Cost-Effectiveness of Extended High-Efficacy Lighting Requirements

DOE Proposal: R-5; ICC proposal: TBA
For 2018 IECC residential code
Pacific Northwest National Lab
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T. Taylor, V. Mendon and M. Zhao

PURPOSE

Determine whether proposed increases in high-efficacy lamp requirements are cost effective.

BASIS

Light Emitting Diode (LED) lamp technologies are advancing quickly and prices are falling dramatically. Those trends are expected to continue over the next several years, making LED lamps a prime candidate for inclusion in the 2018 IECC.

The energy savings and cost-effectiveness potential of changing the definition of high-efficacy lighting were evaluated using DOE's cost-effectiveness methodology.[1]

ENERGY PRICES

DOE's cost-effectiveness methodology specifies that for climate zone-level and national-level analyses, energy prices and escalation rates will be taken from the Energy Information Administration's latest estimates. The anticipated 2018 prices and escalation rates[2] are as follows:

Fuel	Price (2018$)	Effective[3] Escalation Rate (per year, real)
Electricity	$0.137/kWh	0.69%
Natural Gas	$1.154/therm	1.74%
Fuel Oil	$2.299/therm	1.84%

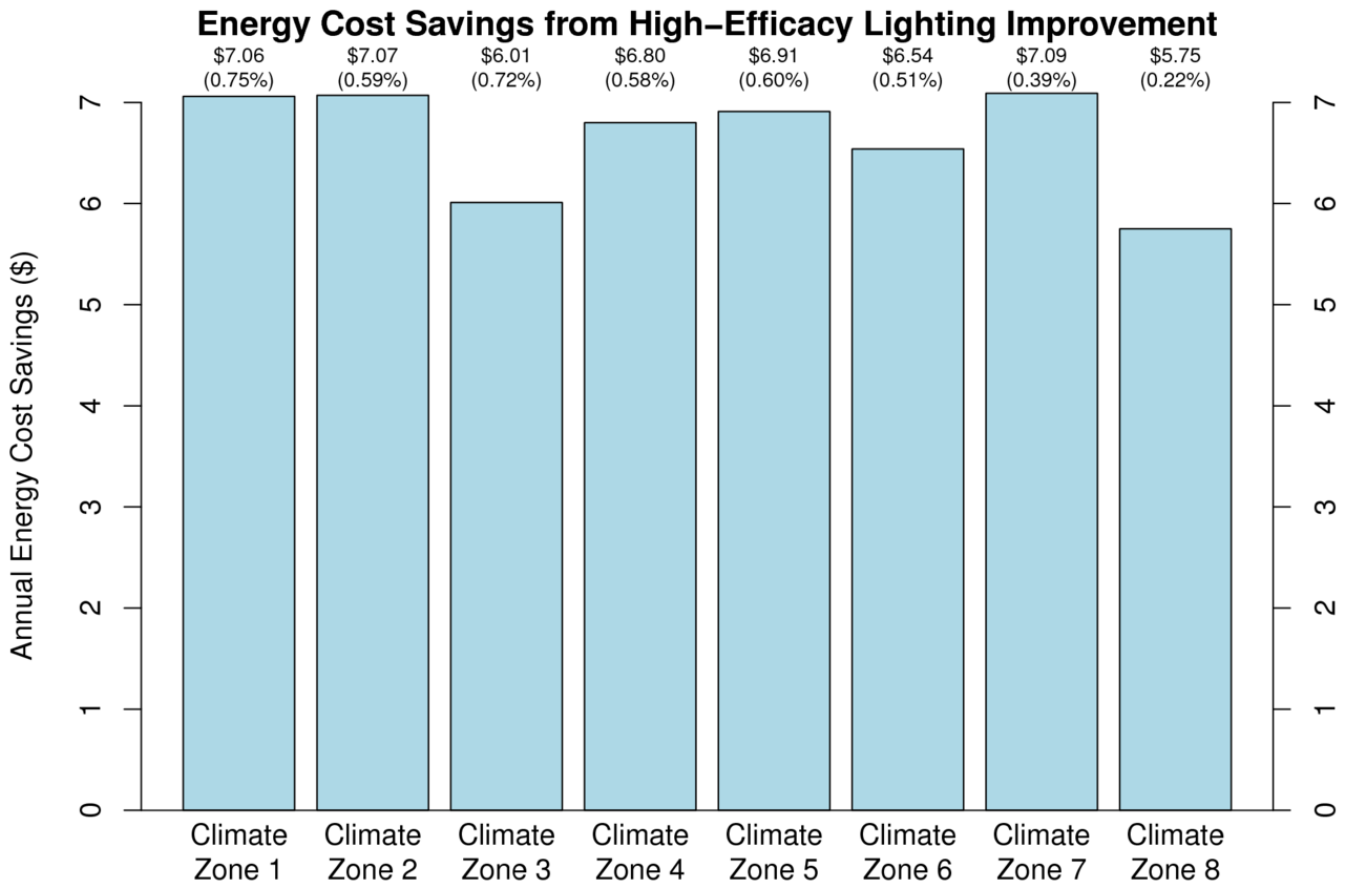
ENERGY COST SAVINGS

In analyzing the energy cost savings and cost-effectiveness of this proposed change, DOE's baseline home prototype was equipped with CFLs (luminous efficacy of 55 lumens/watt) for 75% of its permanent lighting. The proposed change was modeled with LEDs (luminous efficacy of 78 lumens/watt) replacing all the CFLs. The energy analysis indicates that LEDs yield energy savings in all climate zones, with savings ranging from 0.22% to 0.75% of IECC-regulated loads (heating, cooling, water heating, and lighting). The figure below shows the savings by climate zone.

[1] DOE Cost-Effectiveness Methodology available at https://www.energycodes.gov/development/residential/methodology

[2] EIA, Annual Energy Outlook 2015, table accessed 2 Dec 2015 from http://www.eia.gov/beta/aeo/#/?id=3-AEO2015&cases=ref2015; nominal 2018 prices.

[3] LCC calculations are based on year-by-year fuel price ratios derived from price estimates published by EIA (Annual Energy Outlook 2015, table accessed 2 Dec 2015 from http://www.eia.gov/beta/aeo/#/?id=3-AEO2015&cases=ref2015; 2013$ price estimates converted to ratios relative to 2018); the effective rates shown in the table are the uniform annual escalation rates that would give the same present value of energy as the estimated year-by-year price ratios.



MEASURE COST

The cost of LEDs has been rapidly declining over the last several years. Identifying measure costs is therefore challenging because prices vary greatly and change rapidly. One July 2015 report[4] suggests a current price estimate of $12 per lamp, which is 80% lower than in 2010. DOE's Appliance Energy Standards Program (AESP) published a technical support document for its analysis of general service lamps in December 2014[5] that contains price estimates for two "candidate standard levels" (CSLs) that would meet the 75 lumen/Watt threshold proposed here. The price estimates of $10.00/lamp and $9.47/lamp were for luminous efficacies of 80 lumens/Watt and 84.2 lumens/Watt, respectively. The present analysis is based on the $10/lamp estimate. However, because LED prices continue to decline rapidly, that 2014 price was adjusted to estimate its value when the proposed change would be published in 2018. A study by PNNL[6] projected LED price changes for several years going forward. The ratio of prices in 2017 to those in 2014 was used because no projection was available for 2018. That ratio, 0.483, suggests the 2014 estimate of $10/lamp will fall to $4.83/lamp by 2017, one year prior to the new code's publication. This 2017 price estimate is expected to be conservative as prices will likely continue to fall.

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[4] See http://www.mckinsey.com/insights/energy_resources_materials/peering_into_energys_crystal_ball?cid=other-eml-alt-mkq-mck-oth-1507

[5] Preliminary Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: General Service Lamps. U.S. Department of Energy. December 1, 2014.

[6] J. Tuenge. "SSL Pricing and Efficacy Trend Analysis for Utility Program Planning." Pacific Northwest National Laboratories for U.S. Department of Energy; Energy Efficiency & Renewable Energy, October 2013. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_trend-analysis_2013.pdf

Because LEDs replace CFLs in this analysis, an estimate of the price of CFLs is likewise required. The AESP support document referenced above provides estimates for two levels of CFL performance—a baseline level (53.6 lumens/Watt) at $4.84 per lamp and improved luminous efficacy (61.5 lumens/Watt) at $3.10 per lamp. This analysis assumes the lesser of those two price estimates and assumes that price is stable (i.e., will not decline before the new code is published).

The expected operating life of LEDs ranges from 35,000 to 50,000 hours.[7] The present analysis conservatively assumes the life of LEDs to be 25,000 hours which translates to 23 years based on typical patterns of lighting use in homes.[8]

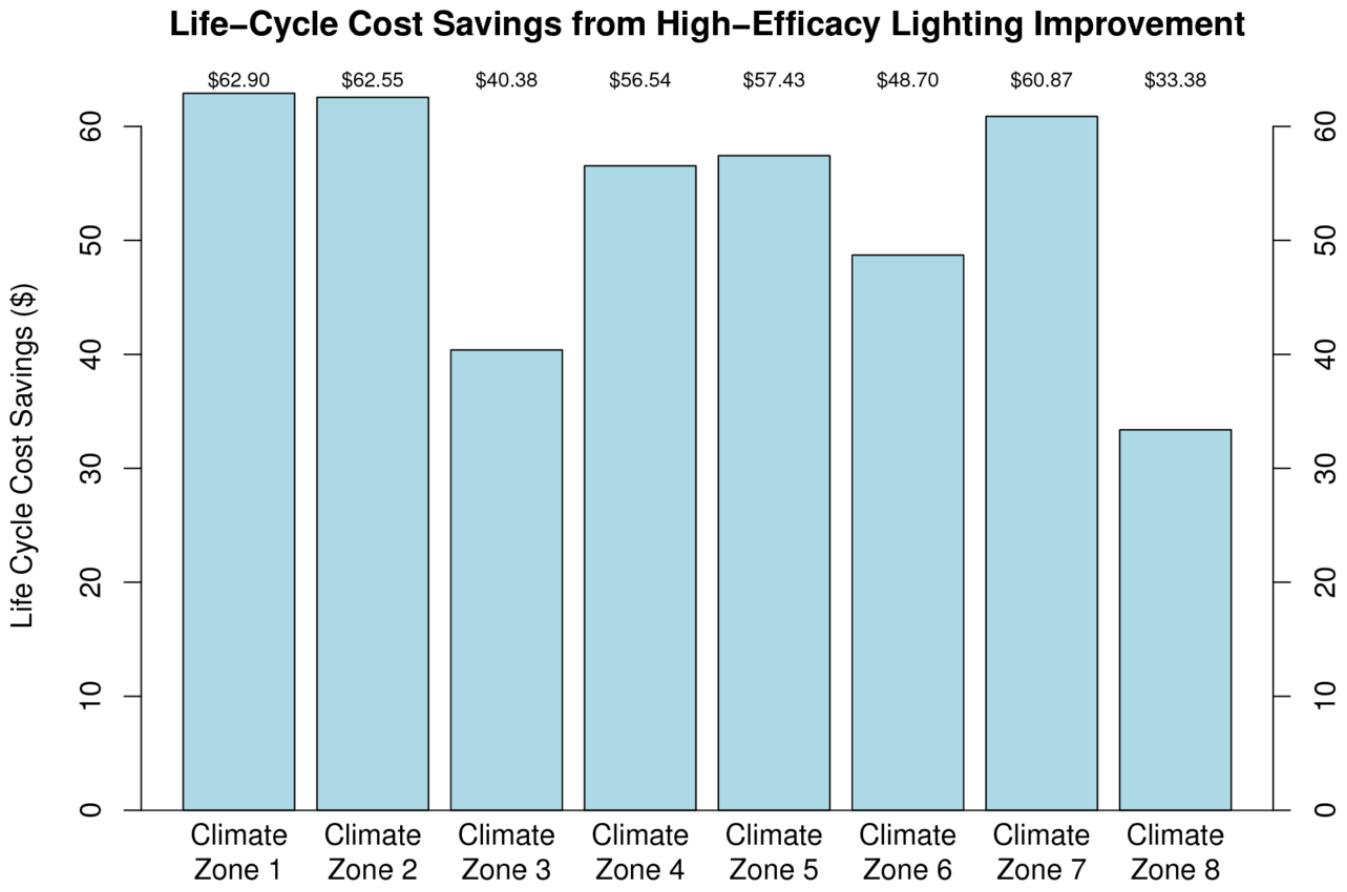
COST-EFFECTIVENESS

Based on these assumptions and the established DOE cost-effectiveness methodology[9], the analysis indicates the proposed improvement in the code's luminous efficacy threshold is life-cycle cost-effective in all climate zones, as shown below.

[7] See http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lifetime_white_leds.pdf

[8] See http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led_general-service-lamps.pdf

[9] DOE Cost-effectiveness Methodology available at https://www.energycodes.gov/development/residential/methodology



CONCLUSION

Increased the code's threshold definition of high-efficacy lighting to 75 lumens/Watt is cost-effective in all climate zones.