United States Environmental Protection Agency

NEXT GENERATION LIGHTING PROGRAMS:

Opportunities to Advance Efficient Lighting for a Cleaner Environment

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EXECUTIVE SUMMARY

Approximately three out of four light sockets in the U.S. still contain inefficient light bulbs. These inefficient light bulbs consume approximately 200 billion kWh per year, resulting in over 140 million metric tons of CO_2 emissions.

Programs promoting compact fluorescent lamps (CFLs) have made significant strides; cost effective energy savings from CFLs have been enormous over the last 20 years. However, more than 70% of screw base sockets are still occupied with inefficient bulbs. The implementation of the Energy Independence and Security Act (EISA) will improve things some, but it will not cause a dramatic shift to more efficient lighting. Going forward, CFLs will continue to play an important role in efficiency program energy savings, but will need to be steadily joined by a set of complementary technologies, each suited to particular applications and situations, to form a portfolio of lighting solutions to fill the vast number of remaining sockets.

Residential lighting programs will continue to offer cost-effective savings well into the future.

New federal standards will reduce the net energy savings from rebating a CFL, but incremental costs (and average rebate amounts) will also drop because the new baseline halogen incandescent bulbs will be more expensive than today's inefficient bulbs. Next generation lighting programs will be more expensive than yesterday's CFL programs, but they will still offer cost-effective residential energy efficiency savings well into the future. These new programs and technologies are essential in order to fill the remaining, harder to reach, lighting applications and sockets.

LED reflector bulbs represent a new opportunity for efficiency programs.

The list of ENERGY STAR® qualified LED light bulbs is currently dominated by reflector bulbs because LEDs are inherently directional light sources. Unlike CFLs, the ability of LEDs to focus light in a given area makes them an appealing technology for directional applications. While LED bulbs cost more than incandescent bulbs, the incremental cost of replacing an incandescent reflector bulb with an LED reflector bulb is lower than the incremental cost of replacing a general purpose incandescent bulb with a general purpose LED bulb. For example, a traditional incandescent general purpose bulb costs $0.50 or less, while today's incandescent reflector bulbs can cost up to $10 each. Today, both LED reflector and general purpose bulbs cost $30 or more. A rebate for an LED reflector bulb will bring the retail price closer to the comparable incandescent reflector bulb than it would for a general purpose bulb. Substantial rebates are needed to help consumers migrate to ENERGY STAR qualified LED reflector bulbs, at least for the next several years; however, the long lifetimes of LED bulbs yield large

energy savings and improve the cost-effectiveness for the measure. After gaining some experience with LED reflector bulbs, efficiency program managers may also design programs for general purpose, omnidirectional LED bulbs as they increase in quality and availability.

Future lighting programs should use a portfolio approach to incorporate a variety of efficient lighting technologies in addition to CFLs.

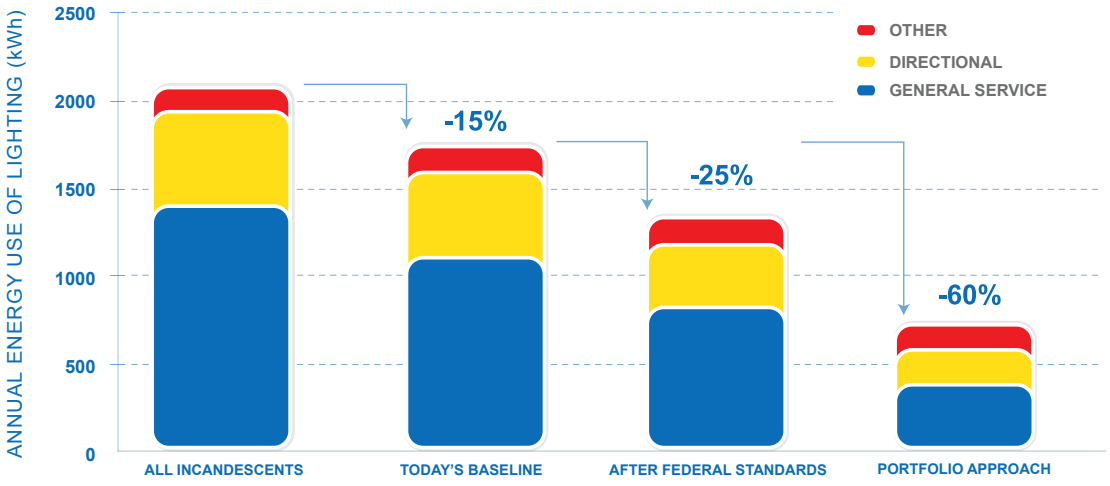
Since nearly three out of four sockets, nationally, contain inefficient light bulbs, a comprehensive approach will be needed to fill these remaining sockets with efficient bulbs. CFL programs have served us well, but they can only go so far, and now there are new technologies and program approaches that are needed to capture the remaining potential. Specialty CFLs, LED bulbs and advanced incandescent bulbs all represent opportunities going forward. A single bulb technology should not be promoted above others; instead, programs should seek to provide a range of efficient lighting solutions that will meet a wide variety of consumer needs.

Increased budgets for consumer education will be needed to mitigate consumer confusion.

New standards coming into force and new technologies promoted by efficiency programs mean that consumer confusion will be high even with new Federal Trade Commission (FTC) labeling requirements, which focus on lumens instead of watts. Efficiency programs can play a critical role in ensuring consumers get the right bulbs in the right sockets. Programs can take advantage of existing consumer education materials, or develop their own. Increased consumer education and awareness will minimize consumer frustration when shopping for light bulbs, and maximize adoption and persistence of new technologies.

Significant savings remain in the market.

By incorporating new technologies into new program approaches, efficiency programs can cut residential lighting energy use in half over the next decade—saving more energy than CFLs have saved over the last 20 years. If lighting energy consumption is cut in half in every household in the United States, more than $13 billion a year in energy costs could be saved, more than 80 million metric tons of CO_2 emissions would be avoided each year, and the need for over 30 power plants could be eliminated.



INTRODUCTION

This report was compiled to highlight the remaining opportunities for energy efficient light bulbs (lamps)[1] in the U.S. The information here can be useful to inform energy efficiency advocates including state regulators, efficiency program managers, utilities, and others about the changing lighting landscape and the opportunities for additional efficiency gains. There are several factors in play now, which make designing and planning lighting programs both interesting and challenging. Just a handful of the drivers changing the U.S. lighting market are: fluctuating CFL annual sales, minimum efficiency standards for general service and reflector lamps, emerging lighting technologies such as LED and advanced incandescent, and consumer confusion about all the above.

After many years of running successful CFL rebate programs, efficiency program managers and their regulators across the country are considering whether these programs should continue, and if so, what they should look like. New light bulb standards will begin to take effect in 2012 that many incorrectly believe will mandate the use of CFLs. These new standards, combined with the facts that most U.S. homes now have at least one CFL and LED bulbs are increasing in availability, are raising questions about the future of residential lighting programs.

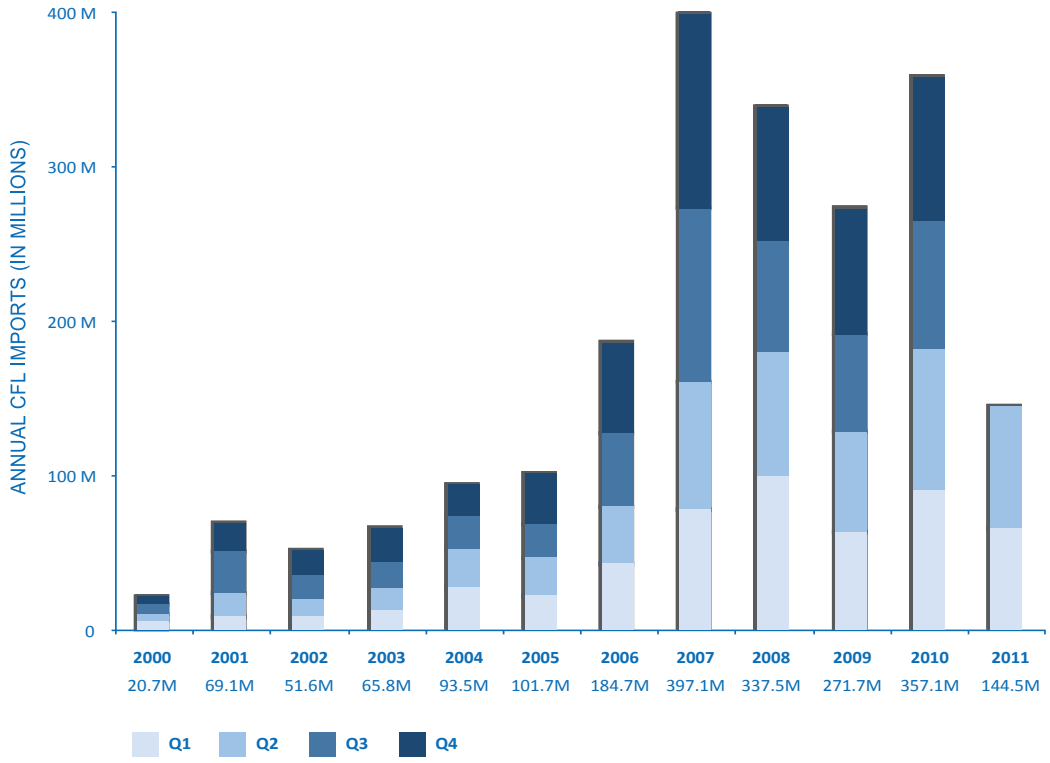
Residential lighting programs can continue to generate significant savings well into the future. To do so, these programs must be redesigned to accommodate changing efficiency standards and technologies. CFL-only programs are quickly becoming a thing of the past. Going forward, next generation lighting programs should use a portfolio approach that promotes a wide variety of efficient light bulbs. A diverse offering will enable programs to reach sockets that today, even after years of CFL program efforts, remain filled with inefficient incandescent light bulbs.

Preliminary discussions with efficiency program managers have generated excitement about the portfolio approach concept and the remaining potential for lighting programs to save energy. A number of questions remain. This report provides basic guidance on specific areas of uncertainty and a starting point for further research.

Is there still a role for efficiency programs to promote CFLs?

Yes. Years of energy efficiency program intervention have made nearly all Americans aware of CFLs and most have at least one in their home. Recent import data suggests that CFL sales rebounded in 2010 after experiencing a 30% decline during 2008 and 2009 when compared to the record number of CFLs sold in 2007. However, CFL imports during the first quarter of 2011 are lower than first quarter imports in 2007, 2008 and 2010. See **Figure 1**.[2] Promotions clearly have had an impact on sales of CFLs, especially over the past five years. Removal of those incentives will have a negative impact on CFL market share. The most recent report from the National Electrical Manufacturers Association (NEMA) supports the observation that CFL market

Figure 1. U. S. Screw-based CFL import data, 2000 – 2011 (through Q2)[3]



share is not increasing. Their most recent data set, for the first quarter of 2011, indicates that CFL market share dropped by 1.1%, while incandescent lamp sales increased by 1.1%. Incandescent lamp sales now represent 79% of sales, while CFLs represent 21% of sales.[4]

Particular regions and utilities that have been aggressively promoting CFLs for decades have achieved socket saturations of more than 30%. Despite the successes of these CFL programs, nationwide nearly 70% of the sockets capable of housing a CFL remain filled with inefficient incandescent bulbs.[5]

A number of factors may explain why CFL sales are not increasing dramatically to fill those sockets:

- Most consumers prefer incandescent bulbs in dimmable sockets because many CFLs do not dim at all and "dimmable" CFLs are larger, more expensive, and do not always dim in a way that is pleasing to consumers.
- Some consumers dislike the small amount of mercury in the bulbs because they are worried about in-home breakage, landfill impacts, or the effort associated with recycling.[6]
- CFLs have a slow warm-up time compared to incandescent bulbs.
- Some CFLs have a different color appearance than incandescent bulbs.
- Some higher wattage CFLs are too large to fit in fixtures, and the "pig tail" appearance is not attractive in fixtures with exposed bulbs.
- Incandescent bulbs are cheaper to buy than CFLs, even though CFLs save money over the life of the product due to energy savings and additional incandescent bulb replacement costs.

For these and other reasons, incandescent bulbs continue to fill the majority of sockets in U.S. homes. Going forward, while there will be product improvements such as faster run up times, shatter-resistant coatings, enhanced color, and improved dimming, most of these barriers will persist, presenting significant opportunities for promotions designed to overcome them. CFLs clearly meet the needs of many users in many applications, but not the needs of all users in all applications.

Won't the new lighting standards require everyone to use CFLs?

No. Many people think the new federal light bulb standards will ban incandescent bulbs, leaving only CFLs and maybe a few LED bulbs available to consumers. This is not true.

In 2007, the U.S. Congress passed the Energy Independence and Security Act (EISA) which included efficiency standards for general purpose light bulbs. It also required the U.S. Department of Energy (DOE) to set efficiency standards for reflector bulbs. Neither standard bans incandescent bulbs, but they both establish minimum efficiency requirements that are higher than traditional incandescent bulbs can meet. Manufacturers have responded early. Today, many new incandescent bulbs using halogen technology meet the laws' requirements and are already available in stores.[7]

EISA divides household bulbs into four light output (lumen) ranges designed around today's typical incandescent bulbs—40 W, 60 W, 75 W and 100 W. Then, the law specifies a maximum wattage limit for each of the ranges. See **Table 1**.

All major lighting manufacturers now produce halogen incandescent bulbs that they advertise as EISA compliant. These bulbs are available at major retailers including The Home Depot, Walmart, Lowe's Home Improvement and Amazon.com. EISA compliant halogen incandescent bulbs look, feel, and operate just like today's incandescent bulbs; they just do it slightly more efficiently. EISA compliant[7] incandescent bulbs are not as efficient as CFL or LED bulbs, but they are fully dimmable and work well with photo sensors and motion detectors. Today, these EISA complaint bulbs cost between $1 and $4 each; and a wide range of prices are expected given the differences in light output and efficacies. Prices are expected to drop further as these bulbs become more commonplace. See **Table 2** for two examples of EISA compliant halogen incandescent bulbs that are currently for sale in the U.S compared to today's typical incandescent 100 W bulbs.

Table 1. EISA requirements for standard spectrum general service bulbs relative to typical products

EISA Effective Dates	Typical Incandescent Replaced	Typical Incandescent Light Output	Typical Incandescent Efficacy	EISA Replacement	EISA Light Output Ranges	EISA Minimum Efficacy Ranges
1/1/12	100 W	1690 lm	17 lm/W	72 W	1490-2600 lm	21 – 36 lm/W
1/1/13	75 W	1170 lm	16 lm/W	53 W	1050-1489 lm	20 – 28 lm/W
1/1/14	60 W	840 lm	14 lm/W	43 W	750-1049 lm	17 – 24 lm/W
1/1/14	40 W	490 lm	12 lm/W	29 W	310-749 lm	11 – 26 lm/W

Table 2. Replacement options for today's 100 W bulbs

Examples of Non-Compliant Incandescent Bulbs	Examples of EISA compliant Incandescent Bulbs
	
1,600 – 1,710 lumens	1,490 – 1,600 lumens
100 W	70 – 72 W
16 lumens/watt	20.7 – 22.9 lumens/watt
Standard incandescent	Halogen or halogen infrared reflective (HIR)[9]
~ $0.25 - $ 0.50/bulb	~ $1.00 - $4.00/bulb

Prices based on EPA Bulb Pricing Database, as of August 2011

While EISA's efficiency requirements target the general service light bulbs most commonly used by consumers, many types of rarely-used and specialty bulbs are exempt from the law. Three-way, shatter resistant, rough service, and vibration service bulbs are not covered initially, but DOE has the authority to apply efficiency standards to them at a later date if their sales increase substantially. Modified spectrum incandescent bulbs (which use blue/purple tinted glass to provide a different shade of white light) are covered by EISA, but they are allowed to meet a less stringent standard.

Another current exemption from EISA is for higher light output lamps (greater than 2600 lumens) which are represented today by 150, 200 and 300 W incandescent bulbs. Consumers may migrate to these higher wattage bulbs if they are seeking more light than minimally compliant 72 W bulbs provide. Manufacturers have recently introduced 150 W standard incandescent lamps that are just bright enough to exceed the lumen range currently covered by EISA. The consequence for energy efficiency program managers is that these bulbs present opportunities for consumers to continue to buy traditional incandescent technology instead of EISA compliant halogen incandescent bulbs. While the end result is not known, these bulbs are likely to erode some of the intended savings from EISA.

Another potential unintended consequence of EISA is that the introduction of EISA compliant halogen incandescent bulbs may cause some consumers to switch from CFLs to the less efficient EISA compliant bulbs. EISA compliant halogen incandescent bulbs are frequently advertised as "energy saving," and consumers are likely to be confused between the small savings these bulbs offer and the much larger savings that CFLs offer. For people who want to save energy but dislike CFLs, EISA compliant halogen incandescent bulbs are likely to be very appealing. For example, see the customer comment below, taken from Amazon.com[10] regarding an EISA compliant halogen incandescent light bulb.

"I love these bulbs! They are so bright. I hate those twist bulbs but wanted to switch to something that is energy saving. I love that they don't have mercury — I really feel like I am doing something for the environment!"

Customer review of EISA-complaint halogen bulb

Although the customer is clearly excited about the prospect of saving energy, she does not realize that the bulb she is reviewing is far less efficient than a CFL. The product's claim of 25% of energy savings persuaded this customer that this bulb is a suitable energy-efficient replacement for a CFL.

While the number of consumers who will choose the new EISA compliant halogen incandescent bulbs over CFLs is not known at this point, the sentiment above suggests that there is still significant customer concern and misconception with CFLs, and that as long as some types of incandescent bulbs are available, CFLs will not be the "new baseline." Here, EISA regulations are shown to be eroding, not building, CFL market share. This potential for CFL market share erosion, or backlash, needs careful study and consideration when efficiency program managers develop estimate of future CFL market share and program baselines.

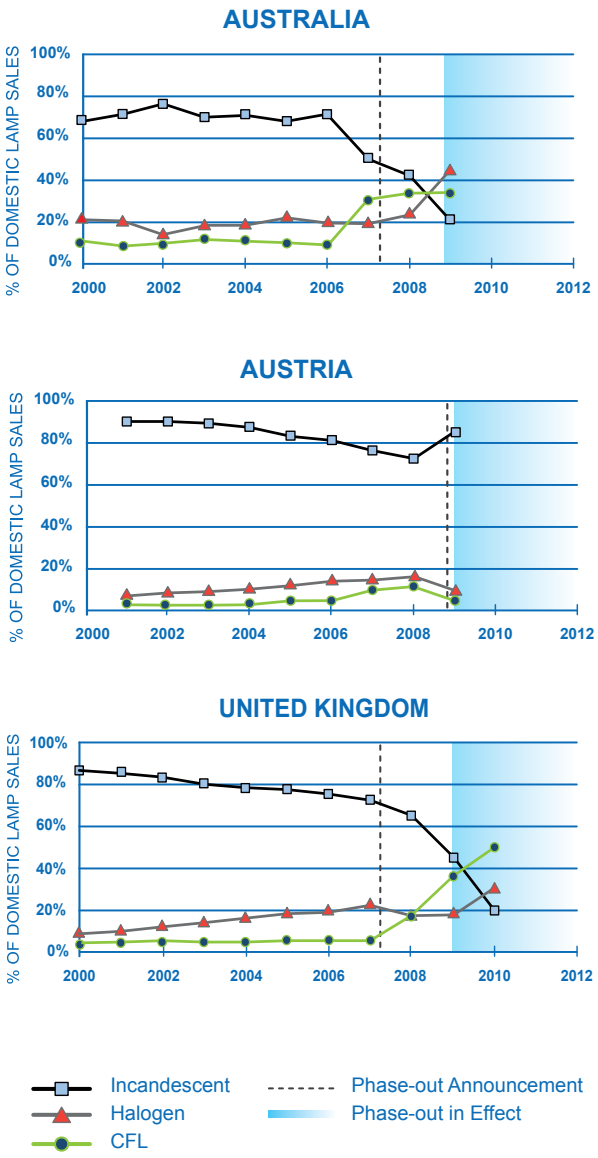
What will the CFL market share be after EISA takes effect?

While the future technology mix for residential lighting will not be known with certainty for a number of years, market factors do not suggest that EISA will drive a significant near-term shift to CFLs. According to NEMA, CFLs have accounted for about 25% of light bulb sales since early 2007, although the exact percentage has fluctuated somewhat each quarter.[11] As **Figure 1** shows, CFL imports alone have declined for most years after a sharp peak in 2007. Imports are a good indicator of CFL sales in the United States. Therefore, in light of these declines and EISA's potential limitations, a conservative early assumption would be to use today's market share for incandescent/CFL sales until market studies are done. There are several factors that support this assumption:

- Consumers will have numerous attractive choices of EISA compliant incandescent bulbs: standard halogen, IR halogen, modified spectrum halogen.
- Manufacturers are clearly betting that sales of EISA compliant halogen incandescent bulbs will be strong, as shown by their early introduction of numerous models into national sales channels.
- Many types of incandescent bulbs are not covered initially by EISA or DOE Incandescent Reflector Lamp (IRL) standards and will continue to be available on store shelves: candelabra-base bulbs up to 60 W, intermediate-base bulbs up to 40 W, rough service, three-way, greater than 2600 lumens (e.g. 150 W), shatter proof, and vibration service A-lamps and many common types of reflector lamps (e.g. 65 W BR30/40, R20 and MR16).
- Market factors in China, such as increases in material costs (e.g. plastic, glass, and rare earth elements used for fluorescent phosophor)[12] and a declining value of the dollar to the RMB (Chinese currency) are pushing CFL prices up.
- According to a July 2011 report by the International Energy Agency's (IEA) Mapping and Benchmarking Annex of the Efficient End-use Electrical Equipment Implementing Agreement (4E), in many countries, when regulations have been adopted that allowed consumers the choice between halogen incandescent bulbs and CFLs, consumers have gravitated towards halogen incandescent bulbs.[13]
- This same report predicts a similar trend for the U.S. – "As there are already indications that the U.S. market is saturated for those wishing to adopt CFLs voluntarily, consumers may generally switch to halogen incandescent bulbs as the regulations come into force, hence yielding lower savings than may have initially been anticipated."[14]

Figure 2 shows three international examples of the change in distribution of annual domestic sales of incandescent, halogen and compact fluorescent

Figure 2. Domestic bulb sales (by technology) in relation to the announcement and implementation of mandatory efficiency standards[15]



lamps leading up to and after the announcement of mandatory efficiency standards. These examples illustrate the very different outcomes that have occurred around the world in the period of time after the standards were announced.

Australia for example, did see a surge in CFL sales from 2006 to 2008; however, after the announcement of the mandatory standards, sales of halogen lamps nearly doubled from 2008 to 2009, while CFL sales stayed fairly flat. Austria exhibited an even more dramatic shift in lamp sales leading up to the announcement of an incandescent phase-out, with both CFL and halogen lamp sales declining from 2008 to 2009. There was a corresponding up-tick in incandescent lamp sales, largely attributed to consumer hoarding.[16] The United Kingdom (UK) represents a best case scenario, showing a rapid decline in incandescent lamp sales, strong CFL sales, and a modest increase in halogen lamp sales. This was largely due to a voluntary agreement between the UK government and retailers to remove incandescent bulbs from the shelves early, in order to reduce the likelihood of consumers hoarding the incandescent bulbs. Therefore U.S. regulators and efficiency program managers should not automatically assume that sales will shift to CFLs following the implementation of EISA.

An additional example of the market impacts of regulation can be observed in California, where the state implemented the first step of the EISA light bulb guidelines on January 1, 2011, one year ahead of the rest of the country. In-store surveys seven months later show that incandescent bulbs still remain on store shelves; there has not been a significant shift to CFLs thus far.[17]

Given the range of options consumers will have after EISA goes into effect, and the fact that many consumers are likely to purchase halogen incandescent bulbs that they may mistakenly believe are as efficient as CFLs, CFL sales in the U.S. could rise only slightly or may even decline in the coming years. It is important to note that CFLs purchased today may simply be replacing old CFLs (and not incandescent bulbs), which will not contribute to increased energy savings (or CFL socket saturation) over today's baseline.

What will the program "baseline" be after EISA takes effect?

A conservative early assumption would be to use the wattage limits from EISA, which represent

the minimally compliant halogen incandescent bulb wattages as a program baseline. In reality, in the coming years actual average baseline bulb wattages are likely to be higher than the wattage levels mandated by EISA. There are several reasons why:

- There is already evidence from the U.S. news media and the experience in Europe that some fraction of consumers will hoard traditional incandescent bulbs for their own use or for resale as those bulb types begin to disappear from store shelves.[18]
- There is evidence from California[19] that manufacturers and retailers accumulated substantial inventories of 95 W bulbs[20] to continue selling for perhaps four to eight months, even though CA state law took effect for this bulb category at the beginning of 2011. Since the deadline applies to the date of manufacture, it is anticipated that non-compliant bulbs will remain on store shelves well beyond the implementation date, as retailers work through the stock of bulbs manufactured before the deadline.
- Because many bulb types are excluded from initial coverage under EISA, some consumers may search out these products if they wish to continue using traditional incandescent bulbs indefinitely.[21]
- The lumen ranges allowed by EISA are so wide, especially with the inclusion of special standards for modified spectrum bulbs, that they will yield some degree of "bin jumping." In this situation, consumers bring home a bulb that claims to be equivalent in brightness to the bulb they previously purchased, but the light output is at the low end of the lumen range allowed by EISA. Many minimally complaint bulbs already in the market have lower light output ratings than the traditional bulbs they claim to replace. The consumer finds the bulb isn't bright enough and jumps up to the next "bin" of bulbs, negating most of the energy savings.
- Because the standards are being phased in sequentially, consumers who are accustomed to purchasing light bulbs on the basis of wattage may be confused to find 72 W bulbs on the shelf next to 75 W traditional incandescent bulbs. They may incorrectly assume that the 75 W bulbs are brighter and purchase them instead.

As a result, we expect the following approximate baseline incandescent bulb wattages to be typical at the national level in each of the following lumen bins and years:

Table 3. Estimated baseline wattages by year[22]

Lumen Bin	2011	2012	2013	2014
1600 lumens	94-100 W	88-93 W	78-83 W	74-78 W
1100 lumens	71-75 W	70-74 W	63-66 W	56-59 W
800 lumens	57-60 W	57-60 W	53-57 W	47-50 W
450 lumens	38-40 W	38-40 W	36-38 W	32-34 W

PROGRAM OPTIONS

What approaches might be necessary to continue progress in the residential light bulb market?

Nearly 20 years of nationwide efforts by efficiency programs and advocates have resulted in strong sales of CFLs—clearly a success story. However, the fact remains that 70% of residential light bulb sockets still use inefficient lighting, and EISA will not reverse that trend on its own. In order to fill those remaining sockets, efficiency programs may need to shift from the traditional rebate on bare spiral CFLs to more of a lighting market segmentation, or portfolio approach, which results in the promotion of a wider variety of bulbs tailored to specific consumer needs. A portfolio approach will require more research to justify various program costs and benefits, and will result in higher costs for saved energy, but is still very likely to remain one of the most cost effective residential energy efficiency program options.

ENERGY STAR "specialty" CFLs

Many program implementers are considering increasing the number of specialty CFL choices in their programs. Specialty CFLs can include: bare CFLs with special features, (e.g. dimmable, three-way, and shatter-resistant), "covered" CFLs that have a glass or plastic decorative outer shell, (e.g. globe, candle, pear and reflector shapes) and CFLs with candelabra (E12) bases, or any combination of the above (e.g. a candle-shaped dimmable CFL with a candelabra base). The increasing variety of ENERGY STAR qualified specialty CFLs presents new savings opportunities. See **Figure 3**.

Specialty CFLs can fill sockets where a basic spiral CFL may not fit, look, or perform well, and an ENERGY STAR qualified LED bulb may be too expensive or non-existent. Because many incandescent bulbs in the durable and decorative categories will be exempt or have limited coverage under EISA's light bulb standards, efficiency programs can capitalize on comparable energy savings to today's programs in many of these niche applications.

Manufacturers have developed a wide variety of specialty CFLs to address many qualities of basic CFLs that consumers dislike. Shatter-resistant CFLs

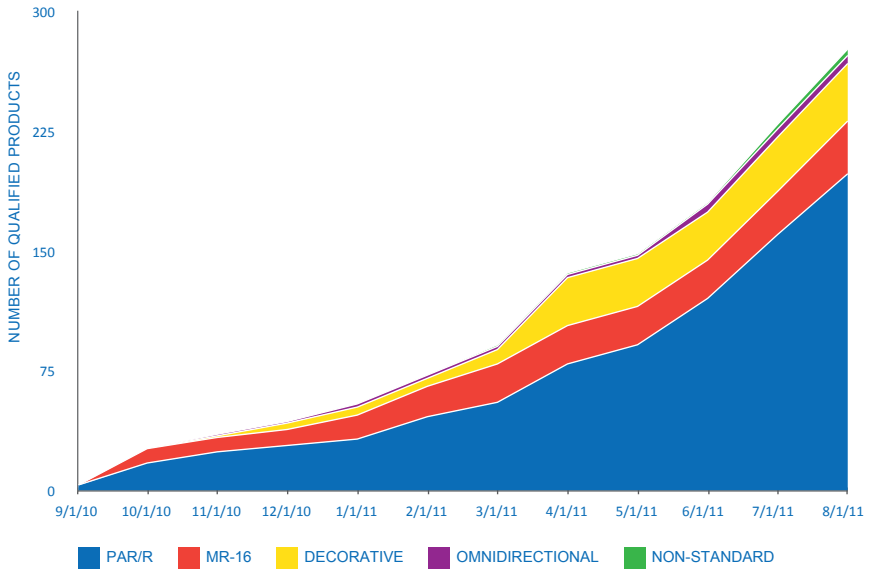
Figure 3. Example ENERGY STAR qualified specialty CFLs

Shatter-Resistant[23]	Three-Way[24]
	
	
Decorative[25]	**Reflector[26]**

address customer fears of mercury exposure from broken bulbs. "Covered" CFLs address complaints of bare spiral CFL appearance; and new, small CFLs, (both bare and covered) can fit in any fixture that typical incandescent bulbs do. Globe-shaped CFLs are available for multi-socket bath bar fixtures. More and more dimmable and three-way CFLs, as well as CFL-specific dimmers, are becoming available that address performance and compatibility problems. Reflector CFLs do not perform as well in all directional applications compared to incandescent, halogen, and LED reflector bulbs, but can work in applications where diffuse light is desired.

Many programs in the northeast have already begun transitioning to a portfolio approach. For example, Long Island Power Authority (LIPA) has indicated they are successfully moving a portion of their lighting programming emphasis from bare spiral towards specialty bulbs, and are having success in doing so.[27] Other programs may be able to follow suit.

Figure 4. Number and types of ENERGY STAR qualified LED bulbs (9/10 – 8/11)



The Importance of ENERGY STAR as a Mark of Quality for LED Bulbs

LED light bulbs can vary widely; therefore, consumers benefit greatly from a quality assurance program. ENERGY STAR is known for advancing efficiency, but is equally strong on overall product quality since the specification includes:

- Verified compliance with 26 separate industry standards and procedures
- Third-party testing of products off the retail shelf (in development for 2012)
- Rapid cycle testing of every product model, thousands of times to find early failures
- High heat testing to stress the products in operating environments similar to actual field operation
- Verification of packaging claims
- Minimum 3 year warranties

ENERGY STAR qualified LED bulbs

When examining the residential lighting market, it is important to recognize than no single technology can meet all consumer needs for varying lighting applications. As a result, program managers should develop custom program approaches designed to overcome specific barriers. Many of the current generation of LED light bulbs are attractive new options for efficiency programs because they overcome some of the barriers associated with consumer adoption of CFLs: instant on, dimmability, no mercury content and manufacturer promises of extended lifetimes (up to 50,000 hours). In addition to these desirable performance characteristics, LED light bulbs are not yet widely adopted and therefore net-to-gross ratios should be very high in all regions of the U.S. since current sales are extremely low and incremental new sales could be properly attributed to efficiency program promotions.

As of September 2011, there were more than 250 ENERGY STAR qualified LED bulbs. The majority of these are directional bulbs for fixtures such as recessed ceiling cans and track lights. See **Figure 4** for a detailed breakdown. As the market continues to develop more products for a wide variety of applications will become available.

What types of LED bulbs should programs include?

A popular light fixture in residential homes is the recessed can, or "downlight." Popular due to its low profile, ease of installation and acceptance by homebuilders, approximately 400 million recessed can fixtures are in U.S. homes; some large homes contain more than 100.[29] LEDs are inherently directional light sources; therefore, lighting manufacturers have incorporated them into several popular shapes and sizes of directional bulbs. CFLs, though available in reflector models, are not as well suited to replace the incandescent reflector bulbs found in these fixtures due to the diffuse nature of their light output. A recent study in California concluded that incandescent reflector bulbs represent the largest share of the remaining energy savings potential of any bulb type.[30]

Typical incandescent standard directional bulb shapes are Parabolic Aluminium Reflector (PAR), Reflector (R), Bulged Reflector (BR) and Multi-faceted Reflector (MR). Many LED bulbs are now available in similar shapes and sizes. Unlike general purpose bulbs, which shine light in many directions to illuminate rooms or areas, directional light bulbs are intended to illuminate specific surfaces like walls, counters or floors. As of September 2011, more than 200 models of ENERGY STAR qualified directional LED bulbs are available so there is already sufficient supply and competition for efficiency programs.

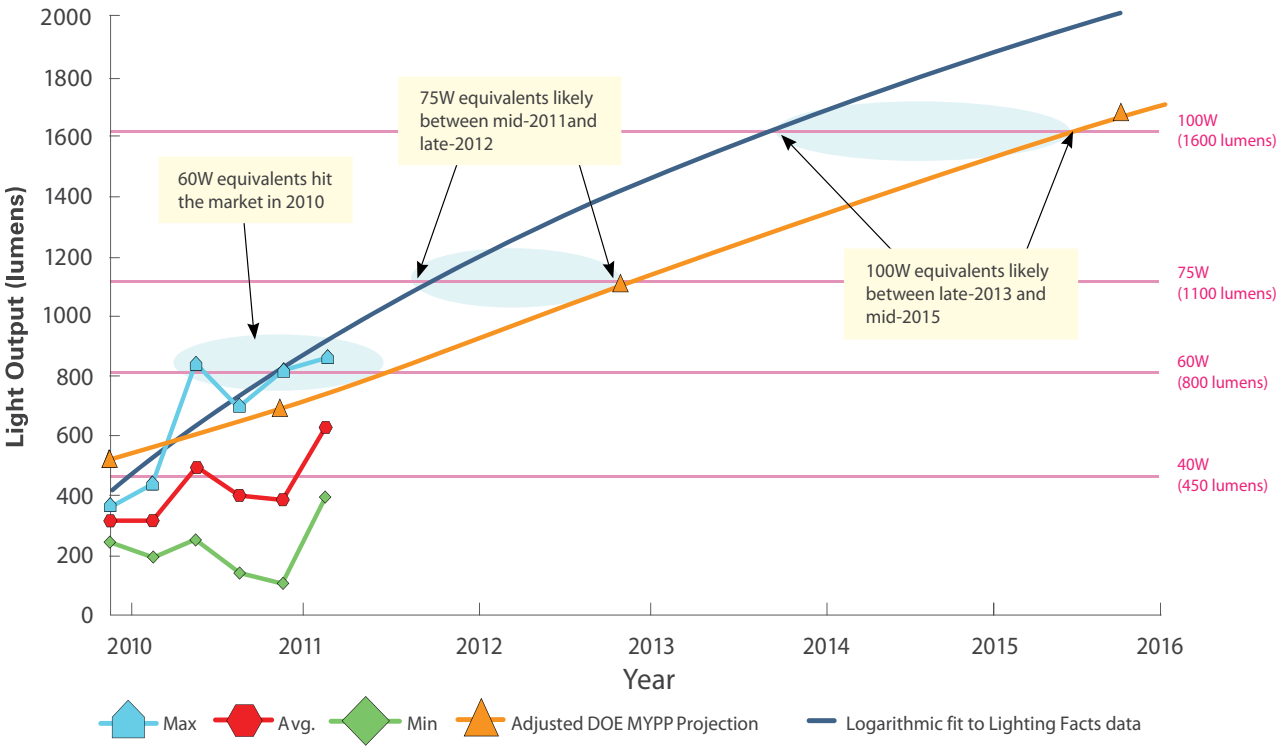
According to the DOE, there are more than 620 million incandescent reflector bulbs in use in the U.S. in residential and commercial sectors as of 2010. See **Table 4.** While the DOE has established minimum efficiency standards that take effect in mid-2012 for particular reflector lamp shapes, numerous exemptions currently exist[31] that will still allow standard incandescent (not halogen) lamps to be sold. The potential for future regulation exists

Table 4. Opportunities for energy savings with reflector lamps[28]

Lamp Type	Number of Lamps (in millions)			% of Total	Average W*
	Residential	Commercial	Total		
PAR	133	68	202	33%	66
BR	219	27	245	40%	65
R	48	5	53	9%	45
MR16	42	78	120	19%	37
Total	**442**	**178**	**621**	**100%**	**59**

* Weighted averages based on DOE data

Figure 5. Non-directional LED lamp performance trends and projections[32]



for the currently-exempted reflector lamp types; however, until that time, this provides an opportunity for efficiency programs to improve the baseline. ENERGY STAR qualified LED reflector bulbs could fill many of these sockets. Given this large opportunity for savings in the directional/reflector bulb category, multiple California investor-owned utilities (IOUs) have conducted incentive level tests on a variety of LED reflector bulbs. Based on their positive results, Pacific Gas and Electric and other CA IOUs may begin incentivizing ENERGY STAR qualified LED PAR and MR16 lamps in their residential programs by early 2012.[33]

LED bulbs are also well-suited for decorative applications such as chandeliers. LED bulbs are more effective than CFLs at mimicking the "sparkle" that many people associate with incandescent bulbs. Considering that some chandeliers contain six or more sockets that are typically filled with 25 W, 40 W, or even 60 W incandescent light bulbs, low-wattage LED bulbs can offer significant savings in these applications. As of September 2011, the ENERGY STAR qualified product list had fourteen models of candle-shaped decorative LED bulbs.[34]

Increasing LED lighting performance

Figure 5 shows performance data by year for non-directional LED replacement bulbs from the DOE's Lighting Facts® program.[35] Horizontal lines depict the typical light output and wattage of today's incandescent lamps. The upward trend of the data illustrates continuous improvements in light output and efficiency (also known as luminous efficacy for lighting). The DOE's performance projections for solid-state lighting products are depicted by the yellow line.

Most non-directional LED bulbs available today produce less than 600 lumens, (similar amounts of light to today's 25 W and 40 W incandescent bulbs), and most of the light falls within a 90 degree cone. Based on the projections in **Figure 5**, we can expect that non-directional LED bulbs that produce 800 or more lumens, (as much light as today's 60 W, 75 W

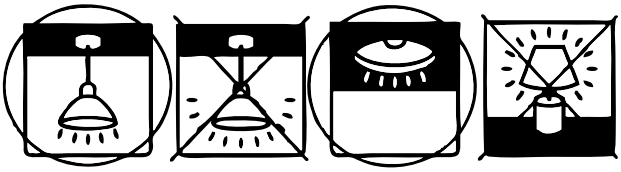
and 100 W bulbs), will become increasingly available in the near future as manufacturers continue to meet DOE projected targets.[36]

When considering which LED bulbs to promote as replacements for today's typical incandescent bulbs, programs should take into account not only a bulb's "brightness," or light output, but also its light distribution pattern. Typical A-shaped incandescent household bulbs (A-lamps) provide omnidirectional light; they shine evenly in all directions, as do CFLs. LEDs are directional by nature and require sophisticated engineering to produce a more omnidirectional light distribution, which better mimics that of an incandescent A-lamp. For this reason, the ENERGY STAR LED lamp specification has very specific distribution requirements for LED bulbs claiming to replace standard A-lamps. The specification also allows for "non-standard" bulbs. LED bulbs that don't claim to replace a specific standard shape fall into this category, and do not have to meet a specific light distribution requirement. This category was intended to foster innovation, allowing LED bulbs to provide light efficiently without having to conform to existing standards. The first ENERGY STAR qualified non-standard LED bulb may not claim to replace a standard A-lamp on the package, but it is shaped like one.

Figure 6 is a visual comparison between an LED bulb that appears to be an A-lamp, but does not have an omnidirectional light distribution (left), and an LED bulb that meets the ENERGY STAR omnidirectional light distribution requirements for an A-lamp (right).

Figure 6. Comparison of LED bulb light distribution in table lamps[37]

Figure 7. Sample ENERGY STAR LED bulb light distribution icons



To help consumers understand where to use non-standard LED bulbs, ENERGY STAR qualified models must use icons on bulb packages that indicate the recommended use for the bulb. (See **Figure 7** for a few sample graphics; many other icons are available to manufacturer partners.[38]) Icons, like those shown in Figure 7, must appear on packages of non-standard LED bulbs. This particular example indicates that this bulb would be appropriate for certain ceiling light applications, but not for a table lamp.

Non-standard lamps have a role to play; they can be very good for certain applications, and may cost less than a truly omnidirectional standard A-lamp, but caution should be used by program managers. Those that wish to include non-standard bulbs should develop educational materials to help prevent consumers from using non-standard lamps in traditional table lamps, for example, where non-standard lamps may not meet consumer expectations.

Will LED bulb prices come down soon?

Program managers might be questioning the feasibility of including LED light bulbs in their programs due to their relatively high purchase prices when compared to CFLs. However, this picture is changing relatively quickly. As an example, the first ENERGY STAR qualified omnidirectional LED bulb to produce over 800 lumens (60 W equivalent), the Philips EnduraLED, was brought to market in late 2010 at a cost of $40 per bulb. After less than a year this same bulb

now costs less than $30.[39] LEDs are expected to drop steadily in price and improve rapidly in light output and efficiency over the next few years.[40] In addition, notable features like instant start, dimmability and excellent color quality are now commonly found in the best new products.

According to the DOE's most recent Solid-State Lighting Research and Development Multi-Year Program Plan (MYPP),[41] LED bulb prices are currently much higher than CFLs, but are trending downward quickly; they should continue to drop in price and become more price competitive through 2015. A market research firm, Canaccord Genuity, reports that the recent progress in LED manufacturing capacity "has resulted in a 200%+ increase in capacity compared to a 90% increase in demand, which has led us to greater than a 50% drop in pricing—much of which has occurred in the last nine months."[42] To highlight the efficiency and longevity advantages of LED lighting products and to help overcome the higher incremental costs, program managers should consider offering higher rebates for LED bulbs than currently offered for CFLs, but this may not be the case for long.

Next generation incandescent light bulbs

While the new EISA compliant halogen incandescent bulbs may be garnering attention now, a more efficient type of incandescent bulb, sometimes called "2x" incandescent, may begin to appear in stores in early 2012. These will be the first incandescent bulbs that could be included in efficiency programs since they could offer considerable savings over baseline halogen incandescent bulbs. The first 2x bulb (50 W = 100 W) is expected to be available in 2012. The name 2x indicates that these bulbs are twice as efficient as today's incandescent bulbs. In other words, they use half the power to provide the same amount of light so that a typical 100 W bulb could be replaced with a 50 W 2x bulb that is just as bright. In addition, 2x bulbs are expected to last twice as long as today's incandescent bulbs.

These significant gains are a result of advanced halogen infrared reflective (HIR) coatings on the outside of the halogen capsule. Unlike LED bulbs, which are making inroads in low and medium light applications, these "2x incandescent" bulbs will be capable of delivering fully dimmable light at high output levels—specifically output similiar to 150 W, 100 W and 75 W incandescent A-lamps and high wattage reflector bulbs. Depending on how this technology develops, it could fill a consumer need over the next several years, and could spur a next generation of high efficiency incandescent bulbs. As efficiency program planners do more with market segmentation and design new programs to fill the remaining light bulb sockets, consumer incentives and education about these 2x products may be warranted.

Will residential lighting programs be cost-effective after federal light bulb standards take effect?

Yes. Residential lighting programs have delivered such inexpensive energy savings to states and utilities in recent years, that even if program costs rise significantly, these programs will still be cost effective. If declining net-to-gross ratios, declining net savings, and rising rebate amounts push program costs up, residential lighting programs may still be less expensive than non-lighting residential efficiency programs and will offer significant remaining savings.

- Program costs will almost certainly go up due to decreasing net-to-gross allowances in some markets, the addition of LED bulbs which are more expensive than CFLs, and increasing needs for consumer education.
- Savings for each promoted bulb will go down in most cases because the new baseline halogen incandescent bulbs are

$$TRC = \frac{sum\,(Benefits)}{sum\,(Costs)} = \frac{sum\,(Energy\ Savings * Avoided\ Costs)}{sum\,(Incremental\ Costs * Program\ Costs)}$$

a little more efficient than today's standard incandescent bulbs.

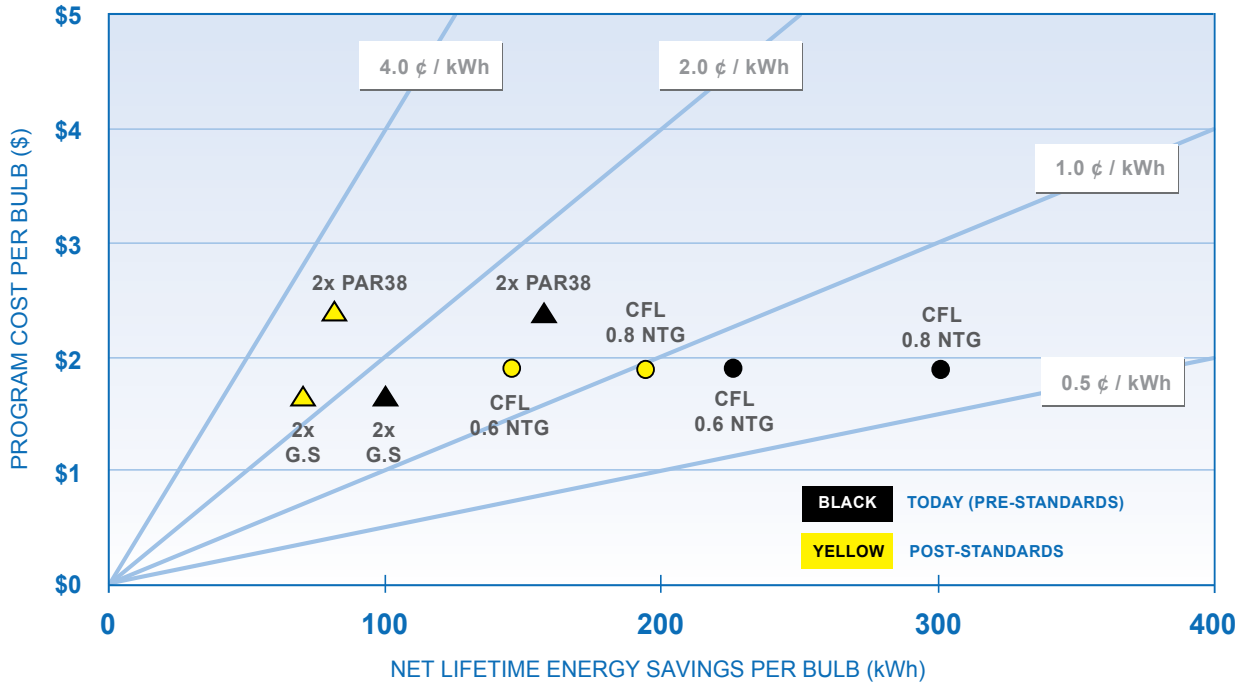
- Incremental costs will also decrease with purchase prices of baseline bulbs higher than today's standard incandescent bulbs.

Halogen incandescent bulbs that just meet the minimum EISA standards will form the new general purpose baseline. These bulbs are likely to cost approximately $2-3 each[43] instead of $0.20 to $0.30 for today's incandescent bulbs, for example. So, efficient light bulbs will still cost customers more at the store, but not as much more as they did in the past. These lower incremental costs help improve overall program cost-effectiveness in the common Total Resource Cost (TRC) formula. If all other costs and benefits are unchanged, a decrease in incremental costs will improve a TRC level.

Efficiency program managers can work closely with the EPA and regulators to ensure they accurately and completely consider all of these changes in the lighting landscape when planning next generation lighting programs.

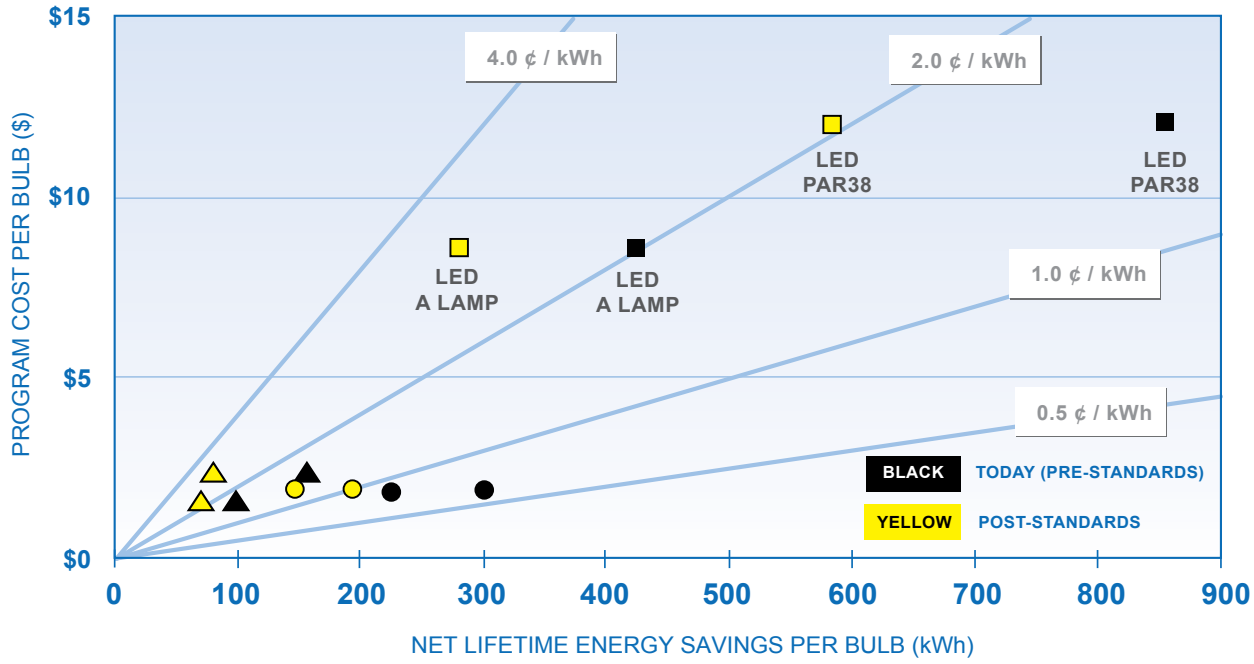
To illustrate how program costs are changing, **Figure 8** compares sample program cost (rebate plus administration costs) per rebated bulb to lifetime energy savings for a variety of bulb types and net-to-gross ratios. These are modeled scenarios based on today's typical CFL programs, and future

Figure 8. Costs per lifetime kWh saved for CFLs and 2x bulbs, before and after federal standards



options for next generation residential lighting programs.[44] (Each program should conduct their own cost effectiveness calculations based on their requirements.) Black icons show costs compared to savings for examples of today's programs, where standard incandescent bulb wattages are used for the baseline. Yellow icons illustrate several post-standards scenarios, where minimally-compliant halogen incandescent bulb wattages are used for the new baseline. **Figure 9** is expanded to show higher program costs for an ENERGY STAR qualified LED omnidirectional bulb (A-lamp) and a PAR38 reflector bulb, both before and after standards take effect. Note that even with a $12 program cost for the LED PAR38, and a $9 program cost for the LED omnidirectional bulb, both rebated bulbs yield lifetime energy savings at less than 4¢/kWh after standards take effect. Prior to EISA standards, the savings for both LED bulb types are closer to 1-2¢/kWh. Prices for LED bulbs vary, but both bulbs used for this exercise retail for about $40 currently. Upstream buy-down rebates of $10 or more would bring LED bulb pricing down to a level that many customers would find affordable.

Figure 9. Cost per lifetime kWh saved for LED bulbs, before and after federal standards



PORTFOLIO APPROACH

How does the portfolio approach work?

Next generation lighting programs have new opportunities to achieve energy savings by shifting from CFL-only programs to a diverse portfolio approach that includes specialty CFLs, LED bulbs and 2x incandescent bulbs, as well as some continued support for bare spiral CFLs. Bulbs that achieve the most savings should receive the highest rebates. Bare spiral CFLs will continue to make up a significant portion of rebated bulbs in the near term, but the growing number of ENERGY STAR qualified LED bulbs means that LED replacement bulbs are an increasingly viable program option. As other new efficient technologies, like 2x incandescent bulbs, become available, they can also be included in the mix of rebated bulbs, and rebated according to the savings they provide. Improved CFL technology, with faster start-up times, improved dimming, and longer lifetimes, will continue to add to the diversity of available solutions.

Consumers continue to want more choices to light their homes efficiently, so the message program managers need to convey is becoming much more comprehensive and nuanced than "CFLs good, incandescents bad." New lighting technologies promoted by carefully designed programs will help fill the remaining 70% of screw-based sockets with efficient bulbs best suited to a very wide variety of lighting needs.

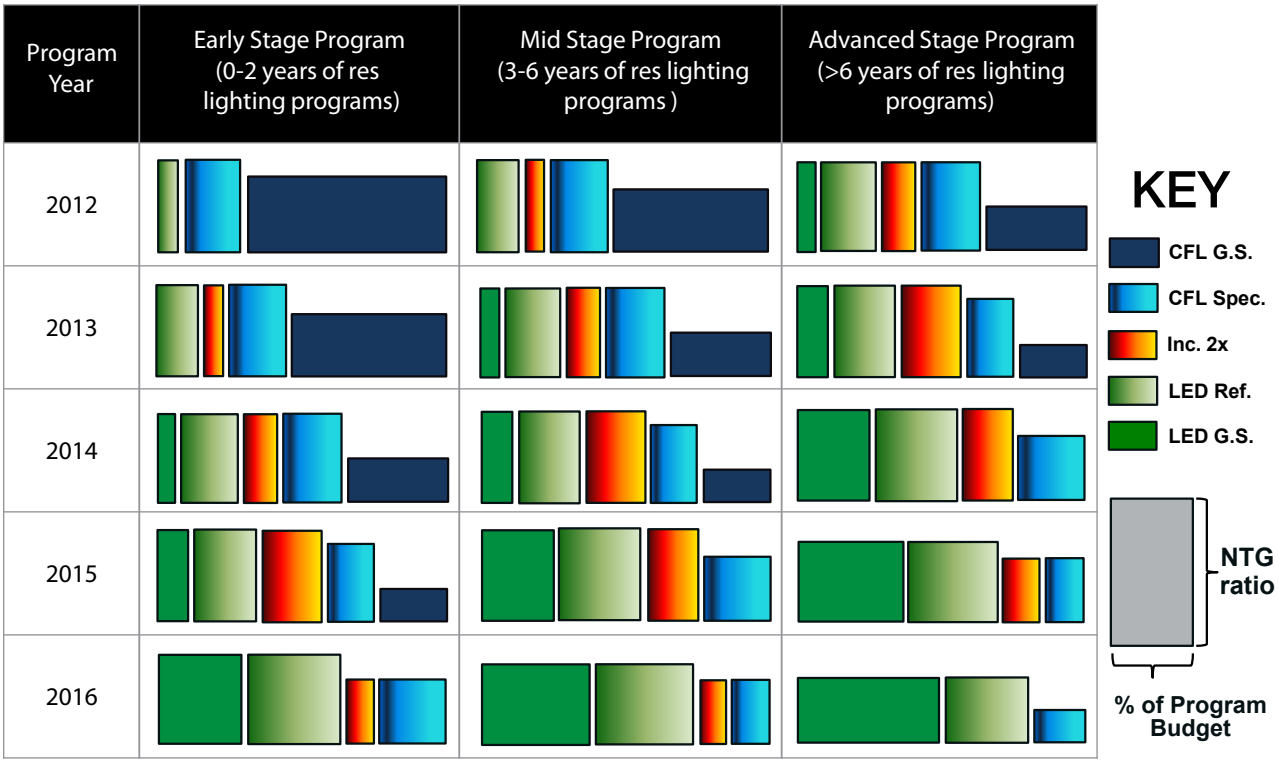
With its high consumer recognition and emphasis on quality, the ENERGY STAR program remains an effective platform for promoting efficient lighting products. The program's recent evolution to a technology-neutral approach in setting high efficacy requirements levels the playing field for technologies across the portfolio and positions the ENERGY STAR label to remain an effective designator of energy saving models even as new and different technologies enter the market.

When should lighting programs start making changes?

Each efficiency program and region is different. That said, many new technologies are ready for promotion today. Timing of program re-designs should take into account customer preferences and awareness levels, regulatory climate, and current adoption rates of CFLs. Programs should also be tailored to the adoption of efficient lighting in each region, the number of years incentives have previously been offered, and other regionally-specific factors.

- Well-established programs that have been rebating CFLs for many years are likely to benefit most by offering a diverse technological mix (i.e. 2x, dimmable compact flourescent, and LED bulbs). Net-to-gross ratios for basic CFLs may be low, whereas new technologies will likely have higher net-to-gross ratios. This approach is also appropriate for regions where consumers have a high level of energy awareness and an interest in new technologies.
- Programs that have been rebating CFLs for a few years can also offer a diverse group

Figure 10. Illustrative concepts for how portfolio approaches may vary based on program experience



of technologies initially, but continue to rebate some basic CFLs in the near term. As the program matures, these programs can shift more and more of their budgets to alternatives bulbs.

- Programs that have just begun to rebate CFLs may want to continue to promote basic CFLs heavily in the near term to capture savings, but then migrate to a more diverse portfolio as interest in, and options for efficient lighting grow.
- ENERGY STAR qualified LED bulbs will soon become the most efficient residential lighting option which gives programs incentives to promote them now, and cost-effectiveness will continue to improve as incremental costs come down. Therefore we expect more programs to incorporate LED bulbs in the future.

As **Figure 10** illustrates, it is reasonable to assume that some programs will no longer be rebating basic CFLs after 2015, having made an orderly transition to more advanced alternatives. While designed to be very conceptual, the visual suggests that advanced programs will lead the way with the introduction of new technologies/applications to their portfolios, and it can be assumed that younger programs will follow suit based on the performance and success of more advanced programs.

With so many new choices, won't customers be confused?

Yes, there is significant risk that consumers will be very confused by the numerous new bulb choices. Programs should include increased budgets for education and outreach efforts to help customers save energy by getting the right bulbs in the right sockets. Currently, there is little public awareness of the pending federal lighting standards, and many of those who are aware of the standards believe that incandescent bulbs are being banned. This could lead to hoarding of inefficient incandes-

cent bulbs prior to the standards effectiveness date. After EISA begins to take effect, consumers will find a confusing array of bulbs on store shelves, and not all of these bulbs will be very efficient. Instead of the familiar 40 W, 60 W, 75 W and 100 W bulbs, shelves will have a wide variety of wattages due to EISA's new wattage limits and wide lumen bins. Not all bulbs that claim to replace a 60 W incandescent bulb, for example, will be equally bright.

If consumers don't learn how to purchase bulbs based on light output (in lumens), many could end up with bulbs that are too bright (and use more energy than their old bulbs) or too dim. Some consumers may believe that the new halogen incandescent bulbs that just barely meet the efficiency in EISA will save as much energy as CFLs do. Others may be hesitant to try LED bulbs due to the higher upfront costs. Worse, if high quality ENERGY STAR LED bulbs aren't promoted, consumers may gravitate to the least expensive, and potentially lowest quality, LED bulbs and incorrectly conclude that LED bulbs are a poor choice for residential lighting. For consumers who insist on incandescent bulbs in some or all sockets, the 2x incandescent bulb will be a more efficient choice than the baseline halogen incandescent bulbs. Well-designed programs can help tailor solutions to the need.

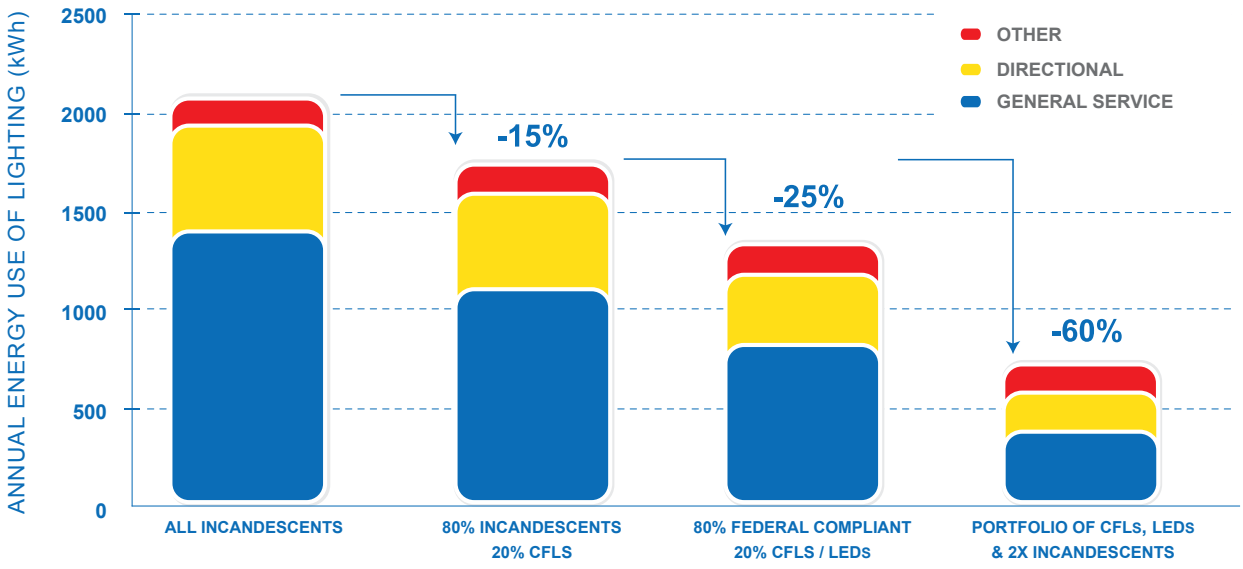
Efficiency program managers seeking educational support on the changing lighting market are encouraged to leverage existing materials, and new materials in development.[45] This way, the chances of a coordinated national message for consumers will be strengthened. Efficiency program managers should also consider joining or following a group called the LUMEN Coalition[46] that is working on a set of national educational materials for retailers, efficiency programs and energy efficiency advocates.

How much more can the portfolio approach save?

To date, CFL programs have reduced residential lighting energy use by about 15% relative to what would have occurred in their absence. This significant success is the result of efficiency program support of the best and most efficient lighting choices. But it's not time to stop. While future programs may cost more than yesterday's programs, a portfolio approach has the potential to reduce today's residential lighting energy use by half.

Figure 11 illustrates three scenarios for lighting

Figure 11. Savings potential from a portfolio approach



energy use from a typical home. The model used to generate the data presented is based on recent California residential lighting surveys that collected information on fixture types, time of use, and light source technology distribution by room.[47] The model is based off a typical U.S. residence that contained an average of 50 sockets. The first stacked bar shows lighting energy use from this home that has all of its screw-based sockets filled with traditional incandescent bulbs; this home uses a little more than 2000 kWh per year for lighting. The second bar shows the lighting energy use of that same home, but with 20% of its traditional screw-based incandescent bulbs replaced with CFLs. This is what many CFL programs have achieved by rebating CFLs for many years—approximately 15% energy savings, and considered today's baseline. The third bar shows the lighting energy use when all existing incandescent bulbs are replaced with bulbs that just barely comply with upcoming federal regulations, which results in energy savings of 25% over today's baseline. The bar on the right shows the savings potential at that same home by filling sockets with a mix of CFLs, LED bulbs, and 2x incandescent bulbs. Comprehensive use of lighting controls, such as dimmers and vacancy sensors to reduce unwanted operating hours can yield further savings. In total, the potential remains to cut today's lighting energy use by more than half. Some of those savings will come from growing market acceptance of LED bulbs and the gradual effect of federal standards, but most of that will not happen without active program involvement.

On a national level, if every household in the U.S. followed the portfolio approach to illuminate their homes, this would result in over $13 billion in annual energy savings, reduce CO_2 emissions by at least 80 million metric tons a year, and eliminate the need for over 30 power plants.

CONCLUSION

With baselines shifting to align with new federal light bulb requirements, savings from residential lighting programs will achieve smaller per unit savings than they have in the past. With the promotion of newer, more expensive technologies like LED lamps, lighting programs will also cost more than they had previously. However, if strategically re-designed, residential lighting programs can continue to be among the most cost-effective energy efficiency programs.

The challenges faced by efficiency programs developing lighting programs today are reminiscent of the introduction of CFLs. An emerging technology promised substantial energy savings and long product lifetimes; however, initial CFL products were large, bulky, and expensive, with poor light quality—all factors that attributed to early consumer dissatisfaction that has been difficult to overcome. High quality ENERGY STAR qualified LED products are now available that can be used in a number of applications, and although they are expensive, they are technically ready for promotion.[48] At the same time, incandescent technology is undergoing rapid improvements in efficiency and lifetime. While LED bulbs are excelling in medium to low light applications, advanced incandescent bulbs will soon be available for the brightest residential applications. These two new technologies are complimentary to each other, and provide consumers efficient lighting choices in addition to CFLs (which remain both cost effective and widely available). Efficiency programs can and should play a critical role into the future, steering consumers to the best products for every application through promotional, education, and rebate programs that accelerate market adoption and safeguard against early adopter dissatisfaction.

APPENDIX

Appendix A: Program Baseline Assumptions

Assumptions used to generate the estimated baseline wattage by year, as shown in **Table 3**.

The effort to forecast a baseline for incandescent lamps begins with an understanding of what EISA requires. The law establishes wattage caps across broad lumen ranges. The law depends for its energy savings on consumers moving to the "right" new wattage level, which may prove to be difficult or confusing for customers accustomed to purchasing on the basis of wattage, rather than lumens. If they do try to purchase the same number of lumens they are accustomed to, they may find themselves buying in the next higher wattage bin, because of the overlap in light output between the standard spectrum products of one wattage bin with the modified spectrum products of the next higher bin:

Baseline data

Lumen Bin	Current Lamps (W)	EISA Target (W)	Next Higher Bin (W)	EISA Cut-off Date[a]	% Energy Savings from EISA
1118-2600 lm	100	72	≥150[b]	1/1/12	28%
788-1489 lm	75	53	72	1/1/13	29%
563-1049 lm	60	43	53	1/1/14	28%
232-749 lm	40	29	43	1/1/14	28%

The cut-off dates apply to the date of manufacture or import, rather than the date of sale. As a result, manufacturers and retailers can both accumulate substantial inventories of products manufactured before the deadline but sold significantly afterwards. This phenomenon has been evident in national chain retail stores in California, which is implementing EISA one year early. Even six months into the law's implementation, non-compliant products were still routinely available at promotional pricing in many of the largest retail chains. As a result, the market share for compliant products is not expected to be 100% during the first year of implementation.

Share of incandescent bulbs on shelves at EISA target due to manufacturer and retailer inventory buildup

Lumen Bin	2011[c]	2012	2013	2014
1118-2600 lm	10%	60%	100%	100%
788-1489 lm	7%	15%	70%	100%
563-1049 lm	7%	10%	30%	80%
232-749 lm	7%	10%	30%	80%

Nine months into the law's implementation, EISA compliant 72 W bulbs were being offered by some California retailers at far higher prices than the other EISA compliant wattages, presumably due to the declining availability of conventional, and much less expensive, substitutes. This encourages consumers to look for substitutes online or via other means, or to hoard non-compliant lamps, or to switch to some of the niche lamp types that are currently exempted, but could be regulated in the future if their sales increase significantly. This hoarding and switching should decline over time as customers become more familiar with, and accepting of, efficient alternatives:

Fraction of consumers that hoard non-compliant incandescent light bulbs at standard wattages

Lumen Bin	2011	2012	2013	2014
1118-2600 lm[d]	0%	15%	10%	5%
788-1489 lm	0%	0%	12%	8%
563-1049 lm	0%	0%	0%	7%
232-749 lm	0%	0%	0%	7%

Fraction of possible buyers that switch to exempted lamp types

Lumen Bin	2011	2012	2013	2014
1118-2600 lm	0%	5%	10%[e]	5%
788-1489 lm	0%	0%	4%	8%
563-1049 lm	0%	0%	0%	3%
232-749 lm	0%	0%	0%	3%

Lumen Bin	Typical wattage of exempted lamp
1118-2600 lm	125 W[f]
788-1489 lm	75 W
563-1049 lm	60 W
232-749 lm	40 W

EISA's lumen ranges within a particular wattage bin are very different from the minimum lumen output levels ENERGY STAR requires to claim a particular wattage equivalency to conventional incandescent lamps.

ENERGY STAR minimum light output (for equivalency claims) compared to EISA lumen bins

Today's Wattage	ENERGY STAR Minimum Light Output to Claim Wattage Equivalency (Lumens)	EISA Standard Spectrum Lumen Range (Lumens)	EISA Modified Spectrum Lumen Range (Lumens)
100	1600	1490-2600	1118-1950
75	1100	1050-1489	788-1117
60	800	750-1049	563-787
40	450	310-749	232-562

The Federal Trade Commission's new labeling guidelines do not stipulate similar minimum light output levels to claim a particular wattage equivalency. As a result, a number of EISA compliant lamps have already been introduced that claim equivalent light output to one wattage of incandescent lamps, but are really much closer in light output to the next lower wattage bin. Thus, we expect to see some "bin-jumping" as buyers struggle initially to buy the amount of light output they need, and learn to shop on the basis of lumens rather than watts. We expect this to be the most likely in the first 12 to 18 months after a particular standards level takes effect, and then to tail off over time as consumers' understanding of labeling information improves and manufacturers' wattage equivalency claims are evaluated by FTC and the courts.

Fraction of possible buyers that bin-jump

Lumen Bin	2011	2012	2013	2014
1118-2600 lm	0%	5%	10%	5%
788-1489 lm	0%	0%	4%	8%
563-1049 lm	0%	0%	0%	3%
232-749 lm	0%	0%	0%	3%

A smaller degree of short-term bin-jumping can occur when consumers seek wattages that are closest to what they are familiar with during the sequential phase-out of different lumen ranges. In 2012, for example, 100 W bulbs will start to disappear from retail shelves in favor of 72 W replacements. But conventional 75 W lamps will still be on the shelves. Some consumers will incorrectly believe the old 75 W bulbs are brighter than the new 72 W bulbs, leading to some lost energy savings. Both effects are addressed here:

Wattage bought after bin-jumping occurs

Lumen Bin	2011	2012	2013	2014
1118-2600 lm		75[g]	75	75
788-1489 lm			66[h]	72[i]
563-1049 lm				53
232-749 lm				43

Combining all of the above effects yields the following baseline. Note that baseline wattages are lower than today's standard wattages, in part because sales of EISA compliant lamps have begun prior to the regulatory deadlines.

Estimated traditional incandescent wattage purchased without program involvement (baseline)

Lumen Bin	2011	2012	2013	2014
1118-2600 lm	97	90	80	76
788-1489 lm	73	72	64	58
563-1049 lm	59	58	55	49
232-749 lm	39	39	37	33

see following page for table notes

Table Notes

[a] This refers to date of manufacture or import, rather than date of sale.

[b] There is no 150 W bin in EISA, per se, but the upper end of the lumen range addressed by EISA still allows many 150 W incandescent light bulbs to continue being sold without improvements to their efficiency. In-store visits to California in mid-2011 suggests inventory of non-compliant lamps could last 4-6 months.

[c] Estimate for current stocking practices for EISA compliant halogen lamps; no public sales data are available regarding the market share these products have achieved to date of incandescent sales.

[d] We estimate that hoarding will occur in this lumen bin predominately, due to difficulty in matching lamp brightness.

[e] The fraction of consumers who switch to an exempted lamp type is expected to increase slightly in 2013 because a traditional lamp that was installed in 2012 is expected to last approximately one year.

[f] Assumes that half are brighter 150 W bulbs and half are other 100 W bulb types.

[g] The possibility of jumping to 150 W bulbs is already accounted for in the previous table, since the brighter-than 1950 to 2600 lumen bulbs are technically exempted rather than being inthe next higher regulated bin.

[h] Assumes half of buyers move to next higher bin and half buy the higher wattage (but dimmer) 60 W lamps still available.

[i] 60 W lamps largely disappear by 2014, so buyers just jump up to the next bin.

Appendix B: Program Cost Assumptions

Supporting calculations for **Figure 8** and **Figure 9**, program costs per lifetime kWh saved, are below. Note that each rebated bulb produces approximately the same amount of light as the baseline bulb to which it is compared.

Bulb Type	Pre or Post standards	Baseline bulb power (W)	Rebated bulb power (W)	Rebated bulb lifetime (hours)	NTG assumed	Lifetime energy saved (kWh)[1]	Modeled program cost/bulb (admin + rebate)	Cost/ lifetime kWh saved[2]
CFL	Pre	60	13	8,000	0.8	301	$1.90	$0.006
CFL	Pre	60	13	8,000	0.6	225	$1.90	$0.008
CFL	Post	43	13	8,000	0.8	194	$1.90	$0.011
CFL	Post	43	13	8,000	0.6	146	$1.90	$0.013
2x	Pre	100	50	2,000	1	100	$1.65	$0.017
2x	Post	72	50	2,000	1	70	$1.65	$0.023
LED A-lamp	Pre	60	12	8,800[3]	1	422	$8.65	$0.021
LED A-lamp	Post	43	12	8,800[3]	1	281	$8.65	$0.031
LED PAR 38	Pre	75	18	25,000	1	855	$12.00	$0.014
LED PAR 38	Post	57	18	25,000	1	585	$12.00	$0.021

[1] (baseline bulb power – rebated bulb power) * rebated bulb lifetime/1000 * NTG assumption

[2] modeled program cost per bulb/lifetime kWh saved

[3] LED A-lamp assumed lifetime capped at 8,800 hrs due to baseline uncertainty after 2020 (EISA Tier 2) 8,800 hrs = 8 years of use (2012 – 2020) at 3 hrs/day

End Notes

1 The technical term for light bulbs, “lamps,” will be used interchangeably with “light bulbs” and “bulbs” throughout this report.

2 CFL import data can be used as a proxy for sales since almost all CFLs sold in the U.S. are imported, however, the lag time between import and sale varies depending on market conditions.

3 NEMA Electroindustry, Aug 2011, Vol. 16 No.8. p 31.

4 Ecos analysis of U.S.A Trade online data.

5 CFL Market Profile 2010, http://www.energystar.gov/ia/products/downloads/CFL_Market_Profile_2010.pdf

6 While these concerns may be based on technical misunderstandings, they remain barriers to purchasing CFLs.

7 This type of halogen bulb is substantially different from halogen torchieres which years ago were subject to recall by the Consumer Product Safety Commission.

8 More specific information about EISA compliant halogen lamps can be found at the following websites:
www.gelighting.com/na/home_lighting/products/2012_energy_legislation/
www.lighting.philips.com/us_en/products/halogena_energy_saver/
www.sylvania.com/ConsumerProducts/New+Products/HALOGENSuperSaver/
www.bulbrite.com/products_en_7_64_453_0_0-ECO-Friendly-Halogen-A19.php

9 HIR bulbs utilize specialized coatings on the surface of the halogen capsule that reflect infrared radiation back to the filament. This results in less power to produce the same amount of light, making HIR lamps more efficient than standard halogen incandescent bulbs.

10 Consumer review of an EISA compliant modified spectrum halogen lamp, retrieved from www.amazon.com on July 12, 2011.

11 http://www.nema.org/media/pr/20101202a.cfm

12 http://www.sylvania.com/Phosphors/; http://blog.nema.org/blogs/currents/archive/2011/07/15/china-reduces-quotas-for-rare-earth-exports-again.aspx; http://www.fsgi.com/images/ltgtoolbox/fluorescent_lamp_volatility/TCP.pdf

13 IEA 4E Benchmarking Document: Draft Benchmarking Impact of “Phase-Out” Regulations on Lighting Markets, July 2011 (p. 5).

14 Ibid, (p.5).

15 Ibid.

16 http://spectrum.ieee.org/consumer-electronics/standards/deutschland-devours-the-last-of-its-100watt-incandescent-bulbs

17 Findings from Ecos visits to multiple California big box and grocery stores, July 2011.

18 IEA 4E Benchmarking Document: Draft Benchmarking Impact of “Phase-Out” Regulations on Lighting Markets, July 2011 (p. 40).
See also:
http://www.usatoday.com/tech/science/environment/2011-02-07-lightbulbs_N.htm
http://www.reuters.com/article/2009/08/31/us-germany-bulbs-idU.S.TRE57U4WT20090831
http://www.dailymail.co.uk/news/article-1212514/Pensioner-hoards-1-000-incandescent-lightbulbs-read-rest-life-following-EU-ban.html

19 Findings from Ecos visits to multiple California big box and grocery stores, July 2011.

20 Note that a previous regulation in California required many common household bulbs use 5% less power than traditional bulbs, so a 95 W bulb in California is similar to 100 W bulbs found in the rest of the country.

21 Provisions in EISA allow for future rulemaking on these lamp types if sales reach a pre-determined threshold.

22 See Appendix A for more detail on these baseline calculations.

23 www.clearlite.com

24 http://www.amazon.com/47448-29-Watt-150-Watt-equivalent-Energy/dp/B000WUEP9U

25 http://www.attictrunk.com/feec7w40w12f.html

26 www.homedepot.com

27 Presentation by Lisanne Altmann, LIPA, February 10, 2011, AESP Brown Bag webinar.

28 Navigant Consulting, Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications, January 2011, prepared for U.S. Department of Energy.

29 http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17456.pdf

30 Gaffney, Mahone and Johnson. 2011. KEMA Inc. Residential Lighting: Shedding light on the Remaining Savings Potential in California. (p. 7).

31 Current exemptions from DOE IRL standard include BR30/BR40 (65 W and < 50 W), R20 (< 45 W) and all MR16s.

32 DOE Lighting Facts Program. Product Snapshot: LED Replacement Lamps, April 2011. Prepared by D&R International.

33 Statewide Lighting Market Transformation Program Report, June 2010.

34 Four of the currently-qualified ENERGY STAR candelabra LED bulbs are listed as dimmable, which is considered an important attribute for this product category.

35 http://www.lightingfacts.com/

36 http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2010_web.pdf

37 Source: GE Lighting. All rights reserved, ©GE 2011.

38 See “icons for non-standard lamps” at http://www.energystar.gov/index.cfm?fuseaction=products_for_partners.showILEDL

39 EPA now tracks online pricing of ENERGY STAR qualified LED bulbs, selected CFLs, and EISA compliant halogen incandescent bulbs in the EPA Bulb Pricing Database to help efficiency programs monitor changes to retail prices and scale rebates appropriately.

40 http://www1.eere.energy.gov/buildings/ssl/sslbasics_randd.html

41 http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2011_web.pdf

42 Canaccord Genuity, Update to the Third Cycle – Revised Forecasts of the LED Lighting Market and Global Supply-Demand Analysis, May 2011.

43 Range of EISA compliant halogen lamp prices currently on the market.

44 Note that this analysis is illustrative only, and does not use a standard cost effectiveness test due to the number of utility-specific variables necessary as inputs. See Appendix for the assumptions used in these calculations.

45 For example, see: http://www.nrdc.org/energy/lightbulbs/files/lightbulbguide.pdf

46 http://lumennow.org/

47 http://www.calmac.org/publications/FinalUpstreamLightingEvaluationReport_Vol2_CALMAC.pdf

48 Statewide Lighting Market Transformation Program Report, June 2011.

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www.energystar.gov/lightingresources