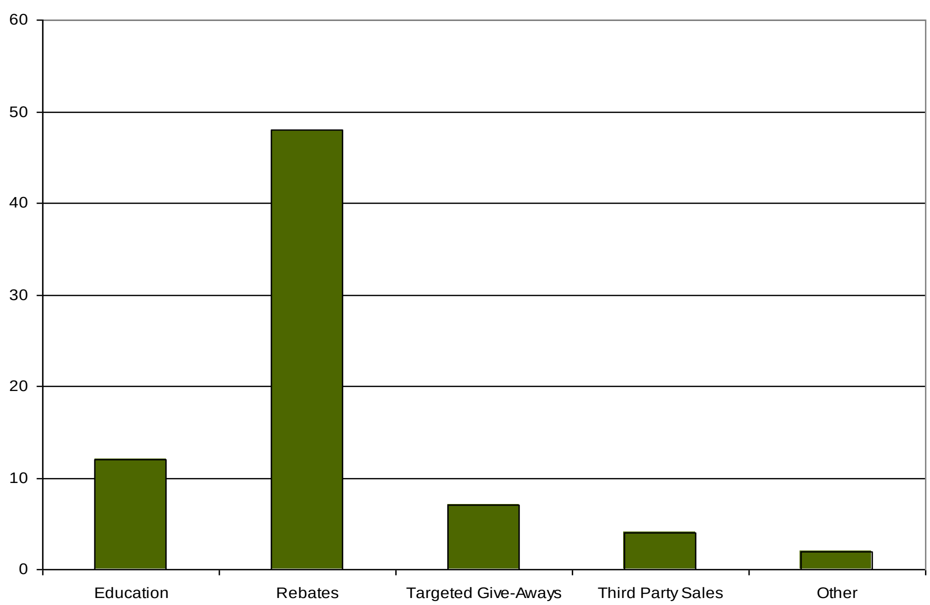


Figure 12: Types of Lighting Programs

As Figure 12 shows, rebates are the most common type of lighting program offered to residential customers. A few utilities use other methods, such as providing consumer education on their websites, or focusing on a specific target group to giveaway free light bulbs, but most of these programs rely on providing a financial incentive to promote energy efficient lighting to residential customers.

These programs are differentiated by their delivery methods, falling into one or more of the following categories:

1. **Educational programs** that promote energy efficiency lighting technologies through product brochures, bill inserts, advertising materials, and related educational methods.

2. **Give-away Programs** that are designed to increase customer awareness through free product samples of CFL bulbs.

3. **Rebate programs** that are designed to reduce the premium price associated with the cost of the CFL bulbs. This is the most common program delivery method. Rebates are paid through a variety of ways including “instant” rebates or coupons that are redeemable at the time of purchase, and mail-in rebates.

4. **Third-party retail sales** of CFL bulbs and related energy efficiency products that are sponsored or co-branded with the utility. These retail sales offer the utility customers discounts on purchases of energy efficient lighting technologies, and in some cases, a full-range of energy efficient products.

Education Programs

Education programs provide information one-on-one in response to individual consumers needs. These programs provided tailored advice and expertise designed to help customers understand, and hopefully increase, their overall satisfaction and use of energy efficient technologies (Fernstrom, 1994).

Education programs encompass a broad range of activities including discussions with an account representative, brochures, and toll-free hotlines such as the "Energy Ideas Clearinghouse" sponsored by the Washington State Energy Office or Pacific Gas & Electric Company's (PG&E)’s "Smarter Energy Line" provide detailed answers to utility customers.

Sometimes these educational activities are designed to increase awareness among key members of the supply chain, such as builders, architects, and designers. For example, Pacific Northwest's Lighting Design Lab in Seattle, PG&E's Pacific Energy Center, and the Southern California Edison Company's Customer Technology Applications Center all provide detailed information on lighting technologies for trade allies in the new construction market (Fernstrom, 1994).

Give-away Programs

Another common delivery method for residential lighting programs is to offer free bulbs to specific targeted groups. These giveaway programs take many forms. In California, each Investor-Owned Utility (IOU) was required to do a targeted giveaway program for CFLs; however, each utility focused on a unique market and developed a specialized approach, as shown in Table 16.

Table 16: Targeted Giveaway Programs

Utility	Target Group	# of Events	# of CFLs Given Away
SDG&E	**Senior Citizens**	**60**	**20,000**
SCE	**"Hard to reach" customers such as non-English speakers, rural communities, and low-income residents**	**16**	**25,000**
PG&E	**Asian customers**	**1**	**1,500**

Source: Rassmussen, McElroy & Rubin, 2002

These giveaway events included participating in local community activities such as fairs, festivals, and workshops.

Door-to-door giveaway programs focus on delivering a high volume of CFLs to a targeted group of residents who are located in close proximity to one another. In 2001, California's Powerwalk program targeted households located in low-income neighborhoods. Through the Powerwalk program, the California Conservation Corps distributed 1.9 million CFLs to approximately 475,000 low-income households statewide (Rasmussen & McElroy, 2002).

A related strategy is to incorporate a giveaway program into an existing utility program. This "leveraging" strategy maximizes the energy saving of existing energy efficiency programs with minor incremental cost. In 2001, SCE introduced a CFL incentive with its refrigerator-recycling program. SCE offered participating customers the choice of $35.00 or a five-pack of CFLs. A total of 5,500 people opted for the CFLs, representing 10 percent of those given the option (Rasmussen & McElroy, 2002).

Bundling Energy Efficiency Measures to Shed Load: Seattle City Light's Conservation Kit

Seattle City Light faced an urgent need to reduce utility loads in 2001. So, the utility offered two conservation kits that included two free CFL bulbs to every Seattle City Light residential customer. The two lighting initiatives are referred to as the Conservation Kit and Retail Coupon Programs and were promoted via direct mail.

The municipal utility also included other CFL giveaway programs to help reduce overall electric load. The average Seattle City Light residential customer paid a rate of 6.21¢ per kiloWatt-hour in 2001. At this rate, the direct energy savings attributable to Conservation Kit CF bulbs (18,275 MWh) yielded annualized residential customer bill savings of $1,134,878. Additional CF bulbs purchased and installed by participants and nonparticipants after the Conservation Kit offer (11,963 MWh) yielded additional annualized residential customer bill savings of $742,902. The cumulative impact of Kit and purchased CF bulbs for Participating customers was a reduction in an individual annual household energy bill of $10.00.

Lighting Measure Impacts	**Delivered**	**Installed**	**Annual MWh**	**2002 MW**
Conservation Bulb Kit	178,481 (kits)	285,570	16,330	1.961
Block Watch CF Bulb Targeted Giveaway	17,000	12,750	1,402	0.168
Low-Income Targeted Giveaway	32,606	24,455	1,333	0.160
Baseball Game Bulb Giveaway	10,000	1,500	82	0.010
Other Targeted Giveaways	59,606	38,705	2,818	0.338
Overall Net Impacts	299,632	466,050	28,075	3.372
Combined Plan Impacts	__	504,755	30,893	3.710
(Source:Tachibana & Brattesani, 2002)				

At an average $69.41 per MWh cost of delivering energy in 2001, the direct energy savings due to Conservation Kit CF bulbs (18,275 MWh) yielded avoided annual wholesale power purchases of $1,268,468. Additional CF bulbs purchased and installed by participants and nonparticipants subsequent to the Conservation Kit offer (11,963 MWh) yielded additional annualized wholesale purchase power savings of $830,352.

Financial Incentive Programs

Energy organizations also rely on a variety of financial incentive programs to help reduce the higher first-cost associated with energy efficiency lighting technologies. To lower this market barrier, many energy organizations employ coupons, rebates, manufacturer buy-downs, and other financial incentives designed to reduce the first-cost barrier and encourage customers to purchase and install energy efficient lighting.

The next table illustrates the range of incentives used in the residential lighting programs summarized previously. As this table shows, the average amount rebated for a CFL is approximately $4.00, while the rebates are significantly higher for the ceiling fans, fixtures, and torchieres.

Table 17: Range of Rebates for Residential Lighting Programs

	Range of Incentives		
Equipment Type	**Low**	**High**	**Average Amount**
CFLs	$2.00	$15.00	$3.63
Ceiling Fans	$10.00	$50.00	$19.50
Hard-Wired Fixtures	$5.00	$40.00	$14.63
Portables	$12.00	$32.00	$22.00

Incentives for CFLs are relatively low, averaging $3.63 per CFL package while the incentives for the portable (torchiere) and hard-wired fixtures are more generous.

Coupons and Rebates

Financial incentives come in many forms. Some may be paid to the customer as instant or point-of-purchase coupons or mail-in rebates. These methods have differing success rates and rationales for implementation.

Mail-in rebates have a relatively low redemption rate, ranging from 20 to 80 percent, while instant coupons have a 100 percent redemption rate. However, instant or point-of - purchase coupons do require a higher level of retail participation, which may be difficult to accomplish. Coupons and rebates may encourage dealers to carry products that they normally would not carry and offer cooperative special price reductions beyond the coupon's value (Rasmussen, McElroy & Rubin, 2002).

Direct Sales

Another rebate strategy that is gaining in popularity is direct sales by third-parties. These direct sale programs may be offered in the form of a catalog sent out by the utility to all of its customers. This approach is currently being used at state-level programs in Maine and Vermont.

These direct sales programs are particularly relevant to utilities in locations that do not offer a variety of retailers providing the particular product. Successful mail-order programs have featured full-sized cutouts of CFLs to give prospective purchasers a better idea of the size of the lamps, but they have not offered such low prices that consumers stocked up, waiting for a socket to "open up" (Rasmussen & McElroy, 2002).

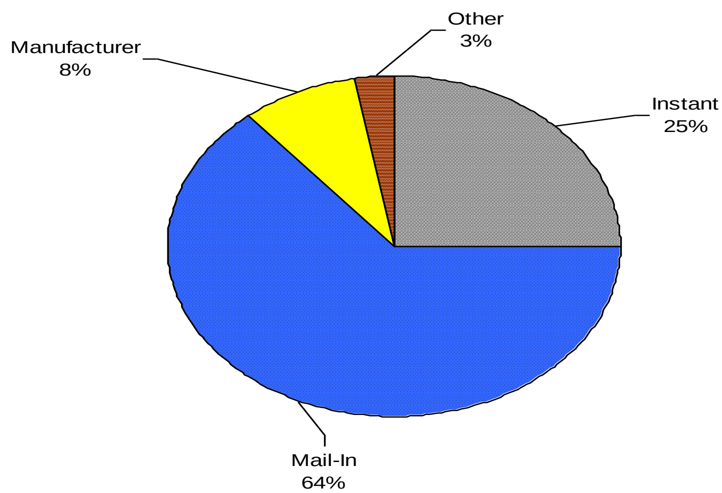


Figure 13: Types of Rebate Programs Offered to Residential Customers

As Figure 13 shows, most residential lighting programs feature mail-in rebates to encourage the purchase of energy efficient lighting equipment. A few utilities and organizations rely on third-parties to handle the rebate processing. In some cases these rebates are given to the customer at the time of purchase (instant rebate) or through a reduced retail price because of a manufacturer buy-down. However, most energy organizations rely on the customers to mail-in the proof of purchase to receive their rebate checks.

Third-Party Sales

As an offshoot of direct sales, several utilities have teamed up with leading lighting manufacturer to promote sales of energy efficient lighting technologies. One of the leading lighting manufacturers, Technical Consumer Products (TCP) Inc., based in Ohio, has developed third-party relationships with a number of electric utilities across the United States.

Technical Consumer Products, Inc. was formally incorporated in February 1993 with major concentration in the CFL marketplace. In 1996, with the development of its

SpringLamp design and the dimming ballast, TCP recognized that these new products could be applicable in the residential market and began marketing directly under the trade name "TCP". To reinforce its commitment to residential lighting products, TCP is also an ENERGY STAR partner, offering a variety of ENERGY STAR approved CFLs and fixtures.[4]

TCP has developed a number of relationships with leading electric utilities around the United States with its online distributor, the Energy Federation International (EFI). EFI is a nonprofit organization specializing in promoting a variety of energy conservation products for residential and commercial customers. EFI also acts as a third-party in order fulfillment and rebate processing for electric utilities throughout the Northeast. Currently, EFI offers the complete TCP residential product line on its website, located at www.energyfederation.org.

This third-party sales approach offers electric utilities the opportunity to promote energy efficient products without committing significant administrative or overhead expenses. EFI has developed a number of program options allowing electric utilities to offer these products to their customers through specially designed web pages. Depending upon the arrangement, electric utilities can become affiliated with EFI through a revenue-sharing agreement and no upfront costs.

Promoting CFLs Online: Wakefield Municipal Gas & Light Department (WMGLD)

Nearly every utility in Massachusetts is offering lighting rebates through catalog and online sales. Through the ENERGY STAR Light Program, a full range of lighting products are available for sale through catalog and website sales. The products, which are ENERGY STAR-labeled technologies are offered for sale at reduced prices. These rebates range from price reductions between $2.00 and $4.00 for CFLs, $10.00 off for exterior fixtures, $15.00 off the retail price for interior fixtures, and $20.00 off for torchieres. All rebates and order processing is handled through its third-party administrator, EFI, Inc.

www.estarlights.com
www.infotech-maine.com/wakefiledmgld.com

Other Delivery Strategies

The literature review also identified several other, rather innovative delivery methods that were used by various energy organizations to promote energy efficient residential lighting. For example, Black Hills Electric Cooperative provides low-interest loans up to $5,000 at 5 percent over seven years. These loans can be used for a variety of home energy improvements including energy efficient lighting (Source: http://www.bhec.coop/)

[4] Information from TCP's website, www.tcpi.com, accessed July 6, 2004.

CFLs as a Fund-Raising Tool

Central Power Maine (CWP) took a unique approach to encouraging customers to purchase and install CFLs by working through the Lions Club. Each year, the Lions Club sells incandescent light bulbs door-to-door in October. CMP decided to use this organization's existing fundraising strategy as a way to increase awareness and installation rates of energy efficient light bulbs. In the first year of the program, the utility offered a six-pack of halogen bulbs for $5.00 sold through the Lions Club. CMP also included a small brochure on energy-efficient lighting that described several different kinds of compact fluorescent bulbs in the six-pack of halogens. CMP also ran three-quarter-page newspaper ads throughout the service area and a 30-second television spot ran for two weeks on seven stations. During the first year, the Lions sold 81,000 six-packs of halogen bulbs to approximately 34,000 customers.

The following year, CMP tested various CFLs with utility employees and selected the Osram Dulux-15 for the second part of the program with the Lions. CMP also prepared television and newspaper advertising. These advertising materials included a one-dimensional cardboard cut-out of the bulb bill stuffer so customers could estimate how many bulbs might fit in their homes before the Lions came to their doors.

The results from this second level of effort were sales of 90,000 CFL bulbs in one week. The combined program sales had sold enough bulbs to save over 81 million kWh and reduce demand by 5,100 kW (Goldfarb, 1994).

Leasing CFLs: Burlington Electric Department (BED)

BED's Smartlight program leases compact fluorescent bulbs to its customers. After the lease ends the customer owns the bulb. Participating customers receive an immediate savings on their electric bills because the monthly energy savings is greater than the small monthly lease fee.

During the first 10 years of the program operation, in 1999, the Smartlight program had leased nearly 60,000 CFLs to more than 7,000 Burlington homes and business. Annual estimated electrical savings is approximately $390,000.

Leasing Smartlights:
Residential: 20¢/month, 5-year lease term ($12.00 total)
Commercial: 35¢/month, 3-year lease term ($12.60 total)

Customers are billed for Smartlights on their monthly electric bills.

The net savings is about $50.00 per Smartlight over its 10,000-hour lifetime. CFLs last about seven times longer than incandescent bulbs, reducing the time and expense of frequent bulb replacements.

Sale of used Smartlights
Used Smartlights are available from BED for $3.00 plus tax. The used bulbs come with a one-year guarantee that BED will replace the burnt-out bulb with a comparable used bulb.

Source: http://www.burlingtonelectric.com/EnergyEfficiency/smart.htm

New Construction Lighting Programs

Energy organizations also incorporate lighting technologies into their comprehensive new construction programs as shown in Table 18. The Environmental Protection Agency (EPA) has even developed a guidebook designed to assist program implementers in approaching builders, distributors, and lighting vendors to install energy efficient lighting in new homes.

Table 18: Summary of New Construction Programs

Utility	***State***	***Utility Type:***	***Single Family Builders***	***Single Family Owners***	***Multi -family***	***Fixtur es***	***Torch-ieres***	***Ceiling Fans***	***Delivery Method***
Seattle City Lights Build Smart Program	WA	Municipal			X	*X*			Rebate: $25.00/fixture- up to 4 fixtures per home
Portland General Electric Earth Advantage Program	OR	IOU	X			*X*	X		Rebates for Energy Star fixtures
Vermont Energy Star	VT	State Agency	X			*X*			Energy Star Ratings- must install 4 fixtures in moderate to high use locations: Rebate up to $1,800.00 per home.
SMUD New Home Lighting Efficiency Program	CA	Municipal	X			*X*			Rebate: $25.00/fixture up to 4 fixtures per home
New England Energy Star Homes	MA	State Agency	X						Rebate up to $900.00/home based on HERS compliance
Wisconsin Energy Star Homes	WI	State Agency		X		*X*	X	X	Rebates of $10.00-$20.00 for energy efficient lighting installed in new home.
New Jersey Energy Star Homes	NJ	State Agency		X		*X*			Rebates: $30.00 for each recessed can; $20.00 for other energy efficient fixtures

Source: Vrabel, Zugel, Grady-Hoye, & Banwell, 2002.

As the previous table shows, these new home construction programs are designed to increase the installation rates of energy efficient fixtures. Most programs rely on some type of rebate to defray the high costs associated with purchasing energy efficient fixtures.

6. Key Findings and Recommendations

The literature review identified the following key findings based on the analysis of the residential lighting market.

1. Even though energy efficient lighting has been available for more than two decades, standard incandescent bulbs are installed in 85 percent of all lighting fixtures in the U.S.

2. Residential lighting accounts for a significant portion of a household's total energy usage. Estimates vary among the national and regional studies, however, on average lighting accounts for 13 percent of residential energy use.

3. The average American home has approximately 41 lighting sockets in 21 fixtures. However, the critical issue is not how many lights are installed in a typical home, but rather the *frequency of use* by these lights (Siminovich and Mills 1995) reported that between 20 and 30 percent of all lighting sockets may account for as much as 70 to 80 percent of all lighting used in a home.

4. Significant barriers still remain to installing energy efficient technologies, such as CFLs and HIRs. The high first cost of energy efficient lighting makes a whole-house energy lighting change-out costly.

5. Customers still rely on energy organizations to provide information and funding to promote the installation of energy efficient lighting and to determine the best applications for these technologies.

6. Utilities can achieve significant load reductions in winter-peaking hours due from residential lighting programs promoting CFL bulbs and hard-wired fixtures.

Recommended Strategies

The literature review also identified some recommended program strategies for DMEA to consider.

1. Winter-peaking utilities, such as DMEA, would benefit from a residential lighting program. However, impacts from these load reductions would have to be monitored closely in order to accurately track savings.

2. The most successful lighting strategy is to target high use areas where bulbs are used for at least three hours per day. Targeting the most commonly used lamps in a household would lead to the most significant energy savings at the lowest installed costs. These high use areas include kitchens, outdoor lights, torchieres, and task lighting.

3. Another potential strategy to increase installation rates of CFLs is to target them for replacement in "hard to reach" applications such as high ceilings. These may be an effective second-tier strategy to maximize energy savings.

4. Effective lighting programs can be offered to residential customers in a variety of ways. DMEA should identify which approach would be most effective with its members and move forward with a pilot program in 2004 or 2005.

5. CFLs offer significant savings opportunities for residential users; however other lighting technologies also offer savings as well. DMEA needs to determine which lighting technologies it wants to focus on in the program, and which ones to exclude for the time being.

6. DMEA should consider partnering with a lighting manufacturer, such as TCP, that offers a comprehensive product line designed to meet all residential customer lighting needs.

7. To reduce the administrative cost and overhead burden, DMEA may want to consider entering into third-party agreements with either lighting vendors and/or third-party administrators to implement the lighting program and fulfill member orders. These relationships would provide DMEA an opportunity to offer members lighting products at competitive prices, without taxing additional internal resources.

Next Steps

Before initiating a residential lighting program, DMEA needs to complete the following steps:

1. **Determine the lighting program's size and scope.**

This includes identifying the most appropriate equipment to be included, the amount of funding available for a residential lighting program, and identifying appropriate deployment strategies, including potential partnership strategies. These issues will be developed in DMEA's Residential Lighting Implementation Plan, due to be completed by September 2004.

2. Establish Budget/Set Aside Funds to Obligate

Next, DMEA needs to establish a budget to fully account for both the anticipated program and administrative costs and the amounts of funds required for initial program implementation. These estimated costs will be identified in the Implementation Plan.

3. **Develop a strategy for estimating load reductions attributable to the lighting program.**

Since measuring actual savings from residential lighting reductions would be difficult, DMEA needs to develop a Lighting Savings Model to estimate these savings. This Lighting Savings Model will be completed by the end of July 2004.

4. **Identify benchmarks for effective program management and evaluation**.

The Lighting Implementation Plan will identify the appropriate benchmarks for success, specifically installation rates, participation targets, and increases in member awareness of residential lighting technologies.

5. Plan Marketing Campaign and Program Launch

The final step for DMEA is to develop and launch its marketing campaign. This campaign should target DMEA's high-use residential members. DMEA should use its existing promotional tactics, including radio spots, direct mail, and print ads, to generate program awareness regarding residential lighting applications for DMEA employees and members.

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