Supporting analysis for proposed changes to the commercial provisions of the 2012 IECC: Increase Duct and Plenum Insulation

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Proposal Description

This proposal modifies Section C403.2.7of the 2012 IECC for the 2015 version. It increases the insulation requirement for ductwork outside the buildings from R-8 to R-12 in climate zones 5 through 8.

Energy Impact

Based on average national energy prices[1] of $0.99 per therm and $0.1032 per kWh, the cost for heat loss and gain to the ductwork is determined based on the degree hour determined for a typical building heating and cooling profile

The cost of ductwork loss and gain annual cost on a square foot basis is shown in Figure 1. The result for R-8 (the current requirement) is compared with the proposed requirement, R-12. The savings in $/square foot-year is shown as well. Results are shown for climate zones 4 and 5 and for gas heating and heat pump heating. The impact of cooling heat gain and beneficial loss is included in the analysis.

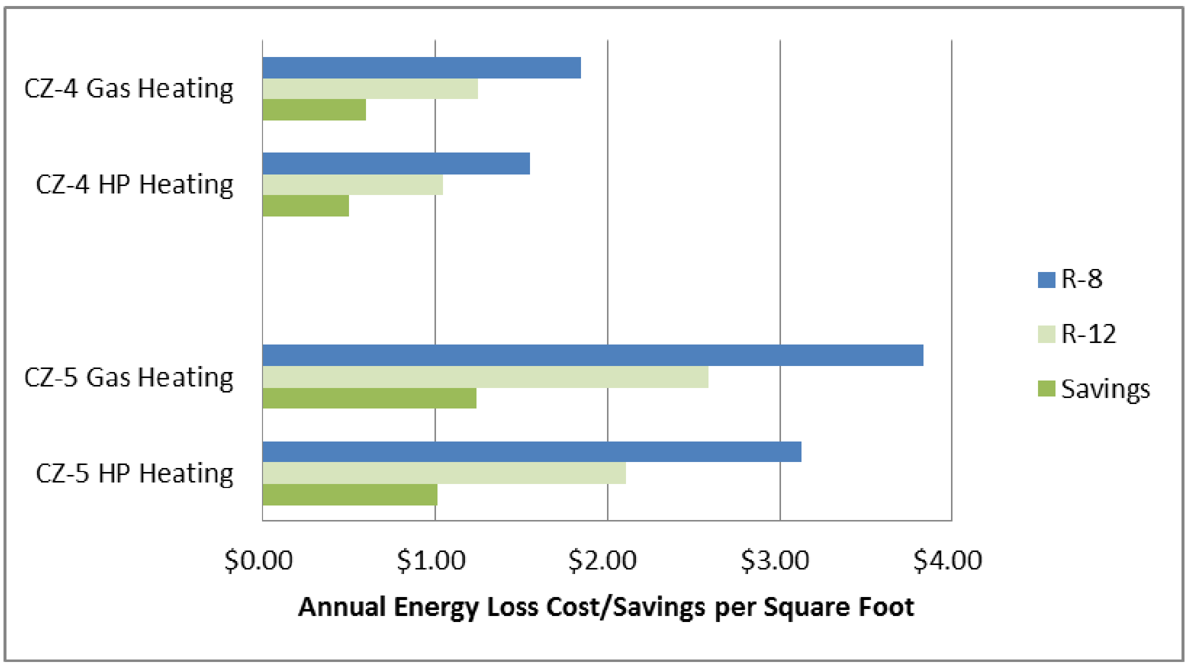

Figure 1: Exterior Ductwork Annual Loss Cost and Savings

Based on this analysis, there is demonstrated savings from ductwork insulation increase in both cases, and higher savings in climate zone 5.

Approach

To test if additional ductwork insulation is cost effective, analysis of a typical thermal zone in Climate zones 4 and 5 was completed. Evaluation was restricted to ductwork outside the building where heat loss is greatest. Based on a temperature bin analysis, the degree hours for the exterior ductwork are found for various operating modes of a unitary conditioning system.

[1] Weighted commercial national average energy prices developed by the ASHRAE 90.1 standards committee for analysis of 90.1-2013 proposals; based on national data from the 2011 *Annual Energy Outlook* by US Energy Information Administration. www.eia.gov.

In all cases, one square foot of ductwork insulation is analyzed. The combined impact on the heating and cooling system is determined for various insulation levels and a life cycle cost performed to determine the incremental net benefit compared with the prior insulation level. Where the net benefit to the building owner is positive, the insulation level is recommended.

For each combination of ductwork type and location, the "degree hours" is found, based on the temperature difference between the air in the ductwork and outside. In addition to times when the ductwork is in heating or cooling, the impact of recirculating air during the heating and cooling periods is accounted for. A bin calculation for each climate zone finds degree hours for exterior ductwork and operating hours in heating, cooling, and recirculation modes.

For each combination of ductwork type and location, the life cycle operating cost is found, using the degree hours, insulation U-value, and life cycle cost parameters. For each location, the incremental insulation and energy cost is found, to arrive at a net present value of energy savings for the proposed insulation level.

Basis for Analysis

Unitary heating and cooling equipment operates in a cycling manner with continuous fan operation during occupied hours.

Conditioning equipment efficiency: Meets 2012 IECC minimum requirements.

Conditioned building with a balance point (no heating or cooling) at 52°F outside temperature.

The incremental ductwork insulation cost from R-8 to R-12 is $0.70 per square foot.[2]

Cost Effectiveness

Two different cost effectiveness techniques are applied:

- The ASHRAE 90.1 committee scalar method uses the economic factors to arrive at a discounted threshold or target simple payback based on the measure life. If the calculated simple payback is less than this target, it is deemed to be cost effective. This method accounts for tax impacts and uses a discount rate appropriate to commercial and private industry owners.

- The DOE/FEMP method uses an institutionally oriented discount rate to determine the net present value (NPV) for a particular measure. The discount rate considers the real time value of money, fuel escalation costs, and the measure life to arrive at an NPV. The NPV is the present value of savings minus the first cost. When that NPV is greater than zero, a measure is considered cost effective. This method does not include tax considerations or the opportunity value of invested capital.

Economic factors for the scalar method are those arrived at by the ASHRAE 90.1 committee for analysis of Standard 90.1-2013 measures. National average electric and gas rates are from EIA for 2011. The DOE/FEMP discount rate and electric and gas present value factors are from

[2] R S Means. *Mechanical Cost Data*. Kingston MA: Reed Construction Data.

the NIST Life Cycle Cost 2011 supplement (NISTIR 85-3273-26).[3] The factors shown in Table 1 are used.

Table 1: Economic Factors

	ASHRAE SPP Method	DOE/ FEMP NPV
Economic Life - Years	24	24
Fuel Escalation Rate - %	3.76%	N/A
Gas UPWF	N/A	17.52
Electric UPWF	N/A	16.28
Discount Rate - %	7.00%	3.00%
Loan Interest Rate - %	6.25%	N/A
Federal Tax Rate - %	34.00%	N/A
State Tax Rate - %	6.50%	N/A
Heating - Gas Price - $/therm	$0.9900	$0.9900
Cooling - Electric Price - $/kWh	$0.1032	$0.1032
Metric for cost effectiveness	SPP	NPV
Metric threshold	< 14.169	> 0

The cost effectiveness results are shown in Figure 2 for net present value using FEMP economic criteria. The net present value is the present value of savings over the life of the measure minus the first cost and the present value of any replacement costs. In a net present value analysis, the project is cost effective when the net present value is greater than zero. Using this criterion, the added insulation is cost effective in climate zone 5, but not climate zone 4.

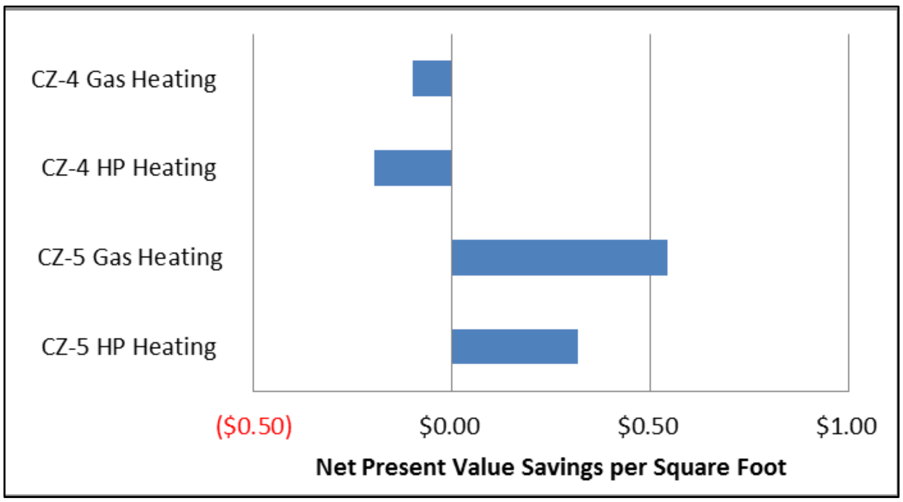

Figure 2: Net Present Value of Savings

The cost effectiveness results are shown in Figure 3 for simple payback compared to a discounted payback limit. The simple payback period (SPP) is the cost of the project, including the discounted cost of any replacements, divided by the annual energy savings in dollars. The discounted payback limit is calculated using a method and agreed to parameters developed by the ASHRAE 90.1 standard committee.[4] The discounted limit (also known as the scalar) accounts for discounting, tax impacts, and fuel escalation and a measure is cost effective when

[3] Amy Rushing, Joshua Kneifel, and Barbara Lippiatt, "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – 2011" (NIST for USDOE FEMP, September 2011), http://www.nist.gov/customcf/get_pdf.cfm?pub_id=909539.

[4] M. F. McBride, "Development of Economic Scalar Ratios for ASHRAE Standard 90.1 R," in Proceedings of Thermal Performance of the Exterior Envelopes of Buildings VI, ASHRAE (presented at the Thermal Performance of the Exterior Envelopes of Buildings VI, ASHRAE, 1995), http://consensus.fsu.edu/FBC/2010-Florida-Energy-Code/901_Scalar_Ratio_Development.pdf.

the simple payback is less than the discounted simple payback limit. For the added insulation, the simple payback is below the discounted limit, and therefore cost effective, in climate zone 5, but not climate zone 4.

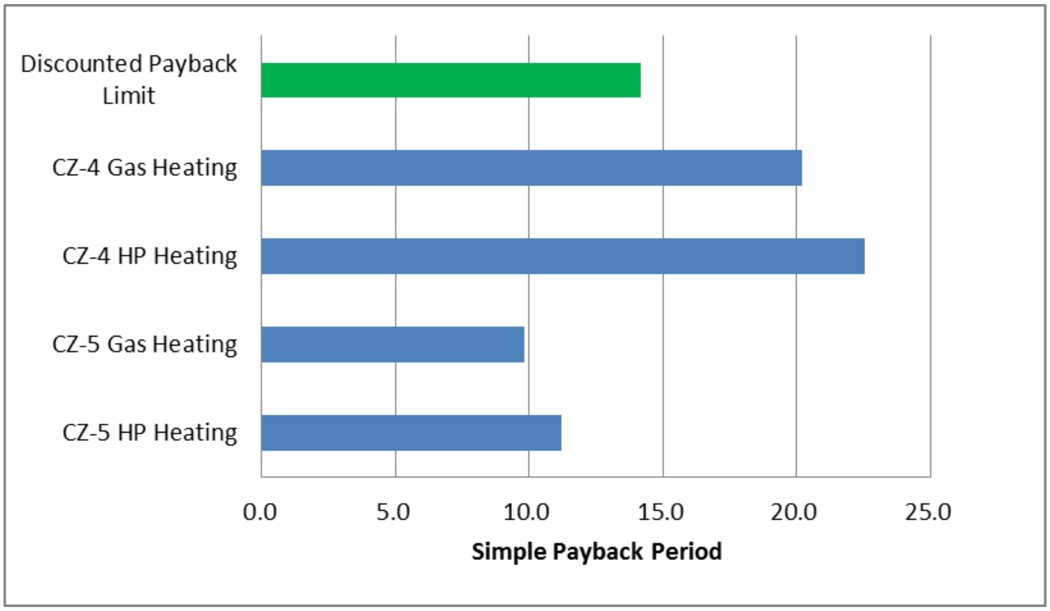

Figure 3: Simple Payback for Added Duct Insulation

Under both analysis methods, the added insulation is cost effective in climate zone 5, but not climate zone 4. Colder climate zones will have greater savings and will also be cost effective as the cost is constant. As a result of the analysis, the additional insulation is recommended in climate zones 5 through 8.