Cost-effectiveness Analysis of Expanding use of Occupancy Sensors

DOE Proposal: C-6; ICC proposal: TBA
for 2018 IECC commercial code
Pacific Northwest National Laboratory
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Purpose

Find the cost-effectiveness of occupancy sensor use in open office areas of commercial buildings.

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 small offices are simulated in EnergyPlus.

20.0 year measure life; Basis: 50,000 hour life dimming ballasts are the major component of the advanced system.

Scenario 1 electric UPW factor[5] with 3% discount and EIA energy escalation for PV savings: 15.89

Blended Fossil UPW factor with 3% discount and EIA energy escalation for PV savings: 17.38

The Scenario 3 threshold for electric savings over a 20 year measure life is 13.0 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				
Fossil Price			Conversion to therms				quads heating per BEDB	
Natural Gas	8.87	$/ kCuFt		0.097124	$0.8615	$/therm	1.69	89.4%
Heating Oil	3.72	$/ gal		1.385	$2.6859	$/therm	0.20	10.6%
Blended Fossil Rate					**$1.0555**	**$/therm**	1.90	
Electricity Price					**$0.1075**	**$/kWh**		

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.

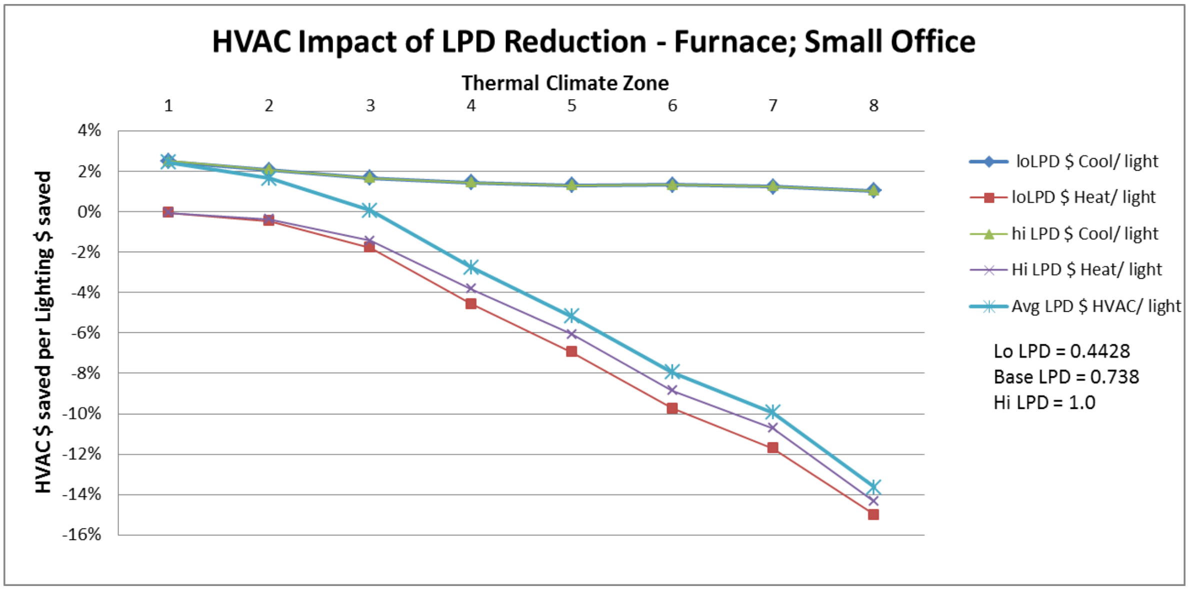
[3] Based on the approach and assumptions established by the ASHRAE Standard 90.1project committee for 90.1-2016.

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

[5] Rushing, Amy S., Joshua D. Kneifel, and Priya Lavappa. *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis-2014: Annual Supplement to NIST Handbook 135*, 2015. http://dx.doi.org/10.6028/NIST.IR.85-3273-29.

Energy Savings Results

Using results a small office analysis of LPD impact, the increased heating that offsets lighting savings is greatest in Climate Zone 8, so analysis is completed for Climate Zone 8, as net savings will be greater in other climate zones. If an interior lighting measure is found cost-effective in Climate Zone 8, it will be cost-effective in all other climate zones. The impact on HVAC of occupancy sensor control will be similar to LPD reduction on a kWh basis. The relative impact of HVAC costs for lighting reductions by climate zone is shown in the graph below.



The energy savings is developed using results from analysis of occupancy sensor floor area in the small office prototype.

Increase in occupancy controlled area from 3535 to 4135 square feet of floor area or from 64.2% to 75.2%.

	Gas $	Elec $	Tot $	Tot $/sf	for Scenario 1 analysis
Base	$915	$4,685	$5,600	$1.018	Base with 2015 IECC LPD - Primary Occ Sensor
Open	$918	$4,647	$5,565	$1.012	Base with 2015 IECC LPD - Add 400 sf Occ Sensor
Savings	-$3.05	$37.77	$34.72	$0.087	Occupancy Sensor Savings per 400 sf
			$547	$1.368	PV$, 20 years

	Gas $	Elec $	Tot $	Tot $/sf	for Scenario 3 analysis
Base	$866	$4,415	$5,281	$0.960	Base with 2015 IECC LPD - Primary Occ Sensor
Open	$869	$4,379	$5,249	$0.954	Base with 2015 IECC LPD - Add 400 sf Occ Sensor
Savings	-$2.89	$35.59	$32.70	$0.082	Occupancy Sensor Savings per 400 sf
			$515	$1.288	PV$, 20 years

Cost

Recent advances in lighting control technology allow for acceptable small zone occupancy control of lighting in open office areas. Local overhead lighting is switched off when there is no activity in a local zone, while general background overhead lighting is maintained throughout the open area. Often advanced systems will have an occupancy sensor on every fixture, although the code proposal allows multiple fixtures serving about four workstations to be controlled together.

An advanced system retrofit was recently reviewed by LBNL for GSA and included estimated incremental costs between $0.90 and $1.00 per square foot for such a system.[6] For a simplified approach, just switching zones covering four workstations rather than individual fixtures, the 2014 Means Electrical[7] cost for a PIR occupancy sensor installed is $197, and is expected to be around $250 including general contractor profit and overhead.

COST-EFFECTIVENESS

The primary cost component of the advanced measure is an upgrade to dimming ballasts or drivers. They have a 50,000 hour life, and at 2500 hours per year operation have a 20 year life.

The cost-effectiveness is evaluated using Scenario 1 for the public sector and Scenario 3 for the private sector.[8] An analysis of both a simple occupancy sensor installation every 400 square feet and a more advanced wireless lighting control system are included.

Scenario 1 analysis (Publicly-Owned)		$/400 sf	$/sf	
Present Value of Savings		$547	$1.368	PV$, 20 years
Cost (Simple / System)		$250	$0.950	
Savings to Investment Ratio (SIR)		2.2	1.4	
SIR threshold:	≥1.0	Pass	Pass	

Scenario 3 analysis (Privately-Owned)		$/400 sf	$/sf
Annual Savings		$32.70	$0.082
Cost (Simple / Advanced System)		$250	$0.950
Simple Payback Period, Years:		7.6	11.6
90.1 Scalar Threshold:	≤13.0	Pass	Pass

CONCLUSION

The open office occupancy sensor control proposal is cost-effective both for public and private buildings and for both a simple and advanced lighting control system.

[6] Joy Wei, Francis Rubinstein, Jordan Shackelford, and Alastair Robinson. “Wireless Advanced Lighting Controls Retrofit Demonstration.” Lawrence Berkeley National Laboratory for General Services Administration, April 2015. http://www.gsa.gov/portal/mediaId/227615/fileName/Wireless_Advanced_Lighting_Controls_Retrofit_Demo_FINAL-508-062915.action.

[7] Means, R. S. 2014 Electical Cost Data. R.S. Means Company, 2014. http://www.rsmeans.com/.

[8] 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.