Cost-effectiveness Analysis of Reduce Exterior Lighting Allowances

DOE Proposal: C-10; ICC proposal: TBA
for 2018 IECC commercial code

Pacific Northwest National Laboratory
September 2015
R. Hart, J. Zhang, and E. Richman

Purpose

Determine cost-effectiveness of reductions in exterior lighting allowances.

Basis

The cost-effectiveness analysis is conducted according to the DOE cost-effectiveness methodology.[1] In the DOE method, the long term economic impacts for two cases are determined:

- Scenario 1 is for publicly-owned buildings and is based on a FEMP method. [2]
- Scenario 3 is for privately-owned buildings and is based on the 90.1-2016 scalar method.[3]

DOE prototypes[4] for large office and mid-rise apartments are simulated in EnergyPlus.

Study period of 14 years based on an LED lamp and driver life of 50,000 hours and 4380 hr/yr operation

Electric Uniform Present Worth (UPW) factor: 11.95.[5]

The Scenario 3 threshold for electric savings over a 14 year measure life is 9.1 years. In Scenario 3, measures are found cost-effective when the simple payback ≤ the scalar threshold.

Energy Prices

Commercial Sector			2014	Annual Average		Most recent full year
			2015 July	EIA Short Term Energy Outlook		
Prices	$0.1075	$/kWh	$1.0555	$/therm	(2014 EIA average)	for Scenario 1 analysis
	$0.1013	$/kWh	$1.0000	$/therm	SSPC 90.1 for 2016	for Scenario 3 analysis

---

[1] Hart, R., and Liu, B. (2015). *Methodology for Evaluating Cost-effectiveness of Commercial Energy Code Changes.* Pacific Northwest National Laboratories for U.S. Department of Energy; Energy Efficiency & Renewable Energy. PNNL-23923 Rev1. https://www.energycodes.gov/development/commercial/methodology.

[2] Fuller, Sieglinde, and Stephen Petersen. "LIFE-CYCLE COSTING MANUAL for the Federal Energy Management Program." NIST, U.S. Deptartment of Commerce, 1995. http://fire.nist.gov/bfrlpubs/build96/PDF/b96121.pdf.

[3] Based on the approach and assumptions established by the ASHRAE Standard 90.1project committee for 90.1-2016.

[4] Details on building prototypes available at: https://www.energycodes.gov/commercial-prototype-building-models.

[5] Lavappa, Priya, and Joshua D. Kneifel. Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis-2015: Annual Supplement to NIST Handbook 135, 2015. http://dx.doi.org/10.6028/NIST.IR.85-3273-30.

ENERGY SAVINGS RESULTS:

The energy savings is developed based on evaluation of the national stand-alone retail parking lighting, as used in the DOE prototype models. These are simulated in EnergyPlus with 2015 IECC exterior lighting controls in all climate zones. The UPW factor is used to determine the present value of savings discounted over the life of the measure so it can be compared with today's first cost. The range of results is as follows:

Per fixture Stand Alone Retail Savings Results across all Climate Zones

	Per Fixture Annual Savings			Present Value Lifetime Savings
	kWh/year	Scenario 1	Scenario 3	Scenario 1
Minimum	649	$69.78	$65.75	$834
Average	**650**	**$69.87**	**$65.84**	**$835**
Maximum	653	$70.22	$66.17	$839

The range of results is very tight (±0.3%) across climate zones, so the average is used in the analysis.

COST

Costs were developed for the upgrade from HID to LED parking lot fixtures, as shown below. The annual cost of maintenance and replacements is based on the service lives shown relative to 4300 operating hours per year. The difference in annual costs between the base and proposed case is discounted to present value so it can be combined with the incremental installation first costs. Labor is based on 2014 Means Electrical.[6] The costs for LED lighting are changing rapidly due to manufacturing innovation of this developing technology and are adjusted based on a broad study of LED lighting price trends. While it is entirely appropriate to project the cost of LED fixtures from 2013 when costs were collected to at least the date of the new code, we have limited adjustment to from Q4 of 2015 to Q4 of 2017 based on the end of statistical cost projections in the study and to be conservative.

Cost source and adjustment

Cost Item	Source	Original $	Adjustment	Revised Mat $
Base Case				
Pulse Start MH, lamp & Ballast included	GoodMart 2014	$679.00	102.4%	$695.16
Lamp Cost	Grainger 2014	$66.30	102.4%	$67.88
Proposed Case				
LED, lamp & Driver included	Canadian Study 2013[7]	$1,082.00	81.8%	$884.81

2.38% 90.1 adopted annual inflation rate

81.8% LED future cost from 2017Q3 to 2017Q3 due to new product innovation[8]

[6] Means, R. S. *2014 Electrical Cost Data*. R.S. Means Company, 2014. http://www.rsmeans.com/.

[7] William A. Smelser. "Product Characteristics and Capability Data on Currently Available LED Exterior Lighting Products." Laurilliam Lighting Technologies, Inc. for National Research Council Canada, December 2013.

[8] 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.

Parking Lot Fixture Upgrade Cost Analysis

Item	Q	Material	Labor	OH&P	First Cost	Yrs Svc	Annual Cost
Base Case							
Pulse Start MH, lamp & Ballast included	6	$695.16	$188.00	25%	$6,624	12	
Lamp Cost (15,000 hours life)	6	$67.88	$20.60	35%		3.5	$205
Total Base Cost					**$6,624**		**$205**
Proposed Case							
LED, lamp & Driver included	6	$884.81	$188.00	25%	$8,046	12	
Total Proposed Cost					**$8,046**		**$0**
Incremental First & Annual Cost					**$1,422**		**-$205**
PV of annual Costs at real discount rate:	3.0%				-$2,045		
Scenario 1 Incremental Present Value					**-$623**		
PV of annual Costs at real discount rate:	6.8%				-$1,649		
Scenario 3 Incremental Present Value					**-$227**		

Cost-Effectiveness

For both scenarios, the present value of the lamp replacement savings is greater than the cost, so the net present value of savings is positive and the measure is cost-effective. The cost-effectiveness is evaluated using Scenario 1 for the public sector and Scenario 3 for the private sector.[9] For Scenario 1, the savings to investment ratio (SIR) indicates a measure is cost-effective when greater than 1.0.

Savings for 6 fixtures	
Scenario 1 (Publicly-Owned)	Parking Lot
Average Annual Savings	$420
Average Present Value Savings	$5,010
Net Present Value of Costs	-$623
Savings to Investment (SIR)	infinite
SIR threshold: ≥1.0	Pass

In Scenario 3, the simple payback (Cost/annual savings) is compared to a scalar threshold that includes commercial discount rates and loan costs. When the cost is negative, due to reduced lamp replacements, a measure is considered cost-effective. The threshold for electric savings over a 12 year measure life is 9.1 years. In Scenario 3, measures are found cost-effective when the simple payback ≤ the scalar threshold or the cost is negative.

Scenario 3 (Privately-Owned)	Parking Lot
Average Annual Savings	$395
Net Present Value of Costs	-$227
Simple Payback	immediate
90.1 Scalar threshold: ≤9.1	Pass

Conclusion

Improved parking lot lighting fixtures that provide a lower power density are cost-effective both for public and private buildings.

[9] Hart, Reid, and Bing Liu. "Methodology for Evaluating Cost-Effectiveness of Commercial Energy Code Changes." Pacific Northwest National Laboratories for U.S. Department of Energy; Energy Efficiency & Renewable Energy., August 2015. https://www.energycodes.gov/development/commercial/methodology.