



MEMORANDUM

To: Rob Underwood, Ed Synoski
From: Matt Socks
Date: March 20, 2019
Subject: Delaware Energy Code Adoption Support

INTRODUCTION

The Home Builders Association of Delaware, as part of the energy code update process, has proposed a weakening amendment to the proposed code, the 2018 International Energy Conservation Code (IECC), that will essentially allow homes smaller than 2,000 square feet to meet reduced blower door testing requirements. This memo attempts to answer the follow two related questions:

1. What are the costs and energy (and energy cost) savings associated with the 2018 IECC improvements to air tightness requirements?
2. What is the current code status of other Mid-Atlantic states with respect to air tightness requirements?

To orient the reader, it should be noted that the air sealing requirements of 2012 IECC (un-amended) are essentially equivalent to the same requirements of 2018 IECC. In the discussion that follows, references to 2012 IECC can be interpreted as equivalent to Delaware's proposed code, 2018 IECC, where air sealing requirements are concerned. Throughout this discussion, references are made to tables and calculations contained within the attached Excel workbook ("DE Codes Analysis 2019-03-20.xlsx").

COSTS AND ENERGY IMPACTS

What are the costs and energy (and energy cost) savings associated with the 2018 IECC improvements to air tightness requirements?

Improved Air Sealing Construction Costs

A 2013 Pacific Northwest National Laboratory (PNNL) study estimated that the incremental cost of meeting the air sealing requirements of 2012 IECC relative to 2009 IECC was \$0.20 per square foot of home floor area. This equates to a total cost of \$300 for a 1,500 square foot home. The testing option of 2009 IECC (R402.4.2.1) requires less than 7 air changes per hour when tested with a blower door at a pressure of 50 Pa (ACH50). 2012 IECC (R402.4.1.2) requires less than 3 ACH50 for Climate Zones 3 through 8. All of Delaware is within Climate Zone 4. Therefore, the estimated cost to reduce air leakage

by 4 ACH50 in a 1,500 square foot home is \$300. Since Delaware's current energy code requires less than 5 ACH50, this estimate overstates the cost of improving from Delaware's current code to 2018 IECC (again, essentially equivalent to 2012 IECC with respect to air sealing requirements). To adjust for this, we assume that improved air sealing costs scale linearly with ACH50 reductions. This approximation is likely valid until very low air leakage rates are reached. Therefore, the estimated costs to meet the air sealing requirements of 2018 IECC relative to Delaware's current code are \$150 for a 1,500 square foot home. See Table 1 in the attached workbook for calculations and sources.

A 2012 study from the National Association of Homebuilders (NAHB) itself estimated that the incremental cost of meeting the air sealing requirements of 2012 IECC for Climate Zones 3 through 8 relative to 2006 IECC was \$0.41 per square foot of home floor area. The same study estimated that the costs to meet 2012 IECC for Climate Zones 1 and 2 relative to 2006 IECC were \$0.26 per square foot. This is convenient as the testing requirement for 2012 IECC for Climate Zones 1 and 2 is 5 ACH50. Therefore, the difference in these two cost estimates is the equivalent of going from a 5 ACH50 requirement to a 3 ACH50, which is exactly the change from going from Delaware's current code to 2018 IECC. This cost is \$0.15 per square foot or \$225 for a 1,500 square foot home. See Table 2 in the attached for calculations and sources.

In summary, the cost estimates from these sources are in fairly close agreement and range from \$150 to \$225 per home.

Relative to the median home price in Delaware, this represents less than a 0.1% increase—hardly likely to price potential buyers out of the market. See Table 3 in the attached for calculations and sources.

Improved Air Sealing Energy Savings

Published estimates of energy cost savings specifically for increasing air sealing requirements from 5 ACH50 to 3 ACH50 are lacking, not to mention those specific to Delaware's climate and energy costs. Energy code improvements are typically analyzed as a package, so while the costs can be isolated with relative ease, the energy (and energy cost savings) cannot be.

Regardless, we can reasonably approximate the energy impacts of improved air sealing in Delaware using published data. We begin by estimating the typical heating and cooling energy consumption for homes in Delaware. According to the 2015 Residential Energy Consumption Survey (RECS), the average annual electric energy consumption for space cooling in a home in the Middle-Atlantic region is 1,101 kWh. From the same source, average annual gas consumption for space heating in gas heated homes in the Middle-Atlantic region is 57 MMBtu. See Table 3 in the attached for explicit sources.

Next, we use average retail energy rates to estimate the average energy cost burden for heating and cooling homes in Delaware. According to the Energy Information Administration, average annual statewide retail electric rates in 2017 were \$0.134 per kWh in 2017. Gas rates were \$12.38 per MMBtu. See Table 4 in the attached for explicit sources.

Multiplying the annual consumption and rate estimates and summing yields an average annual heating and cooling energy cost of \$852 for the average Delaware home. See Table 5 in the attached for calculations.

Next, we estimate the percentage of heating and cooling energy (and energy cost) that is due to air leakage. Estimates vary, but a commonly cited range is 33-50%. In other words, 33-50% of residential heating and cooling energy consumption is due to air leakage. Since this range is likely more indicative of older, existing homes, we assume a conservatively low value for this analysis of 20% to approximate homes built to 5 ACH50 requirements. See Table 6 in the attached for sources.

Therefore, air leakage in homes built to a requirement of less than 5 ACH50, Delaware's current energy code requirement, is responsible for \$171 in heating and cooling energy costs. See Table 7 in the attached for calculations.

Finally, we note that a reduction from 5 ACH50 (current Delaware code) to 3 ACH50 (2018 IECC) represents a 40% reduction in air leakage. **Applying this air leakage reduction to the energy costs associated with air leakage yields an annual energy cost savings of \$68.** See Table 9 in the attached for calculations.

Improved Air Sealing Participant Economics

Assuming increased construction costs of \$150-\$225 and an annual energy cost savings of \$68 estimated above, we can assess the economics of improved air sealing requirements.

The estimated simple payback ranges from 2.2 to 3.3 depending on the cost assumption. See Table 11 in the attached for calculations.

Assuming a discount rate of 5% and an improvement lifetime of 20 years, typical for building envelope improvements, the lifetime participant net benefits range from \$625 to \$700 (2019\$) and the benefit-cost ratios range from 3.8 to 5.7, again depending on the cost assumption. See Table 12 in the attached for calculations.

Comparison to Other Energy Cost Saving Estimates.

As one additional point of comparison, a 2012 DOE analysis estimated that improving from Minnesota's then current energy code to 2012 IECC (including all code provisions, not just the air sealing requirements) would yield average annual energy savings of \$669. An alternative analysis from the same study looked at the energy cost savings from all code improvements without any increased air sealing which yielded a value of \$259. If these two values are subtracted, it represents the energy cost savings from the air sealing improvements alone—essentially aligning with an improvement from 7 ACH50 to 3 ACH50. This yields an energy cost savings of \$410. Finally, if this is adjusted to account for the fact that this represents a 4 ACH50 improvement vs. the 2 ACH50 improvement represented by 2018 IECC relative to current Delaware energy code, this annual energy cost savings is \$205. While this value is not directly comparable to the \$68 estimated above due to differences in assumptions around home sizes, heating and cooling loads, energy retail rates, etc., this at least serves to demonstrate that the estimated energy cost savings for Delaware (\$68) is likely a conservatively low estimate.

REGIONAL ENERGY CODE STATUS

What is the current code status of other Mid-Atlantic states with respect to air tightness requirements?

A list of the current code by state, including any amendments and impacts thereof, follows.

- New York
 - Current Residential Energy Code: 2015 IECC w/ 2016 Supplement
 - Requires less than 3 air changes per hour tested at 50 Pa (ACH50) (i.e., supplement does not weaken air tightness requirements)
 - Link: https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_C_HR4.pdf§ion=energy_code_2016
 - Supplement Link: <https://www.dos.ny.gov/dcea/pdf/2016%20EC%20Supp-Revised-2016-08-12-approved%20bycouncil%20V-A.pdf>
- New Jersey
 - Current Residential Energy Code: 2015 IECC w/ amendments
 - Requires less than 3 ACH50.
 - Amendment allows compliance with R402.4.1 by meeting R402.4.1.1 OR R402.4.1.2 (i.e., compliance can be met with itemized air sealing checklist and visual inspection in lieu of testing).
 - Link: https://www.state.nj.us/dca/divisions/codes/codreg/pdf_regs/njac_5_23_3.pdf
- Pennsylvania
 - Current Residential Energy Code: Allows 3 compliance paths (2018 PA-Alt, the 2015 IRC, and the 2015 IECC)
 - 2018 PA-Alt revises R402.4.1.2 to require less than 5 ACH50.
 - Link: https://www.phrc.psu.edu/assets/docs/Publications/2018_Pennsylvania_Alternative_Energy_Provisions.pdf
- Maryland
 - Current Residential Energy Code: 2015 IECC
 - Requires less than 3 ACH50.
 - Allows local (non-weakening) amendments
- Washington, D.C.
 - Current Residential Energy Code: 2015 IECC w/ amendments
 - Amended to require less than 5 ACH50.

- Amendment allows compliance with R402.4.1 by meeting R402.4.1.1 OR R402.4.1.2 (i.e., compliance can be met with itemized air sealing checklist and visual inspection in lieu of testing)
- Link:
https://dcra.dc.gov/sites/default/files/dc/sites/dcra/publication/attachments/DCMR%2012_ConstructionCodes_2013.pdf
- Virginia:
 - Current Residential Energy Code: 2015 IECC w/ amendments
 - Amended to require less than 5 ACH50.
 - Amendment essentially allows compliance with R402.4.1 by meeting R402.4.1.1 OR R402.4.1.2 (i.e., compliance can be met with itemized air sealing checklist and visual inspection in lieu of testing).

CONCLUSIONS

In summary, the increased cost of the improved air sealing requirements will not have a significant impact on total home prices. To suggest that this code change will price potential buyers out of the market is disingenuous.

The lifetime benefits of improved air sealing greatly outweigh the costs with simple paybacks and BCRs ranging from 2.2 to 3.3 and 3.8 to 5.7, respectively. Accepting the Home Builders Association's proposed amendment would strand Delaware homebuyers with decades of increased energy costs to avoid an approximate one-time cost of \$200.

There is a local precedent for adopting the 2018 IECC air sealing requirements; both New York and Maryland have already adopted air sealing requirements that are equivalent to those contained in 2018 IECC

Finally, in addition to all the other reasoning provided above, it should be noted that meeting the mandatory air sealing activities as required by IECC 2018 (R402.4.1.1), if done properly, will achieve the 3 ACH50 blower door testing targets. In effect, the testing requirement can be viewed as an audit of the quality of workmanship, not a more stringent air sealing requirement.

Improved Air Sealing Constuction Cost Estimates

Table 1. PNNL Improved Air Sealing Constuction Cost Estimates

Item	Cost	Unit	Total Cost for 1,500 ft2 home	Total Cost per unit ACH50 improvement
IECC 2006 to IECC 2012 (N/R)		0.25 \$/ft2	375	
IECC 2006 to IECC 2009 (N/R)		0.05 \$/ft2	75	
IECC 2009 to IECC 2012 (7 AC)		0.2 \$/ft2	300	75
DE Code to IECC 2018 (5 ACH50 to 3 ACH50)			150	

Source: PNNL 2013. Cost-Effectiveness Analysis of the 2009 and 2012 IECC Residential Provisions – Technical Support Document. <https://www.nahb.org/en/nahb-priorities/construction-codes-and-standards/>

Table 2. NAHB Improved Air Sealing Constuction Cost Estimates

Item	Cost	Unit	Total Cost for 1,500 ft2 home
IECC 2006 to IECC 2012; Zone		0.26 \$/ft2	390
IECC 2006 to IECC 2012; Zone		0.41 \$/ft2	615
DE Code to IECC 2018; Zones		0.15 \$/ft2	225

Source: NAHB 2012. 2012 IECC Cost Effectiveness Analysis. <https://www.nahb.org/en/nahb-priorities/construction-codes-and-standards/>

Table 3. Delaware Median Home Price, 2019

\$ 238,200 Source: <https://www.zillow.com/de/home-values/>

0.08% Improved air sealing cost estimate as percentage of median home price, Calculated

Improved Air Sealing Energy and Energy Cost Savings Estimates

Table 4. Average HVAC Consumption per Household, Middle Atlantic region

End-Use	Usage	Source
Cooling (kWh)		1,101 RECS 2015, https://www.eia.gov/consumption/residential/data/2015/c&e/pdf/ce5.
Space Heating (MMBtu)		57 RECS 2015, https://www.eia.gov/consumption/residential/data/2015/c&e/pdf/ce5.

Table 5. Average Annual Retail Rates, Delaware, 2017

Fuel	Rate	Source
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Electric (\$/kWh)
Gas (\$/MMBtu)

0.134 EIA 2018, <https://www.eia.gov/electricity/data/state/avgprice/annual.xlsx>
12.38 EIA 2018, https://www.eia.gov/dnav/ng/ng_pri_sum_a_EPGO_PRS_DMcf_a.htm

Table 6. Average Annual HVAC Energy Costs per Household, Delaware (\$)

End-Use	Cost	Source
Cooling	\$ 147	Calculated
Space Heating	\$ 706	Calculated
Total	\$ 853	

Table 7. Percent of HVAC loads due to Air Leakage (infiltration)

Source
25-50% Literature Review (e.g., https://www.energystar.gov/index.cfm?c=new_homes_features.hm_f_reduced_air_20%_conservative_low_estimate_for_new_homes_built_to_5_ACH50_requirement).

Table 8. Average Annual HVAC Energy Costs per Household Due to Air Leakage

End-Use	Cost	Source
Cooling	\$ 29	Calculated
Space Heating	\$ 141	Calculated
Total	\$ 171	

Table 9. Reduction in Air Leakage Required by IECC 2018 Relative to DE Code

40% 5 ACH50 to 3 ACH50 Calculated

Table 10. Average Annual HVAC Energy Costs per Household From IECC 2018 Air Leakage Reductions

End-Use	Cost	Source
Cooling	\$ 12	Calculated, assumes reduction in natural air changes per hour (ACHnat) is proportional
Space Heating	\$ 56	Calculated, assumes reduction in natural air changes per hour (ACHnat) is proportional
Total	\$ 68	

Air Sealing Participant Economics

Assumptions

Measure Lifetime 20 years
Discount Rate 5%

Table 11. Simple Payback

Low	2.2
High	3.3

Table 12. Life-Cycle Cost Analysis

	Low	High
PV Costs	\$150	\$225
PV Benefits	\$850	\$850
PV Net Benefits	\$700	\$625
BCR	5.7	3.8