

UC Davis

UC Davis Previously Published Works

Title

This article is a summary of CLTC research aimed at developing a technology-neutral Super Lamp specification for replacement of incandescent sources in the residential sector

Permalink

<https://escholarship.org/uc/item/7td2w9j4>

Journal

Lighting Design and Application LD and A, 40(3)

ISSN

0360-6325

Authors

Fernandes, LL

Siminovitch, M

Papamichael, K

Publication Date

2010-03-01

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

Peer reviewed

research MATTERS

BY LUÍS LOMELINO FERNANDES, MICHAEL SIMINOVITCH,
KONSTANTINOS PAPAMICHAEL

The Super Lamp initiative is a collaborative effort among California utilities (Pacific Gas and Electric, Southern California Edison, San Diego Gas and Electric, and Sacramento Municipal Utility District), the Natural Resources Defense Council and the California Lighting Technology Center (CLTC), to meet California's goal of reducing residential lighting consumption to 50 percent of 2007 levels by 2018.

The strategy is to foster the development of high-efficacy light sources that achieve, as much as possible, interchangeability with incandescent lighting, in terms of compatibility with electrical infrastructure and with popular lighting expectations. This article is a summary of research performed at the CLTC to achieve required energy performance and develop a technology-neutral Super Lamp specification for replacement of incandescent technologies in the residential sector.

Some recent history helps to explain the initiative. In 2006, California passed the Global Warming Solutions Act of 2006, which mandated reducing greenhouse gas emissions to 1990 levels by 2020. This in turn spurred initiatives to curtail emissions from several activities, including lighting. For residential lighting, in particular, several legislative options were considered in order to address the still prevalent use of incandescent lighting—much less efficacious than other available alternatives such as

CFLs. Alternatives included putting in place higher efficacy requirements amounting to an outright ban of incandescent light sources and setting a mandate to reduce energy consumption by 50 percent (relative to a 2007 baseline) by 2018. The latter proposal was signed into law in late 2007.

At the request of the California Energy Commission, the CLTC researched the possible impacts of these and other options under con-

in the “zero growth” scenario there is still growth in overall energy consumption, due to accounting for growth in the number of lamps per household, a significant trend observed in the 2000-2005 period. Also shown in Figure 1 is the energy consumption attributed to houses that comply with the more stringent 2005 California building codes. The increase is due not only to new construction but also to retrofits, and therefore the growth rate is higher

This article is a summary of CLTC research aimed at developing a technology-neutral Super Lamp specification for replacement of incandescent sources in the residential sector

sideration on California's residential lighting energy consumption in the 2007-2018 period, such as full substitution for higher-efficacy incandescent or reliance on building codes only. Using available data, a mathematical model for projecting the evolution of California residential lighting energy consumption over the following decade was built. **Figure 1** shows the projected energy consumption as a percentage of 2007 levels if no actions were taken. Three levels of growth in number of households were considered: continuing the trends from 2000-2005; 50 percent of that trend; and zero growth. Note that

than for the whole population.

The same model was also used to project energy consumption throughout sudden (**Figure 2**) and gradual (**Figure 3**) transitions to high-efficacy lamps, and gradual transition to higher-efficacy incandescent lamps in accordance to the then-proposed federal and European Union legislation (**Figure 4**).

The research results indicated that if there is a single measure that has the potential to achieve a 50 percent reduction in residential lighting by 2018, it is the replacement of incandescent lighting with high-efficacy alternatives like CFLs, products based on LEDs or other

technologies able to achieve the same levels of efficacy. These alternatives occupied approximately only 20 percent of screw-base sockets in California residences. Efforts then turned to determining how best to address the remaining 80 percent of screw-base sockets with incandescent lamps.

DEVELOPING A SPEC

The list of complete Super Lamp specifications requirements can be found at <http://cltc.ucdavis.edu/content/view/652/342/>. The first step towards developing the spec was to identify the major obstacles to increased high-efficacy lighting use in California residences. In 2007, high-efficacy lighting for screw-base sockets meant almost exclusively CFLs, but several issues were preventing this technology from being accepted by a larger section of the population. The CLTC specification had to consider the following factors:

- color
- size
- flicker and noise
- run-up time
- frequent lamp failure in enclosed luminaires or downlights
- inability to dim; lamp failure/erratic behavior when operated on electronic switches (e.g., timers)
- mercury content

Color. CFLs and LEDs are usually available in a variety of color temperatures. Although this is very well understood by lighting experts, that is rarely the case with the



Figure 1: Aggregate lighting energy consumption by California households under current policy (projection).



Figure 2: Aggregate lighting energy consumption by California households under 2010 incandescent ban (projection).

public, which can result in disappointment when lamps of different color temperatures are unintentionally used in the same space. For this reason, the Super Lamp specification focuses only on lamps with a nominal correlated color temperature (CCT) of 2,700K.

As the lamp is dimmed, color temperature can vary along a band

centered on the blackbody locus.

Given the tradeoffs between color rendering and efficacy, minimum values were specified for special color rendering indices (R_1 to R_{14}), as well as for CR_{18} (average of R_1 to R_8) and CRI_{14} (average of R_1 to R_{14}). These values were determined by estimating, based on efficacy and CRI measurements

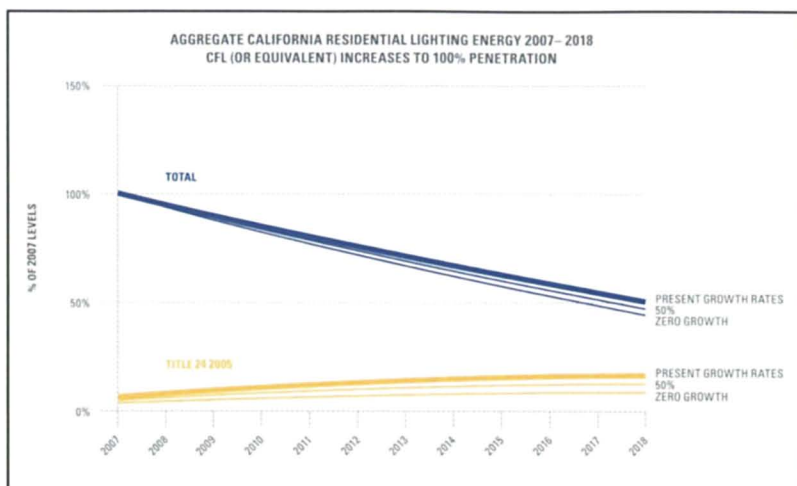


Figure 3: Aggregate lighting energy consumption by California households with gradual achievement of 100% CFL or equivalent market penetration (projection).

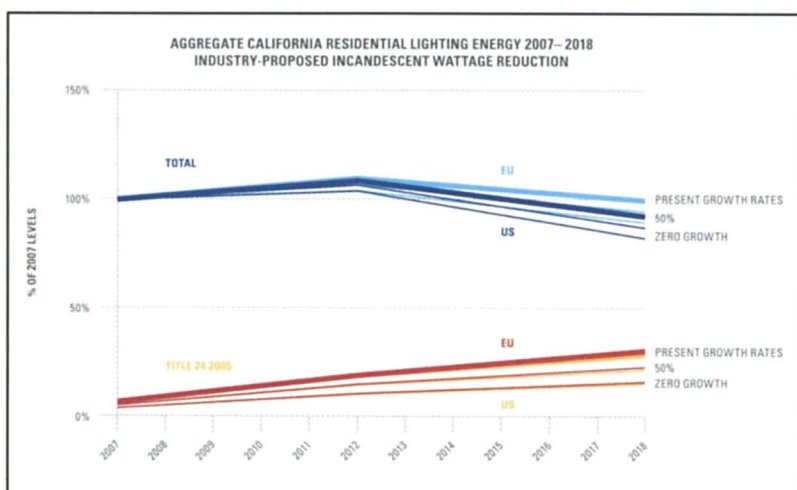


Figure 4: Aggregate lighting energy consumption by California households with gradual wattage reduction between 2012 and 2018, according to U.S. and EU industry proposals (projections).

of 2,700K CFLs of varying CRI, the highest CRI indices—and in particular R_9 —that would still result in meeting the Energy Star requirements for efficacy. The requirement for R_9 (*strong red*), usually the most challenging special color rendering index for CFLs, is a minimum value of 12, with a minimum of 40 for all other 13 special indices. A minimum average of 70 is required for all 14 indices (CRI_{14}), and minimum

CR_{18} is set at 82, a small increase over the Energy Star requirements.

Size. The specification addresses some of the most common lamp shapes: A19, R30, PAR38 and G30. For some of these, it is difficult to manufacture CFLs that exactly fit the ANSI standard shape, most commonly because the ballast demands more space than allowed. To minimize incompatibilities with existing luminaires, we determined,

from physical measurements of available lamps, the smallest deviation possible from the standard that would encompass at least one existing model. Super Lamp space drawings were then developed by making slight modifications to ANSI standard lamp space dimensions. This was not necessary for PAR38 and G30 shapes, since existing CFLs were found that already complied with the standard. Figure 5 shows the Super Lamp requirements for A19 lamps of less than 20 watts.

Run up and starting. Amalgam lamps can take a few minutes to achieve 80 percent of full output, whereas non-amalgam lamps can take around 15 seconds or less. However, non-amalgam lamps perform poorly in high-temperature environments, which is a desirable Super Lamp feature. The Super Lamp requirement for run-up time, 45 seconds, was based on the fastest run-up characteristic observed in the CLTC laboratory with commercially-available amalgam lamps.

Many dimming CFLs are not able to start unless the dimmer is set close to full power. In order to achieve performance closer to that of incandescent lamps, it is required that lamps start at 70 percent power, a value deemed achievable with today's technology by several lamp manufacturers.

Flicker and acoustic noise. Flicker and acoustic noise were some of the original complaints about CFLs. While in some cases this is due to improper use of CFLs, such as operating a non-dimming lamp on a dimmer, it is important to limit the amount of flicker and acoustic

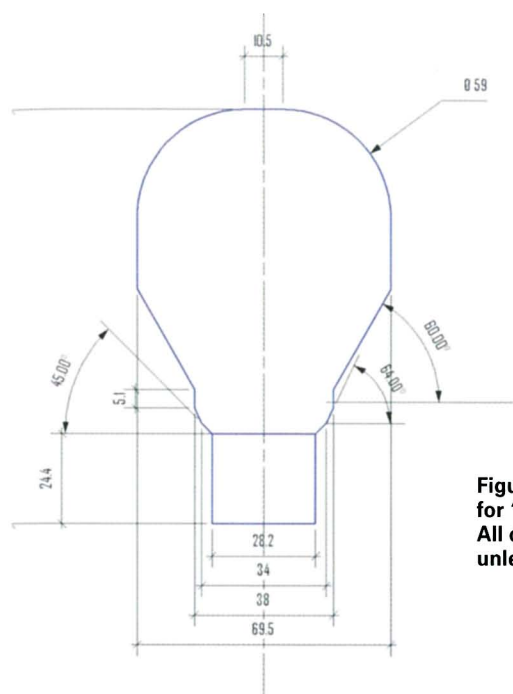


Figure 5. Super Lamp shape for "A-lamps" under 20 watts. All dimensions are in millimeters unless otherwise specified.

value of 3 milligrams as being a reasonable compromise.

STATUS AND NEXT STEPS

The current version of the Super Lamp specification is now publicly available and the CLTC is accepting sample submittals from lamp manufacturers. Meanwhile, the California utilities are in the process of determining their incentive structure for high-efficacy screw-base lamps. At the time of writing, it is expected that incentives for lamps that qualify for the Super Lamp program will be significantly higher than incentives for other lamps.



Luís Fernandes is a research engineer at CLTC. He holds a Ph.D. in Civil Engineering from the University of Colorado, Boulder and a Lic. Eng. in Physics Engineering from Instituto Superior Técnico, Portugal. His research focuses on daylighting, energy efficiency in buildings and visual comfort.



Michael Siminovich is the director of the CLTC and a professor in the UC Davis Design Program. He holds an M.S. in Industrial Design from the University of Illinois and a Ph.D. in Architecture and Human Factors Engineering from the University of Michigan. His work focuses on R & D in new residential and commercial lighting technologies.



Konstantinos Papamichael is the co-director of CLTC and a professor in the UC Davis Department of Environmental Design. He holds an A.E. Degree from the Aristotelian University of Thessaloniki, Greece, an M.S. in Architecture from Iowa State, and a Ph.D. in Architecture

noise produced by Super Lamps. With the aim of ensuring a high degree of satisfaction in residential use, the CLTC is currently investigating measurement procedures and performance requirements for these quantities.

Performance in high temperature environments. Most CFLs aren't suitable for use in enclosed luminaires and usually carry a warning for installations in such environments. Unfortunately, that warning is sometimes ignored and contributes to a perception of unreliability. For this reason, in the Super Lamp specification it is required that lamps of all shapes meet the elevated temperature requirements that Energy Star at present makes only for reflector lamps, such as life, lumen maintenance and maximum temperature rating. These include lumen maintenance and lamp life.

Dimming and electronic switch compatibility. In 2009, dimmer

switches controlled 12 percent of the sockets in California homes. However, most CFLs are not compatible with dimmers. The same happens with electronic switches that require a trickle current to run through the lamp when it is in the off state. As mentioned above, for compatibility with high temperature environments, CFLs usually carry a warning, which is not always considered. For this reason, Super Lamps must be dimmable—a feature available in some of today's lamps—and also compatible with electronic switches, a feature that several manufacturers deemed to be achievable. Lamps should be dimmable down to 20 percent of full light output.

Mercury. Due to widespread concern with toxic hazards in the home, we sought to specify a mercury level that was as low as possible without jeopardizing lamp life and the ability to dim to low levels. Consultation with lamp manufacturers yielded a

from UC Berkeley. His work focuses on the development of energy-efficiency strategies and technologies for buildings, focusing on fenestration systems and daylighting.

REFERENCES

"Efficiency Opportunities for Edison-Based Luminaires."

<http://cltc.ucdavis.edu/images/cltc%20lamp%20report.pdf>, California Lighting Technology Center, n.d. Web. 29 Jan. 2010

"Specification for 'Super Lamp'-designated Lamps."

http://www.etcc-ca.com/images/2009_super_lamp_spec_11aug2009.pdf, California Lighting Technology Center, 11 Aug. 2009 Web. 29 Jan. 2010

"Energy Star Program Requirements and Criteria for CFLs - Version 4.0."

http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/cfls/Criteria_CFLs_V4.pdf, Energy Star, 19 May 2009 Web. 29 Jan. 2010

Huffman Bill: AB1109 California Lighting Efficiency and Toxics Act (2008). California legislature 2007-08 session

"Residential Lighting Metering Study—Preliminary Results." KEMA, 2009.

Levine, Bill: AB 722, An act to amend Section 25402.5 of the Public Resources Code, relating to energy, (2008). California legislature 2007-08 session

"Increasing Market Acceptance of Compact Fluorescent Lamps (CFLs)." Lighting Research

Center (LRC) final project report, Sep 30, 2003. Print. 29 Jan. 2010.

"Residential Energy Efficient Lighting Consumer Research." Northwest Energy Efficiency

Alliance (NEEA), Report #00-051. April 2000. Print. 29 Jan 2010.

"Market Transformation Strategy: Compact Fluorescents in Residential Lighting." Swedish Energy Agency (STEM). 30 Oct. 2006. Discussion paper. 29 Jan. 2010.

BALLASTS ARE OUR BUSINESS.



ULTRASAVE offers a wide range of ballasts for electronic and magnetic fluorescent, as well as HID applications.

Contact us today to find out more about our latest additions.

ULTRASAVE

www.ultrasave.ca



T8 ELECTRONIC BALLASTS

Energy efficient ballasts available in high, normal and low ballast factor. Meet most Canadian Hydro rebate program requirements.



T5/T5HO ELECTRONIC BALLASTS

Programmed rapid start ignition with lamp EOL protection circuit and 90°C case temperature rating. T5HO series also available with auto-reset thermal protection.



CFL ELECTRONIC BALLASTS

Operate 1 or 2 CFL 13/18/26/32/42W lamps, of various types.



ELECTRONIC HID BALLASTS

Complete range of 120-277 and 347V models, side/bottom mount versions.

ULTRASAVE LIGHTING LTD. | T 905.940.0888 | F 905.940.0338 | Toll-Free Number 1 866.733.9217
RESIDENTIAL COMMERCIAL RETAIL INSTITUTIONAL

make your voice
HEARD!

Join an IES committee:
Fax: 212-248-5017