Cost-effectiveness Analysis Summary for SHGC upgrade

DOE Proposal: C-2; ICC proposal: TBA

For 2018 IECC commercial code

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PURPOSE

Verify cost-effectiveness of increasing the stringency of Solar Heat Gain Coefficient (SHGC) in Climate Zones 1 and 2 from 0.25 to 0.22 for windows facing East, South, and West.

BASIS

Simulation of the energy impact of change in SHGC for the mid-rise apartment and medium office buildings.

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 an established 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 mid-size office and mid-rise apartments are simulated in EnergyPlus.

40.0 year measure life is the accepted value used by ASHRAE 90.1 committee for envelope analysis.

Electric Uniform Present Worth (UPW) factor with 3% discount and EIA energy escalation:[5] 25.7

Gas UPW factor with 3% discount and EIA energy escalation: 33.8

For years 31-40, the equivalent year 1-30 compound rate was applied

Scenario 3 (90.1-16) Scalar threshold is 18.4; a blend of 18.2 for electric and 21.4 for fossil fuels. In Scenario 3, measures are found cost-effective when the simple payback ≤ the scalar threshold.

Cost estimating consultant to PNNL provided incremental costs for SHGC from 0.25 to 0.22

ENERGY PRICES

Commercial Sector				2014	Annual Average		Most recent full year	
		2015 July EIA Short Term Energy Outlook						
Electricity					**$0.1075**	**$/kWh**		
Heating							quads 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				**$1.0555**	**$/therm**		
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.

Annual Energy Savings, per square foot of fenestration (Scenario 1 prices)

Climate Zone	kWh/sf/year Mid Ofc	kWh/sf/year Mid Apt	therm/sf/year Mid Ofc	therm/sf/year Mid Apt	Elec $/sf/year Mid Ofc	Elec $/sf/year Mid Apt	Gas $/sf/year Mid Ofc	Gas $/sf/year Mid Apt	Total $/sf/year Mid Ofc	Total $/sf/year Mid Apt
1a	1.3076	0.9845	0.00000	0.00000	$0.1406	$0.1058	$0.0000	$0.0000	$0.1406	$0.1058
2a	1.2773	0.8094	-0.00470	-0.00048	$0.1373	$0.0870	-$0.0050	-$0.0005	$0.1323	$0.0865

COST-EFFECTIVENESS

The cost-effectiveness is evaluated using Scenario 1 for the public sector and Scenario 3 for the private sector.[6] For Scenario 1, the savings to investment ratio (SIR) indicates a measure is cost-effective when greater than 1.0. 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 blended savings over a 40 year measure life is 18.4 years.

Cost-Effectiveness Analysis: DOE Commercial Methodology Scenario 1 Scenario 3 (90.1-16)

Climate Zone	Added First cost per sf glazing Mid Ofc	Added First cost per sf glazing Mid Apt	PV Savings Mid Ofc	PV Savings Mid Apt	Net PV Savings Mid Ofc	Net PV Savings Mid Apt	Savings to Investment Ratio Mid Ofc	Savings to Investment Ratio Mid Apt	Simple Payback Mid Ofc	Simple Payback Mid Apt
1	$1.42	$1.42	$3.61	$2.72	$2.19	$1.30	2.5	1.9	10.7	14.2
2	$1.42	$1.42	$3.38	$2.22	$1.96	$0.80	2.4	1.6	11.4	17.4

Average Office and Apartment Weighted Average: 23.2% Residential/Lodging 76.8% Commercial

Climate Zone	Added First cost per sf glazing	PV Savings	Net PV Savings	Savings to Investment Ratio	Weighted Simple Payback, Scenario 3 Savings	Weighted Simple Payback, Scenario 3 Payback
1	$1.42	$3.40	$1.98	2.4	$0.1249	11.4
2	$1.42	$3.11	$1.69	2.2	$0.1147	12.4
Average of Climate Zones 1 & 2					**$0.120**	**11.9**

CONCLUSION:

The SHGC reduction from 0.25 to 0.22 is cost-effective in both Climate Zones 1 and 2 for both building types and for both public and private economic scenarios.

[6] 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.