Are we done yet? An assessment of the remaining barriers to increasing compact fluorescent lamp installations and recommended program strategies for reducing them

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Abstract
Residential energy efficiency lighting programs in active regions of the United States have been successful in dramatically increasing compact fluorescent lamp (CFL) purchases over the last decade – where currently a majority of households have one or more CFLs installed. However, in these regions CFLs are used in less than 10 percent of residential lamp sockets, and much untapped energy savings potential remains.

Consumers in these active regions with CFLs already installed could expand their existing CFL installations by a factor of five. The reasons that they are not doing so include waiting for incandescent bulbs to burn out, issues with CFL performance, the need for specialty CFLs (which are expensive and not widely available) and the higher cost of CFLs.

Programs in these active regions should consider the following recommendations for increasing CFL installations: encourage consumers to retrofit more CFLs and not to wait for incandescent bulbs to burn out; track and address CFL performance issues for the range of CFL products; broaden program strategies to address specialty CFLs; expand incentives to year-round and to more stores and products; and track market barriers at both the household and lamp socket level.

In regions of the United States or countries with emerging residential CFL programs, program planners should consider the following recommendations: research the lighting market and introduce program strategies within existing market channels; focus first on the most basic style of CFLs that are designed to replace standard incandescent bulbs and move to specialty CFLs later; and track and monitor product quality from program inception.

Introduction
Even after years of residential lighting program activities and market progress, compact fluorescent lamps (CFLs) are installed in less than 10 percent of residential lamp sockets even in the most progressive regions of the United States. Thus, a great deal of residential CFL energy savings potential remains. What technical and market barriers exist to expanding CFL saturation and realizing the remaining potential? How should mature residential lighting programs address these remaining barriers? How can emerging residential lighting programs learn from mature programs and where and how should their resources be focused?

Background
Residential energy efficiency lighting programs have been active in the United States since the 1980s. In their early incarnations, electric utilities[1] gave out or directly installed CFLs in households at no cost to their residential customers. Later, some utilities mailed CFL coupons or sold CFLs direct to customers via energy efficiency mail or Internet catalogs.

1. These programs were typically a part of a larger Demand-Side Management portfolio. In some regions of the country, Demand-Side Management programs are funded by taxes on electricity and/or gas bills. Programs may also be funded as a cost-effective alternative to new supplies of energy. Not all regions or states of the country have DSM programs. The federal government has its own energy efficiency programs, which are administered by the Department of Energy.

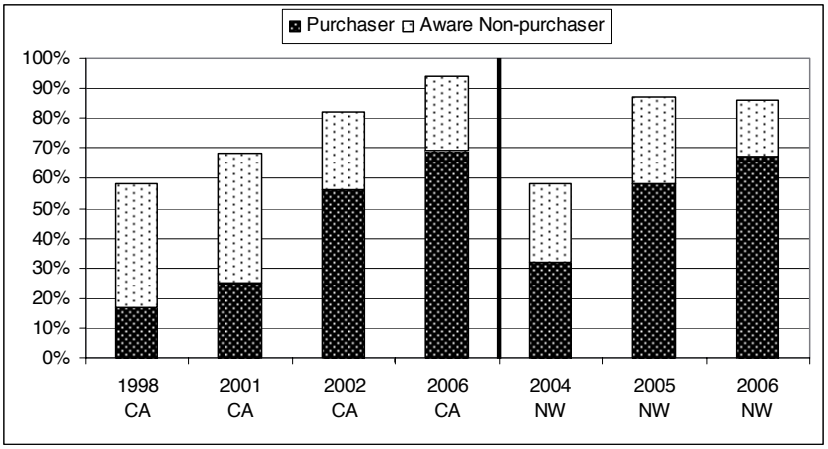

Figure 1. Consumer Awareness and Purchases of CFLs in California and the Northwest from 1998 – 2006. (Sources: Itron and KEMA 2007, KEMA 2007, KEMA-XENERGY and Quantum Consulting 2003, XENERGY 2002) 1998 n=334, 2001 n=721, 2002 n=1,001, 2004 n=1,530, 2005 n=560, 2006 NW n=667, 2006 CA n=1,000

By the late 1990s, energy efficiency programs in the more active regions of the country underwent a shift in design.[2] Instead of focusing on merely achieving energy savings, programs were intended to transform markets for energy-using equipment, such that markets would experience lasting change and the need for programs would eventually cease. Program design in these regions was informed by market research studies that assessed how markets operate and where barriers to the installation of energy efficient equipment exist. Program strategies in turn were designed to address a broad range of market barriers, with specific interventions addressed to market participants such as manufacturers, distributors, retailers and consumers. [Eto et al 1996]

In the case of residential lighting, managers of these newer market transformation programs focused first on manufacturers, encouraging the expansion of efficient lighting (mainly CFLs) product production, greater diversity of CFL products, and reduced cost. Many programs paid incentives directly to manufacturers. Later, programs shifted their focus to retailers – providing salesperson training, advertising support, and incentives to reduce product cost (via coupons or point-of-sale retailer discounts). Collectively, these program strategies represented a shift from prior strategies by working through existing market channels and with active market participants such that market changes would be felt long after program strategies were removed. [Rasmussen et al 2003]

This paper focuses on two regions of the country where residential lighting programs have been active for many years and the share of CFL sales to overall lighting sales is among the highest – the state of California and the region of the Pacific Northwest (comprised of 4 states: Oregon, Washington, Montana and Idaho). In California, the California Public Utilities Commission and the major investor-owned utilities[3] have sponsored residential lighting programs since the 1980s. In the Pacific Northwest (or Northwest), the Northwest Energy Efficiency Alliance has sponsored market transformation initiatives including some that address residential lighting in conjunction with utilities in the region for the last decade.

Increasing Household CFL Awareness and Purchases

In the early years of residential lighting programs, program success was typically measured by the number of CFLs delivered or installed. Later, as a reflection of the goals of market transformation, program success was measured in terms of market participants. Two key metrics that have been tracked over the last 5 to 10 years in order to assess CFL program success are the percentage of households that are aware of and have purchased CFLs. Changes in these metrics over time may reflect the success of various program strategies, such as consumer education and manufacturer and retailer incentives.

Figure 1 shows data from several phases of market studies that were conducted in both California and the Northwest from 1998 to the present day. In 1998, when market-based programs were first launched in California, CFL awareness was at 58 percent and CFL purchases at 17 percent of households. Three years later, CFL awareness had climbed to 68 percent and the purchase rate to 25 percent. By 2002, the CFL purchase rate had soared to 58 percent – a reflection of increased program resources and enhanced consumer concern about saving energy as a result of the state's energy crisis from 2000-2001. [Calwell and Zugel, 2003]

CFL awareness and purchase rate trends are similar in the Northwest. In 2006, 86 percent of consumers in the Northwest were aware of CFLs and 67 percent had reportedly bought them.

CFL programs in these regions have been successful in contributing to the increase in households that are buying CFLs relative to inactive regions of the country.[4] But to what degree do purchasing households retrofit their lighting stock to CFLs?

2. In 1997, the California Public Utilities Commission declared that the purpose of energy-efficiency programs should be to transform the markets for energy-efficient goods and services so that individual customers and suppliers in the future competitive market will make more rational choices.

3. Pacific Gas and Electric Company, Southern California Edison Company and San Diego Gas and Electric Company.

4. Additional factors likely played a role as well, including the California energy crisis of 2001, increasing consumer awareness and acceptance of CFLs and wider availability of CFLs. However, CFL sales per person in California and the Northwest exceeded those of other regions of the United States during this same time period. [Itron 2006, ECONorthwest 2004 and KEMA 2007.]

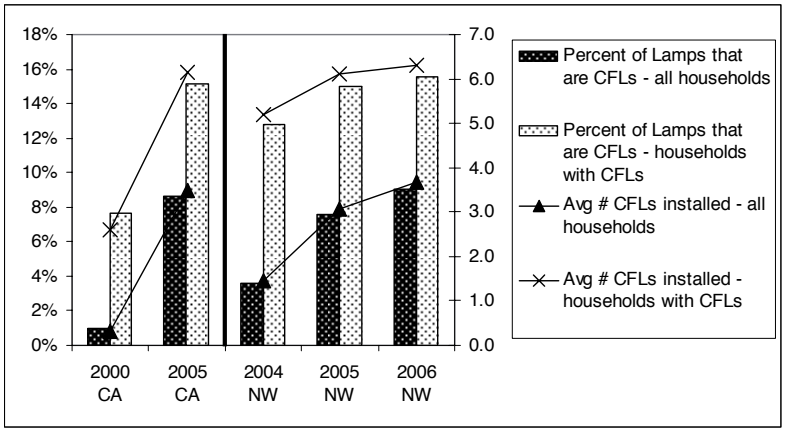

Figure 2. CFL Saturation in California and the Northwest from 2000 to 2006. (Sources: RLW 2005, KEMA 2007) 2000 n=1,083 on-site surveys, 2004 n=1,530 telephone surveys, 2005 NW n=560 telephone surveys, 2005 CA n=806 on-site surveys, 2006 n=667 telephone surveys

Is it enough to track the CFL purchase rate (i.e., the percentage of households that have purchased at least one CFL), or should program planners and evaluators also focus on the average number of CFLs installed per household? The next few sections of this paper explore the depth of barriers to expanding CFL installations among purchaser households.

CFL Saturation

Figure 2 shows the average percentage of lamp sockets that are filled with CFLs (the CFL saturation) from 2000 to 2006 among California and Northwest households. The chart shows CFL saturation for all households as well as only households with CFLs. In 2000, 12 percent of households in California had CFLs installed[5], with an average of 3 CFLs installed per home (of 34 total lamps) – for a CFL saturation of 8 percent for CFL households and 1 percent across all households. By 2005, 57 percent of California households had CFLs installed, with 6 CFLs installed per home (of 41 total lamps) – for a CFL saturation of 15 percent for CFL households and 9 percent across all households. The Northwest in 2006 was very similar to California in 2005, with a CFL saturation of 16 percent for CFL households and 9 percent across all households. While these trends show great progress, they also indicate great untapped potential.

CFL Technical Potential

As shown in Figure 3 below, the remaining 91 percent of lamp sockets (that are not filled with CFLs) in California households as of 2005 is comprised mostly of incandescent bulbs. There exists a CFL for practically every incandescent application imaginable – from the basic A-line bulb to candelabras and 3-way and dimmable bulbs[6]. But the major increase in CFL sales over the last 5 years has been predominantly from the twister-style CFL, which is designed to replace a standard incandescent bulb. This type of bulb is currently globally manufacturered on a large scale and available in some markets for $ 1 per bulb or less [Itron and KEMA 2007]. In California and the Northwest, these CFLs are available not just in home improvement/hardware stores, but also in a wide variety of mass merchandise, small hardware and drug and grocery stores in metro and non-metropolitan areas alike [Itron and KEMA 2007 and KEMA 2007].

In 2005, about 37 percent of lamps in California homes were standard incandescent – many of which could be replaced with the cheap and ubiquitous twister-style CFL.[7] Another 38 percent of bulbs (specialty incandescent bulbs such as flood, globe and reflector) could be replaced with specialty CFLs, but those bulbs are much more costly, much less available and not a tried and true technology like twister-style CFLs [Itron and KEMA 2007 and KEMA 2007].

Below, we discuss barriers to increasing CFL saturation among CFL households (i.e., homes that already have CFLs installed) and non-CFL households.

Potential for Increasing CFL Saturation among CFL Households

The majority of Northwest and California CFL households first bought CFLs prior to 2004 [KEMA 2007 and Itron and KEMA 2007]. Thus, we could consider the current CFL saturation the extent to which the majority of CFL households will retrofit their household with CFLs. Indeed, the majority of Northwest CFL households are storing CFLs – on average 6 each[8] [KEMA 2007]– suggesting that stored CFLs are intended for bulbs that

5. Note that the percentage of households with CFLs installed is typically lower than the percentage of households who have purchased CFLs because not all purchaser households will have CFLs installed at the time of a survey. (Some will have removed them or not yet installed them.)

6. Refer to http://www.energystar.gov.

7. Even though twister-style CFLs are very small and approximate the size of a standard incandescent bulb, there are some fixtures that take standard incandescent bulbs where even a twister-style CFL will not fit.

8. Many retailers sell CFLs in multi-packs of 4 or more bulbs, and often the multi-pack bulbs are promoted while single CFLs are not. This likely leads to a high number of CFLs being stored.

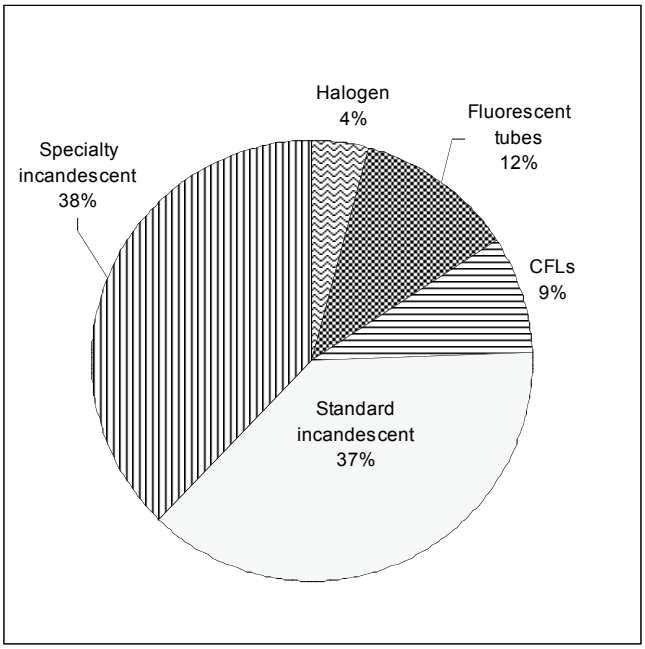

Figure 3. Distribution of Residential Lamp Sockets, California 2005. (Source: RLW 2005 n=847 onsite surveys)

burn out in the future (CFLs or incandescents), and that any new CFLs purchased are not intended for retrofit.

Figure 4 below shows the main factor preventing Northwest CFL households from installing more CFLs. As shown, the most common factor cited by respondents (note that respondents were not prompted with a list of factors) is waiting for incandescent bulbs to burn out.[9] Ten percent of CFL households feel that CFLs cost too much and 13 percent of households need specialty bulbs that work in 3-way or dimmable applications. We would expect this percentage to rise in the future as CFL saturation increases and more standard incandescent bulbs are replaced, leaving mostly specialty applications.

One-third of Northwest CFL households mention an aspect of CFL performance (their fit, brightness or color and delay in lighting up) as preventing them from expanding their CFL installations. Based on independent CFL testing results conducted by the Program for the Evaluation and Analysis of Residential Lighting (PEARL), one third of CFLs that are ENERGY STAR rated fail at least one of the four tests required for compliance with ENERGY STAR. [Titus et al 2005.] As such, it is not surprising that some consumers are dissatisfied with CFL performance. However, Northwest CFL households are much more generous about their satisfaction with the performance of CFLs that they already have installed – with only 13 percent giving a rating of 5 or less on a 10 point general satisfaction scale (where 10 means "very satisfied" and 1 means "not at all satisfied"). [KEMA 2007] These results suggest that consumers may be willing to accept certain CFL performance issues for some of their fixtures (e.g., the fixtures where they have them installed now) but not all of them (e.g., fixtures that could accept them now, but where they are not installed). Consumers may be installing their first few CFLs in their highest use or out of the way fixtures or in multi-purpose applications, whereas remaining applicable fixtures may have more prominence in the home or be used for specific applications.

9. Even though incandescent light bulbs burn out much faster than CFLs, CFL households are likely to have installed CFLs in the higher use fixtures, such that remaining incandescent bulbs take longer to burn out.

Potential for CFL Purchases among Non-CFL Households

AWARE NON-PURCHASERS

As of 2005, about 20 percent of Northwest households were aware of CFLs yet had never purchased or installed them (from Figure 1 above). Figure 5 below shows the main factor preventing these "aware non-purchasers" from installing CFLs. The most commonly cited factor is that CFLs are too expensive (33 percent). Nearly one-quarter would likely install a CFL after an incandescent bulb burns out. Twenty-two percent have issues with an aspect of CFL performance (their fit, brightness or color and delay in lighting up) and 6 percent are in need of specialty CFLs (3-way or dimmable).

UNAWARE

As of 2006, 14 percent of Northwest households had never heard of CFLs (from Figure 1 above). A sample of these unaware households were provided with a description of CFLs and their current market conditions[10] and asked how likely they would be to buy CFLs in the next year. As shown in Figure 6, the majority gave a rating of 4 or a 5 on a 1 to 5 scale, with 1 being "not at all likely" and 5 being "very likely". These results suggest that there exists potential among this group for future CFL installations. However, it is uncertain how costly it will be to reach this group – given that CFL initiatives in both the Northwest and California have been designed to reach the mass market.[11]

Figure 7 shows the reasons given by respondents that gave a 1 or a 2 rating in Figure 6 indicating that they are unlikely to buy CFLs in the next year (note that respondents were not prompted with a list of reasons, and each provided one reason). As shown, most are happy with "regular bulbs" or are storing bulbs (presumably incandescent bulbs).

10. The CFL description read, "CFLs use two-thirds less energy than a standard bulb, and last up to 10 times as long. Some styles of CFLs are available for $ 2 or less – and they are about the same size and color as a standard bulb and can be installed in almost any fixture where you would put a standard bulb. They can be purchased at the same places you purchase standard bulbs, including some drug and grocery stores. CFLs save about $ 30 in electricity costs over the life of the bulb. By using less energy, CFLs also help the environment."

11. For example, in both regions, program strategies such as retailer support and incentives are aimed at drug and grocery and mass merchandise stores in both metropolitan and nonmetropolitan areas. These promotions are in addition to continuations of prior promotions aimed at traditional channels such as hardware and home improvement stores.

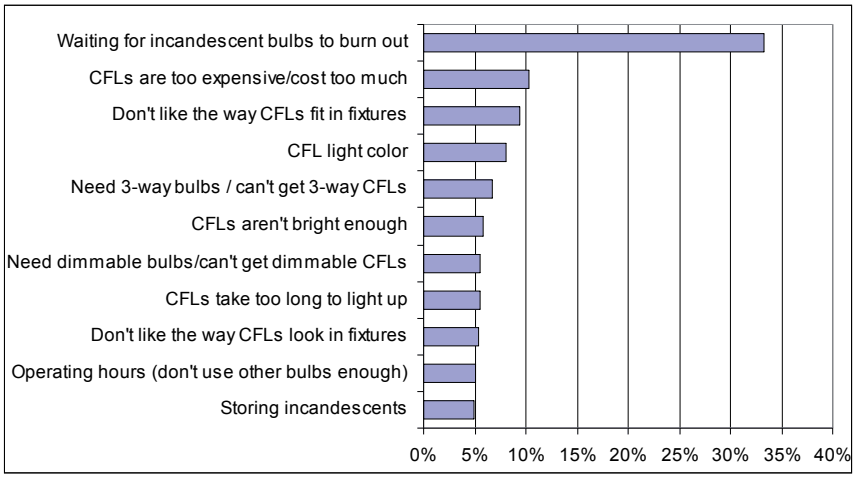

Figure 4. Main Factor Preventing Increased Saturation of CFLs Among Northwest CFL Households, 2006. (Source: KEMA 2007) n=327

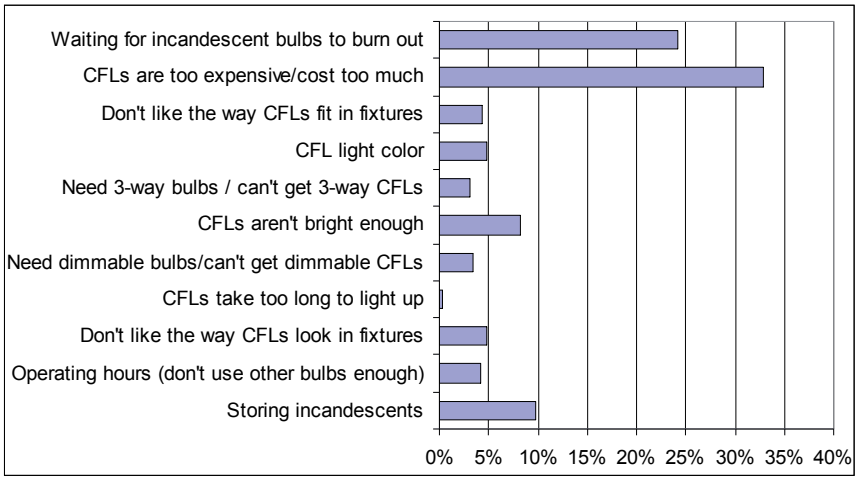

Figure 5. Main Factor Preventing Increased Saturation of CFLs Among Northwest Non-CFL Households, 2006. (Source: KEMA 2007 n=224)

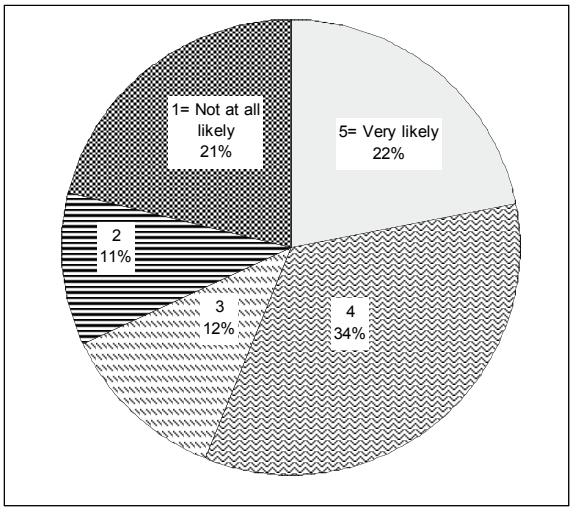

Figure 6. Likelihood of CFL Purchase Next Year Among Northwest Unaware Households who were Made Aware. (Source: KEMA 2007 n=76)

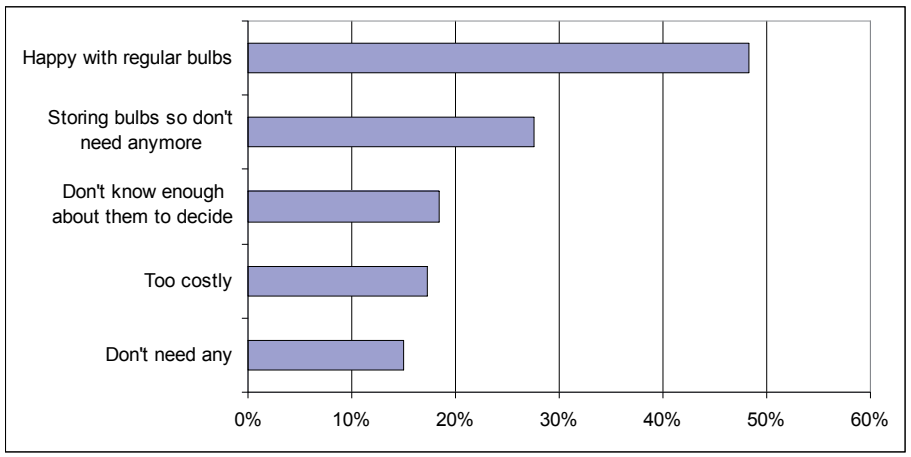

Figure 7. Reasons for being Unlikely to Purchase CFLs within the Next Year Among Unlikely Future Purchasers, 2006. (Source: KEMA 2007) n=27, multiple mentions allowed, so percentages sum to more than 100%

Conclusions

Residential market transformation programs in active regions of the United States have been successful in increasing the rate of CFL purchase. However, CFL saturation is still low and much untapped energy savings potential remains.

MEETING THE UNTAPPED CFL ENERGY SAVINGS POTENTIAL

About half of the untapped CFL energy savings potential can be met today with readily available and cheap twister-style CFLs (which replace standard incandescent bulbs). This style of CFL has been aggressively marketed across the United States and particularly in active regions such as California and the Northwest. These present conditions are a reflection of many years of residential lighting programs that worked through existing market channels to make CFLs more available, the product supply more diverse and the cost lower. The other half of untapped CFL energy savings potential cannot be met easily today, requiring specialty CFLs (to replace specialty incandescent bulbs and applications). These CFLs are more than twice as expensive as twister-style CFLs and typically stocked only by hardware, home improvement and lighting specialty stores or available via Internet specialty lighting web sites. Many residential CFL programs are beginning to shift their focus from twister-style CFLs to specialty CFLs in order to address the future need for a wide, diverse and cheap supply of specialty CFLs.

REMAINING MARKET BARRIERS IN ACTIVE REGIONS AND WAYS TO ADDRESS THEM

Some of the remaining market barriers to increasing CFL installations in active regions of the United States include:

- *Waiting for incandescent bulbs to burn out*. Even though most households only have a small fraction of their lamp sockets filled with CFLs, many do not plan to install more CFLs until their incandescent bulbs burn out. Fortunately, there is a high incidence of CFL storage and number of CFLs in storage, suggesting that many households will actually replace burnt-out incandescent bulbs with CFLs. However, program planners should take into account that each CFL purchase in a given year does not translate into a CFL installation in that year. It may take several years to realize the energy savings associated with CFL purchases from a given year.[12] Program planners might change their messaging to consumers by emphasizing the household and societal benefits from replacing 5-10 incandescent bulbs with CFLs rather than a single CFL in order to encourage more retrofits.
- *CFL performance issues*. Both households with CFLs and those without cite a range of CFL performance issues as reasons for not installing more/any CFLs. Moreover, there appears to be a disconnect between satisfaction ratings on CFLs that are already installed and potential satisfaction with installing more CFLs in additional fixtures. Residential CFL programs in the United States have collectively been addressing CFL performance over the last decade through the federal government's ENERGY STAR labeling program and the support of an independent quality testing body (such as the PEARL). These efforts should be continued and possibly expanded, especially as the market for specialty CFLs becomes more active. Likewise, programs should further educate consumers on how to select the appropriate CFL for various applications. The most efficient and effective way to do so may be through encouraging retailers and manufacturers to develop and enhance product packaging and retailer promotional materials.
- *The need for specialty CFLs*. While not a major barrier now since so many standard incandescent lamps are still in use, in the near future the need for and lack of availability and high cost of specialty CFLs could become more of a barrier to expanding CFL installations. A small fraction of CFL households are not installing more CFLs because they need them in 3-way or dimmable fixtures or other fixtures that do not readily accept CFLs (including standard incandescent lamps where twister-style CFLs do not fit). CFLs

12. Program planners in California, the Northwest and other active regions of the United States are increasingly aware of and concerned about the high incidence of CFL storage because of its effect on short-term program energy savings. In response, some programs such as the Wisconsin Department of Administration's Focus on Energy have capped the number of CFLs per purchase that are covered by promotions. [Mapp et al 2005] Also, most regions are tracking CFL storage over time in order to understand what factors contribute to it, to control for it by modifying program strategies and to measure market response to program changes.

are presently produced to fit almost every incandescent application, yet they are not widely available, are very expensive and both consumers and retail salespeople are not yet comfortable with the new technology. Residential CFL program planners, if they have not already, should expand their programs to address the broad range of specialty CFLs. It is likely that this class of CFLs will need as much attention as the market for twister-style CFLs, which took many years of support (in active areas of the country) to get to over a 50 percent rate of purchase.

- *Lack of awareness*. While not a major barrier, even in the most active regions of the country there are still around 10 percent of households that have not yet heard about CFLs and thus have not installed any. In both California and the Northwest, programs have addressed the mass market by engaging with the full range of retailers that sell lighting products (including drug and grocery stores) in both metropolitan and nonmetropolitan areas. It is uncertain whether it will be cost-effective for programs to adopt new strategies to reach these remaining households.
- *CFL cost*. Even among households that have bought CFLs, the higher cost of CFLs as compared to incandescent bulbs is still a barrier to expanding CFL installations. It is also a barrier to households that have heard of CFLs but have not yet bought them. In both California and the Northwest, twister-style CFLs are often priced at $1 during promotions. However, promotions are not typically year-round (and are not targeted at every lighting store and every twister-style CFL model). In order to address the remaining 20 to 25 percent of households that have not tried CFLs (but who are already aware of them), it may necessary to expand program reach to cover more stores, more products and more months of the year.

PROGRAM FOCUS FOR REGIONS OR COUNTRIES WITH EMERGING RESIDENTIAL CFL PROGRAMS

The paper's authors considered whether some of the lessons learned over the course of the last decade implementing residential lighting programs in the United States could be generalized to other countries. Obviously, consumer attitudes and awareness levels, lighting supplier market conditions and even the types of lighting fixtures being used may be different than those of the United States. We developed a short list of recommendations that we feel would likely apply in a broad array of contexts.

- *Use market-based approaches*. Working within existing market channels is important to generate lasting market change. Often, it may be useful to conduct market research studies to understand the market players and distribution channels. [PNNL 2006] It may be most effective to initiate contact with lighting manufacturers, since there are fewer of them (than retailers or consumers). Next, a program might focus its resources on retailers – by offering incentives and/or product promotional support.
- *Focus on twister-style CFLs first*. As mentioned previously, this style of CFL is already produced at a very large-scale across the globe, and may be used to replace standard incandescent bulbs, which likely are the predominant style of bulb in residential fixtures. Once the twister-style CFL becomes widely available and cheap, consider shifting focus to specialty CFLs.
- *Monitor product quality*. Consumers' negative perceptions of CFLs or even fluorescent lighting can derail a CFL program. It is important that there exist some mechanism for tracking and ensuring CFL product quality from the very start of the program. It is better to start slowly and ensure good consumer experiences than to flood the market with cheap and poorly performing products. Likewise, it is imperative to educate consumers on how to select and use CFLs in their homes.

TRACKING OF MARKET BARRIERS AT BOTH THE HOUSEHOLD AND SOCKET LEVELS

In order to aid future program planning and program design, the authors of this paper recommend that program planners and evaluators track not only households (e.g., CFL purchase and awareness rates) but also CFL saturation.[13] Furthermore, the assessment of market barriers should be done not only at the household level but also at the lamp socket level. Households may be willing to retrofit a few but not all incandescent bulbs. From there, they may wait for the remaining incandescent bulbs to burn out, or there may be fixture-specific barriers that prevent them from replacing additional lamps such as the need for 3-way or dimmable CFLs. Likewise, CFL performance issues (such as fit, color, brightness, etc.) may not be a barrier for the first few CFLs that a household installs – but may be obstacles to replacing additional incandescent bulbs for that same household (e.g., specific applications where brightness or color matters).

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13. Some have argued that tracking CFL saturation alone is a cheap and effective way of measuring market progress [Kates et al 2005]. This paper argues that the combination of household and saturation data, including the assessment of barriers, is important to measure market progress and inform future program design.

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Glossary

Aware non-purchaser household: A household that is aware of CFLs but has not bought any to-date.

CFL: Compact fluorescent lamp

CFL saturation: The percentage of lamp sockets that are filled with CFLs across households. CFL saturation may also be expressed in terms of the average number of CFLs that are installed per household. The base of the calculation could be all households or just households with CFLs.

CFL household: A household that has at least one CFL installed.

CFL purchaser: A household that has bought a CFL at some time in the past. This same household may or may not have CFLs presently installed.

ENERGY STAR: A joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that aims to help residents save money and protect the environment through energy efficient products and practices Certain household products are eligible to earn the ENERGY STAR if they meet strict energy efficiency guidelines set by the Environmental Protection Agency and US Department of Energy. See http://www.energystar.gov.

Market transformation: Market transformation is a strategy that promotes the manufacture and purchase of energy-efficient products and services. The goal of this strategy is to induce lasting structural and behavioral changes in the marketplace, resulting in increased adoption of energy-efficient technologies. See http://www.cee1.org/cee/mt-primer.php3.

Northwest Energy Efficiency Alliance: The Northwest Energy Efficiency Alliance (NEEA) is a non-profit corporation supported by electric utilities, public benefits administrators, state governments, public interest groups and energy efficiency industry representatives. These entities work together to make affordable, energy-efficient products and services available in the marketplace. See http://www.nwalliance.org.

PEARL: The Program for the Evaluation and Analysis of Residential Lighting (PEARL) is a watchdog program. It was created in response to complaints received by utility program managers about the performance of certain ENERGY STAR lighting products being promoted within their service territories and the lack of a self-policing mechanism within the lighting industry that would ensure the reliability of these products and their compliance with ENERGY STAR specifications. To remedy these problems, PEARL purchases and tests products that are available to the consumer in the marketplace. See http://www.lrc.rpi.edu/programs/PEARL/index.asp.

Twister-style CFL: A style of CFL that is bare (i.e., not enclosed) and characterized by a twisted circular tube, usually about the same size as a standard incandescent lamp.