Analysis of Energy Savings and Incremental Construction Costs for New Row Houses in Philadelphia, PA under the 2012 IECC

Summary

EECC has conducted a preliminary analysis of the energy savings and incremental construction costs associated with the possible adoption of the 2012 IECC for infill row houses in Philadelphia, PA. This analysis specifically aims to calculate the impact of the latest energy code compared to the city's current code, the 2009 IECC.

This analysis finds that incremental costs range from $1,456 to $1,837 per new home**,** depending on wall insulation type, representing an estimated increase in the first-cost of a new home (excluding land) of less than one percent. Estimated energy cost savings range from $194 per year (for R-20 exterior walls) to $205 per year (for R 13+5 exterior walls). **Monthly utility bill savings to the home owner are about twice 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 less than four years (or sooner if the loan allows a down payment below 20%). After that date, the owner continues to save $99 to $125 annually in lower utility bills – and even more if energy prices increase.

Energy Savings and Construction Cost Methodology

To calculate energy savings and incremental construction costs, this analysis defined a "typical" row house to represent new residential development in Philadelphia. This row house is three stories in height, 16 feet wide, and 40 feet in depth with a slab on grade foundation, a flat roof, brick-veneer front and rear walls over wood-frame construction, and shared party walls with neighboring buildings. This description was based on interviews with the City Planning department, building inspection officials, and architects currently practicing in the city. Although some leading builders in Philadelphia are already building to a higher standard than the 2012 IECC, for purposes of this analysis we assume a baseline home that just meets the requirements of the 2009 IECC.

Using this model home as a baseline, we identified the building components that would have to be upgraded from the current 2009 IECC code, according to the prescriptive requirements in the 2012 IECC. These changes included upgrades to front and rear wall insulation, third floor ceiling (roof) insulation, envelope air sealing & testing, an increase from 50 percent to 75 percent compact florescent lamps or fixtures, and (although not specifically required by the energy code) upgraded bathroom vent fans to provide additional mechanical ventilation.

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 numbers 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.
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Both the existing 2009 IECC code and the new 2012 IECC code 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. 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, the total incremental cost includes material costs, labor, and contractor overhead and profit. For this analysis many of these costs were also confirmed with local building suppliers in Philadelphia.

To meet the 2012 IECC, builders will have flexibility in the type of exterior wall assembly they chose to build for the front and rear of the home. 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 wood sheathing for with an insulated sheathing—an engineered product that combines structural reinforcement with insulation equivalent to R-5 to create an R-13 + 5 wall. Alternately, if builders choose to meet the R-20 requirement, 2 x 4 walls are upgraded to 2 x 6 wall construction for the front and rear walls. 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. (See **Appendix B** for additional details.)

Table 1: Incremental Cost Analysis for Meeting 2012 IECC

Building Component	Total Area	Incremental Cost/ Square Foot	Total	Location Factor[3]	Adjusted Total
Wall Option 1: R-13 + 5	960	$0.34	$322.50	117%	$377
Wall Option 2: R-20 Walls with Studs Spaced 16" on Center	960	$0.59	$566.40	117%	$662
Wall Option 3: R-20 Walls with Studs Spaced 24" on Center	960	$0.25	$240.00	117%	$281
Roof (16' x 40')	640	$1.22	$780.80	117%	$914
Air Sealing and Testing	N/A	N/A	N/A	N/A	$350
75% CFLs (from 50%)	N/A	N/A	N/A	N/A	$15
Bathroom Vent Fan Upgrade (2)	N/A	N/A	N/A	N/A	$100
HVAC System Savings	N/A	N/A	N/A	N/A	-$204
Total Incremental Costs (Varies Based on Wall Type Above)					**$1,456 to $1,837**

Among other changes, the 2012 IECC requires builders to upgrade roof insulation from R-38 to R-49, which we estimate will cost an additional $781 per new home. We estimate that the improved air sealing standards in the 2012 IECC and the required whole house "blower door" testing will add about $350 per new home.[1] To improve ventilation, an additional $100 is estimated for upgrading two bathroom vent fans to units with an Energy Star rating. Finally, builders will 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 25 percent of fixtures (or six CFLs) will cost $15.[2] A final 2012 IECC code change involving hot water distribution lines was beyond the scope of this preliminary cost estimate but we believe the cost impact is small.[3]

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 this prototype townhome, builders are able to reduce the cooling system capacity from 27,000 kBtuh to 24,000 kBtuh or from 2.25 to 2 tons. This reduction in air conditioner capacity can result in first-cost savings of approximately $204 for each new house.[4]

Taking into account both incremental costs and savings, **this study estimates that *net* incremental costs will range from $1,456 to $1,837, depending on which wall construction type is selected by builders.** These options are $1552 (R-13 + 5 wall), $1,837 (R-20 wall with 16" spacing between studs), and $1,456 (R-20 wall with 24" spacing between studs).

Energy Cost Savings

According to the model used in this analysis, **upgrading to the 2012 IECC will result in energy cost savings for homeowners, ranging from $194 per year (based on R-20 exterior walls) to $205 (based on R-13+5 exterior walls)**. In both scenarios, these annual energy cost savings represent about 11% of the home's total energy use that is regulated by the building code. It is noteworthy that these savings

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[1] $350 is commonly used as an expected air sealing and testing requirement for new single-family detached homes nationwide. We expect that this cost may be lower in the Philadelphia row house we modeled since it has a small percentage of exposed wall area as compared to a single family detached home with the same floor space.

[2] This is a conservative assumption for several reasons: first, it does not account for the avoided cost of purchasing 8 or more conventional incandescent bulbs that would be needed over the longer lifetime of a CFL. Nor does this estimated added first-cost for CFLs reflect the new federal light bulb standards to be phased in over 3 years (2012-2014), which will require efficiency equivalent to either a CFL or an improved, high-efficiency halogen incandescent lamp, currently priced at about the same first-cost as a CFL but with lower efficiency and shorter lifetime. After the phase-in of new light bulb standards, savings from this code requirement will also be reduced.

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

[4] 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, to meet the 2.25 tons of needed cooling capacity estimated for the baseline 2009 townhome, builders would have to install the next size up, a 2.5 ton unit, so our cost savings estimate for only 0.25 ton is very conservative. 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).

assume constant energy prices; if energy prices continue to rise consistent with historical trends, savings will be greater in future years.

Mortgage Payback for Homeowners

Homebuyers will be able to include in their mortgage the incremental first-costs of meeting the 2012 IECC, while benefiting from lower utility bills starting on day one. With estimated energy cost savings from $194 to $205 per year, monthly utility bill savings are about twice 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 as little as 2 years and 6 months, up to a maximum of 3 years and 9 months (or sooner if the loan allows a down payment below 20%). After that date, the owner continues to save $99 to $125 annually in lower utility bills – and even more if energy prices increase.

This payback analysis assumes a baseline construction cost of $310,877 for homes currently built to the 2009 IECC (**Table 2**). This estimate is sourced from RS Means and also includes expected land costs and developer profit.[5] When added to this baseline home cost, incremental first-costs for homes built to the 2012 IECC would add less than one percent to overall construction costs (including builder profit but excluding land cost).

Table 2: Cost Baseline for 2009 IECC Compliant Home	
Baseline Model	Row house
Building Area (Square Feet)	1,920
Construction Cost/Square Foot	$100.28*
Location Factor	117%
Adjusted Cost/Square Foot	$117.33
Total Building Cost	$225,273
Including 15% Land Costs	$259,065
Including Developer Profit of 20% on cost	$310,877

*** RS Means 3 Story construction cost for brick veneer exterior wall, with 91% adjustment factor for row house.**

For a homebuyer, purchasing a new home with 20% down at an interest rate of 5.0 percent would result in an increased down payment ranging from $291 to $367 with additional monthly mortgage cost of $6 to $8 per month. Taking into account energy savings and lower utility bills, a cash flow analysis indicates that the homebuyer would break even within as little as two years and six months and no more than three years and nine months. After that break-even date, **home owners would continue to save from $99 to $125 per year in energy costs**. Homebuyers with a lower down payment—such as 5 or 10 percent—will realize payback much more quickly. Mortgage payback to homeowners for each scenario is presented below in **Table 3**.

Table 3: Mortgage Payback for Homebuyers by Exterior Wall Type*					
	Incremental Costs	Energy Savings/ Month per	Down Payment Increase (and Mortgage Increase per	Breakeven Point	Annual Profit for Homeowner after

[5] This analysis assumes land costs represent an additional 15% of construction costs. Additionally, the final price assumes developers achieve a 20% profit on total construction and land costs.

		home	Month)		Breakeven Point
R-13 + 5 Wall	$1,552	$17	$310 (plus $7/month)	**2 years, 7 months**	**$125**
R-20 Wall, Studs Spaced 16”	$1,837	$16	$367 (plus $8/month)	**3 years, 9 months**	**$99**
R-20 Wall, Studs Spaced 24”	$1,456	$16	$291 (plus $6/month)	**2 years, 6 months**	**$119**

***Assuming 20% down payment, 30 year term, 5% annual interest rate**

About the EECC

The Energy Efficient Codes Coalition (EECC) is a coalition of energy efficiency advocates involved in the development of the national model energy codes. EECC draws supporters from government, regional energy efficiency alliances, academia, think tanks, utilities, environmental groups, utilities, low-income housing groups, energy consumers, and businesses. The EECC has been heavily involved in the most recent two cycles of IECC code development. Our partner organizations and supporters are also deeply involved in the processes of state and local adoption and implementation of the model codes.

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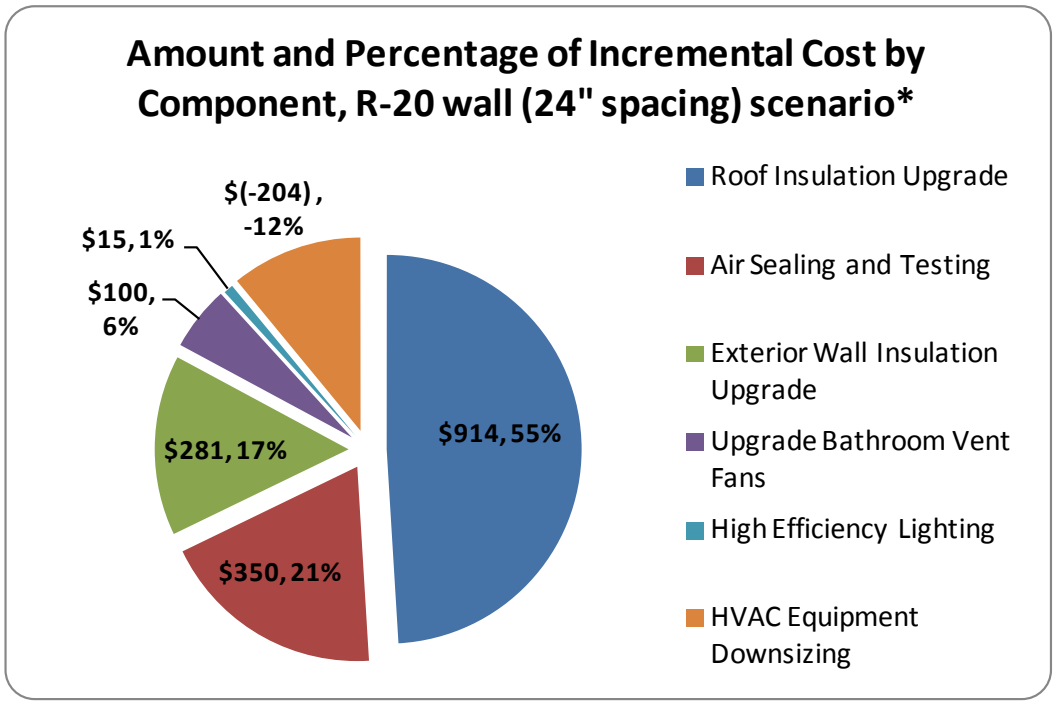
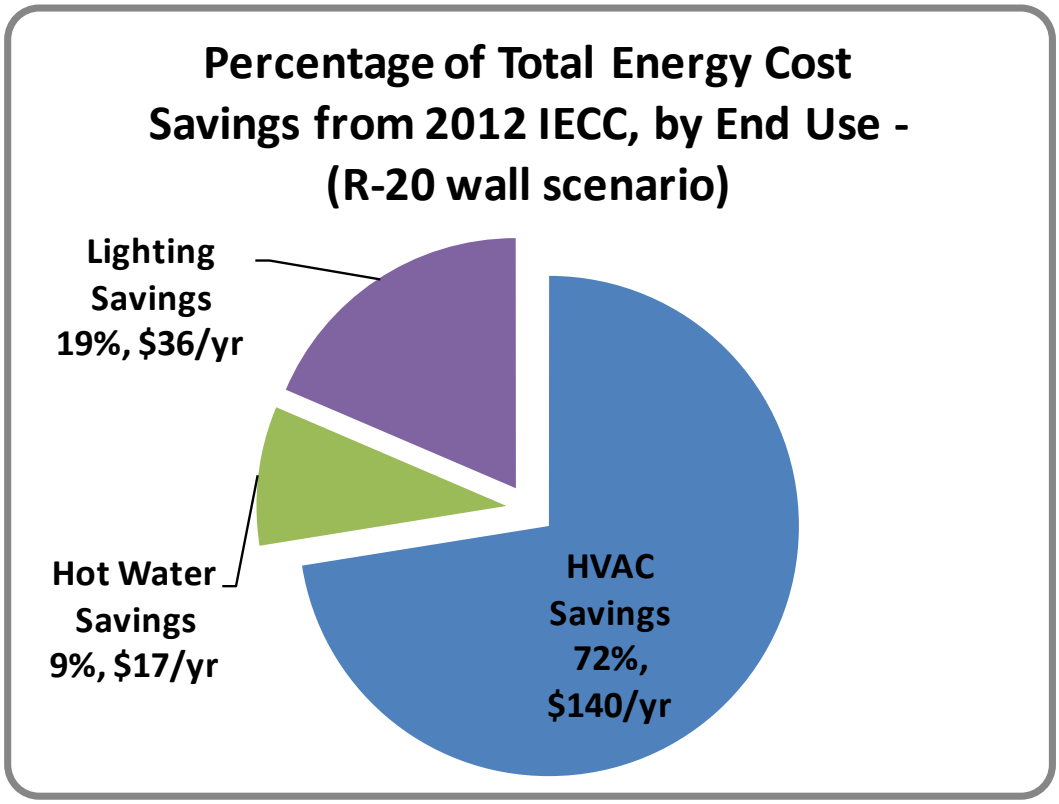
Appendix A: Components of Incremental First-Costs and Energy Savings by End Use



* For a townhome with wood=frame walls using R-20 cavity insulation and 24" spacing between 2x6 studs.



Appendix B: Building Specifications Used to Estimate Incremental Costs

Table A-1: Components used to Build Wall and Roof Assemblies		
Select Building Components	Cost per Square Foot	
R13 Wall (2009 IECC Baseline)		
2 x 4 Studs, 16" O.C.	$	1.09
Plates, 2 x 4, double top, single bottom	$	0.41
7/16" thick OSB Sheathing	$	0.83
R-13 Kraft faced fiberglass batt, 3-1/2" thick, 15" wide	$	0.60
Total	**$**	**2.93**
R13 + 5 Wall (Studs 16” on center)		
2 x 4 Studs, 16" O.C.	$	1.09
Plates, 2 x 4, double top, single bottom	$	0.41
R5 Insulated Sheathing	$	1.17
R-13 Kraft faced fiberglass batt, 3-1/2" thick, 15" wide	$	0.60
Total	**$**	**3.27**
R20 Wall (Studs 16” on center)		
2 x 6 Studs, 16" O.C.	$	1.39
Plates, 2 x 6, double top, single bottom	$	0.52
7/16" thick OSB Sheathing*	$	0.83
5.5" thick, R-21, 15" Kraft Faced Fiberglass Batt	$	0.78
Total	**$**	**3.52**
R20 Wall (Studs 24” on center)		
2 x 6 Studs, 24" O.C.	$	1.05
Plates, 2 x 6, double top, single bottom	$	0.52
7/16" thick OSB Sheathing	$	0.83
5.5" thick, R-21, 15" Kraft Faced Fiberglass Batt	$	0.78
Total	**$**	**3.18**
Above Deck Roof Insulation Options (addition of R11 to achieve R 49)		
R11 equivalent 1 (3" Expanded Polystyrene, R11.49)	$	1.25
R11 equivalent 2 (2" Polyisocyanurate, R 13)	$	1.19
Average	**$**	**1.22**

***Local building supplier quote for OSB and R-5 sheathing, installation and contractor overhead for OSB and R-5 sheathing installation are sourced from RS Means.**