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Prepared for the U.S. Department of Energy
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Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Kansas City, Missouri

R Lucas

September 2011

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Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the 2006 IECC. The notable changes are

- Improved duct sealing verified by testing the duct system
- Increased duct insulation
- Improvement of window U-factors from 0.40 to 0.35
- Efficient lighting requirements.

An analysis of these changes resulted in estimated annual energy cost savings of about $145 per year for an average new house. Construction cost increases are estimated at $655. Home owners will experience an annual cost savings of close to $100 per year because reduction to energy bills will more than compensate for increased mortgage payments and other costs.

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Overview of the 2009 IECC

The IECC scope includes residential single-family housing and multifamily housing three stories or less above-grade intended for permanent living (hotel/motel is not "residential"). The code applies to new buildings and additions/alterations/renovations/repairs.

The table below shows the primary building envelope requirements for all residential buildings in the 2009 IECC. Kansas City is in Climate Zone 4.

Table 1 - Envelope Requirements in the 2009 IECC

Ceiling	R-38
Skylight U-factor	U-0.60
Window U-factor	U-0.35
Wood Frame Wall	R-13
Mass Wall	R-5/10[(1)]
Floor	R-19
Basement Wall	10/13[(2)]
Slab	10, 2 ft deep
Crawlspace	10/13

[(1)] The second R-value applies if more than half the insulation is on the interior of the mass wall.

[(2)]First number is R-value requirement if continuous insulation is used; second number is requirement for cavity insulation option.

Additional requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Supply ducts in attics must be insulated to R-8. Return ducts in attics and all ducts in crawlspaces, unheated basements, garages, or otherwise outside building envelope must be insulated to R-6.
- All ducts must be sealed and either:
  - *verified by pressure testing* – the duct system has to be tested and the air leakage out of ducts must be kept to an acceptable maximum level.
  - *installed entirely within the building thermal envelope* – testing is not required if all ducts are inside the building thermal envelope (for example in heated basements), although the ducts still have to be sealed.

- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Less insulation is allowed for mass walls and more insulation is required for steel framing.
- 50% of the lighting "lamps" (bulbs, tubes, etc.) in a building must be high efficacy. Compact fluorescents qualify; standard incandescent bulbs do not.
- Standard I-code administrative requirements (inspections, documentation) apply.
- A certificate must be posted near the electrical panel listing insulation levels and other energy-efficiency measures.

Exemptions/allowances from prescriptive measures:

- One door and 15 ft^2 of window area are exempt.
- Skylight U-factors are allowed to be U-0.60.

Mandatory requirements:

Windows can never exceed an area-weighted U-factor of 0.48. The 2009 IECC also identifies a set of other requirements that are strictly "mandatory" that must be done in all buildings, such as building envelope and duct sealing.

Compliance paths:

The IECC effectively contains three alternative compliance paths.

1) Prescriptive measures. This is considered the simplest path. These requirements do not vary by building size, shape, window area, or other features. The IECC has a single table of requirements for insulation R-values and window and door U-factors and solar heat gain coefficient (SHGC). There is a corresponding U-factor table that permits compliance of less common component types (e.g., structural insulated panels), albeit without any cross-component trade-offs.
2) Total building envelope UA (U-factor multiplied by area). This is the path predominantly used by the RES*check*™ software. Based on the prescriptive U-factor table, it allows trade-offs whereby some energy-efficiency measures can fall below code requirements if balanced by other measures that exceed code requirements.
3) Simulated performance (requires software programs). This path allows compliance if the home has a calculated annual energy consumption (or energy cost) equal to or less than that of a standard reference design that just meets the code's prescriptive requirements. This path allows for crediting energy-efficiency measures not accounted for in the other paths, such as renewable energy measures. The 2009 performance path differs from previous editions of the IECC in that it allows no trade-off credit for the use of high-efficiency space heating, space cooling, or water heating equipment.

Main Difference between the 2006 IECC and the 2009 IECC

The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The 2006 IECC differs from the 2009 IECC resulting from the four amendments described above. In addition to this, other major differences between the state code and the 2009 IECC are listed below

- The 2006 IECC requires ducts to be sealed but not to a specific leakage rate verified by testing, as is required in the 2009 IECC (if any ducts are outside the building envelope).
- 50% of the lighting "lamps" (bulbs, tubes, etc.) in a building have to be high efficacy in the 2009 IECC; the 2006 IECC has no lighting requirement. Compact fluorescents qualify; standard incandescent bulbs do not.
- Trade-off credit can no longer be obtained for high-efficiency HVAC equipment in the 2009 IECC. For example, if a high-efficiency furnace is used, no reduction in wall insulation is allowed. (This will have a substantial impact on the flexibility allowed by the RES*check*^{TM} software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 2.

Other changes in the 2009 IECC compared to the state code include:

- R-3 pipe insulation on hydronic distribution systems (increased from R-2)
- Stricter area limits on door exemptions
- Improved (more detailed) air-sealing language
- Snow melt controls
- Pool covers are required for heated pools.

Table 2 - Comparison of Envelope Requirements

Components	Climate Zone 4	
	2006 IECC	2009 IECC
Ceiling	38	38
Skylight U-factor	0.60	0.60
Fenestration U-factor	**0.40**	**0.35**
Fenestration SHGC	NR	NR
Wood Frame Wall	13	13
Mass Wall	**5/13[(1)]**	**5/10[(1)]**
Floor	19	19
Basement Wall	10/13[(2)]	10/13[(2)]
Slab	10, 2 ft	10, 2 ft
Crawlspace	10/13	10/13

[(1)] The second R-value applies if more than half the insulation is on the interior of the mass wall.

[(2)]First number is R-value requirement if continuous insulation is used; second number is requirement for cavity insulation option.

Energy Analysis

A brief energy analysis was conducted comparing the 2006 IECC to the 2009 IECC. The EnergyGauge™ software (Florida Solar Energy Center 1999) was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ utilizes the DOE-2 energy simulation software developed by the U.S. Department of Energy (DOE).

Two sets of buildings were simulated: one with energy-efficiency levels set to the prescriptive requirements of the2006 IECC, and one with energy-efficiency levels set to the prescriptive requirements of the 2009 IECC. All inputs other than the changes in energy-efficiency levels were identical in the two sets of simulations.

The analysis assumed a two-story, single-family house with a conditioned floor area of 2,400 ft^2. It was assumed that the house had 9-ft high ceilings, a ceiling area (bordering the unconditioned attic) of 1,200 ft^2, a gross exterior wall area of 2,380 ft^2, and a window area of 360 ft^2 equally oriented north, south, east, and west. Both a heated basement and an unconditioned crawlspace foundation were examined.

Heating with a 78% annual fuel utilization efficiency (AFUE) natural gas furnace ($1.17/therm) and cooling with a 13 seasonal energy efficiency ratio (SEER) central electric air conditioning ($0.105/kWh) were assumed. All fuel prices were obtained from the DOE Energy Information Administration and are residential prices specific for Missouri. Natural gas costs are based on an average of the last five heating seasons (2005-2006 to 2009-2010) because the cost in the most recent heating season was exceptionally low (http://www.eia.gov/dnav/ng/hist/n3010mo3m.htm). Electricity prices have been relatively stable over recent years; therefore, prices from the past year were used (http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html).

Table 3 shows the estimated annual energy usage for the 2006 IECC and the 2009 IECC. For heating energy use with a natural gas furnace, the first value is natural gas energy use; the second value is fan electricity use for distributing the heated air. Table 4 shows these impacts in terms of energy cost including the savings per house that results from meeting the improved requirements in the 2009 IECC. Total savings and percent savings includes space heating and cooling (air conditioning) only.

Table 3 - Annual Energy Use

Annual Energy Use			
2006 IECC		*2009 IECC*	
Heating	Cooling (kWh)	Heating	Cooling (kWh)
60.6 MBtu + 332 kWh	3805	57.8 MBtu + 315 kWh	3820

Table 4 - Annual Energy Costs and Percentage Savings

Annual Energy Cost ($)				*Total savings 2009 IECC vs. 2006 IECC*	
State Code (based on 2006 IECC)		*2009 IECC*			
Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
$744	$400	$638	$361	$145	12.7

Improved duct sealing was assumed to save 10% of the heating and cooling costs. This impact was not included in the simulation analysis, but rather was applied directly to the simulation results. The 10% savings was assumed in the state analysis report (Lucas and Cole 2009). However, it is important to emphasize that actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of testing requirements.

High-efficacy lighting requirements were not included in Table 3 and 4 because savings attributable to the lighting requirements in the IECC will become less relevant because Federal law requires improved light bulbs in 2012 to 2014. However, if efficient lighting is assumed to increase from 10% to 50% of all lighting within the home, lighting energy use decreases by 26%.

Purchase Price Impacts

The more stringent requirements in the 2009 IECC will increase the cost of new homes. The construction cost impacts assumed in this analysis are documented below.

Window U-factor Reduction from U-0.40 to U-0.35

It is difficult to accurately assign a cost to this U-factor improvement. For either the U-0.40 or U-0.35 level, double-paned windows with a low-emissivity (low-E) coating and a non-aluminum frame (such as vinyl or wood) will typically be needed. Many windows with these characteristics will meet the U-0.35 requirement, and therefore have no impact on either the construction cost or energy usage. However, to analyze the impact of this improvement, a cost was established for this U-factor improvement. A study done for North Carolina (Appalachian State 2010) reports an average cost of $360 per house to improve from U-0.40 to U-0.32. An interpolated cost of $225 was assumed here for the improvement to U-0.40 to U-0.35.

Improved Duct Sealing Verified by Testing

The IECC duct sealing requirement has two cost components. First is the cost of testing the installed ducts using duct pressurization equipment. Hammon and Modera (1999) estimate a cost of $131 to $163 for testing, and suggest costs will be even lower in a mature market. The Journal of Light Construction (Uniacke 2003) quotes a cost of $220 for testing. The Appalachian State study (2010) reports a cost of $175 to $250. It is important to note that the 2009 IECC allows the ducts to be tested by the HVAC contractor immediately after the ducts are installed. This should help keep both costs and construction timeline impacts to a minimum. A cost of $200 for duct testing was assumed for this analysis.

There is a one-time cost of purchasing a “duct blaster” and related equipment for pressurizing the duct system and testing the air leakage. Frank Spevak of the Energy Conservatory (a manufacturer of blower doors) verbally reported a price of $1800 for this equipment. Another source reports a cost of $1500-2000 (Sherman et al. 2004). This cost was not included in the economic analysis results below because the cost per home should be minimal because the equipment can be used many times.

Hammon and Modera (1999) estimate a cost of $214 for materials and labor for improved duct sealing. Research for the 2011 Energy Star Home estimates a cost of $0.10/ft^2 of home floor area for improved sealing (EPA 2009). For the 2400 ft^2 home analyzed here, this is a cost of $240, which was the cost assumed in this analysis.

Cost Effectiveness of the 2009 IECC requirements

Total construction cost increase from the 2009 IECC assumed in this report is $655.
Because most houses are financed, consumers will be very interested in the financial impacts of buying a home that complies with the 2009 IECC requirements. Mortgages spread the payment for the cost of a house over a long period of time. In this analysis, a 30-year fixed-rate mortgage was assumed. It was also assumed that homebuyers will deduct the interest portion of the payments from their income taxes.

The financial and economic parameters required for input to this analysis are summarized below. These parameters are used to calculate the costs and benefits of increased energy efficiency from the homeowner's perspective.

- New-home mortgage parameters:
  - 5.0% mortgage interest rate (fixed rate)
  - points and loan fees equal to 1% of the mortgage amount
  - 30-year loan term
  - 20% down payment.

- Other rates and economic parameters:
  - 28% marginal Federal income tax
  - 6% state income tax
  - 1% property tax

Table 5 shows the impacts to consumers' cash flow resulting from the improvements in the 2009 IECC. The upfront costs include the down payment, points, and loan fees. The savings from income tax deductions for the mortgage interest will slowly decrease over time. The annual values shown in the table are for the first year. Table 5 also includes increases in annual property taxes because of the higher assessed house values. The net annual cash flow includes energy costs, mortgage payments, mortgage tax deductions, and property taxes but not the upfront costs. The time to positive cash flow is less than 2 years. This includes all costs and benefits, including the down payment and other upfront costs.

Table 5 - Impacts to Consumers' Cash Flow from Compliance with 2009 IECC

	Cost Impact
Down payment and other upfront costs	139
Annual energy savings	145
Annual mortgage increase	39
Net annual cash flow savings	97

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