Cost-effectiveness Analysis of Occupant standby control for HVAC

DOE Proposal: C-3; ICC proposal: TBA
for 2018 IECC commercial code
Pacific Northwest National Laboratory
September 2015
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PURPOSE

Find the cost-effectiveness of occupancy sensor control of HVAC for high occupancy spaces.

BASIS

The cost-effectiveness analysis is conducted according to the DOE cost-effectiveness methodology.[1] Under this methodology, DOE may use analysis by others as a basis after careful review. A CASE study[2] conducted for California Title 24 in 2011 showed that occupancy sensor HVAC control was cost-effective in new construction and similar provisions were included in California Title 24. The results from that study are adapted here using national energy rates. 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.[3]
- Scenario 3 is for privately-owned buildings and is based on the 90.1-2016 scalar method.[4]

Measure life for electronic controls: 15 years[5]

Scenario 1 electric uniform present worth (UPW) factor with 3% discount and EIA energy escalation:[6] 12.65

Scenario 3 scalar threshold for electric savings: 10.8 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] PECI, and Taylor Engineering. (2011). "Light Commercial Unitary HVAC, 2013 California Building Energy Efficiency Standards, CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)." California Utilities Statewide Codes and Standards Team for California Energy Commission.

[3] 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.

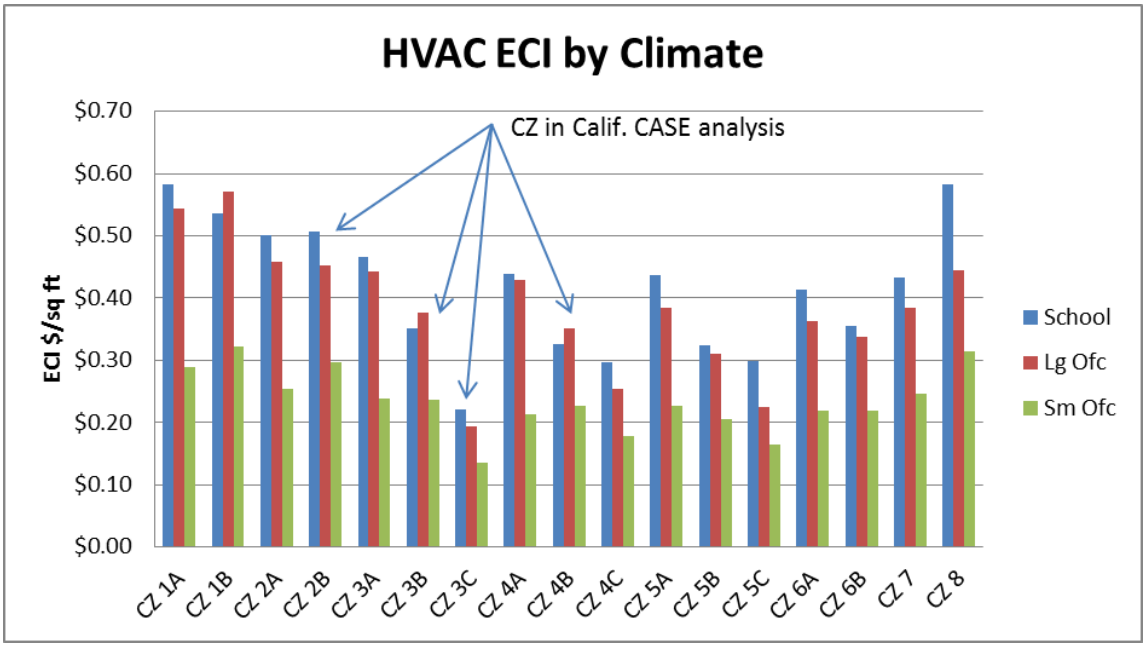
[4] Based on the approach and assumptions established by the ASHRAE Standard 90.1project committee for 90.1-2016.

[5] ASHRAE. (2015). *2015 ASHRAE Handbook Applications*. American Society of Heating, Refrigerating and Air Conditioning Engineers [ASHRAE], Atlanta, GA.

[6] 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:

The energy savings is developed using results from the CASE study. These results are for generally mild climate zones in California. A review of national range of HVAC energy use for the applicable building types[7] is shown in the graph below. The end use results are also used to provide a maximum cap for national building prototypes based on 90.1-2013 end use analysis that is similar to 2015 IECC. The maximum cap limits savings to 25% of HVAC use in schools and 15% of HVAC use in offices, with an adjustment for affected areas; 31% in schools and 5% in offices.



When the HVAC Energy Cost Indices (ECI) are reviewed nationally, it can be seen that the California average savings results are likely lower than the national average results, as savings from DCV will be somewhat proportional to overall HVAC energy costs. The savings from the CASE analysis for multiple climate zones in California, in kWh/ft^2 in the affected rooms are as follows:

Annual kWh Savings/ square foot served:

	Large Office	School	Small Office
Minimum	13.0	179.2	1.0
Average	**30.8**	**375.3**	**2.2**
Maximum	41.7	504.0	2.9

When adjusted for the maximum limit discussed above and with national average energy rates applied, the cost savings for a 150 square foot conference room or portion of classroom is expected to be:

Savings for 150 square foot room	Average Annual Cost Savings			
	Large Office	School	Small Office	Average
Scenario 1 (Publicly-Owned)	$182	$53	$35	$90
Scenario 3 (Privately-Owned)	$171	$50	$33	$85

[7] Hart, Reid, and Y. Xie. "End-Use Opportunity Analysis from Progress Indicator Results for ASHRAE Standard 90.1-2013." Pacific Northwest National Laboratory (PNNL), Richland, WA (US), October 2014. http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24043.pdf.

COST

Based on a CASE study[8] conducted for California Title 24 in 2011, the added cost of occupancy sensor controlled thermostats in new construction is $178 per zone. Updated for inflation of 2.38% for 4 years, the cost is $196 per room.

COST-EFFECTIVENESS

The cost-effectiveness is evaluated using Scenario 1 for the public sector and Scenario 3 for the private sector.[9] Under the FEMP analysis, the uniform present worth (UPW) factor for electricity is 12.65. The UPW factor is used to determine the present value of savings over the life of the measure discounted so it can be compared with today's first cost. The savings to investment ratio indicates a measure is cost-effective when greater than 1.0.

Savings for 150 square foot room

Scenario 1 (Publicly-Owned)	Large Office	School	Small Office	Average
Average Annual Savings	$182	$53	$35	$90
Average PV Savings	$2,300	$672	$445	$1,139
Savings to Investment (SIR)	11.8	3.4	2.3	5.8
SIR threshold: ≥1.0	Pass	Pass	Pass	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 payback is less than the threshold, a measure is considered cost-effective. The threshold for electric savings over a 15 year measure life is 10.8 years.

Scenario 3 (Privately-Owned)	Large Office	School	Small Office	Average
Average Annual Savings	$171	$50	$33	$85
Simple Payback	1.1	3.9	5.9	2.3
90.1 Scalar threshold: ≤10.8	Pass	Pass	Pass	Pass

CONCLUSION

Occupancy sensor control of HVAC fans or ventilation air with standby setback is cost-effective both for public and private buildings in high-occupancy spaces. While these savings results are for mild California climates, the savings are expected to increase in warmer or colder climates, and cost-effectiveness is expected for high-occupancy rooms across all climate zones.

[8] PECI, and Taylor Engineering. (2011). "Light Commercial Unitary HVAC, 2013 California Building Energy Efficiency Standards, CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)." California Utilities Statewide Codes and Standards Team for California Energy Commission.

[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.