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Pennsylvanians Buying 2012 IECC Homes Will Save Thousands

An Analysis of Cumulative Homeowner Profit after Paying Incremental Construction Costs for New Single Family Homes Meeting Building Energy Code

Summary

Pennsylvanians buying new single family homes meeting the 2012 International Energy Conservation Code (IECC) will pocket between $7,623 to $19,191 in net energy savings over the life of their 30 year mortgage, according to an analysis of energy savings and incremental construction costs by the Building Codes Assistance Project and ICF, International.

The energy savings from the 2012 code are enough to pay back the buyer's additional down payment in 6 to 29 months (depending on construction methods and the climate zone where the home is located). **After that break-even point, owners will continue to pocket between $276 and $650 in estimated profit annually — money that would otherwise go to pay higher utility bills.** These savings take into account additional mortgage fees and will be even greater if energy costs rise over the next 30 years.

This report assesses energy savings and incremental construction costs of new, 2,400 square foot single family homes in Pennsylvania that meet the latest model energy code, the 2012 IECC, compared to the state's current code, the 2009 IECC. Specifically, this analysis finds an average new home meeting the 2012 IECC will cost between an additional $1,403 and $3,375 per new home over the construction costs of meeting the current energy code. **Energy cost savings are estimated at between $431 and $726 per year.** Stated differently, a homeowner's monthly utility bill savings are at least three times more than the additional mortgage payment needed to cover the cost of energy saving features required by the 2012 code.

The majority of the state—represented by climate zone 5 cities including Allentown, Erie, Harrisburg, Pittsburgh, Wilkes-Barre, and Williamsport—has the lowest incremental costs ($1,403 per new home) statewide under the 2012 IECC, meaning homeowners will break even on energy efficient improvements in no more than nine months and enjoy a profit on their investment of $408 annually.

Energy Savings and Construction Cost Methodology

To calculate energy savings and incremental construction costs, this analysis defined a "typical" single family house to represent new residential development in Pennsylvania. The home modeled is two stories in height, with exterior dimensions of 30 by 40 feet, wood-framed walls, and a full basement foundation. This size and foundation type is based on regional construction practices. The home size modeled is 2,400 square feet—which is also the approximate size of the average new home built nationwide.

For the purposes of this analysis we assume a baseline home that meets the requirements of the 2009 IECC, which is the state's current code. Although some leading builders are already meeting or exceeding many elements of the 2012 IECC already, for purposes of this analysis we assume a baseline home that exactly meets the requirements of the 2009 IECC. Also, although we err on the side of good building practice, in an effort to be conservative we have included some incremental costs that may not be necessary. For instance, although it is a good building practice for builders to install conventional "hard ducted" return air ducts, some builders may be using basement joist cavities (panned floor or enclosed

interior wall cavities) in lieu of conventional "hard ducted," metal or other return ducts. In an effort to anticipate this possible cost (and others) for some builders, we include the incremental costs of upgrading to hard ducted return ducts, which are required in the 2012 IECC.

Using the 2,400 square foot model home as a baseline, we calculated incremental costs by identifying the building components that would have to be upgraded from the current 2009 IECC, according to the prescriptive requirements in the 2012 IECC. Although required code changes (and incremental costs) differ between climate zones, all climate zones in the state have some incremental costs in common. Statewide, the following requirements apply to all climate zones: improved house air sealing and testing, insulating hot water pipes, increasing the percentage of compact florescent bulbs in hard-wired fixtures from 50 to 75 percent, bathroom vent fan upgrades, and upgrading from panned to "hard ducted" return ducts. Changes to windows, exterior walls, basement insulation, and ceiling insulation occur in some but not all climate zones.

Energy savings were modeled by ICF International (ICFI), an international energy consulting firm with extensive experience in the use of hourly building energy simulation software to estimate energy performance and energy savings of alternative building codes and design concepts. Although the values included in the analysis represent a careful, independent technical judgment by ICFI staff, it should be kept in mind that – like any such analysis – the results depend on a number of assumptions about the physical features of a typical new home, operating practices, energy prices, and other factors.

Both the existing 2009 IECC and the new 2012 IECC codes allow a builder to choose among a number of alternatives to comply with the code. In this case, ICFI conservatively chose to compare the results from the prescriptive path of each version of the code. ICF uses BeaconTM, an hourly simulation model that utilizes DOE-2 or EnergyPlus, and summarizes building performance in terms of estimated annual energy costs, based on long-term average weather conditions in a given climate zone (city), DOE/EIA state level energy costs. For this model, energy savings are estimated for one (or multiple) cities within each climate zone. Climate zone four is represented by Philadelphia; climate zone five cities included are Allentown, Erie, Harrisburg, Pittsburgh, Wilkes-Barre, and Williamsport; and Bradford represents climate zone six. ICF also estimates energy consumption by end-use, fuel type, electricity peak demand, and air conditioner size in each prototype home. More details of the modeling assumptions used in this analysis are available on request.

Incremental Costs

To estimate incremental costs, we rely on construction costs from the well-regarded *2011 RS Means Contractor's Pricing Guide* to approximate actual costs of new home construction. This resource is known to be conservative and is useful for this analysis because all estimated construction costs are inclusive of material costs, labor, and contractor overhead and profit.[1]

Costs Shared by Climate Zones 4, 5, and 6

Although the 2012 IECC presents different code requirements (and incremental costs) in each of the state's three climate zones, some costs are shared between all three climates zones. Among other changes, the

[1] RS Means also includes a location factor, which indicates an estimate of local costs as a percentage of RS Means national average estimates. For this analysis, the location factor is assigned to the city modeled by ICF within each climate zone. For climate zone 4, the location factor is 117%, indicating that construction costs in Philadelphia are approximately 17% higher than the national average. For climate zone 4, the location factor used is Pittsburgh (100%) and climate zone 5 the location factor is Bradford (90%).

2012 IECC requires builders to perform additional air sealing and testing. We estimate that the additional required air sealing in the 2012 IECC and the required whole house air leakage (commonly known as "blower door") and duct leakage testing will add about $350 per new home.[2] Because the resulting home will have fewer air and duct leaks to the outside, ventilation will have to be improved, a cost we estimate at $180 for upgrading one bathroom vent fan to a unit with an Energy Star rating along with the installation of an automatic control which is set to automatically exhaust indoor air.[3]

An additional 2012 IECC code change will require builders to insulate hot water distribution lines to kitchens. We believe the cost impact of this change is small, as R-3 insulation costs less than 50 cents per linear foot and most insulation products can be "clipped" around supply pipes after the plumbing rough-in.[4] As a result, this cost is estimated at $100 per new home. Builders will also have to install high-efficiency lights in 75 percent of hard-wired fixtures, up from 50 percent in the 2009 IECC. Usually, this requirement is met with compact florescent lights (CFLs). Our analysis estimates that the upgrade of 75 percent of fixtures will cost no more than $25.

For builders that are currently using "panned" floor joists in basements as return air ducts, meeting the 2012 IECC will require an upgrade to conventional "hard ducted" returns in basement ceilings. Many builders already use conventional ducts in basements as returns, but this cost has been included in this analysis regardless. Calculating the cost change between panned and conventional ducts is challenging, as panned ducts are not priced in RS Means and many construction cost sources. After consulting with HVAC contractors, who indicated the cost of panned ducts was roughly half of conventional ducts, incremental costs are estimated in this analysis as one-half of cost of flexible return ducts. We believe this cost is reasonable due to the significant amount of labor required for panned ducts, as contractors must screw sheet metal between two adjacent joists and seal the edges with mastic. RS Means estimates the installed cost of flexible, non-insulated, 6" diameter ducts at $4.58 per linear foot.[5] As such, the cost to upgrade the estimated 75 feet of return duct (which some builders will have to upgrade) is estimated as half of this cost, approximately $155 to $201 depending on the climate zone.

[2] $350 is a commonly used as an expected air sealing and testing cost for new single-family detached homes nationwide.

[3] Ventilation system and costs are described in an August 2005 report from Lawrence Berkeley National Laboratory "Review of Residential Ventilation Technologies." Although the costs of these components have decreased in recent years, the 2005 estimate ($180 per new home) is quoted in this analysis.

[4] It is difficult to determine what combination of redesign, resizing, and/or partial insulation of hot water lines would be done in a typical new home. Insulating distribution lines to the kitchen and very long runs would add costs while downsizing lines would reduce costs; in any case we believe the net effect would be small.

[5] Less expensive duct options are available, but this product matches the modeling assumptions used by ICFI.

Incremental Costs Unique to Climate Zone 4
Representative Cities: Philadelphia

The 2012 IECC would require builders in climate zone 4 (which takes up the lower southeasternmost corner of the state) to upgrade ceiling insulation and exterior walls[6]. Ceiling (or attic) insulation would have to be upgraded from R-38 to R-49, which is estimated by RS Means to cost an additional $576 per new home. Exterior walls will also have to be upgraded to meet the 2012 IECC, but builders will have flexibility in the type of exterior wall assembly they chose to build. At present, the 2009 IECC requires R-13 walls, while the 2012 IECC mandates an insulation upgrade to R-13 + 5 or R-20. To build an R-13 + 5 wood frame wall, builders retain 2 x 4 framing with R-13 fiberglass batts as cavity insulation, but replace the conventional OSB sheathing with structurally insulated sheathing—an engineered product that combines structural reinforcement with insulation equivalent to R-5, thus creating an R-13 + 5 wall.[7] Alternately, if builders choose to meet the R-20 requirement, 2 x 4 walls are upgraded to 2 x 6 wall construction. The larger framing allows for R-21 fiberglass batts to be placed between studs instead of the R-13 batts required in the 2009 IECC. Additionally, because of the superior strength of 2 x 6 construction, builders can introduce a cost-saving variant of the R-20 wall that increases the space between studs from 16 inches apart to 24 inches—thus saving lumber and dramatically reducing incremental cost. Many builders prefer to retain 16 inch spacing however, and thus all three wall framing alternatives are presented in **Table 1**, which summarizes incremental costs for Climate Zone 4.

An increase in wall thickness for two of the three wall assembly options presented in climate zone 4 will also require an additional $300 for window jamb extensions. Specifically, these window jamb extensions will be required for both R-20 wall options (options 1 and 2) in Table 1, below. These jamb extensions are required because the wall thickness increases with a change from 2 x 4 to 2 x 6 framing. While some window manufacturers offer jamb extensions as a factory-built option, most builders are reported to prefer to field-fabricate extension jambs, which are attached to the interior jamb of the window and create a consistent wood or drywall transition between the window and wall. These extensions, essentially four pieces of wood or drywall that "frame" the interior window jamb, are estimated at $300 after a brief survey of installers, who put costs at $10-12 per window. By contrast, the Ohio HBA estimates this cost as slightly higher, at $390 per new house. Note that extension jambs are assumed to not be required in other climate zones (or in the 13+5 climate zone 4 wall) as overall wall thickness stays constant or does not increase more than one quarter inch per wall.

Taking into account both incremental costs and savings, **this study estimates that *net* incremental costs for Climate Zone 4 will range from $2,397 to $3,375, depending on which wall construction type is selected by builders.** These options are $2,397 (R-13 + 5 wall), $3,375 (R-20 wall with 16" spacing between studs), and $2,428 (R-20 OVE-framed wall with 24" spacing between studs).

[6] Additionally, the code also calls for a reduction in SHGC factor in climate zone 4 from "no rating" to .40, but the Efficient Windows Collaborative (EWC) estimates that this will have no impact on cost as commercially available windows with a U rating of .35 already have an SHGC factor of .40, which would be sufficient to meet the 2012 code.
[7] Incremental cost for 13+5 walls relies on local building supply estimates for R5 structurally insulated sheathing (SIS). Incremental costs for walls with SIS also take into account savings from eliminating a conventional vapor barrier, a function that is included in SIS panels.

Table 1: Climate Zone 4 Incremental Costs (Philadelphia)					
Building Component	Total Area	Incremental Cost/ Square Ft	Total	Location Factor	Adjusted Total
Wall Option 1: R-13 + 5	2,380	$0.35	$ 825.40	117%	$966
Wall Option 2: R-20 Walls with Studs Spaced 16" on Center	2,380	$0.59	$ 1,404.20	117%	OR $1,643
Wall Option 3: R-20 Walls with Studs Spaced 24" on Center	2,380	$0.25	$ 595.00	117%	OR $696
Upgrade Blown-in Ceiling insulation from R-38 to R-49	1,200	$0.41	$ 492.00	117%	$576
1st Floor Panned Return Ducts Upgraded to Flexible Ducts	75 linear ft	$2.29/lf	$ 171.75	117%	$201
Increased Air Sealing and Testing	N/A	N/A	N/A	N/A	$350
Insulating Hot Water Pipes	N/A	N/A	N/A	N/A	$100
75% CFLs in hardwired fixtures (from 50% in 2009 IECC)	N/A	N/A	N/A	N/A	$25
Bathroom Vent Fan Upgrade	N/A	N/A	N/A	N/A	$180
Window Jamb Extensions (for wall option 2 and 3 above only)	N/A	N/A	N/A	N/A	$300
Total Incremental Costs (Varies Based on Wall Type Above)					**$2,397 to $3,375**

Incremental Costs Unique to Climate Zones 5
Representative Cities: Allentown, Erie, Harrisburg, Pittsburgh, Wilkes-Barre, and Williamsport

Climate Zone 5 is the largest climate zone in the state and contains the majority of the state's counties and population. Unlike Climate Zone 4, to meet the 2012 in climate zone 5, no change is required for exterior walls, which remain either R13+5 or R20. However, unlike climate zone 4, windows are upgraded from a U factor of .35 to .32. To meet these requirements, the Efficient Windows Collaborative (EWC) conservatively estimates incremental costs as no more than $1.00 per square foot of window area. It is important to note that many builders may already install windows that already meet the 2012 IECC slightly-improved requirements, but in an effort to be conservative (and strictly compare the two codes) this analysis assumes that builders are currently using the least-cost window to meet existing code requirements.[8] Total window incremental costs are therefore estimated as $357.

Additionally, many builders will have to upgrade the interior basement insulation. According to local building experts, most builders currently meet the 2009 IECC by installing basement wall or "hanging" fiberglass batt insulation to the inside of basement walls. To meet the 2012 code, these builders will have to upgrade from R-10 to R-15 batts. R-15 hanging batts are not priced in RS Means and calls to local building suppliers yielded only the cost R-19 hanging insulation, which is priced at an additional $0.12 per square foot. Although the R-15 insulation should be less expensive than the quoted R-19, the $0.12 cost per square foot is used in this analysis, which adds $134 in incremental costs. Climate zone 5 is similar to climate zone 4 in that builders will also have to upgrade attic insulation from R-38 to R-49.

Fortunately, the 2012 IECC will also introduce cost savings for builders. While complying with the 2012 IECC increases first-cost in some areas, the new code also presents opportunities to **reduce** costs for HVAC equipment as a result of an improved building envelope. Among other possible savings, builders will be able to reduce the size of costly mechanical equipment. For the prototype house in Climate Zone 5, the

[8] As a result, many builders will be able to reduce or avoid incremental costs for better windows.

estimated size of the cooling system falls from an average of 49,000 kBtuh to 42,000 kBtuh or from 4.01 to 3.5 tons. This reduction in air conditioner capacity can result in first-cost savings of one half ton, which is expected to save approximately $408 for the average new house.[9]

Taking into account both incremental costs and savings, **this study estimates that *net* incremental costs for Climate Zone 5 will be $1,403 per new home.** The estimated incremental costs for climate zone 5 are presented below in Table 2.

Table 2: Climate Zone 5 Incremental Costs (Allentown, Harrisburg, Pittsburgh, Wilkes-Barre, Williamsport)

Building Component	Total Area	Incremental Cost/ Square Ft	Total	Location Factor	Adjusted Total
Upgrade Ceiling insulation from R-38 to R-49	1,200	$0.41	$ 492.00	100%	$492
1st Floor Panned Return Ducts Upgraded to Flexible Ducts	75 linear ft	$2.29/lf	$ 171.75	100%	$172
Window Upgrade to U .32 (from .35)	357	$1.00	$ 357.00	N/A	$357
Basement Wall Insulation Upgrade from R-10 to R-15 (R-19)	1,120	$0.12	$ 134.40	N/A	$134
Increased Air Sealing and Testing	N/A	N/A	N/A	N/A	$350
Insulating Hot Water Pipes	N/A	N/A	N/A	N/A	$100
75% CFLs in hardwired fixtures (from 50% in 2009 IECC)	N/A	N/A	N/A	N/A	$25
Bathroom Vent Fan Upgrade	N/A	N/A	N/A	N/A	$180
HVAC System Savings (downsizing 1/4th ton)	N/A	N/A	N/A	N/A	-$408
Total Incremental Costs (Varies Based on Wall Type Above)					**$1,403**

Incremental Costs Unique to Climate Zones 6
Representative Cities: Bradford

Climate Zone 6 represents eight counties in the northernmost part of the state. In addition to the incremental costs shared by all three climate zones statewide, climate zone 6 would require improvements to windows and the home's exterior wall. Windows, as in climate zone 5, would be upgraded to meet a .32 U factor (from the current .35). This change, as described in climate zone 5, is estimated at $1.00 per square foot. In addition, the code requires an upgrade in the exterior wall from R-20 or 13+5 to R-20+5 or R-13+10. Building the R-20+5 wall begins with a 2 x 6 wall and replaces a layer of conventional OSB sheathing with structurally insulated sheathing with an R value of 5. The R13+10 wall, by contrast, retains the standard 2 x 4 framing but replaces the R-5 insulated sheathing with an R10 insulated sheathing. The incremental cost of the R13+10 wall is not estimated in this analysis, as builders nationwide have shown a

[9] EPA conservatively estimates for their Energy Star Homes Version 3 that first-cost savings for downsizing a 13 SEER air conditioner are $815 per ton. It should be noted that because HVAC systems are usually sold in half-ton increments, so downsizing by one-quarter ton is not possible. However, for many builders the size and configuration of their 2,400 square foot home will mean they will be able to downsize by as much as a half-ton. Thus, one-quarter ton is expected to be saved on the average new home. By "right-sizing" the HVAC equipment, building occupants will also benefit from a reduction in equipment short-cycling (i.e., where equipment is too large for the cooling load and cycles on and off frequently, thus wasting energy and losing some of its ability to dehumidify indoor air). Please note that additional cost savings could be obtainable from downsizing heating equipment, but this study does not attempt to calculate those savings.

preference for the 20+5 wall assembly. As in climate zones 5, HVAC downsizing savings are again estimated as one-half ton.

Taking into account both incremental costs and savings, **this study estimates that *net* incremental costs for Climate Zone 6 will be $1,640.** The estimated incremental costs for climate zone 5 are presented below in Table 3, below.

Table 3: Climate Zone 6 Incremental Costs (Bradford)					
Building Component	Total Area	Incremental Cost/ Square Ft	Total	Location Factor	Adjusted Total
Upgrade to R20+5 walls from R20	2,380	$0.41	$ 978.78	90%	$881
1st Floor Panned Return Ducts Upgraded to Flexible Ducts	75 linear ft	$2.29/lf	$ 171.75	90%	$155
Window Upgrade to U .32 (from .35)	357	$1.00	$	N/A	$357
Increased Air Sealing and Testing	N/A	N/A	N/A	N/A	$350
Insulating Hot Water Pipes	N/A	N/A	N/A	N/A	$100
75% CFLs in hardwired fixtures (from 50% in 2009 IECC)	N/A	N/A	N/A	N/A	$25
Bathroom Vent Fan Upgrade	N/A	N/A	N/A	N/A	$180
HVAC System Savings (downsizing 1/4th ton)	N/A	N/A	N/A	N/A	-$408
Total Incremental Costs					**$1,640**

Energy Cost Savings

According to the model used in this analysis, **upgrading to the 2012 IECC will result in significant energy cost savings for homeowners in Pennsylvania, resulting in savings of between $431 to $726 per year,** depending on the climate zone and type of exterior wall type builders select. Energy savings are broken down by climate zone and wall type in Table 4, below. It is noteworthy that these savings assume constant energy prices; if energy prices continue to rise consistent with historical trends, savings will be greater in future years.

Table 4: 2012 IECC Energy Savings by Climate Zone and Wall Type for Two Story Houses	
House Climate Zone and Wall	**Annual Energy Savings**
Climate Zone 4: Houses with R-20 Walls (studs 16" on center)	$431
Climate Zone 4: Houses with R-20 OVE Walls (studs 24" on center or "OVE")	$431
Climate Zone 4: Houses with R-13+5 Walls	$456
Climate Zone 5: Houses with R-20 Walls	$473
Climate Zone 5: Houses with R-13+5 Walls	$502
Climate Zone 6: Houses with R-20+5 Walls (studs 16" on center)	$726

Mortgage Payback for Homeowners

Homebuyers will be able to include the incremental first-costs of meeting the 2012 IECC in their mortgage, while benefiting from lower utility bills starting on day one. With estimated energy cost savings of between $431 and $726 per year, monthly utility bill savings are at least three times as much as the additional mortgage payment needed to cover the added first-cost of energy saving features required by the 2012 code.

This cash-flow difference is enough to pay back the buyer's added down-payment in approximately 6 to 29 months (depending on the climate zone and wall type). After that date, the owner continues to realize a profit of between $276 and $650 annually due to lower utility bills – and even more if energy prices increase.

This payback analysis assumes that homebuyers purchase a new home with 20% down at the current nationwide interest rate of 4.03 percent. This scenario would result in an increased down payment of between $281 and $675 with an additional monthly mortgage cost ranging from $5 to $13. Taking into account energy savings and lower utility bills, a cash flow analysis indicates that the homebuyer would break even within as little as 6 months and no more than 29 months. After that break-even date, **homeowners would continue to save between $276 and $650 annually,** after additional mortgage costs are subtracted from energy savings. Homebuyers with a lower down payment—such as 5 or 10 percent—will realize payback more quickly. Mortgage payback to homeowners is presented below in **Table 5.**

Table 5: Mortgage Payback for Homebuyers by Exterior Wall Type

Exterior Wall Type	Incremental Costs	Energy Savings/ Month per home	Down Payment Increase (and Mortgage Increase per Month)	Breakeven Point	Annual Profit for Homeowner after Breakeven Point
Climate Zone 4: R-20 Walls	$3,375	$36	$675 (plus $13/month)	**29 months**	**$276**
Climate Zone 4: R-20 OVE Walls	$2,428	$36	$486 (plus $9/month)	**18 months**	**$320**
Climate Zone 4: R13+5 Walls	$2,397	$38	$479 (plus $9/month)	**17 months**	**$346**
Climate Zone 5: R-20 Walls	$1,403	$39	$281 (plus $5/month)	**9 months**	**$408**
Climate Zone 5: R-13+5 Walls	$1,403	$42	$281 (plus $5/month)	**8 months**	**$437**
Climate Zone 6: R-20+5 Walls	$1,640	$60	$328 (plus $6/month)	**6 months**	**$650**

Conclusions

- As estimated in this analysis, incremental costs for new 2,400 square foot homes built to the 2012 IECC in Pennsylvania total $1,403 and $3,375 per new home, depending on Climate Zone. Fortunately, the highest incremental costs are in Climate Zone 4, which only accounts for six of the state's counties.
- Annual profit for Pennsylvania homeowners attributable to the 2012 IECC range from $276 to $650, depending on which exterior wall type builders select.
- Assuming a conservative 20% down payment, new home buyers will break even on their initial investment in as few as 6 months and no more than 29 months after purchase.

About BCAP

As an independent judge of the efficacy of energy codes, BCAP strives to use data to address energy code barriers, including the real or perceived construction costs incurred by code changes. To address concern in the building community that upgrading to the latest version of the residential energy code, the 2012 IECC, will result in cost prohibitive increases in construction cost for new single-family homes, BCAP has completed a nationwide incremental cost analysis as well as analysis for states on demand. Funding for this work is provided by the Environmental Protection Agency, the Department of Energy, and the National Association of State Energy Officials.

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