U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING ENERGY CODES PROGRAM

Impacts of the 2009 IECC for Residential Buildings at State Level

September 2009

Prepared by Pacific Northwest National Laboratory
for the U.S. Department of Energy Building Energy Codes Program

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Executive Summary

The Building Energy Codes Program (BECP) recently conducted a nationwide residential energy code analysis for the U.S. Department of Energy (DOE). The analysis compares the requirements of the 2009 International Energy Conservation Code® (IECC) with the residential code—or typical construction practice in the absence of a code—in most states as of June 2009. The results, which include estimated typical energy savings of updating each state's code to the 2009 IECC, are provided in this report in chapters specific to each state.

An overview of the 2009 IECC and its major chapters, as well as a brief comparison to previous versions, is provided as introductory information. The IECC is then briefly compared to the International Residential Code, which contains a chapter with energy efficiency requirements that are very similar to the IECC.

Several states have either not adopted a mandatory energy code or developed their own codes which have minimal or no connection to the IECC. The latter—including California, Florida, Oregon, and Washington—were not included in this analysis as the codes in these states would be difficult to appropriately compare to the 2009 IECC and most of these states have energy offices that have already assessed the IECC on their own.

Chapter 2 is dedicated to outlining some of the major code differences in the 2009 IECC that are not contained in any previous version of the code, and to which much of the energy savings of the 2009 IECC compared to previous versions is attributable. These energy saving differences are described in further detail in the report, and include:

- Mandatory duct pressure testing coupled with maximum allowable duct leakage rates. These requirements are applicable when any portion of the ducts are outside the conditioned space.
- A requirement that 50% of lamps in a residence must be energy efficient
- Several improvements in basic envelope requirements
- Elimination of trade-off credits for high efficiency heating, cooling, or water heating equipment.

The full results of each state specific analysis are provided in the following report.[1]

[1] DISCLAIMER: The results contained in this report are complete and accurate to the best of BECP's knowledge, based on information available at the time it was written.

Table of Contents

1.0 Chapter 1 Overview of the 2009 IECC

1.1 Introduction

This report examines the requirements of the 2009 International Energy Conservation Code® (IECC) on residential buildings on a state-by-state basis with a separate, stand-alone chapter for each state. A summary of the requirements of the code is given for each state. The 2009 IECC is then compared to the current state code for most states[2] or typical current construction practice for the states that do not have a residential energy efficiency code. Estimated typical energy savings of updating each state's code to the 2009 IECC are reported.

1.2 Overview of the 2009 IECC

The International Energy Conservation Code sets requirements for the "effective use of energy" in all buildings. Certain buildings that use very low energy use (such as buildings with no heating or cooling) are exempt. The code applies to new buildings and to remodels, renovations, and additions to buildings.

Table 1 shows the organization of the 2009 IECC. The IECC has two separate categories of buildings: residential and commercial. The code requirements are almost entirely different for these two categories. Residential buildings are essentially defined as low-rise buildings (3 stories or less above grade) intended for long-term living (hotels/motels are classified as commercial buildings). The requirements for residential buildings are in Chapter 4; the requirements for commercial buildings are in Chapter 5. Chapters 1 though 3 and Chapter 6 apply to all buildings. This report only addresses the residential portion of the IECC, a separate report addresses commercial buildings[3].

The only chapters of the IECC with specific requirements for residential buildings are Chapter 4 and, to a lesser extent, Chapter 1 and Chapter 3. Chapter 4 does reference certain commercial building requirements in Chapter 5 (for example, HVAC systems serving multiple dwelling units). Chapters 2 and 6 only provide supporting information.

Chapter 1 primarily addresses when the code applies and provides instruction to help confirm compliance with the code.

Table 2 below summarizes the sections in Chapter 1.

Chapter 2 defines terms used in the code.

Chapter 3 provides a U.S. map and tables of the climate zones used in the IECC. Climate zones in the code are set on county boundaries. These zones are shown in Figure 1. Section 303 specifies information required at the building site to verify insulation level and specifies National Fenestration Rating Council (NFRC) standards for

[2] States with their own home-developed codes are not compared to the IECC in this report. This includes California, Oregon, Washington, and Florida. This is done for two reasons. First, these states generally have codes that have little resemblance to the IECC, making a thorough comparison beyond the scope of this study. Second, these states generally have highly capable energy offices that are capable of assessing the IECC on their own (and often have). Alaska, Hawaii and Vermont also do not have an energy analysis here because of difficulties in assessing construction practice particular to those states. No energy analysis was conducted for states that have already adopted the 2009 IECC.

[3] Many states adopt the ANSI/ASHRAE/IESNA Standard 90.1 for commercial buildings rather than the IECC and therefore 90.1-2007 is examined for commercial buildings in the separate report. The 2009 IECC permits compliance with Standard 90.1-2007 as one option for complying with the IECC for commercial buildings.

rating fenestration performance. Chapter 3 contains only one element that directly contains a specific construction requirement: protective covering for insulation on the exterior of foundations (Section 303.2.1).

Table 1. IECC Table of Contents

CHAPTER 1 ADMINISTRATION
101 Scope and General Requirements 102 Alternate Materials—Method of Construction, Design or Insulating Systems 103 Construction Documents 104 Inspections 105 Validity 106 Reference Standards 107 Fees 108 Stop Work Order 109 Board of Appeals
CHAPTER 2 DEFINITIONS
201 General 202 General Definitions
CHAPTER 3 CLIMATE ZONES
301 Climate Zones 302 Design Conditions 303 Materials, Systems and Equipment
CHAPTER 4 RESIDENTIAL ENERGY EFFICIENCY
401 General 402 Building Thermal Envelope 403 Systems 404 Electrical Power and Lighting Systems 405 Simulated Performance Alternative
CHAPTER 5 COMMERCIAL ENERGY EFFICIENCY
501 General 502 Building Envelope Requirements 503 Building Mechanical Systems 504 Service Water Heating 505 Electrical Power and Lighting Systems 506 Total Building Performance
CHAPTER 6 REFERENCED STANDARDS

Table 2. Overview of IECC Chapter 1

Section	Overview/summary
101 Scope and General Requirements	Defines how code applies to additions, alterations, renovations, and repairs. Exempts certain low energy buildings.
102 Alternate Materials—Method of Construction, Design or Insulating Systems	Provides code official leeway in interpreting requirements.
103 Construction Documents	Construction documents as required by the code official must be provided.
104 Inspections	Inspections must be permitted and code officials must give approval before allowing further construction or occupancy.
105 Validity	Instructs that remainder of code applies even if a portion is found to be illegal or void.
106 Referenced Standards	Referenced standards must be complied with; the IECC takes precedence if there are any conflicts.
107 Fees	Fees for permits.
108 Stop Work Order	Authority and conditions for stop work orders
109 Board of Appeals	For hearing and deciding appeals.

1.3 Residential Building Requirements – Chapter 4 of the IECC

The 2009 IECC sets construction requirements related to energy efficiency for four energy end-uses:

1) Space heating
2) Space cooling (air conditioning)
3) Water heating
4) Lighting[4]

Table 3 shows the organization of the IECC requirements in Chapter 4.

Most of the requirements in the IECC are contained in Section 402 for the building envelope (ceilings, walls, windows, floor/foundation). Figure 1 shows the prescriptive requirements for most envelope measures (there are also separate requirements for skylights, high mass walls, and steel-framed ceilings, walls, and floors).

[4] Lighting is new to the scope of the IECC for residential buildings in 2009. Previous editions of the IECC only had requirements for space heating, space cooling, and water heating.

Table 3. Overview of IECC Chapter 4

Section	Overview/summary
401 General	Identifies the two compliance paths: prescriptive and performance. Requires a certificate to be posted on the building listing R-values and other energy efficiency information.
402 Building Thermal Envelope	This section contains most of the prescriptive requirements in the code. Insulation and fenestration requirements are given by climate zone. Air sealing requirements.
403 Systems	Contains requirements for heat pump controls, duct testing and sealing, piping insulation, and equipment sizing.
404 Electrical Power and Lighting Systems	Contains requirements for efficient lighting.
405 Simulated Performance Alternative	The performance approach. This utilizes the requirements of Sections 401 through 404 as a starting point and allows trade-offs. Unlike previous versions of the IECC this does not give extra credit for high efficiency heating, cooling, and water heating equipment. Compliance is determined using computer software. Allows more flexibility in meeting the code.

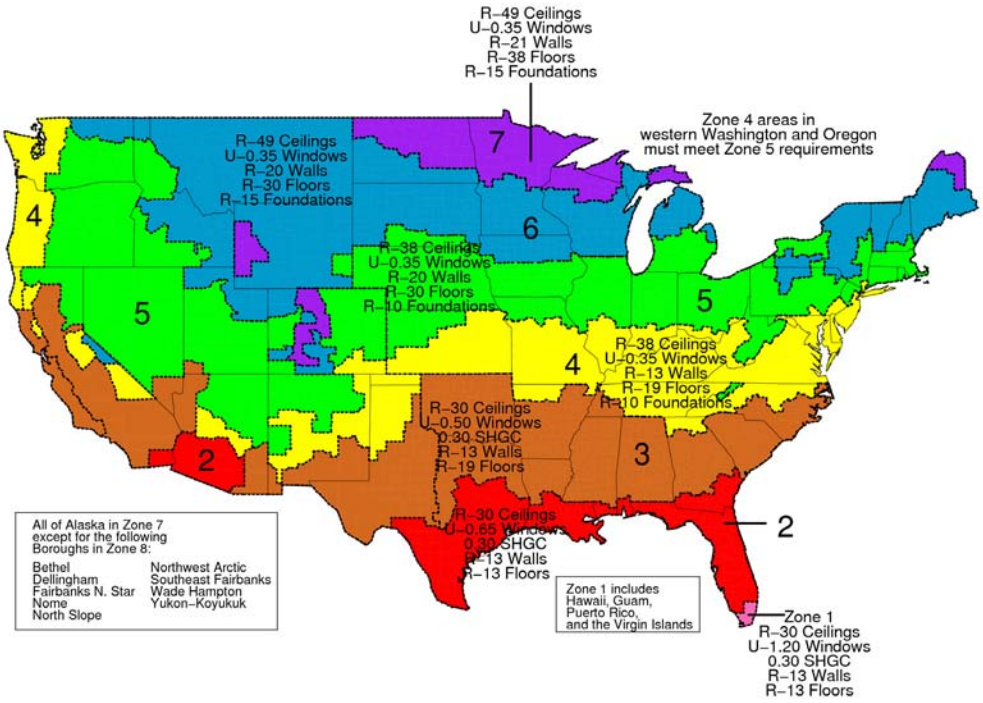

Figure 1. Prescriptive Envelope requirements

1.4 Comparison to Previous Versions of the IECC

The IECC is typically published every three years, though there are some exceptions. In the last two decades, full editions of the MEC came out in 1989, 1992, 1993, and 1995, and full editions of the IECC came out in 1998, 2000, 2003, 2006, and 2009[5].

Though there were changes in each edition of the IECC from the previous one, the IECC can be categorized into two general eras: 2003 and before, and 2004 and after. This is because the residential portion of the IECC was heavily revised in 2004. The climate zones were completely revised (reduced from 17 zones to 8 primary zones in 2004) and the building envelope requirements were restructured into a different format. The code became much more concise and much simpler to use. These changes complicate comparisons of state codes based on pre-2004 versions of the IECC to the 2009 IECC.

The IECC also had substantial revisions from 2006 to 2009. These revisions were not to the code format, but rather were changes to specific requirements to improve energy efficiency and make the code more stringent. The 2009 has some important new requirements:

- The duct system now has to be tested and the air leakage out of ducts must be kept to an acceptable maximum level. Testing is not required if all ducts are inside the building envelope (for example in heated basements), though the ducts still have to be sealed.
- 50% of the lighting "lamps" (bulbs, tubes, etc.) in a building have to be energy efficient. Compact fluorescents qualify, standard incandescent bulbs do not.
- Trade-off credit can no longer be obtained for high efficiency HVAC equipment. For example, if a high efficiency furnace is used, no reduction in wall insulation is allowed. This will have a great impact on reducing the flexibility allowed by the RES*check*™ software. No energy impact is assigned to this code change in the analysis of updating state codes to the 2009 IECC in this report.
- Vertical fenestration U-factor requirements are reduced from 0.75 to 0.65 in Climate Zone 2, 0.65 to 0.5 in Climate Zone 3, and 0.4 to 0.35 in Climate Zone 4.
- The maximum allowable solar heat gain coefficient is reduced from 0.40 to 0.30 in Climate Zones 1, 2, and 3.
- R-20 walls in climate zones 5 and 6 (increased from R-19)
- Modest basement wall and floor insulation improvements
- R-3 pipe insulation on hydronic distribution systems (increased from R-2)
- Limitation on opaque door exemption both size and style (side hinged)
- Improved air-sealing language
- Controls for driveway/sidewalk snow melting systems
- Pool covers are required for heated pools.

1.5 The IECC Compared to the International Residential Code (IRC)

Chapter 11 of the IRC contains energy efficiency requirements that are very similar to the IECC. This Chapter allows compliance with the IECC as an option for IRC compliance. The scope of the IRC is limited to one- and two-family dwellings and to townhouses, whereas the IECC includes other low-rise multifamily buildings such

[5] There was also a published version of the IECC in 2004, but that version is referred to as a "supplement" edition.

as apartments. States can adopt the IRC, the IECC, or both. While nearly all the requirements in the IRC are identical to those in the IECC, there are a few differences between the 2009 IECC and 2009 IRC. Most notably:

- The IRC requires 0.35 solar heat gain coefficient (SHGC) glazing in Climate Zones 1-3, the IECC requires 0.30 SHGC. Impact resistant fenestration in Climate Zones 2 and 3 is allowed to have an SHGC of up to 0.40 in the IRC only.
- The IECC has higher basement wall and floor insulation levels in colder zones.
- The IRC has no "mandatory" (cannot be traded off) requirements related to fenestration U-factor or SHGC, the IECC does.
- Compliance with the IECC is allowed as an alternative to Chapter 11 of the IRC. The IRC does not directly contain a simulated performance alternative; the IECC must be used instead for this compliance alternative.

Because of these changes, the 2009 IRC does not achieve equivalent energy savings to the 2009 IECC.

1.6 Current State Codes

This report addresses each state code individually, but a brief summary of state codes is presented here. Almost 40 states have adopted the IECC or its predecessor, the Model Energy Code (MEC), as their mandatory state code. Many of these states have made some modifications or amendments to the IECC or MEC. These modifications can vary from a few minor changes to extensive revisions.

Some states have no mandatory codes. As of the date of this report, these states are:

- Alabama
- Hawaii
- Kansas
- Mississippi
- Missouri
- North Dakota
- South Dakota
- Wyoming

Four states have developed their own codes that have minimal or no connection to the IECC:

- California
- Florida
- Oregon
- Washington

In certain cases, cities or counties within a state have a different code from the rest of the state. For example, Austin and Houston have adopted progressive energy codes that exceed the minimum Texas statewide code.

2.0 Chapter 2 – Energy Analysis of Major Improvement in 2009 IECC

The 2009 IECC contains major differences that are not contained in any previous version of the IECC. These changes account for much of the energy savings attributable to the 2009 IECC compared to any of the older versions of the IECC.

2.1 Duct Testing

Section 403.2.2 of the 2009 IECC requires air ducts systems, where any of the ducts pass outside of the conditioned space (into attics, garages, etc.), to be pressure tested for leakage with maximum leakage rates specified. The duct system now has to be tested to prove that the air leakage out of ducts is kept to an acceptable level. Testing is not required if all ducts are inside the building envelope (for example in heated basements), though all ducts are required to be sealed.

The IECC has always required ducts to be sealed. However, multiple studies have shown that visual inspection of ducts is not adequate. Ducts are often located in difficult to access areas such as attics and crawl spaces. Cracks and other leakage points in ducts may not be visible because they are covered by insulation, hidden from view, or simply too small to be readily apparent to the human eye. Testing of completed homes in Washington state, where prescriptive code requirements for duct sealing apply, "showed no significant improvement" over non-code homes (Washington State University 2001). Another study from Washington state concluded: "Comparisons to air leakage rates reported elsewhere for homes built before the implementation of the 1991 WSEC show no significant improvement by the general population" despite years of training emphasizing duct sealing (Hales et al. 2003). The requirement to meet a specific leakage limit will result in improving the buildings that would have had the leakiest ducts. Figure 2 illustrates this effect.

Numerous other studies around the nation show substantial duct leakage in new homes, including those in states with codes requiring duct sealing. For example, a 2001 study of 186 houses built under the MEC in Massachusetts reported "serious problems were found in the quality of duct sealing in about 80% of these houses" (Xenergy 2001). Pressurization tests in 22 of these houses found an average leakage to the outside of the house of 183 cfm, or 21.6% of the system flow, at a pressure of 25 Pascals.

The IECC allows a variety of compliance methods. Notably, the testing can be done at rough-in stage immediately after the ducts are installed. This allows potentially costly call backs to be avoided if the tested leakage rate exceeds code requirements.

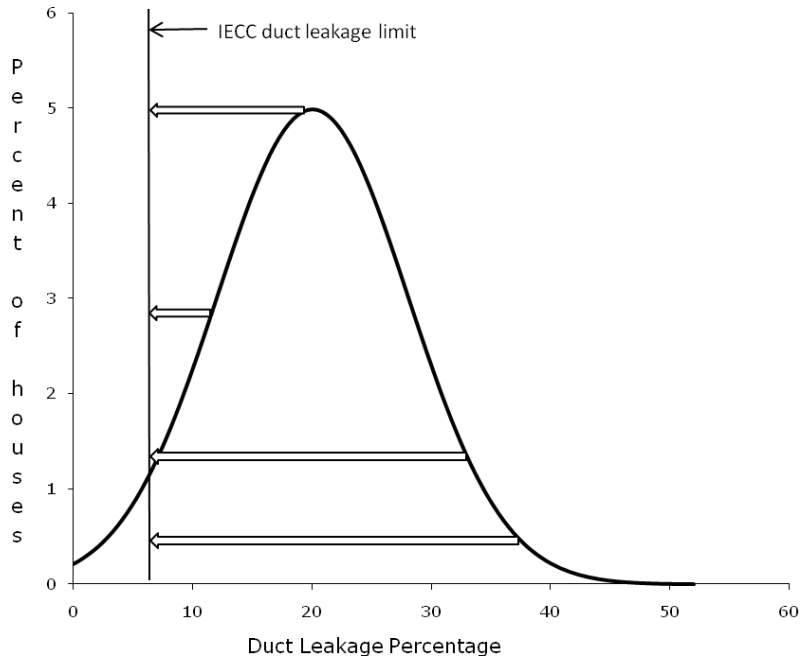

Figure 2. Impact of improved duct sealing. The curve illustrates the approximate distribution of leakage rate in new homes. The arrows show the reduction in duct leakage necessary to meet the code requirement.

2.2 Lighting

The 2009 IECC requires 50% of lamps (bulbs, tubes) within a residence to be energy efficient. There were no requirements for lighting in single-family homes in previous versions of the IECC. This includes but is not limited to CFLs. Standard incandescent bulbs do not qualify. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014.

2.3 Envelope Improvements

The 2009 IECC has a number of improvements in basic envelope requirements over the 2006 IECC. Allowable glazed fenestration (windows and skylights) SHGC has been reduced to a maximum of 0.30, meaning that no more than 30% of the sun's heat can pass through the window into the home. Fenestration U-factor requirements have improved in Climate Zones 2, 3, and 4. Wall insulation for wood frame walls has been bumped up from R-19 to R-20 in Climate Zones 5 and 6. Floor insulation and basement wall insulation have increased in the very coldest zones.

2.4 Elimination of Equipment Trade-offs

Previous versions of the IECC allow reductions in envelope measures to below-code levels if heating and cooling equipment efficiency is improved to above-code levels. For example, a popular trade-off in colder climates is to use a high efficiency gas furnace allowing a reduction of wall insulation. The 2009 IECC eliminates these types of trade-offs. Since these trade-offs are by definition energy neutral, their eliminiation in theory would not impact energy use. However, building envelope measures often have longer lifetimes than heating and cooling equipment so there can be long-term impacts. Additionally, there is expected to be some "free rider" effect where high efficiency equipment will be used regardless of the IECC requirements and the trade-offs, so the older IECC allowed envelope reductions as an unintended side effect.

3.0 References

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Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Alabama

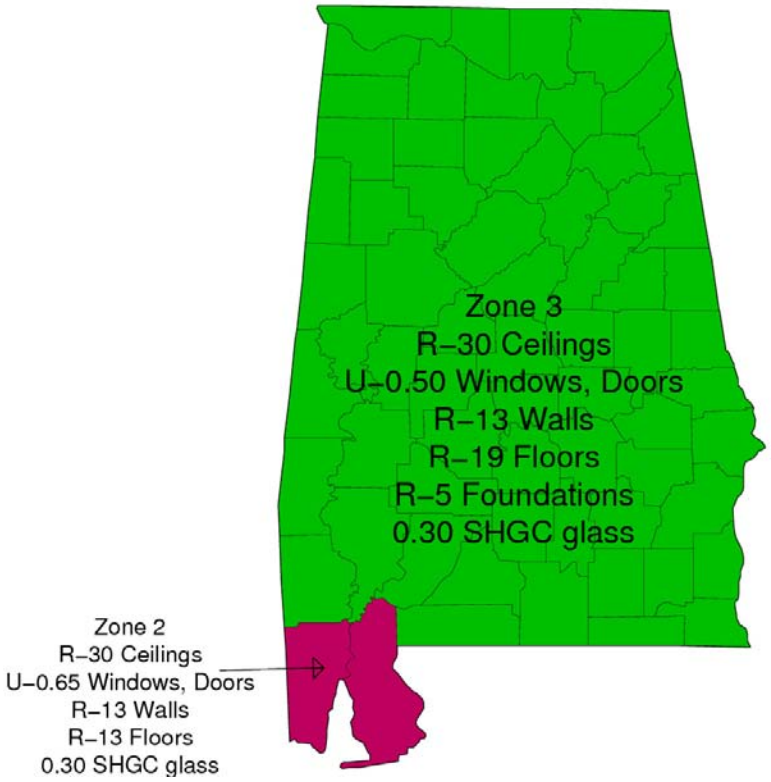
Summary

Alabama currently does not have a mandatory energy efficiency code. The 2009 International Energy Conservation Code (IECC) would substantially improve energy efficiency in Alabama homes. A limited analysis of the impact of the 2009 IECC resulted in estimated savings of $173 to $237 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Alabama.
- 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.
- Insulation is <u>not</u> required for slab-on-grade foundations in Zones 2 and 3.
- 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-0.75 in Zone 2 and U-0.65 in Zone 3
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted SHGC of 0.50. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Alabama Construction Practice and the 2009 IECC

The state of Alabama has no mandatory energy efficiency code. We do not have detailed data on current construction techniques related to energy efficiency in Alabama. Some energy efficient housing may be built to levels at or close to the IECC, others may fall well short of the IECC. Compliance with the 2009 IECC is expected to often result in increased insulation levels, better windows, better insulated and less leaky ducts, and better lighting.

Adoption of the 2009 IECC would likely improve a number of thermal envelope measures in many new houses and other residential construction. These estimated typical improvements are shown in bold in Table 4.

Table 4. Comparison of Envelope Requirements

Components	Climate Zone 2		Climate Zone 3	
	Current Practice	2009 IECC	Current Practice	2009 IECC
Ceiling	30	30	30	30
Fenestration U-factor	**.75**	**.65**	**.75**	**.50**
Fenestration SHGC	**.50**	**.30**	**.50**	**.30**
Wood Frame Wall	13	13	13	13

Energy Analysis

A brief energy analysis was conducted comparing the assumed current practice to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to current practice, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 5 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 5. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings Current Practice vs. 2009 IECC*	
	Current Practice		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Mobile (CZ 2A)	494	327	454	268	173	15
Montgomery (CZ 3A)	629	311	523	254	237	19

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Alaska

Summary

The 2009 International Energy Conservation Code (IECC) contains several improvements in energy efficiency over the current state code, the 2006 IECC with amendments. The most notable changes are improved duct sealing and efficient lighting requirements. A comparison of the overall impacts on energy use for these two codes is not attempted here.

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.

Table 6. Envelope Requirements in the 2009 IECC

Components	*Requirement*
Ceiling	49
Skylight U-factor	.60
Fenestration U-factor	.35
Wood Frame Wall	21
Mass Wall	19/21
Floor	38
Basement Wall	15/19
Slab	15, 4ft
Crawl Space	10/13

Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 4 feet
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Alaska.
- Less insulation is allowed for mass walls and more insulation 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.40. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Alaska Code and the 2009 IECC

Alaska has adopted the 2006 IECC with extensive amendments. The code divides the state into four zones with Zone 6 being the Southeast, Zone 7 being a South-central region including Anchorage, Zone 8 being most of central Alaska and Zone 9 being above the Arctic Circle.

The state code includes an optional performance-based compliance approach that is completely separate from the IECC. A home that receives an energy rating and achieves a level of four stars using the AKwarm™ method meets the state code. The Alaska Housing Finance Corporation reports that code compliance is "most often shown" by this method. As the energy efficiency measures used in rated Alaskan houses can be variable and are not well documented, no attempt at comparing the energy efficiency of the Alaska code to the 2009 IECC is made here.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Arizona

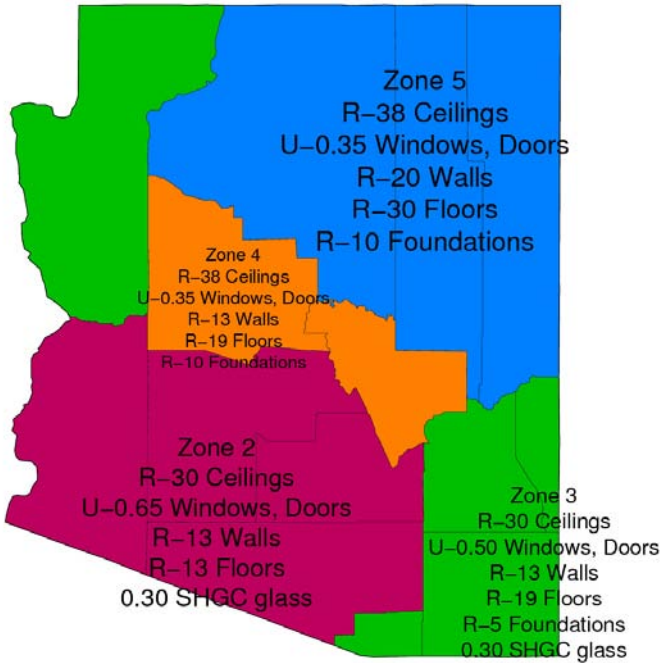
Summary

Arizona is a "home rule" state with no mandatory state-wide energy efficiency code. However, many counties and cities have adopted an energy efficiency code, most often the 2006 International Energy Conservation Code (IECC). The 2009 IECC contains several major improvements in energy efficiency over the 2006 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $211 to $223 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zones 4 and 5. Insulation is not required for slab-on-grade foundations in Zones 2 and 3.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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-0.75 in Zone 2, U-0.65 in Zone 3 and U-0.60 in Zones 4 and 5
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zones 4 and 5 and cannot exceed an area-weighted SHGC of 0.50 in Zones 2 and 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Arizona Code and the 2009 IECC

Many municipalities in Arizona have adopted the 2006 IECC (e.g., Phoenix, Pima County). The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 7.

Table 7. Comparison of Envelope Requirements

	Climate Zone 2B		Climate Zone 3B		Climate Zone 4B		Climate Zone 5B	
	IECC 2006	IECC 2009	IECC 2006	IECC 2009	IECC 2006	IECC 2009	IECC 2006	IECC 2009
Ceiling	30	30	30	30	38	38	38	38
Skylight U-factor	.75	.75	.65	.65	.60	.60	.60	.60
Fenestration U-factor	**.75**	**.65**	**.65**	**.50**	**.40**	**.35**	.35	.35
Fenestration SHGC	**.40**	**.30**	**.40**	**.30**	NR	NR	NR	NR
Wood Frame Wall	13	13	13	13	13	13	**19**	**20**
Mass Wall	4/6	4/6	5/8	5/8	**5/13**	**5/10**	**13/19**	**13/17**
Floor	13	13	19	19	19	19	30	30
Basement Wall	0	0	**0**	**5/13**	10/13	10/13	10/13	10/13
Slab	0	0	0	0	10, 2ft	10, 2ft	10, 2ft	10, 2ft
Crawl Space	0	0	5/13	5/13	10/13	10/13	10/13	10/13

Other changes in the 2009 IECC compared to the 2006 IECC:

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 8 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 8. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs.2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Phoenix (CZ 2B)	306	665	280	554	211	17
Bakersfield CA (CZ 3B)	609	383	537	313	216	17
Prescott (CZ 4B)	969	189	838	171	223	15
Flagstaff (CZ 5B)	1250	74	1116	66	216	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Arkansas

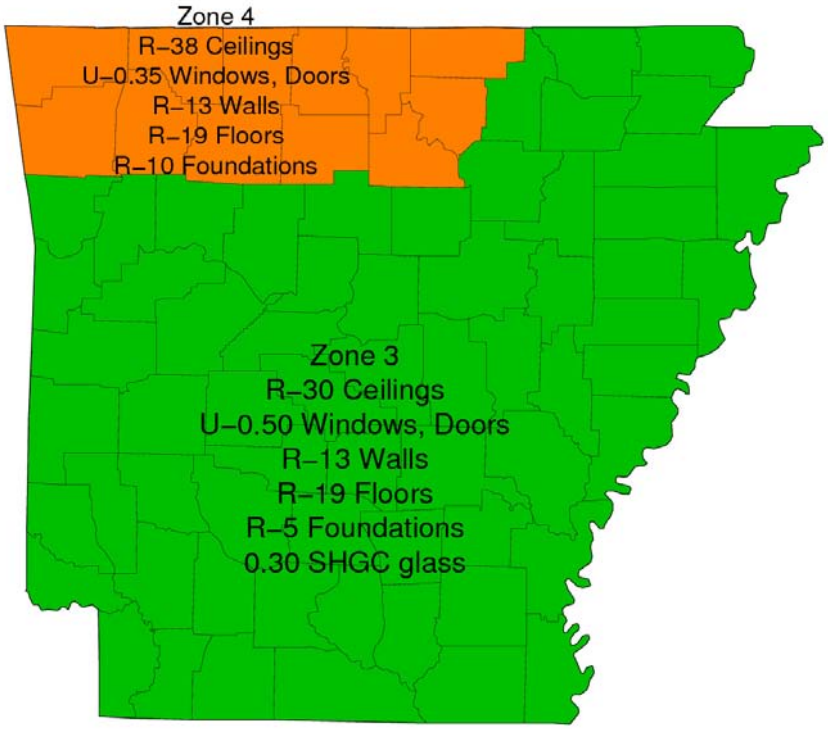
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2003 IECC with amendments. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $242 to $245 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 4. Insulation is not required for slab-on-grade foundations in Zone 3.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Arkansas.
- 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-0.65 in Zone 3 and U-0.60 in Zone 4
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 4 and cannot exceed an area-weighted SHGC of 0.50 in Zone 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Arkansas Code and the 2009 IECC

Arkansas has adopted the 2003 IECC with amendments, including:

- No glazed fenestration SHGC requirement. The 2003 IECC requires a maximum SHGC of 0.40 in south and central Arkansas.
- Duct insulation is set to R-5.6. The 2003 IECC duct insulation values vary from R-2 to R-8.

Major differences between the 2009 IECC and the Arkansas code are listed below:

- The current state code 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 2003 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*™ software and other energy performance analysis tools.)
- The format of the 2003 IECC and 2009 IECC are substantially different. The 2009 IECC has new climate zones that cover larger geographic regions than the zones in the 2003 IECC. The envelope insulation and window requirements in the 2003 IECC vary by window-to-wall area percentage, but not in the 2009 IECC. This change in format makes a simple comparison of the envelope requirements in the two codes impossible.

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 9 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 9. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. Arkansas Code*	
	Arkansas Code		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Little Rock (CZ 3A)	965	300	853	244	242	15
Springfield MO (CZ 4A)	1185	213	1034	193	245	14

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in California

Summary

California has a state-developed residential energy efficiency code known as "Title 24". This code has many differences from the 2009 International Energy Conservation Code (IECC). A comparison of the overall impacts on energy use for these two codes is not attempted here. Requirements of the 2009 IECC are summarized below.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.

Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- R-10 slab-on-grade insulation is required in Zones 4, 5, and 6. Insulation is not required for slab-on-grade foundations in Zones 2 and 3.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are only required in colder zones, including Zones 5 and 6.
- 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-0.75 in Zone 2, U-0.65 in Zone 3, and U-0.60 in Zones 4, 5, and 6.
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zones 4 and 5 and cannot exceed an area-weighted SHGC of 0.50 in Zones 2 and 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Colorado

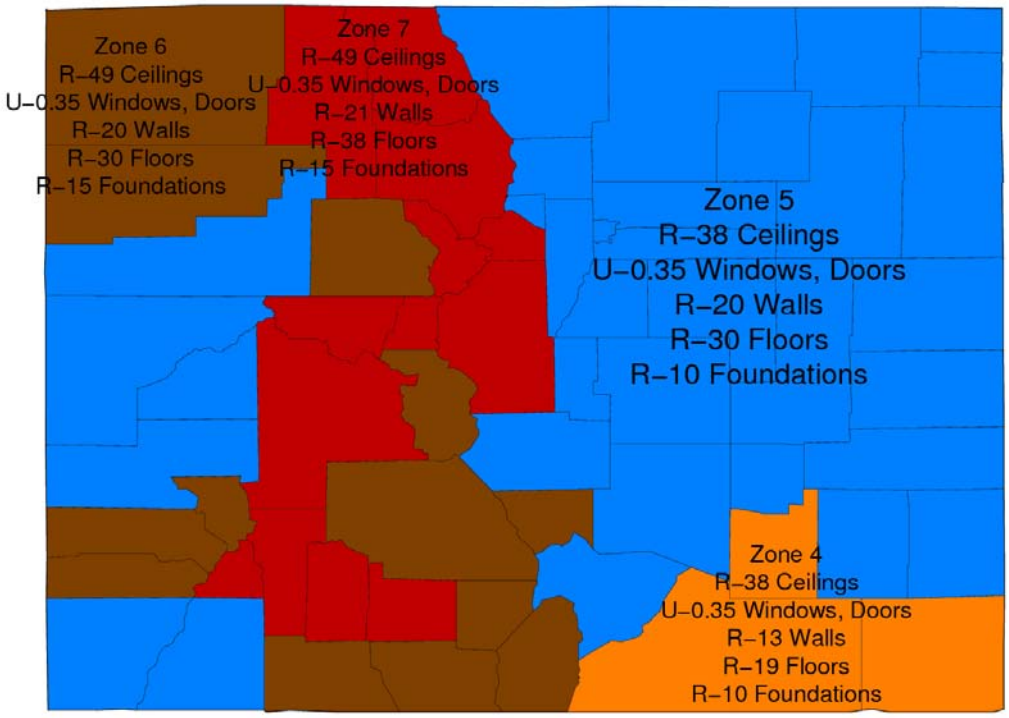
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2003 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $213 to $266 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zones 4 and 5 and 4 feet in Zones 6 and 7.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5, 6, and 7.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zones 4 and 5 and 0.40 in Zones 6 and 7. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Colorado Code and the 2009 IECC

Colorado requires the 2003 IECC as the minimum code though many municipalities have adopted the 2006 IECC, and the 2006 IECC is therefore compared to the 2009 here. The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 10.

Table 10. Comparison of Envelope Requirements

Components	Climate Zone 4B		Climate Zone 5B		Climate Zone 6B		Climate Zone 7B	
	2006 IECC	2009 IECC	2006 IECC	2009 IECC	2006 IECC	2009 IECC	2006 IECC	2009 IECC
Ceiling	38	38	38	38	49	49	49	49
Skylight U-factor	.60	.60	.60	.60	.60	.60	.60	.60
Fenestration U-factor	**.40**	**.35**	.35	.35	.35	.35	.35	.35
Fenestration SHGC	NR	NR	NR	NR	NR	NR	NR	NR
Wood Frame Wall	13	13	**19**	**20**	**19**	**20**	21	21
Mass Wall	**5/13**	**5/10**	**13/19**	**13/17**	15/19	15/19	19/21	19/21
Floor	19	19	30	30	30	30	**30**	**38**
Basement Wall	10/13	10/13	10/13	10/13	**10/13**	**15/19**	**10/13**	**15/19**
Slab	10, 2ft	10, 2ft	10, 2ft	10, 2ft	10, 4ft	10, 4ft	10, 4ft	10, 4ft
Crawl Space	10/13	10/13	10/13	10/13	10/13	10/13	10/13	10/13

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 11 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 11. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	
Wichita KS (CZ 4B)	1247	305	1085	275	266	14
Boulder (CZ 5B)	1152	150	1029	134	213	13
Eagle (CZ 6B)	1530	88	1367	79	246	13
Alamosa (CZ 7B)	1475	68	1318	60	239	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Connecticut

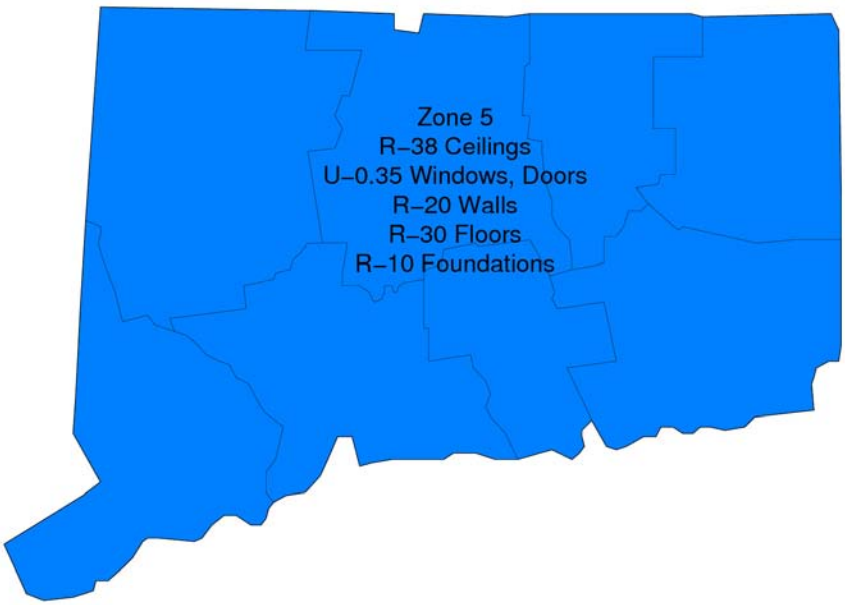
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $235 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.

- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Connecticut Code and the 2009 IECC

Connecticut has adopted the 2006 IECC with minor modifications for sunrooms, greenhouses, and swimming pools. The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have changed in the 2009 IECC. These are highlighted in Table 12.

Table 12. Comparison of Envelope Requirements

Components	Climate Zone 5A	
	2006 IECC	2009 IECC
Ceiling	38	38
Skylight U-factor	.60	.60
Fenestration U-factor	.35	.35
Fenestration SHGC	NR	NR
Wood Frame Wall	**19**	**20**
Mass Wall	**13/19**	**13/17**
Floor	30	30
Basement Wall	10/13	10/13
Slab	10, 2ft	10, 2ft
Crawl Space	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 13 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 13. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Hartford (CZ 5A)	1372	157	1227	141	235	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Delaware

Summary

Delaware recently adopted the 2009 International Energy Conservation Code (IECC). The code becomes effective July 1, 2010.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.

Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Delaware.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in the District of Columbia

Summary

The 2009 International Energy Conservation Code (IECC) is generally similar to the current code, the 2006 IECC with extensive amendments. In fact, the DC code is closer to the 2009 IECC than the 2006 IECC. A limited analysis indicates the DC code will save $59 a year compared to the 2009 IECC for an average new house at recent fuel prices.

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.

Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in DC.
- Less insulation is allowed for mass walls and more insulation 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Current District of Columbia Code and the 2009 IECC

The District of Columbia adopted the 2006 IECC with amendments on October 10, 2008. The amendments are based on the "30% solution" developed by the Energy Efficient Codes Coalition and make the DC code much more similar to the 2009 IECC than the 2006 IECC. The differences in the DC code compared to the 2009 IECC generally (but not entirely) improve energy efficiency. Differences include:

- In the DC code, service water heating piping (for showers, faucets, etc.) must be insulated to a minimum of R-2 for the distance between the service water heater to within 5 feet of each fixture connected to the hot water pipe. The 2009 IECC does not require insulation for service hot water pipes. Service water heating distribution systems require a stub-in connection point for future Solar Hot Water Systems in the DC code.
- Air handlers must be designed to have no more than 2% air leakage at test conditions in the DC code.
- In certain cases the 2009 IECC allows R-6 duct insulation whereas the DC code requires R-8.
- The 2009 IECC requires recessed light fixtures to meet air leakage limits; the DC code does not.
- There are a number of differences in the simulated performance alternative. The DC code:
  - Sets the standard reference design glazing area at 18% of the conditioned floor area. The 2009 IECC sets this at 15%.
  - Sets the assumed heating temperature set point to be 70 ^{o}F. The 2009 IECC is at 72 ^{o}F.
  - For the proposed design, if an inspection for proper insulation installation is not conducted, 5% of the insulation shall be assumed to be missing. The 2009 IECC assumes complete insulation.

- Sets the standard design to have an air-source heat pump if the proposed design has electric heating. This effectively penalizes heating by electric furnace.

- Ceiling and wall insulation are increased in the DC code compared to the 2009 IECC. See Table 14.

Table 14. Comparison of Envelope Requirements

Components	Climate Zone 4A	
	DC	2009 IECC
Ceiling	**49**	**38**
Skylight U-factor	.60	.60
Fenestration U-factor	.35	.35
Fenestration SHGC	NR	NR
Wood Frame Wall	**18**	**13**
Mass Wall	5/10	5/10
Floor	19	19
Basement Wall	10/13	10/13
Slab	10, 2 ft	10, 2 ft

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

Table 15 shows the estimated annual energy savings per house that result from meeting the Washington DC code compared to the 2009 IECC. This includes space heating and cooling accounts for the improved wall and ceiling insulation only. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 15. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. DC Code*	
	2009 IECC		*DC Code*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Washington D.C. (CZ 4A)	856	331	804	324	59	5

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Florida

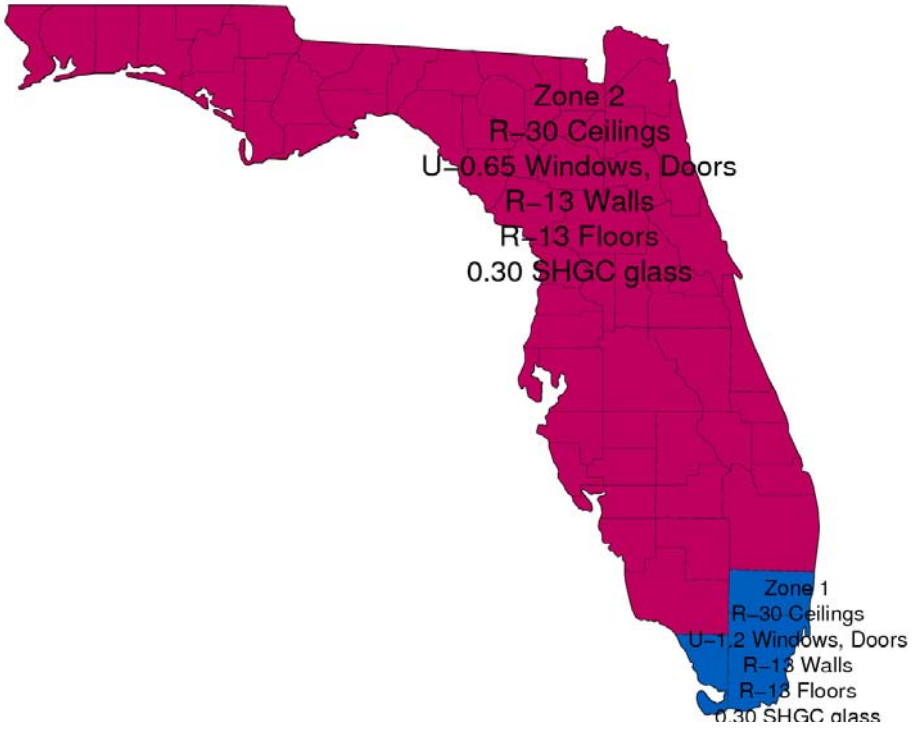
Summary

Florida has a state-developed residential energy efficiency code that has many differences from the 2009 International Energy Conservation Code (IECC). Because of the extensive differences between the Florida code and the IECC, a comparison of the overall impacts on energy use for these two codes is not attempted here.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Florida.
- Less insulation is allowed for mass walls and more insulation 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-0.75
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted SHGC of 0.50 in Zones 1 and 2. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Georgia

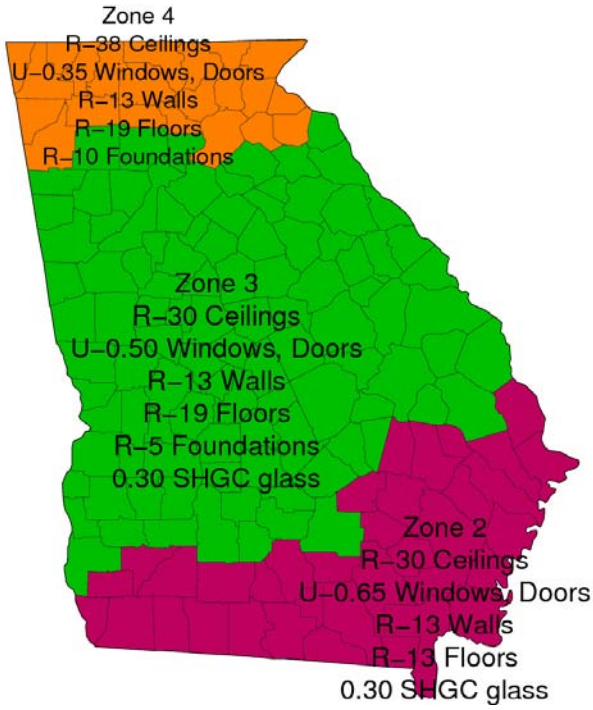
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC with very limited amendments. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $183 to $229 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 4. Insulation is not required for slab-on-grade foundations in Zones 2 and 3.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Georgia.
- Less insulation is allowed for mass walls and more insulation 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-0.75 in Zone 2, U-0.65 in Zone 3 and U-0.60 in Zone 4
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 4 and cannot exceed an area-weighted SHGC of 0.50 in Zones 2 and 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Georgia Code and the 2009 IECC

Georgia has adopted the 2006 IECC with an amendment banning electric resistance as the primary heat source.

The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 16.

Table 16. Comparison of Envelope Requirements

	Climate Zone 2A		Climate Zone 3A		Climate Zone 4A	
	GA Code	2009 IECC	GA Code	2009 IECC	GA Code	2009 IECC
Ceiling	30	30	30	30	38	38
Skylight U-factor	.75	.75	.65	.65	.60	.60
Fenestration U-factor	**.75**	**.65**	**.65**	**.50**	**.40**	**.35**
Fenestration SHGC	**.40**	**.30**	**.40**	**.30**	NR	NR
Wood Frame Wall	13	13	13	13	13	13
Mass Wall	4/6	4/6	5/8	5/8	**5/13**	**5/10**
Floor	13	13	19	19	19	19
Basement Wall	0	0	**0**	**5/13**	10/13	10/13
Slab	0	0	0	0	10, 2ft	10, 2ft
Crawl Space	0	0	5/13	5/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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, a basement ceiling area of 1,200 ft^2, and a window area of 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 17 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 17. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Savannah (CZ 2A)	576	307	524	250	183	15
Atlanta (CZ 3A)	927	221	816	177	229	16
Chattanooga (CZ 4A)	871	238	755	215	213	15

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Hawaii

Summary

Hawaii does not have a mandatory statewide comprehensive building energy efficiency code though several counties have adopted code requirements. Hawaii does require solar water heaters in new homes. The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over current practice in the state. The most notable changes are improved duct sealing and efficient lighting requirements.

It is difficult to assess the impact of the 2009 IECC for Hawaii and no attempt to quantify this is done here. The IECC is not particularly well suited for tropical climates. The Hawaii solar water heater requirement will save water heating energy compared to the IECC, which has no such requirement. Since Hawaii needs virtually no space heating and has modest air conditioning needs, water heating is an important energy use in residential buildings. Requirements in the IECC that can save energy in Hawaii include efficient lighting, ceiling insulation, and duct sealing and insulation.

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.

Notable requirements in the 2009 IECC:

- R-30 ceiling insulation, R-13 wood-frame walls, R-4 mass walls, U-1.20 vertical windows, U-0.75 skylights, and 0.30 or lower SHGCs for windows/skylights.
- 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), though the ducts still have to be sealed.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted SHGC of 0.50. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Idaho

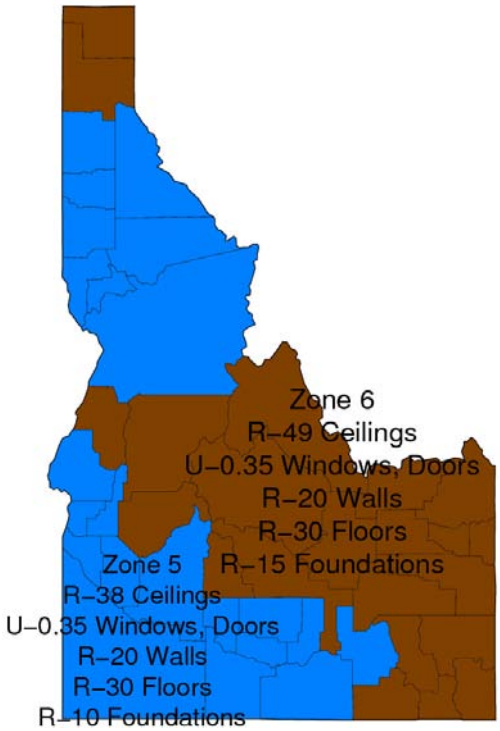
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $224 to $247 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 5 and 4 feet in Zone 6.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5 and 6.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5 and 0.40 in Zone 6. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Idaho Code and the 2009 IECC

Idaho has adopted the 2006 IECC. The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 18.

Table 18. Comparison of Envelope Requirements

Components	Climate Zone 5B		Climate Zone 6B	
	2006 IECC	2009 IECC	2006 IECC	2009 IECC
Ceiling	38	38	49	49
Skylight U-factor	.60	.60	.60	.60
Fenestration U-factor	.35	.35	.35	.35
Fenestration SHGC	NR	NR	NR	NR
Wood Frame Wall	**19**	**20**	**19**	**20**
Mass Wall	**13/19**	**13/17**	15/19	15/19
Floor	30	30	30	30
Basement Wall	10/13	10/13	**10/13**	**15/19**
Slab	10, 2ft	10, 2ft	10, 4ft	10, 4ft
Crawl Space	10/13	10/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements.

EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 19 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 19. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Boise (CZ 5B)	1236	176	1104	158	224	13
Pocatello (CZ 6B)	1501	129	1342	115	247	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Illinois

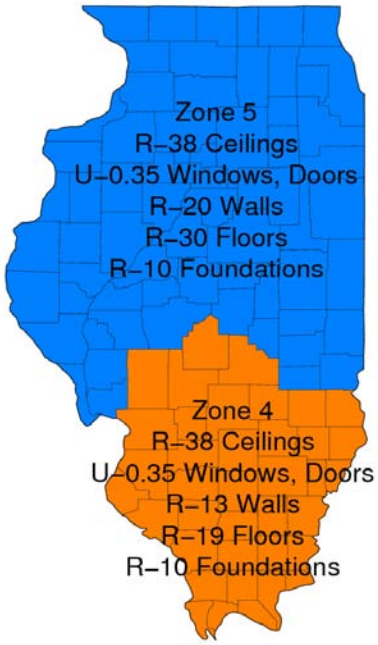
Summary

Illinois recently adopted the 2009 International Energy Conservation Code (IECC).

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.

- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Indiana

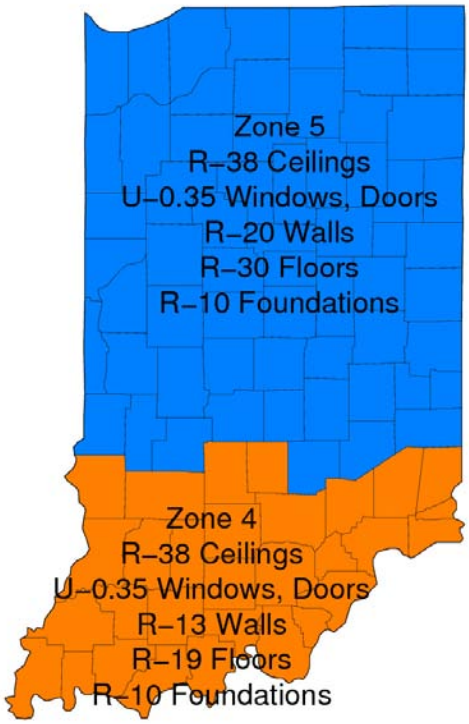
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 1992 Model Energy Code with amendments. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $226 to $250 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Indiana Code and the 2009 IECC

The format of the Indiana code and 2009 IECC are substantially different. The Indiana code is based on an older code, the 1992 Model Energy Code (MEC), and sets U-factor requirements by component (walls, roof/ceilings, floors, slabs, crawl spaces, and basement walls) with similar values to those in the all versions of the MEC and IECC through the 2003 edition of the IECC. The Indiana code does not have any simplified R-value prescriptive requirements contained in more recent versions of the MEC and IECC. The 2009 IECC has new climate zones that cover larger geographic regions than the zones in the Indiana code. The envelope insulation and window requirements in the Indiana code vary by window-to-wall area percentage, but not in the 2009 IECC. This change in format makes a simple comparison of the envelope requirements in the two codes impossible.

Table 20 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 20. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. Indiana Code*	
	Indiana Code		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Evansville (CZ 4A)	1201	247	1049	223	250	14
Indianapolis (CZ 5A)	1264	182	1131	163	226	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Iowa

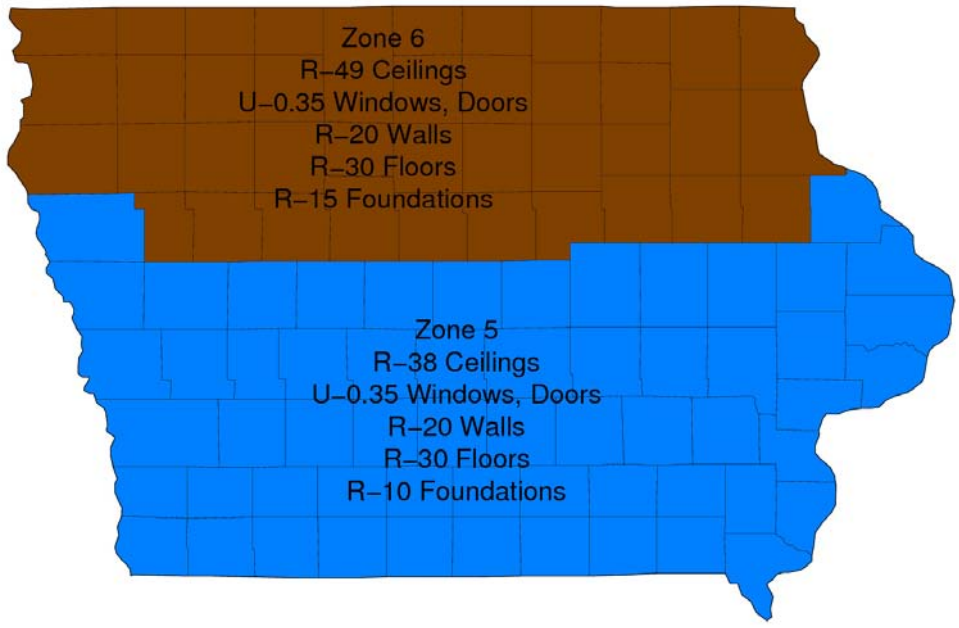
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $245 to $276 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 5 and 4 feet in Zone 6.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5 and 6.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5 and 0.40 in Zone 6. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Iowa code and the 2009 IECC

Iowa has adopted the 2006 IECC. The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 21.

Table 21. Comparison of Envelope Requirements

Components	Climate Zone 5A		Climate Zone 6A	
	2006 IECC	2009 IECC	2006 IECC	2009 IECC
Ceiling	38	38	49	49
Skylight U-factor	.60	.60	.60	.60
Fenestration U-factor	.35	.35	.35	.35
Fenestration SHGC	NR	NR	NR	NR
Wood Frame Wall	**19**	**20**	**19**	**20**
Mass Wall	**13/19**	**13/17**	15/19	15/19
Floor	30	30	30	30
Basement Wall	10/13	10/13	**10/13**	**15/19**
Slab	10, 2ft	10, 2ft	10, 4ft	10, 4ft
Crawl Space	10/13	10/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 22 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 22. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Des Moines (CZ 5A)	1432	186	1280	167	245	13
Mason City (CZ 6A)	1787	134	1598	121	276	12

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Kansas

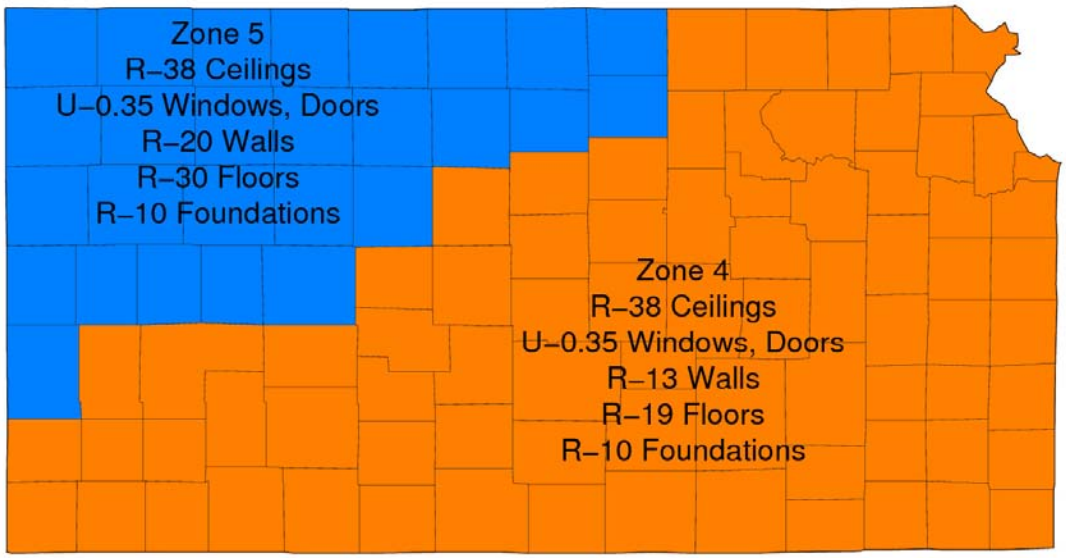
Summary

Kansas currently does not have a mandatory energy efficiency code. The 2009 International Energy Conservation Code (IECC) would substantially improve energy efficiency in Kansas homes. A limited analysis of the impact of the 2009 IECC resulted in estimated savings of $355 to $582 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.

- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between Kansas Current Practice and the 2009 IECC

The state of Kansas has no mandatory energy efficiency code. We do not have detailed data on current construction techniques related to energy efficiency in Kansas. Some energy efficient housing may be built to levels at or close to the IECC, others may fall well short of the IECC. Compliance with the 2009 IECC is expected to often result in increased insulation levels, better windows, better insulated and less leaky ducts, and better lighting.

Adoption of the 2009 IECC would likely improve a number of thermal envelope measures in many new houses and other residential construction. Table 23 compares the 2009 to measures that may often be occurring in new Kansas housing.

Table 23. Comparison of Envelope Requirements

Components	Climate Zone 4		Climate Zone 5	
	Current Practice	2009 IECC	Current Practice	2009 IECC
Ceiling	30	38	30	38
Fenestration U-factor	.50	.35	.50	.35
Wood Frame Wall	13	13	13	19
Floor	19	19	19	30

Energy Analysis

A brief energy analysis was conducted comparing assumed current practice to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to current practice, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 24 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 24. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. Current Practice*	
	Current Practice		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Topeka (CZ 4A)	1407	259	1152	233	355	18
Goodland (CZ 5A)	1648	197	1170	167	582	27

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Kentucky

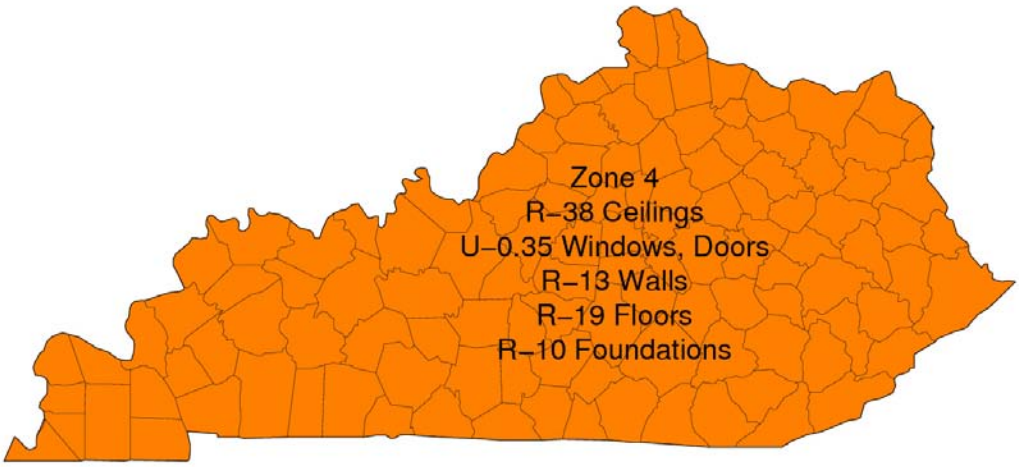
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC and 2006 IRC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $336 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.

- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Kentucky.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 measure 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Kentucky Code and the 2009 IECC

Kentucky adopted the 2006 IECC and the 2006 IRC with amendments. These amendments are:

- A reduction of basement and crawl space wall insulation from R-10 to R-4.
- A reduction of ceiling insulation in attics from R-30 to R-26 when the attic insulation is not compressed or reduced in height at the eaves.

- Requirements for sealing recessed light fixtures are deleted.
- Duct insulation is set to R-4. The 2006 IRC requires R-8 in most cases; the 2009 IECC requires R-8 for supply ducts in attics, R-6 for other ducts.

The 2006 IRC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The Kentucky code has the differences 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 current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 25.

Table 25. Comparison of Envelope Requirements

Components	Climate Zone 4A	
	2006 IECC	2009 IECC
Ceiling	38	38
Skylight U-factor	.60	.60
Fenestration U-factor	**.40**	**.35**
Fenestration SHGC	NR	NR
Wood Frame Wall	13	13
Mass Wall	**5/13**	**5/10**
Floor	19	19
Basement Wall	**4/13**	**10/13**
Slab	**4, 2 ft**	**10, 2 ft**
Crawl Space	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 26 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 26. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Lexington (CZ 4A)	1272	191	1108	173	336	18

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Louisiana

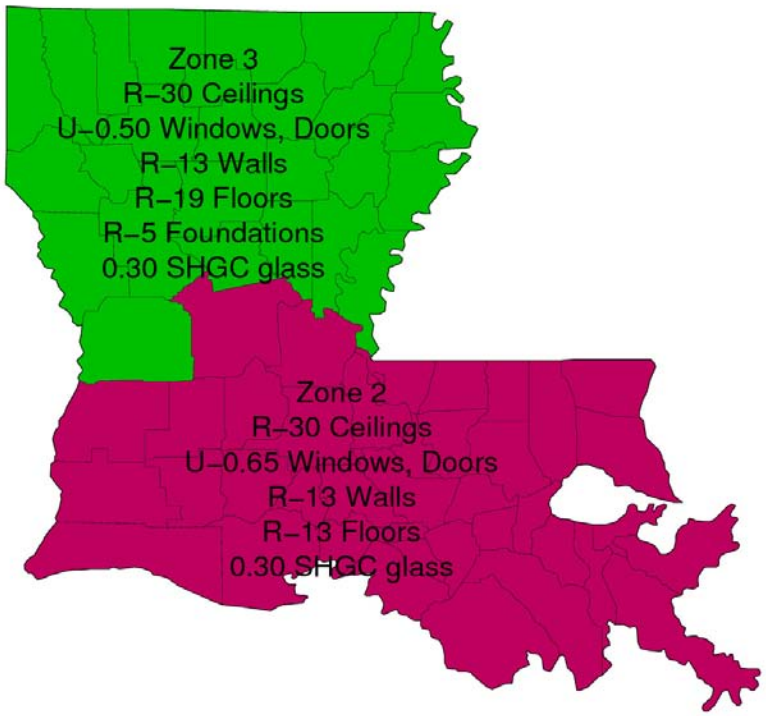
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IRC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $171 to $206 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Louisiana.
- Less insulation is allowed for mass walls and more insulation 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.
- Insulation is not required for slab-on-grade foundations in Zones 2 and 3.
- 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-0.75 in Zone 2 and U-0.65 in Zone 3
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted SHGC of 0.50. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Louisiana Code and the 2009 IECC

Louisiana adopted the 2006 IRC on January 1, 2007. The 2006 IRC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC.

- The current state code 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 thermal envelope).
- The 2009 IECC allows R-6 duct insulation in some cases where the 2006 IRC requires R-8.
- 50% of the lighting "lamps" (bulbs, tubes, etc.) in a building have to be energy efficient. Compact fluorescents qualify, standard incandescent bulbs do not.
- Trade-off credit can no longer be obtained for high efficiency HVAC equipment. For example, if a high efficiency furnace is used, no reduction in wall insulation is allowed. (This will have a great impact on reducing the flexibility allowed by the RES*check*™ software.)
- A number of thermal envelope requirements have improved. These are shown in bold in Table 27.

Table 27. Comparison of Envelope Requirements

Components	Climate Zone 2		Climate Zone 3	
	2006 IRC	2009 IECC	2006 IRC	2009 IECC
Ceiling	30	30	30	30
Skylight U-factor	.75	.75	.65	.65
Fenestration U-factor	**.75**	**.65**	**.65**	**.50**
Fenestration SHGC	**.40**	**.30**	**.40**	**.30**
Wood Frame Wall	13	13	13	13
Mass Wall	4	4/6	5/8	5/8
Floor	13	13	19	19
Basement Wall	0	0	**0**	**5/13**
Slab	0	0	0	0
Crawl Space	0	0	5/13	5/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements.

EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 28 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 28. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IRC*	
	2006 IRC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Baton Rouge (CZ 2A)	476	312	435	256	171	16
Shreveport (CZ 3A)	638	315	564	257	206	16

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Maine

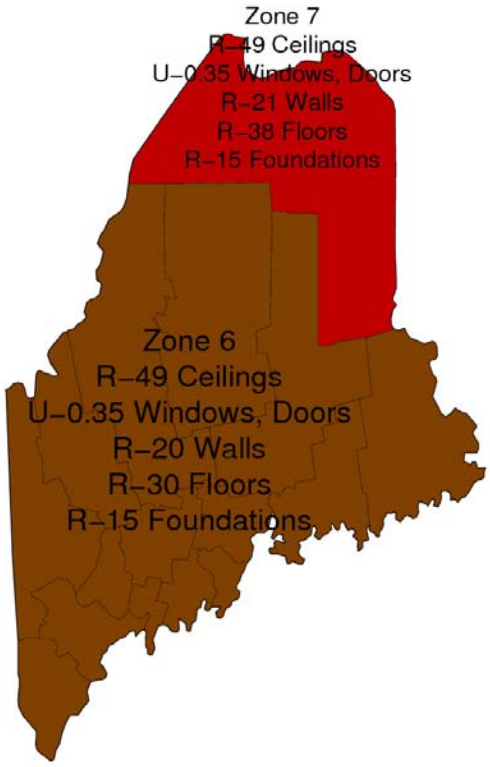
Summary

Maine has not had a mandatory statewide code in the past but has adopted the 2009 International Energy Conservation Code (IECC) with the code becoming effective in 2010 to 2012.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 4 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 6 and 7.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.40 in Zones 6 and 7. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Maine Code and the 2009 IECC

The Maine Uniform Building and Energy Code sets the 2009 versions of the IECC and IRC as the mandatory building code standards for residential energy efficiency in the future. This statute provides express limitations on municipal home rule authority. Beginning July 1, 2010, the Maine Uniform Building and Energy Code must be enforced in municipalities that have more than 2,000 residents and that have adopted any building code by August 1, 2008. Beginning July 1, 2012, the Maine Uniform Building and Energy Code must be enforced in municipalities that have more than 2,000 residents and that have not adopted any building code by August 1, 2008. Communities smaller than 2,000 residents are exempted from adopting the 2009 IECC.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Maryland

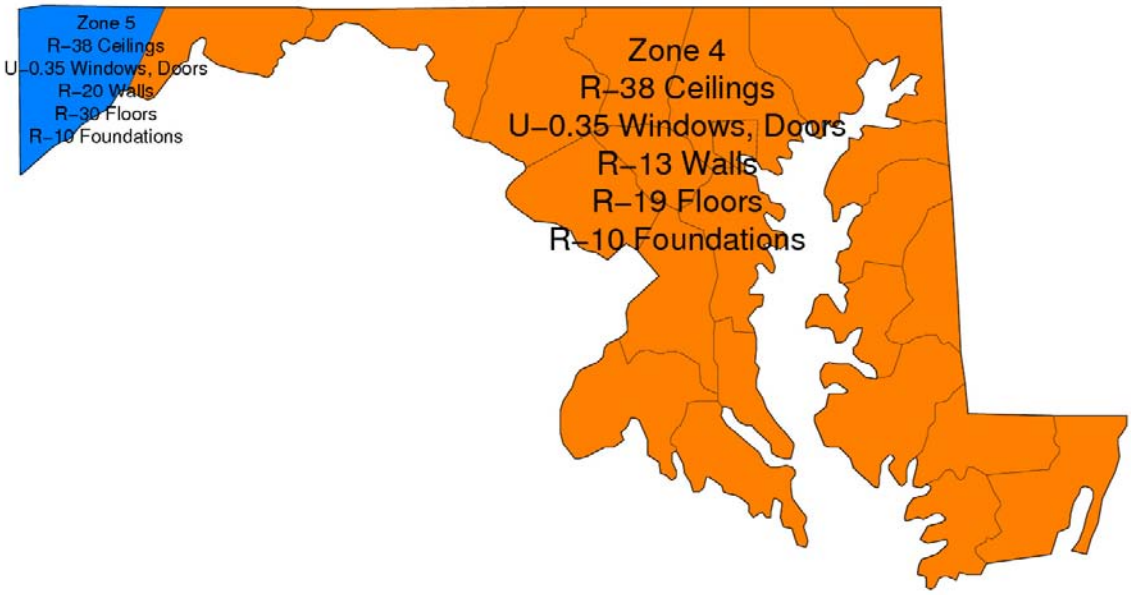
Summary

Maryland has adopted the 2009 International Energy Conservation Code (IECC). The code becomes effective October 1, 2009.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.

- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Massachusetts

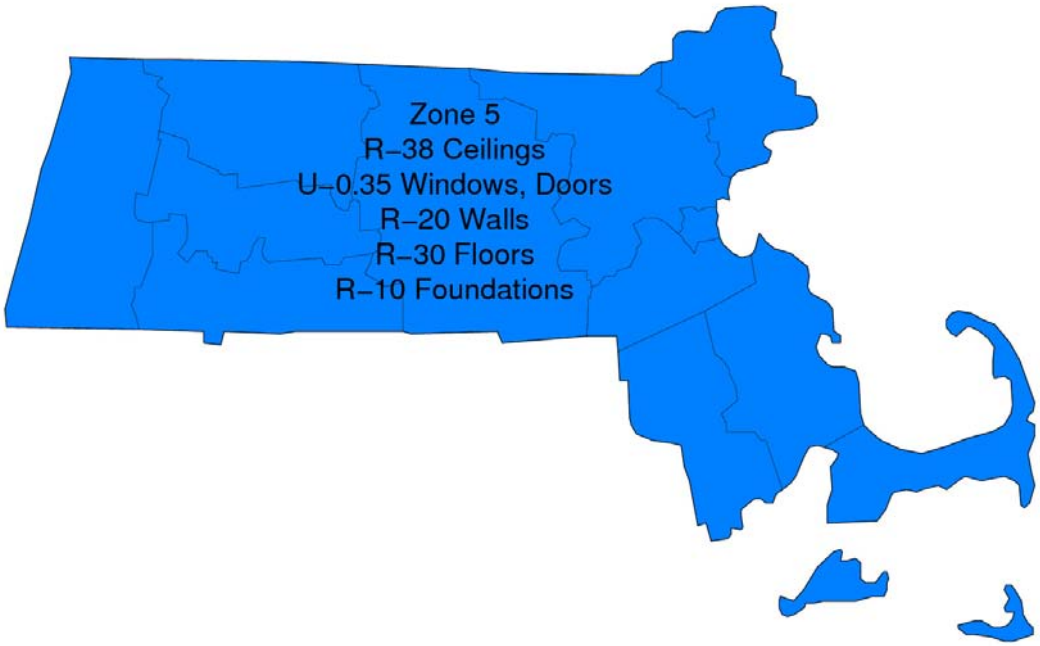
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC with the 2007 Supplement. A limited analysis of these changes resulted in estimated savings of $171 to $230 a year for an average new house at recent fuel prices. Massachusetts is expected to adopt the 2009 IECC in the future as required by the Green communities Act.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Massachusetts Code and the 2009 IECC

Massachusetts has adopted the 2006 IECC with the 2007 Supplement. Massachusetts also allows a HERS score of 100 or lower as a method of compliance. The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have changed in the 2009 IECC. These are highlighted in Table 29.

Table 29. Comparison of Envelope Requirements

Components	Climate Zone 5A	
	2006 IECC	2009 IECC
Ceiling	38	38
Skylight U-factor	.60	.60
Fenestration U-factor	.35	.35
Fenestration SHGC	NR	NR
Wood Frame Wall	**19**	**20**
Mass Wall	**13/19**	**13/17**
Floor	30	30
Basement Wall	10/13	10/13
Slab	10, 2ft	10, 2ft
Crawl Space	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements.

EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 30 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 30. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Boston (CZ 5A)	1350	126	1207	113	230	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Michigan

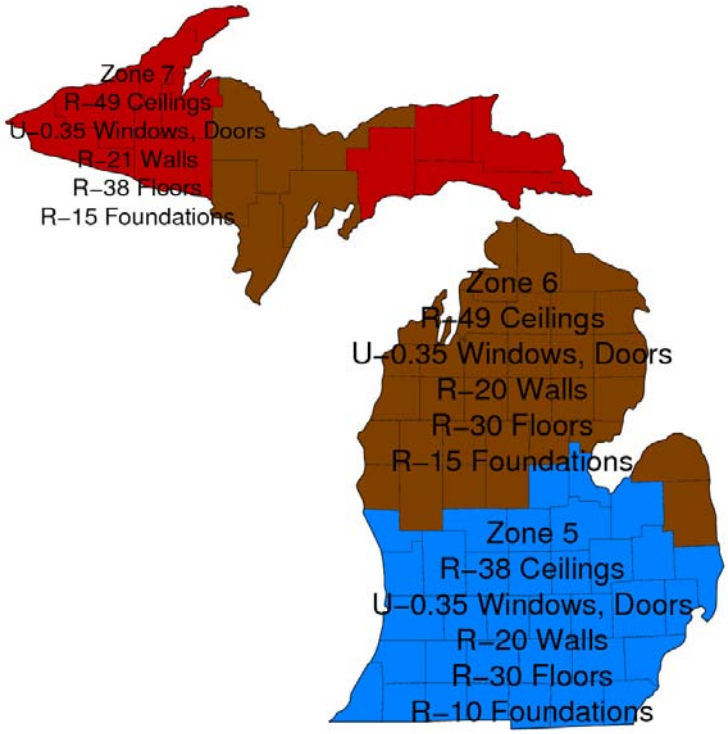
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2003 IRC with considerable amendments. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $256 to $292 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 5 and 4 feet in Zones 6 and 7.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5, 6, and 7.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5 and 0.40 in Zones 6 and 7. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Michigan Code and the 2009 IECC

The Michigan Uniform Energy Code is based on Chapter 11 of the 2003 IRC. Key differences from the 2003 IRC are summarized below.

The Michigan code has combined IRC climate zones into three zones splitting the state into thirds from south to north. The southern zone is the same as zones 13 and 14 from the 2003 IRC. The middle zone is the same as zone 15 from the 2003 IRC and the northern zone is zones 16 and 17 from the 2003 IRC.

The Michigan code has a table of prescriptive envelope requirements (Table 31 below) that has essentially identical requirements as the similar table in the 2003 IRC. For homes with higher glazing areas percentages, the IRC directs users to the 2003 IECC, which generally has more stringent requirements.

Table 31. Prescriptive Envelope Requirements in the Michigan Code

Exterior Enclosure		Zones 1	Zones 2	Zones 3
Walls		R-21	R-21	R-21
Fenestration		U-0.35 (or R-2.85)		
Roof/Ceilings		R-49	R-49	R-49
Floors		R-21	R-21	R-21
Slab-on Grade		R-11, 4 ft	R-13, 4 ft	R-18, 4 ft
Crawl Space Walls		R-20	R-20	R-20
Basement Walls	Continuous Insulation	R-10	R-10	R-15
	Cavity Insulation	R-11	R-11	R-11

The Michigan code incorporates a table of envelope requirements for additions of less than 500 ft^2 from the 2003 IECC. The Michigan code requires R-5 insulation for ducts in unconditioned spaces. This is identical to the 2003 IRC, but it is worth pointing out this is one of the few differences between the 2003 IRC and 2003 IECC. The 2003 IECC generally requires R-8 for supply ducts (ducts downstream from the furnace/air conditioners) but allows only R-4 or even R-2 in some instances for return ducts.

The Michigan code contains a "systems analysis" compliance method (Section N1105) that is not available in the 2003 IRC. Chapter 4 of the 2003 IECC contains a compliance approach that is conceptually identical, but the Michigan code method is considerably more concise. This method requires the proposed building design to have lower heating energy consumption than a "standard" design that has exactly the code requirements. This approach normally will involve the use of software and allows unlimited flexibility in building design as long as the total estimated energy use meets the criterion.

Major improvements in the 2009 IECC compared to the Michigan code are listed below:

- The current state code 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 2003 IRC 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved or decreased in the 2009 IECC. These are highlighted in Table 32. The values shown for the Michigan code are for houses with 15% window area or less.
- The format of the 2003 IRC/IECC and 2009 IECC are substantially different. The 2009 IECC has new climate zones that are similar to the three zones in the Michigan code but cover larger geographic regions than the zones in the 2003 IECC/IRC. The envelope insulation and window requirements in the Michigan code and the 2003 codes vary by window-to-wall area percentage, but not in the 2009 IECC. This change in format makes a simple comparison of the envelope requirements in the two codes impossible.

Table 32. Comparison of Envelope Requirements

Components	Climate Zone 5A		Climate Zone 6A		Climate Zone 7A	
	MI Code	2009 IECC	MI Code	2009 IECC	MI Code	2009 IECC
Ceiling	**49**	**38**	49	49	49	49
Fenestration U-factor	.35	.35	.35	.35	.35	.35
Fenestration SHGC	NR	NR	NR	NR	NR	NR
Wood Frame Wall	**21**	**20**	**21**	**20**	21	21
Floor	**21**	**30**	**21**	**30**	**21**	**38**
Basement Wall	10	10/13	**10**	**15/19**	**15**	**15/19**
Slab	**11, 4ft**	**10, 2ft**	**13, 4ft**	**10, 4ft**	**18, 4ft**	**10, 4ft**
Crawl Space	**20**	**10/13**	**20**	**10/13**	**20**	**10/13**

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north,

south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 33 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 33. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. MI Code*	
	MI Code		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Lansing (CZ 5A)	1590	135	1422	121	256	13
Alpena (CZ 6A)	1784	76	1597	68	269	12
Sault Ste. Marie (CZ 7A)	1906	56	1692	52	292	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Minnesota

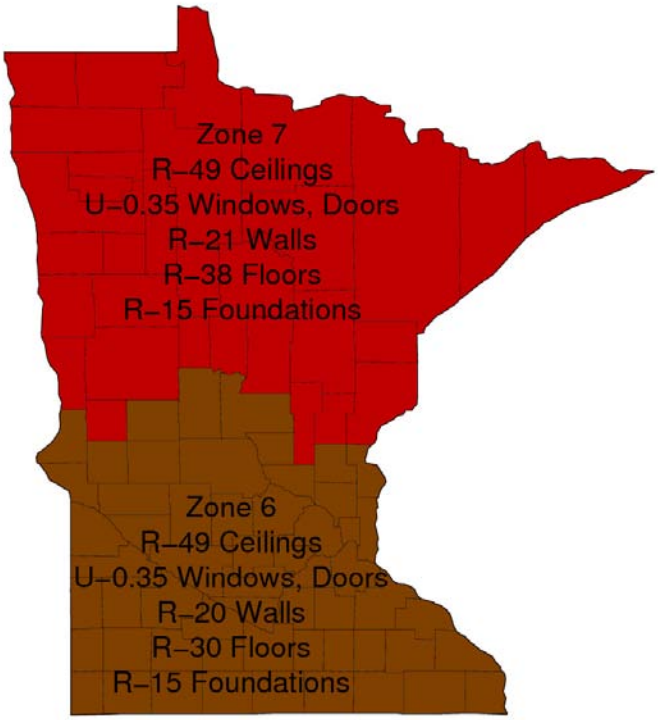
Summary

The energy efficiency requirements in the Minnesota building code are based on the 2006 International Residential Code (IRC) with relatively extensive modifications. The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the 2006 IRC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $284 to $346 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 4 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 7.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.40 in Zones 6 and 7. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Minnesota Code and the 2009 IECC

The Minnesota code is based on the 2006 IRC but has extensive modifications. For example, the Minnesota code allows a reduction to R-5 exterior foundation insulation if attic insulation and heating equipment efficiency are improved. The code specifies additional details for foundation wall insulation not in the IECC, including waterproofing measures. The Minnesota code requires a continuous ventilation system and a passive radon control system. The Minnesota code adds a requirement for wind wash barrier to limit air flow into attics and other spaces.

A number of thermal envelope requirements are higher in the 2009 IECC than in the Minnesota code. These are highlighted in Table 34.

Table 34. Comparison of Envelope Requirements

Components	Climate Zone 6A		Climate Zone 7A	
	MN Code	2009 IECC	MN Code	2009 IECC
Ceiling	**38**	**49**	**44**	**49**
Skylight U-factor	.60	.60	.60	.60
Fenestration U-factor	.35	.35	.35	.35
Fenestration SHGC	NR	NR	NR	NR
Wood Frame Wall	**19**	**20**	**19**	**21**
Mass Wall	**15**	**15/19**	**15**	**19/21**
Floor	30	30	**30**	**38**
Basement Wall	**10**	**15/19**	**10**	**15/19**
Slab	**10, 3.5ft**	**10, 4ft**	**10, 5ft**	**10, 4ft**
Crawl Space	10	10/13	10	10/13

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

- Stricter area limits on door exemptions
- Snow melt controls
- Pool covers are required for heated pools

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 35 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 35. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. MN Code*	
	MN Code		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
St. Paul (CZ 6A)	1729	149	1537	131	284	13
Duluth (CZ 7A)	2148	64	1882	58	346	14

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Mississippi

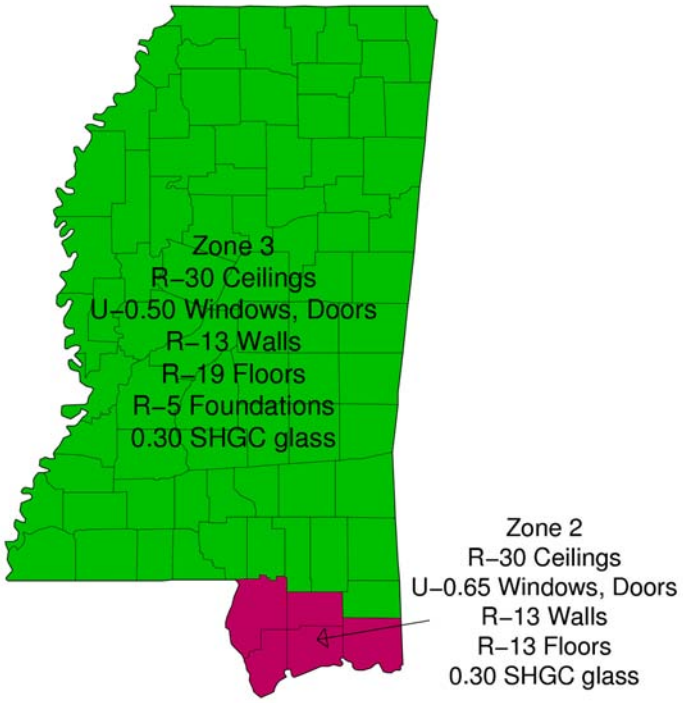
Summary

Mississippi currently does not have a mandatory energy efficiency code. The 2009 International Energy Conservation Code (IECC) would substantially improve energy efficiency in Mississippi homes. A limited analysis of the impact of the 2009 IECC resulted in estimated savings of $173 to $250 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Mississippi.
- Less insulation is allowed for mass walls and more insulation 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.
- Insulation is not required for slab-on-grade foundations in Zones 2 and 3.
- 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-0.75 in Zone 2 and U-0.65 in Zone 3
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted SHGC of 0.50. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Mississippi Construction Practice and the 2009 IECC

The state of Mississippi has no mandatory energy efficiency code. We do not have detailed data on current construction techniques related to energy efficiency in Mississippi. Some energy efficient housing may be built to levels at or close to the IECC, others may fall well short of the IECC. Compliance with the 2009 IECC is expected to often result in increased insulation levels, better windows, better insulated and less leaky ducts, and better lighting.

Adoption of the 2009 IECC would likely improve a number of thermal envelope measures in many new houses and other residential construction. These estimated typical improvements are shown in bold in Table 36.

Table 36. Comparison of Envelope Requirements

Components	Climate Zone 2		Climate Zone 3	
	Current Practice	2009 IECC	Current Practice	2009 IECC
Ceiling	30	30	30	30
Fenestration U-factor	**.75**	**.65**	**.75**	**.50**
Fenestration SHGC	**.50**	**.30**	**.50**	**.30**
Wood Frame Wall	13	13	13	13

Energy Analysis

A brief energy analysis was conducted comparing the assumed current practice to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to current practice, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 37 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 37. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. Current Practice*	
	Current Practice		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Mobile (CZ 2A)	494	327	454	268	173	15
Jackson (CZ 3A)	751	305	631	249	250	18

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Missouri

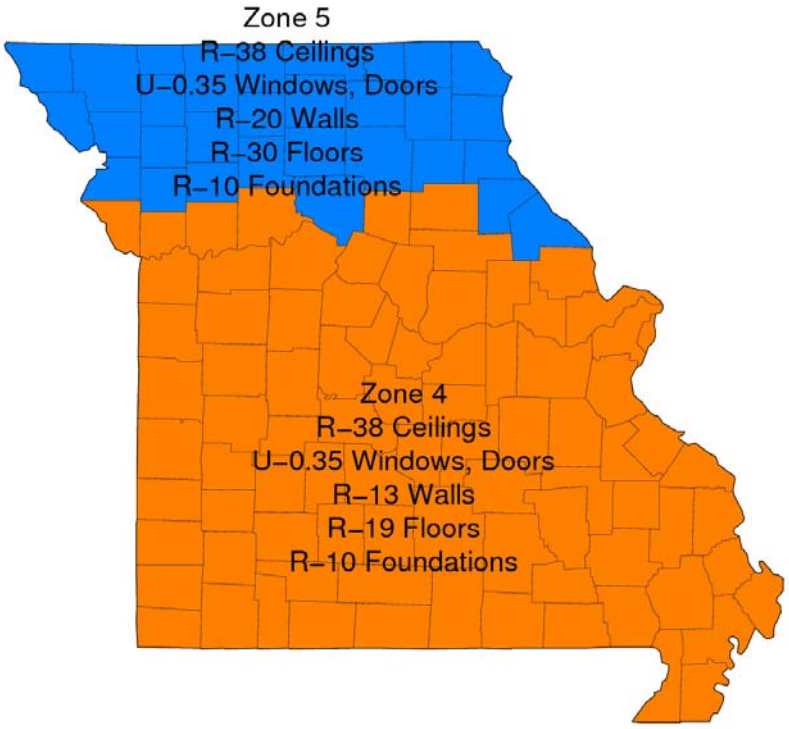
Summary

Missouri currently does not have a mandatory energy efficiency code. The 2009 International Energy Conservation Code (IECC) would substantially improve energy efficiency in Missouri homes. A limited analysis of the impact of the 2009 IECC resulted in estimated savings of $353 to $565 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- Less insulation is allowed for mass walls and more insulation 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Missouri Construction Practice and the 2009 IECC

The state of Missouri has no mandatory energy efficiency code. We do not have detailed data on current construction techniques related to energy efficiency in Missouri. Some energy efficient housing may be built to levels at or close to the IECC, others may fall well short of the IECC. Compliance with the 2009 IECC is expected to often result in increased insulation levels, better windows, better insulated and less leaky ducts, and better lighting.

Adoption of the 2009 IECC would likely improve a number of thermal envelope measures in many new houses and other residential construction. Table 38 compares the 2009 to measures that may often be occurring in new Missouri housing.

Table 38. Comparison of Envelope Requirements

Components	Climate Zone 4		Climate Zone 5	
	Current Practice	2009 IECC	Current Practice	2009 IECC
Ceiling	30	38	30	38
Fenestration U-factor	.50	.35	.50	.35
Wood Frame Wall	13	13	13	19
Floor	19	19	19	30

Energy Analysis

A brief energy analysis was conducted comparing the assumed current practice to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to current practice, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 39 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 39. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. Current Practice*	
	Current Practice		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Saint Louis (CZ 4A)	1386	270	1134	243	353	18
Peoria IL (CZ 5A)	1713	190	1251	161	565	26

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Montana

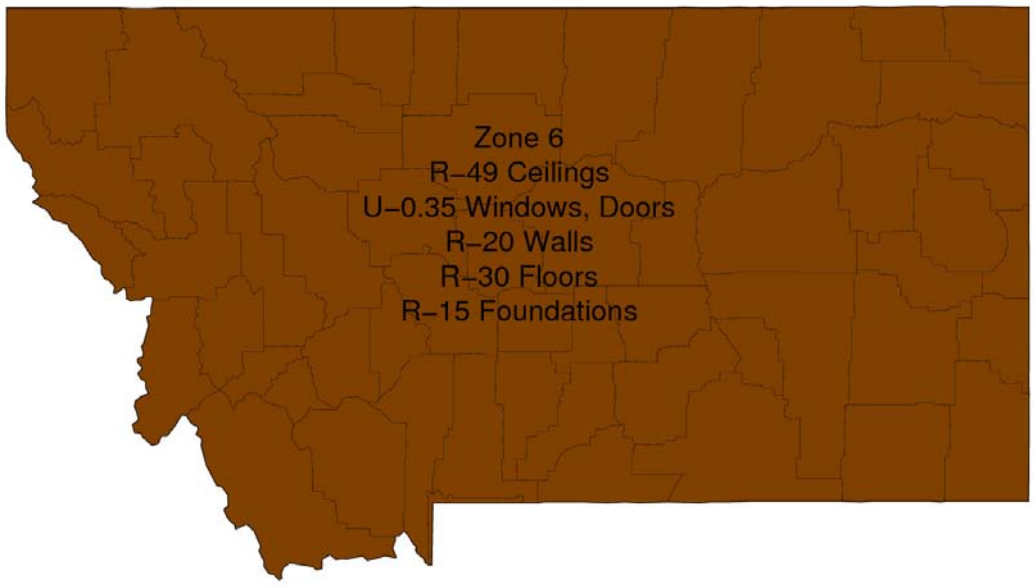
Summary

Montana recently adopted the 2009 International Energy Conservation Code (IECC).

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 4 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 6.

- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.40 in Zone 6. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Nebraska

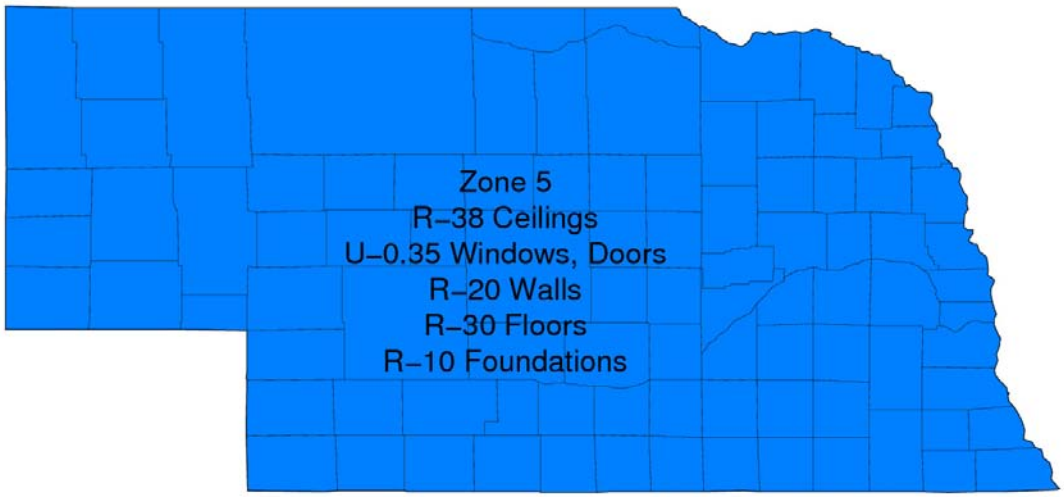
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2003 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $236 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.

- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Nebraska Code and the 2009 IECC

Nebraska has adopted the 2003 IECC. The major differences are listed below:

- The current state code 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 2003 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*™ software and other energy performance analysis tools.)
- The format of the 2003 IECC and 2009 IECC are substantially different. The 2009 IECC has new climate zones that cover larger geographic regions than the zones in the 2003 IECC. The envelope insulation and window requirements in the 2003 IECC vary by window-to-wall area percentage, but not in the 2009 IECC. This change in format makes a simple comparison of the envelope requirements in the two codes impossible.

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 40 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 40. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2003 IECC*	
	2003 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Omaha (CZ 5A)	1333	206	1192	185	236	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Nevada

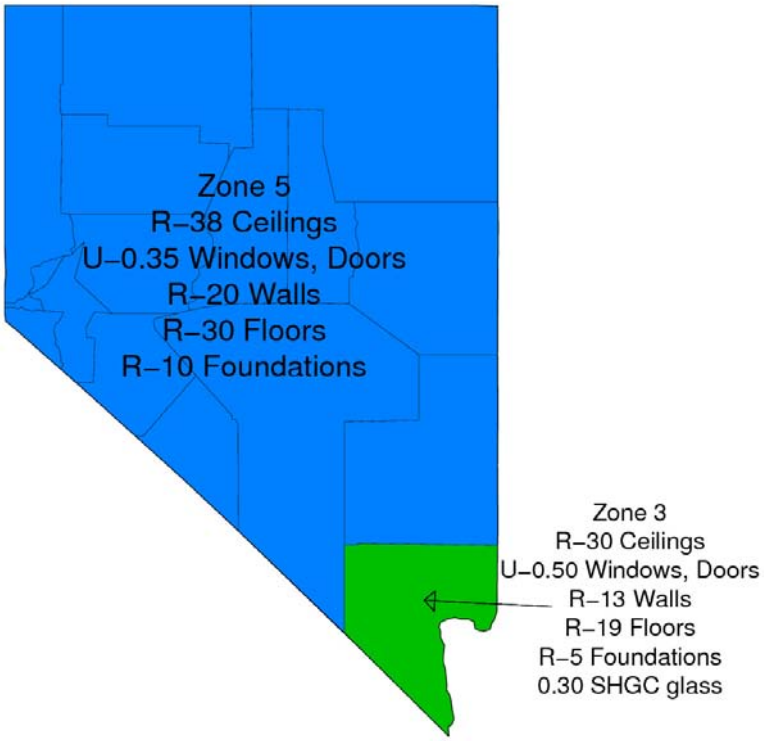
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $205 to $252 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 5. Slab insulation is not required in Zone 3.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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-0.65 in Zone 3 and U-0.60 in Zone 5
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5 and an area-weighted SHGC of 0.50 in Zone 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Nevada Code and the 2009 IECC

Nevada adopted the 2006 IECC with minor amendments. The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 41.

Table 41. Comparison of Envelope Requirements

Components	Climate Zone 3B		Climate Zone 5B	
	2006 IECC	2009 IECC	2006 IECC	2009 IECC
Ceiling	30	30	38	38
Skylight U-factor	.65	.65	.60	.60
Fenestration U-factor	**.65**	**.50**	.35	.35
Fenestration SHGC	**.40**	**.30**	NR	NR
Wood Frame Wall	13	13	**19**	**20**
Mass Wall	5/8	5/8	**13/19**	**13/17**
Floor	19	19	30	30
Basement Wall	**0**	**5/13**	10/13	10/13
Slab	0	0	10, 2ft	10, 2ft
Crawl Space	5/13	5/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 42 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 42 Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Las Vegas (CZ 3B)	606	573	528	473	252	17
Reno (CZ 5B)	1054	168	941	150	205	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in New Hampshire

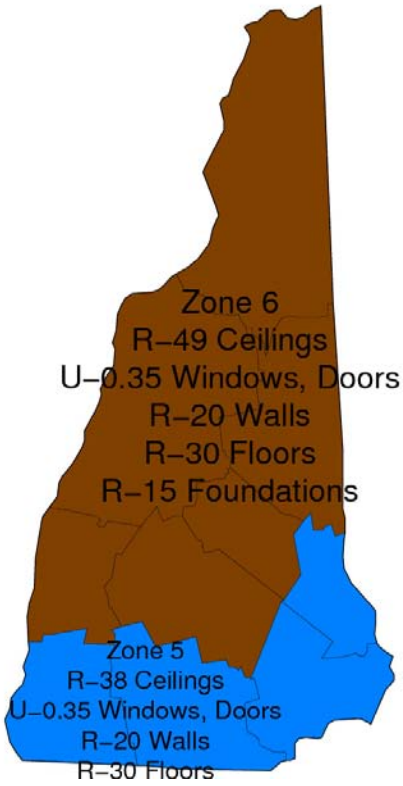
Summary

New Hampshire has adopted the 2009 International Energy Conservation Code (IECC). The code becomes effective October 1, 2009.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 5 and 4 feet in Zone 6.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5 and 6.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5 and 0.40 in Zone 6. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in New Jersey

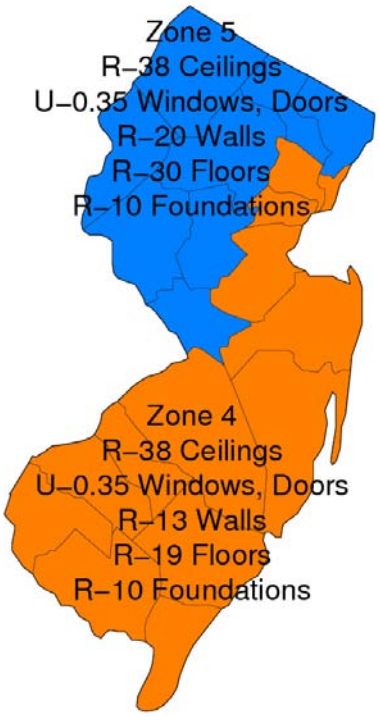
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC with extensive amendments. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $228 to $263 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current New Jersey Code and the 2009 IECC

The text of the New Jersey code is almost entirely from the 2006 IECC. However, there have been substantial modifications to the thermal envelope insulation and window requirements. These requirements are based on the 2003 IECC using county-based climate zones with three major modifications.

First, basements are allowed to be completely uninsulated if there is high efficiency heating equipment installed. This trade-off has the potential to reduce energy efficiency, primarily when the basement is heated. In a worst case scenario, the basement could be 50% of the building living space floor area (i.e., the house only has one-story above grade) and the basement could be up to 4 ft. above grade with nothing but highly conductive concrete between the conditioned space and the outside. To compensate for the lack of basement insulation, the required heating equipment efficiency improvement over minimum Federal standards is only 4% for heat pumps, only 6% for boilers, and 15% for furnaces.

Another modification is an increase in stringency of all envelope "Uo" requirements by 2% beyond the 2003 IECC requirements to improve the code stringency.

A third modification was that two counties were moved into different climate zones from those in the 2003 IECC. Burlington County was moved from zone 11 to zone 10 (a decrease in stringency) and Warren County was moved from zone 12 to zone 13 (an increase in stringency).

The New Jersey code deletes a few other requirements from the 2006 IECC, including the requirement for a certificate listing energy efficiency measures and the "hard limits" on maximum glazing U-factors.

Other major differences between the state code and the 2009 IECC are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 43 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating). Energy use under the New Jersey code may be different if the option allowing an uninsulated basement is used.

Table 43. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. New Jersey Code*	
	New Jersey Code		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Newark (CZ 4A)	1361	185	1189	168	263	14
Allentown (CZ 5A)	1315	145	1176	130	228	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in New Mexico

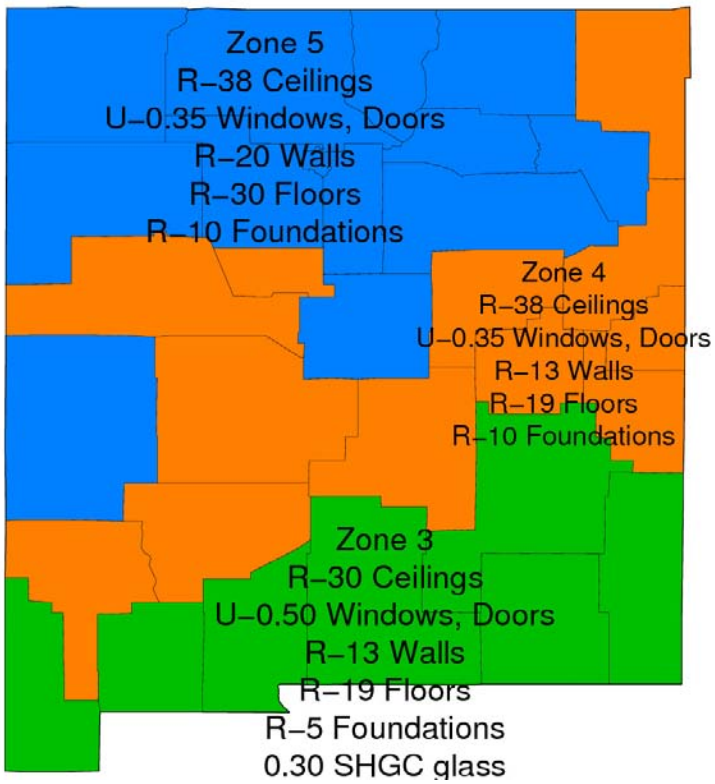
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $216 to $251 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zones 4 and 5. Insulation is not required for slab-on-grade foundations in Zone 3.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- Less insulation is allowed for mass walls and more insulation 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-0.65 in Zone 3 and U-0.60 in Zones 4 and 5
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zones 4 and 5 and cannot exceed an area-weighted SHGC of 0.50 in Zone 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current New Mexico Code and the 2009 IECC

New Mexico has adopted the 2006 IECC. The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 44.

Table 44. Comparison of Envelope Requirements

	Climate Zone 3B		Climate Zone 4B		Climate Zone 5B	
	2006 IECC	2009 IECC	2006 IECC	2009 IECC	2006 IECC	2009 IECC
Ceiling	30	30	38	38	38	38
Skylight U-factor	.65	.65	.60	.60	.60	.60
Fenestration U-factor	**.65**	**.50**	**.40**	**.35**	.35	.35
Fenestration SHGC	**.40**	**.30**	NR	NR	NR	NR
Wood Frame Wall	13	13	13	13	**19**	**20**
Mass Wall	5/8	5/8	**5/13**	**5/10**	**13/19**	**13/17**
Floor	19	19	19	19	30	30
Basement Wall	**0**	**5/13**	10/13	10/13	10/13	10/13
Slab	0	0	10, 2ft	10, 2ft	10, 2ft	10, 2ft
Crawl Space	5/13	5/13	10/13	10/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 45 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 45. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Lubbock TX (CZ 3B)	1002	272	875	222	251	16
Albuquerque (CZ 4B)	941	254	814	230	225	15
Flagstaff AZ (CZ 5B)	1250	74	1116	66	216	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in New York

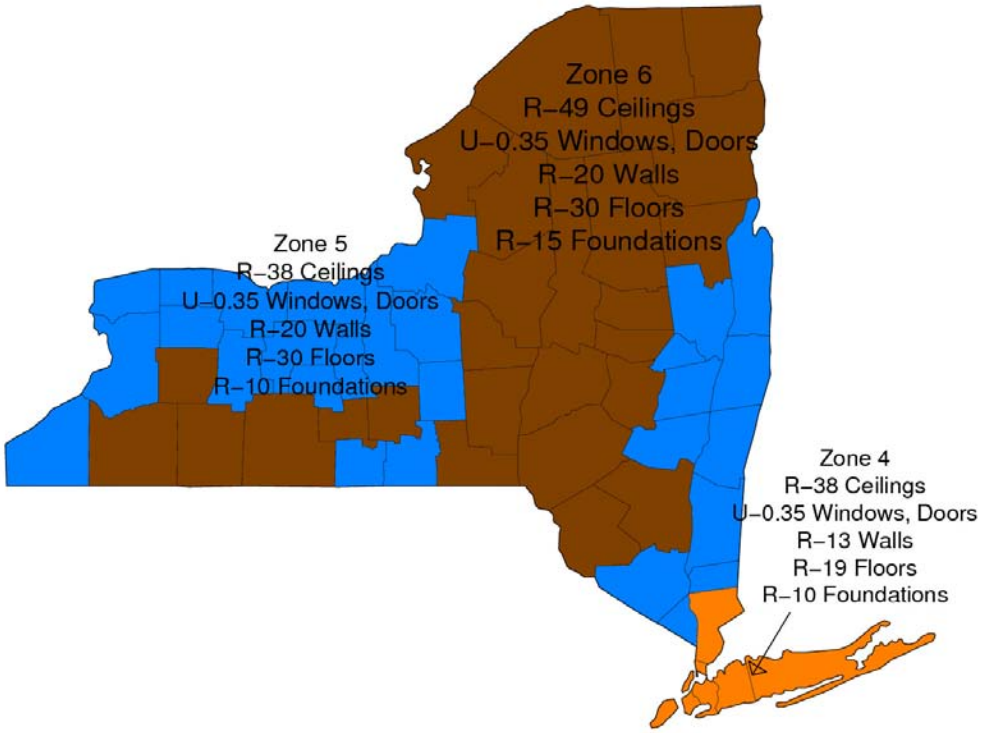
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2004 IECC Supplement with amendments. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $253 to $265 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zones 4 and 5 and 4 feet in Zone 6.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5, 6, and 7.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zones 4 and 5 and 0.40 in Zone 6. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the New York Code and the 2009 IECC

New York requires the 2004 IECC Supplement with amendments. The 2004 Supplement is similar to the 2006 IECC but has increased wall insulation and has two modifications to the performance path that can reduce stringency in certain cases. The New York code adds a prescriptive trade-off not in the IECC that allows reduced ceiling and wall insulation if one of three improvements are made: tested tight building envelope, tested tight ducts, or improved heating equipment efficiency. The New York code has extra stringent requirements for residences using electric resistance heating. The New York code allows an older version of RES*check*™ that utilizes envelope requirements from the 2000/2003 IECC.

The 2004 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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 2004/2006 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 46.

Table 46. Comparison of Envelope Requirements

Components	Climate Zone 4A		Climate Zone 5A		Climate Zone 6A	
	2004 IECC	2009 IECC	2004 IECC	2009 IECC	2004 IECC	2009 IECC
Ceiling	38	38	38	38	49	49
Skylight U-factor	.60	.60	.60	.60	.60	.60
Fenestration U-factor	**.40**	**.35**	.35	.35	.35	.35
Fenestration SHGC	NR	NR	NR	NR	NR	NR
Wood Frame Wall	13	13	**19**	**20**	**19**	**20**
Mass Wall	5/10	5/10	**13/19**	**13/17**	15/19	15/19
Floor	19	19	30	30	30	30
Basement Wall	10/13	10/13	10/13	10/13	**10/13**	**15/19**
Slab	10, 2ft	10, 2ft	10, 2ft	10, 2ft	10, 4ft	10, 4ft
Crawl Space	10/13	10/13	10/13	10/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 47 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 47. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2004 IECC*	
	2004 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
New York City (CZ 4A)	1361	181	1187	164	265	14
Albany (CZ 5A)	1566	135	1401	121	253	13
Binghamton (CZ 6A)	1632	80	1460	71	255	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in North Carolina

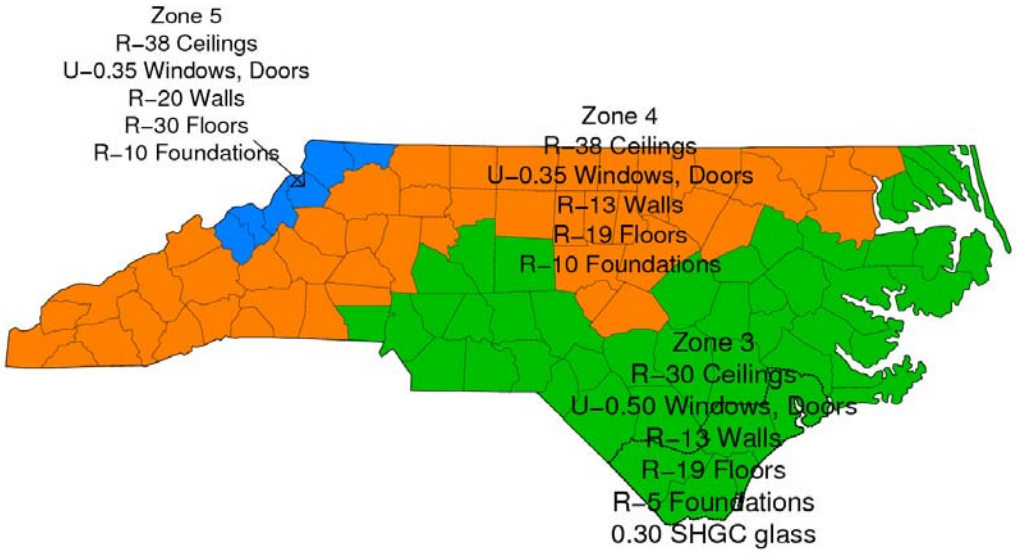
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC with amendments. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $209 to $234 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zones 4 and 5. Insulation is not required for slab-on-grade foundations in Zone 3.
- 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), though the ducts still have to be sealed.

- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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-0.65 in Zone 3 and U-0.60 in Zones 4 and 5
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zones 4 and 5 and cannot exceed an area-weighted SHGC of 0.50 in Zone 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current North Carolina Code and the 2009 IECC

North Carolina has adopted the 2006 IECC with amendments, including:

- An average SHGC of 0.40 or lower for windows and skylights is required for the entire state. The 2006 IECC only requires this in Zone 3, not Zones 4 and 5.
- Fenestration U-factor is allowed to be U-0.40 or lower in Zone 5. The 2006 IECC requires U-0.35.

- Slab-on-grade perimeter insulation is allowed to be R-5 in Zone 4. The 2006 IECC requires R-10.
- The North Carolina code contains some insulation exceptions for termite control in slab and crawl space walls that are not contained in the IECC.
- Unlike the IECC, ducts inside the conditioned space are not required to be sealed.

The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 48.

Table 48. Comparison of Envelope Requirements

	Climate Zone 3A		Climate Zone 4A		Climate Zone 5A	
	NC Code	2009 IECC	NC Code	2009 IECC	NC Code	2009 IECC
Ceiling	30	30	38	38	38	38
Skylight U-factor	.65	.65	.60	.60	.60	.60
Fenestration U-factor	**.65**	**.50**	**.40**	**.35**	**.40**	**.35**
Fenestration SHGC	**.40**	**.30**	**.40**	**NR**	**.40**	**NR**
Wood Frame Wall	13	13	13	13	**19**	**20**
Mass Wall	5/8	5/8	**5/13**	**5/10**	**13/19**	**13/17**
Floor	19	19	19	19	30	30
Basement Wall	**0**	**5/13**	10/13	10/13	10/13	10/13
Slab	0	0	**5, 2ft**	**10, 2ft**	10, 2ft	10, 2ft
Crawl Space	5/13	5/13	10/13	10/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 49 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 49. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost*				*Savings 2009 IECC vs. NC Code*	
	North Carolina Code		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings	Percent Savings
Charlotte (CZ 3A)	922	257	808	211	234	16
Raleigh (CZ 4A)	843	236	730	214	209	15
Elkins WV (CZ 5A)	1330	97	1190	87	224	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in North Dakota

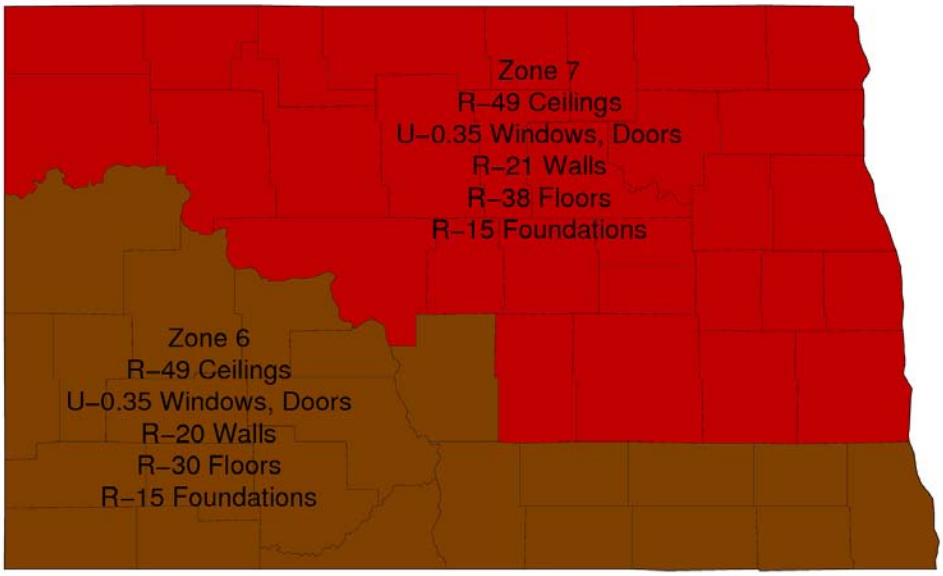
Summary

North Dakota currently does not have a mandatory energy efficiency code. The 2009 International Energy Conservation Code (IECC) would substantially improve energy efficiency in North Dakota homes. A limited analysis of the impact of the 2009 IECC resulted in estimated savings of $273 to $413 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 4 feet.
- 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), though the ducts still have to be sealed.

- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 6 and 7.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.40 in Zones 6 and 7. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between North Dakota Current Practice and the 2009 IECC

The state of North Dakota has no mandatory energy efficiency code. We do not have detailed data on current construction techniques related to energy efficiency in North Dakota. Some energy efficient housing may be built to levels at or close to the IECC, others may fall well short of the IECC. Compliance with the 2009 IECC is expected to often result in increased insulation levels, better windows, better insulated and less leaky ducts, and better lighting.

Adoption of the 2009 IECC would likely improve a number of thermal envelope measures in many new houses and other residential construction. These estimated typical improvements are shown Table 50.

Table 50. Comparison of Envelope Requirements

Components	Climate Zones 6 and 7	
	Current Practice	2009 IECC
Ceiling	38	49
Fenestration U-factor	.40	.35
Wood Frame Wall	19	20

Energy Analysis

A brief energy analysis was conducted comparing the assumed current practice to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to current practice, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 51 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 51. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. Current Practice*	
	Current Practice		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Bismarck (CZ 6B)	1980	125	1652	114	413	12
Minot (CZ 7B)	2100	99	1909	91	273	12

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Ohio

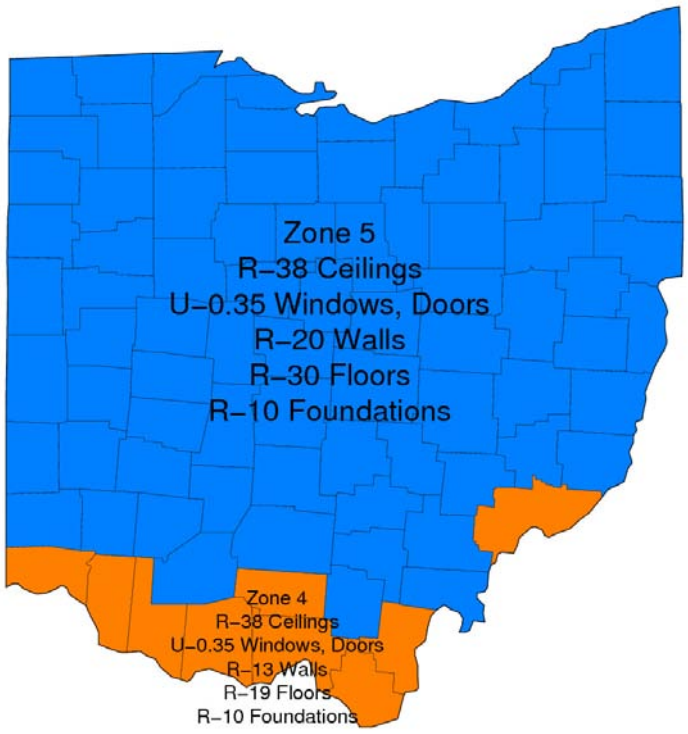
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC with amendments. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $222 to $236 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Ohio Code and the 2009 IECC

The Ohio code allows compliance with either the 2006 IECC or IRC. In addition, Ohio added a prescriptive alternative path allowing R-13 walls, R-19 floors, and R-6 ducts if a 90 AFUE furnace or a 7.7 HSPF heat pump is installed and the window-to-wall ratio (WWR) is no more than 21%.

Other major differences between the state code and the 2009 IECC are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 52.

Table 52. Comparison of Envelope Requirements

Components	Climate Zone 4A		Climate Zone 5A	
	IECC 2006	IECC 2009	IECC 2006	IECC 2009
Ceiling	38	38	38	38
Skylight U-factor	.60	.60	.60	.60
Fenestration U-factor	**.40**	**.35**	.35	.35
Fenestration SHGC	NR	NR	NR	NR
Wood Frame Wall	13	13	**19**	**20**
Mass Wall	5/10	5/10	**13/19**	**13/17**
Floor	19	19	30	30
Basement Wall	10/13	10/13	10/13	10/13
Slab	10, 2ft	10, 2ft	10, 2ft	10, 2ft
Crawl Space	10/13	10/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 53 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 53. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. Ohio Code*	
	Ohio Code		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Charleston WV (CZ 4A)	1148	177	1002	161	236	14
Columbus (CZ 5A)	1236	160	1105	143	222	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Oklahoma

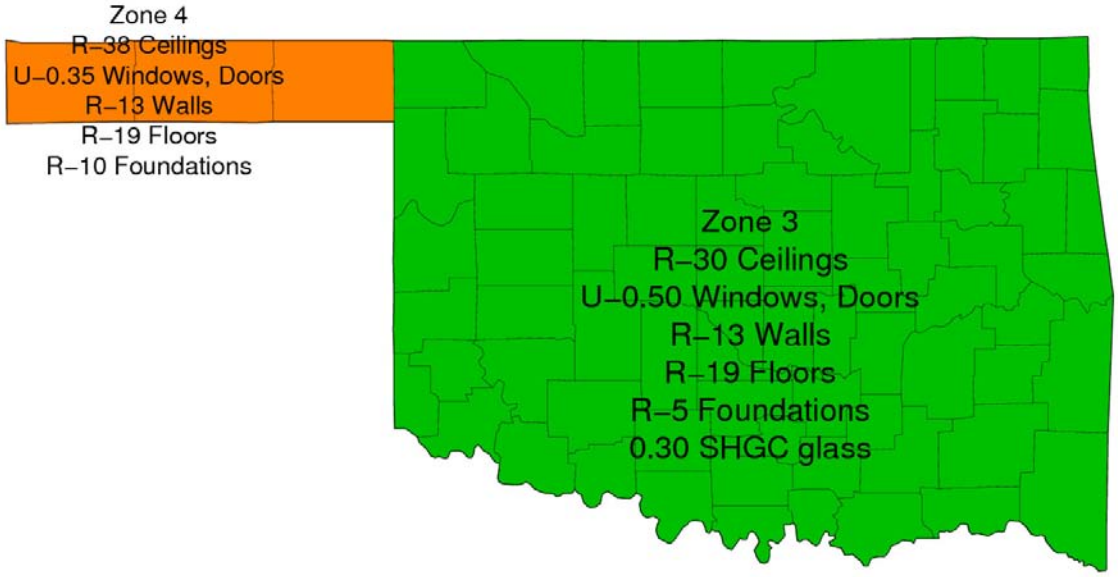
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2003 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $266 to $271 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 4.
- 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), though the ducts still have to be sealed.

- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Oklahoma.
- 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-0.65 in Zone 3 and U-0.60 in Zone 4
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows cannot exceed an area-weighted U-factor of 0.48 in Zone 4 and cannot exceed an area-weighted SHGC of 0.50 in Zone 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Oklahoma Code and the 2009 IECC

Oklahoma has adopted the 2003 IECC.

Major differences between the 2009 IECC and the Oklahoma code are listed below:

- The current state code 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 2003 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*™ software and other energy performance analysis tools.)
- The format of the 2003 IECC and 2009 IECC are substantially different. The 2009 IECC has new climate zones that cover larger geographic regions than the zones in the 2003 IECC. The envelope insulation and window requirements in the 2003 IECC vary by window-to-wall area percentage, but not in the 2009 IECC. This change in format makes a simple comparison of the envelope requirements in the two codes impossible.

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 54 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 54. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2003 IECC*	
	2003 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Oklahoma City (CZ 3A)	1125	326	985	269	271	15
Saint Louis MO (CZ 4A)	1300	269	1134	243	266	14

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Oregon

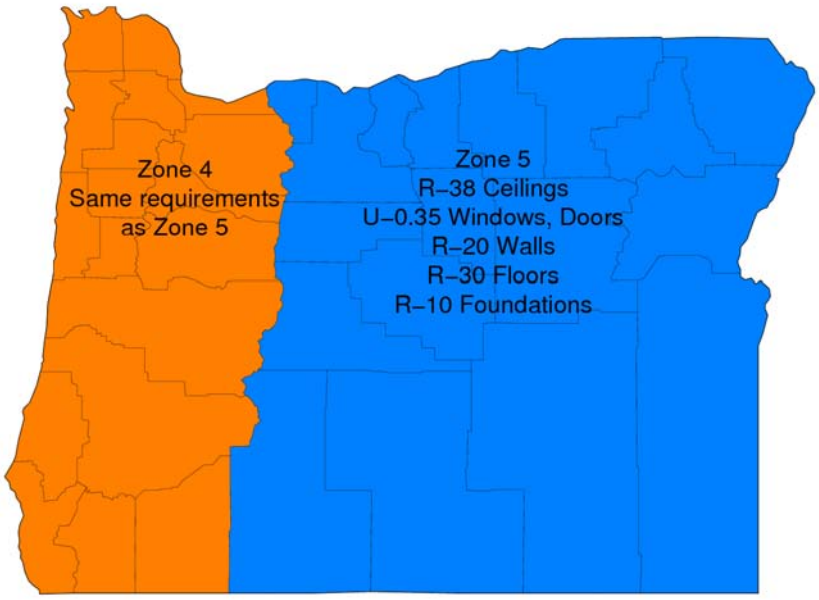
Summary

Oregon has a state-developed residential energy efficiency code that has many differences from the 2009 International Energy Conservation Code (IECC). A comparison of the overall impacts on energy use for these two codes is not attempted here. Requirements of the 2009 IECC are summarized below.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.

- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in all of Oregon.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Pennsylvania

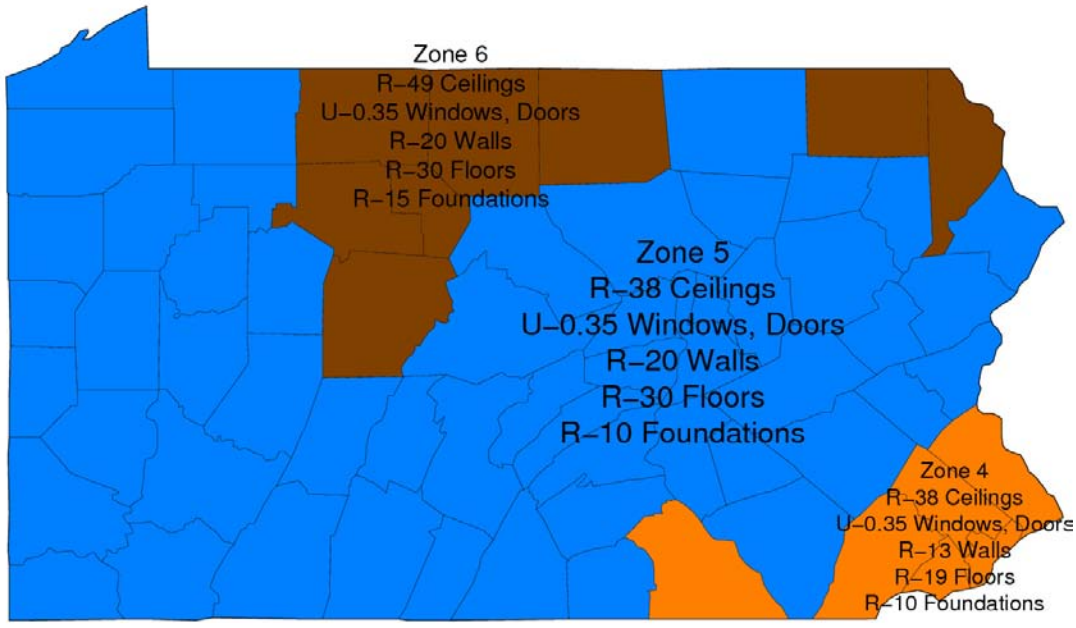
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IRC and IECC with amendments. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $218 to $263 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zones 4 and 5 and 4 feet in Zone 6.
- 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), though the ducts still have to be sealed.

- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5 and 6.
- Less insulation is allowed for mass walls and more insulation 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zones 4 and 5 and 0.40 in Zone 6. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Pennsylvania Code and the 2009 IECC

The Pennsylvania code, known as the Uniform Construction Code (UCC) uses the 2006 IRC and IECC with the addition of an alternative path to Chapter 11 of the 2006 IRC. The UCC regulations are located at:

http://www.dli.state.pa.us/landi/cwp/view.asp?a=310&q=211676

The prescriptive alternative path that Pennsylvania developed is intended to supplement the IRC and be consistent in format and scope. The alternative path defines the counties in the state into South, Central, and North Climate Zones, which are the same as the 2006 IECC/IRC for Climate Zones 4, 5, and 6.

The code requirements in the alternative are nearly all the same as the IRC. The following are the differences we have identified:

A. Ceilings without attic spaces: The Pennsylvania alternative path allows an unlimited area of R-30 insulation in designs of roof/ceiling assemblies where there is not sufficient space for the required higher R-value. The 2006 IECC and IRC limit this provision to 500 ft^2.
B. Fenestration: For Climate Zone 6, the 2006 IRC has a mandatory limit on area-weighted fenestration average U-factor of U-0.55 for windows and U-0.75 for skylights. These limits can never be exceeded regardless of how energy efficient the rest of the building is. In contrast, the Pennsylvania alternative has no such window or skylight U-factor limits.
C. Heating equipment efficiency trade-offs: The Pennsylvania alternative provides a predefined combination of increased minimum equipment efficiencies and reduced thermal envelope requirements as shown in Table PA502. The 2006 IRC and IECC have no such predefined trade-offs though similar trade-offs may be obtain via the performance path in the IECC.

The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences between these editions of the IECC are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 55.

Table 55. Comparison of Envelope Requirements

Components	Climate Zone 4A		Climate Zone 5A		Climate Zone 6A	
	2006 IECC	2009 IECC	2006 IECC	2009 IECC	2006 IECC	2009 IECC
Ceiling	38	38	38	38	49	49
Skylight U-factor	.60	.60	.60	.60	.60	.60
Fenestration U-factor	**.40**	**.35**	.35	.35	.35	.35
Fenestration SHGC	NR	NR	NR	NR	NR	NR
Wood Frame Wall	13	13	**19**	**20**	**19**	**20**
Mass Wall	5/10	5/10	**13/19**	**13/17**	15/19	15/19
Floor	19	19	30	30	30	30
Basement Wall	10/13	10/13	10/13	10/13	**10/13**	**15/19**
Slab	10, 2ft	10, 2ft	10, 2ft	10, 2ft	10, 4ft	10, 4ft
Crawl Space	10/13	10/13	10/13	10/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 56 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 56. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. PA Code*	
	PA Code		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Philadelphia (CZ 4B)	1348	192	1176	175	263	14
Harrisburg (CZ 5B)	1190	185	1065	166	218	13
Bradford (CZ 6B)	1699	63	1521	57	258	12

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Rhode Island

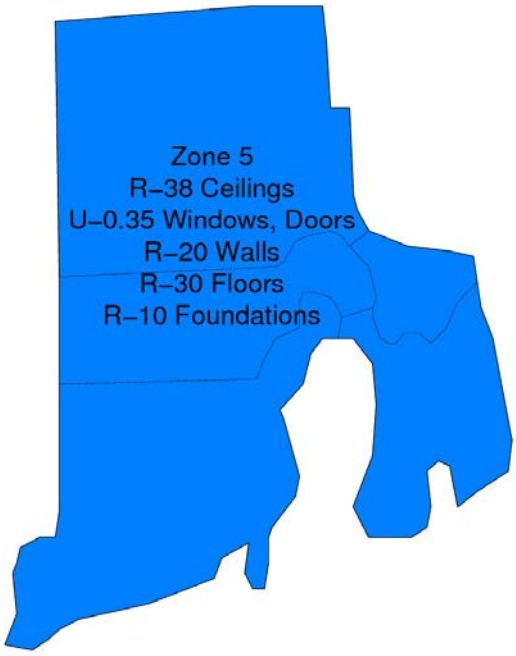
Summary

Rhode Island has adopted the 2009 International Energy Conservation Code (IECC).

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.

- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in South Carolina

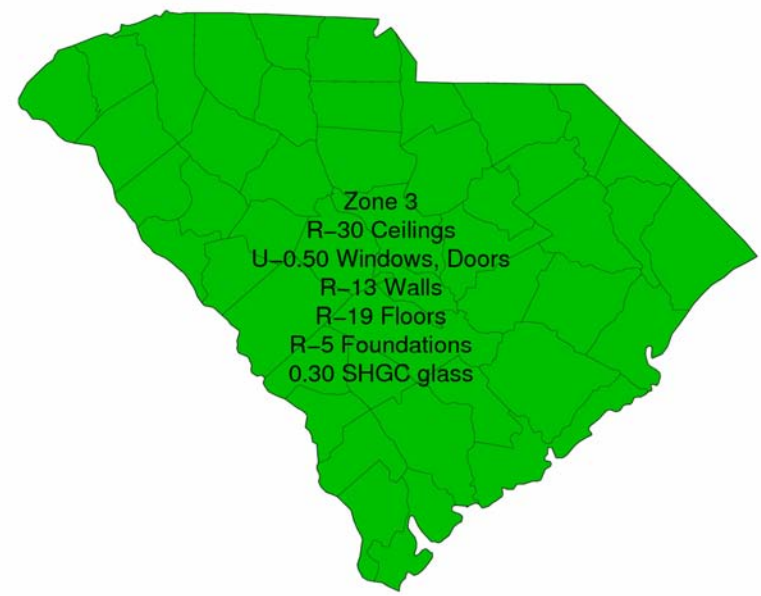
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $207 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.

- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are not required in South Carolina.
- 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.
- Insulation is not required for slab-on-grade foundations in Zone 3.
- 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-0.65 in Zone 3
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted SHGC of 0.50 in Zone 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current South Carolina Code and the 2009 IECC

South Carolina has adopted the 2006 IECC. The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 57.

Table 57. Comparison of Envelope Requirements

	Climate Zone 3A	
	2006 IECC	2009 IECC
Ceiling	30	30
Skylight U-factor	.65	.65
Fenestration U-factor	**.65**	**.50**
Fenestration SHGC	**.40**	**.30**
Wood Frame Wall	13	13
Mass Wall	5/8	5/8
Floor	19	19
Basement Wall	**0**	**5/13**
Slab	0	0
Crawl Space	5/13	5/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 58 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 58. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Columbia (CZ 3A)	678	305	601	249	207	16

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in South Dakota

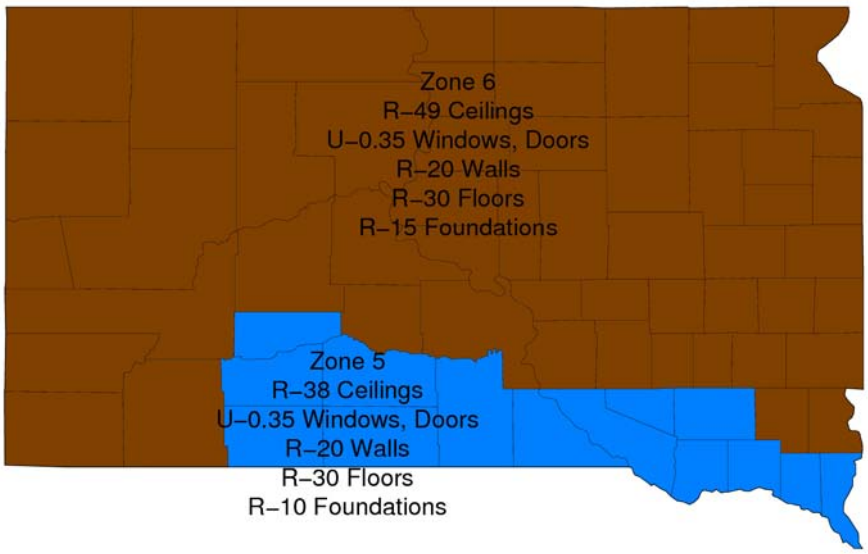
Summary

South Dakota currently does not have a mandatory energy efficiency code. The 2009 International Energy Conservation Code (IECC) would substantially improve energy efficiency in South Dakota homes. A limited analysis of the impact of the 2009 IECC resulted in estimated savings of $383 to $427 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 5 and 4 feet in Zone 6.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.

- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5 and 6.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5 and 0.40 in Zone 6. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between South Dakota Current Practice and the 2009 IECC

South Dakota has no mandatory energy efficiency code. We do not have detailed data on current construction techniques related to energy efficiency in South Dakota. Some energy efficient housing may be built to levels at or close to the IECC, others may fall well short of the IECC. Compliance with the 2009 IECC is expected to often result in increased insulation levels, better windows, better insulated and less leaky ducts, and better lighting.

Adoption of the 2009 IECC would likely improve a number of thermal envelope measures in many new houses and other residential construction. These estimated typical improvements are shown Table 59.

Table 59. Comparison of Envelope Requirements

Components	Climate Zone 5		Climate Zone 6	
	Current Practice	2009 IECC	Current Practice	2009 IECC
Ceiling	30	38	38	49
Fenestration U-factor	.50	.35	.40	.35
Wood Frame Wall	19	20	19	20

Energy Analysis

A brief energy analysis was conducted comparing the assumed current practice to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to current practice, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 60 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 60. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. Current Practice*	
	Current Practice		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Omaha NE (CZ 5A)	1526	204	1192	185	427	21
Pierre (CZ 6A)	1699	181	1408	163	383	18

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Tennessee

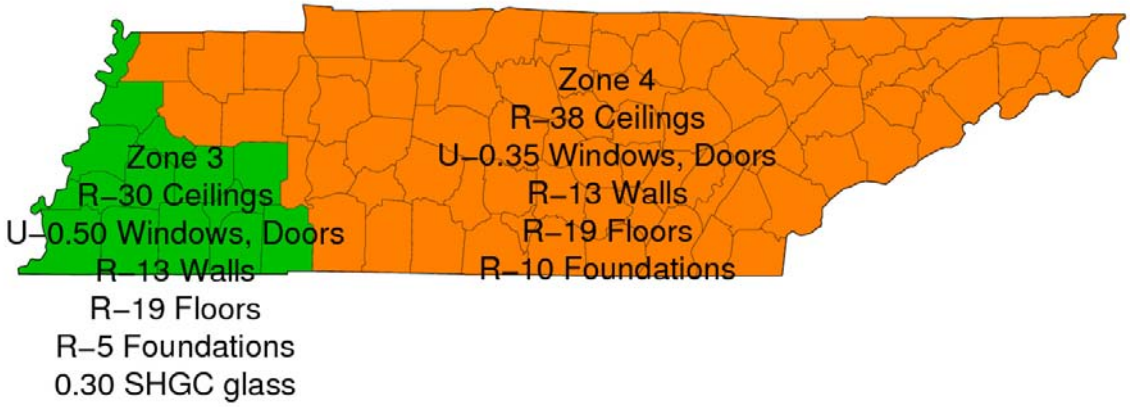
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2003 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $231 to $242 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 4.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor barriers are not required in Tennessee.

- 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.
- Insulation is not required for slab-on-grade foundations in Zone 3.
- 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-0.65 in Zone 3 and U-0.60 in Zone 4
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 4 and cannot exceed an area-weighted SHGC of 0.50 in Zone 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Tennessee Code and the 2009 IECC

Tennessee has adopted the 2003 IECC. Major differences between the 2009 IECC and the Tennessee code are listed below:

- The current state code 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 2003 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*™ software and other energy performance analysis tools.)
- The format of the 2003 IECC and 2009 IECC are substantially different. The 2009 IECC has new climate zones that cover larger geographic regions than the zones in the 2003 IECC. The envelope insulation and window requirements in the 2003 IECC vary by window-to-wall area percentage, but not in the 2009 IECC. This change in format makes a simple comparison of the envelope requirements in the two codes impossible.

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 61 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 61. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2003 IECC*	
	2003 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Memphis (CZ 3A)	884	357	777	296	242	16
Nashville (CZ 4A)	990	301	862	272	231	14

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Texas

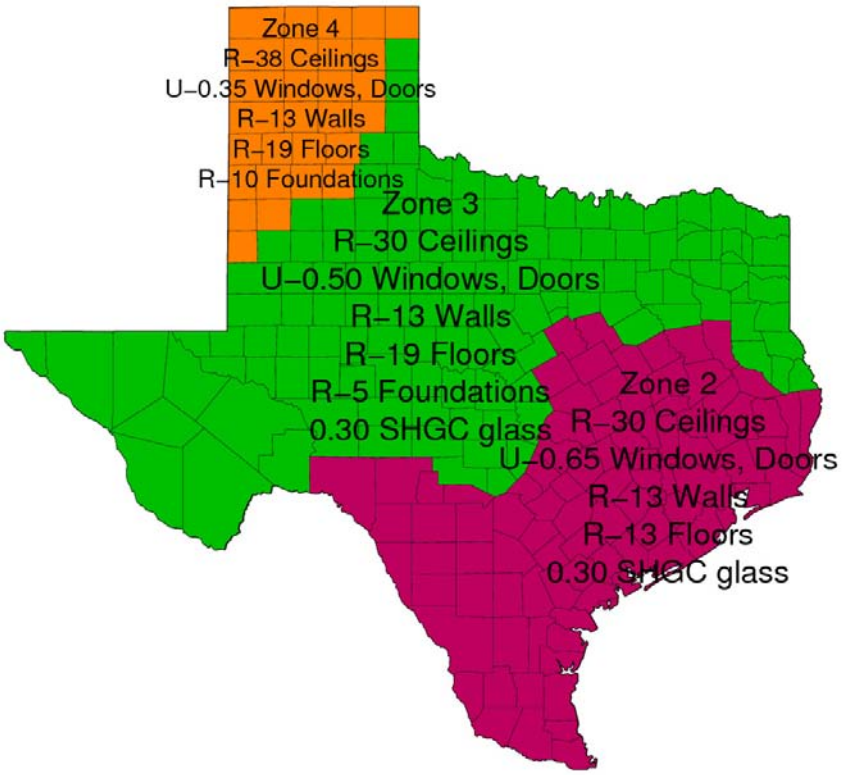
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2001 IECC Supplement. The most notable changes are improved duct sealing and efficient lighting requirements. An energy analysis comparing the 2009 IECC to the state code was not conducted because three major metropolitan areas (Austin, Dallas, and Houston) do not use the state code but rather have developed their own codes.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 4.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Texas.
- 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.
- Insulation is not required for slab-on-grade foundations in Zones 2 and 3.
- 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-0.75 in Zone 2, U-0.65 in Zone 3, and U-0.60 in Zone 4
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted SHGC of 0.50 in Zones 2 and 3. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

The Current Codes in Texas

Texas adopted the 2000 IECC with 2001 IECC Supplement as the statewide code in June 2001. The 2003 IECC was adopted for state-funded residential buildings in September 2005. A special prescriptive trade-off allowing R-6 duct insulation if an improved 14 SEER air conditioner is installed is allowed in most jurisdictions.

Several cities and jurisdictions have adopted a more recent version of the IECC, often with extensive amendments. A summary of the four largest metropolitan and construction areas and their adopted energy code is below.

City of Austin

Austin adopted the 2006 IECC with major amendments that generally improve energy efficiency. Key amendments include:

- Duct testing. Leakage of supply ducts and return plenum/ducts shall not exceed 10 percent of the total design airflow.
- Testing of the building thermal envelope for infiltration. Leakage cannot exceed 0.50 air changes per hour (ACH) as measured by the blower door test.
- "Cool roof" measures. This can be either a roofing material that reflects heat or a radiant barrier layer in the roof. Locating all duct work inside the conditioned space (not in a vented attic) is allowed as an alternative.
- Space heating. All residential buildings and mixed-use building with units in excess of 500 square feet cannot have electric resistance as the heat source.
- Efficient lighting requirements that are generally similar to the 2009 IECC.

Table 62 compares the envelope requirements of the Austin code to the 2009 IECC. The Austin code becomes more stringent as the window/wall area ratio of the building increases.

Table 62. Comparison of Envelope Requirements

Components	*Max. Window to Wall Area Ratio*	Climate Zone 2	
		Austin	2009 IECC
Ceiling	15	30	30
	20	**38**	**30**
	25	**38**	**30**
	30	**38**	**30**
Skylight U-factor	15	**.65**	**.75**
	20	**.55**	**.75**
	25	**.51**	**.75**
	30	**.46**	**.75**
Fenestration U-factor	15	.65	.65
	20	**.55**	**.65**
	25	**.51**	**.65**
	30	**.46**	**.65**
Fenestration SHGC	15	**.40**	**.30**
	20	**.40**	**.30**
	25	**.35**	**.30**
	30	**.35**	**.30**
Wood Frame Wall	15	13	13
	20	13	13
	25	13	13
	30	**16**	**13**
Floor	15	**11**	**13**
	20	**11**	**13**
	25	**19**	**13**
	30	**19**	**13**
Basement Wall	15	**5**	**0**
	20	**6**	**0**
	25	**8**	**0**
	30	**8**	**0**
Slab	--	0	0
Crawl Space	15	**6**	**0**
	20	**6**	**0**
	25	**10**	**0**
	30	**10**	**0**

City of Dallas

Dallas adopted the 2006 IECC with various generally minor amendments. Dallas does not allow RES*check* as a tool for showing code compliance.

Table 63 compares the envelope requirements of the Dallas code to the 2009 IECC. The Dallas code becomes more stringent as the window/wall area ratio of the building increases.

Table 63. Comparison of Envelope Requirements

Components	*Max. Window to Wall Area Ratio*	Climate Zone 3	
		Dallas	2009 IECC
Ceiling	15	30	30
	20	**38**	**30**
	25	**38**	**30**
	30	**38**	**30**
Skylight U-factor	15	.65	.65
	20	.65	.65
	25	.65	.65
	30	.65	.65
Fenestration U-factor	15	**.60**	**.50**
	20	**.54**	**.50**
	25	**.51**	**.50**
	30	**.46**	**.50**
Fenestration SHGC	15	**.40**	**.30**
	20	**.40**	**.30**
	25	**.40**	**.30**
	30	**.38**	**.30**
Wood Frame Wall	15	13	13
	20	13	13
	25	**16, 13 + 3.7 ci**	**13**
	30	**16, 13 + 3.7 ci**	**13**
Mass Wall	15	**6**	**5/8**
	20	**6**	**5/8**
	25	**7**	**5/8**
	30	**7**	**5/8**
Floor	15	19	19
	20	19	19
	25	19	19
	30	19	19
Basement Wall	15	**6**	**5/13**
	20	**6**	**5/13**
	25	**6**	**5/13**
	30	**6**	**5/13**
Slab	--	0	0
Crawl Space	15	**7**	**5/13**
	20	**7**	**5/13**
	25	**7**	**5/13**
	30	**7**	**5/13**

City of Houston

Adoption of the 2006 IECC was approved by the City Council on November 19, 2008. The Houston code has extensive amendments to the 2006 IECC, including the same envelope requirements as are in the Austin code (see Table 63 above). Most significantly, the Houston code requires an additional 15% energy savings beyond their minimum code starting on October 1, 2009. Meeting ENERGY STAR requirements for new homes is identified as complying with this requirement. The updated code provides 10 option packages that achieve this 15% savings. See: http://documents.publicworks.houstontx.gov/document-center/energy-code-related-material/amendments-to-the-2006-iecc/details.htm

City of San Antonio

San Antonio currently enforces the minimum code allowed by Texas, the 2001 IECC with local amendments. See http://www.sanantonio.gov/dsd/codes.asp

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Utah

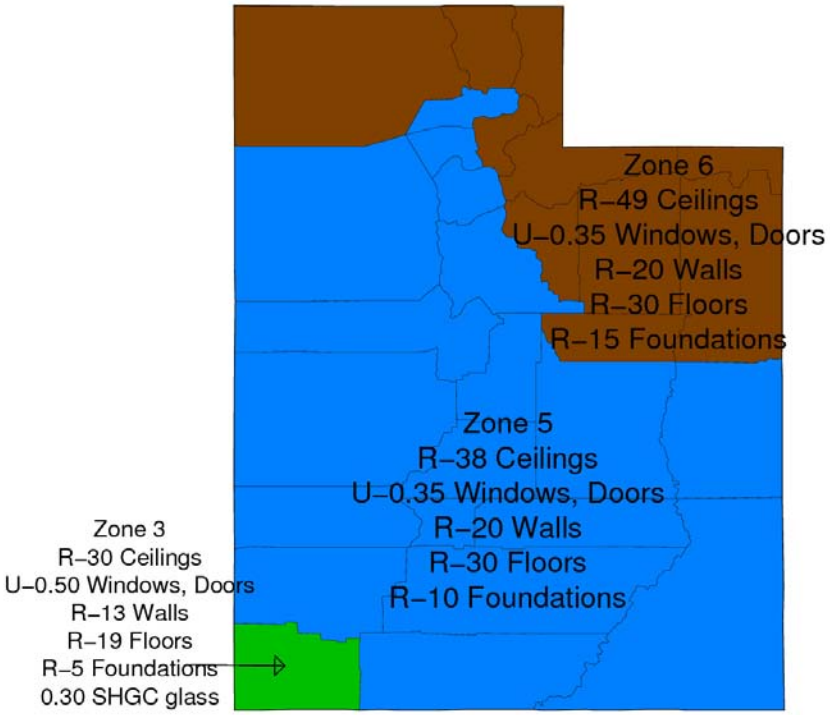
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $219 to $265 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 5 and 4 feet in Zone 6. Slab insulation is not required in Zone 3.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5 and 6.
- 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-0.65 in Zone 3 and U-0.60 in Zones 5 and 6
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5 and 0.40 in Zone 6. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Utah Code and the 2009 IECC

Utah adopted the 2006 IECC on January 1, 2007. The 2006 IECC has the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 64.

Table 64. Comparison of Envelope Requirements

Components	Climate Zone 3B		Climate Zone 5B		Climate Zone 6B	
	2006 IECC	2009 IECC	2006 IECC	2009 IECC	2006 IECC	2009 IECC
Ceiling	30	30	38	38	49	49
Skylight U-factor	.65	.65	.60	.60	.60	.60
Fenestration U-factor	**.65**	**.50**	.35	.35	.35	.35
Fenestration SHGC	**.40**	**.30**	NR	NR	NR	NR
Wood Frame Wall	13	13	**19**	**20**	**19**	**20**
Mass Wall	5/8	5/8	**13/19**	**13/17**	15/19	15/19
Floor	19	19	30	30	30	30
Basement Wall	**0**	**5/13**	10/13	10/13	**10/13**	**15/19**
Slab	0	0	10, 2ft	10, 2ft	10, 4ft	10, 4ft
Crawl Space	5/13	5/13	10/13	10/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 65 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 65. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IECC*	
	2006 IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Las Vegas (CZ 3B)	606	573	528	473	252	17
Salt Lake City (CZ 5B)	1150	217	1028	194	219	13
Kalispell (CZ 6B)	1723	82	1541	73	265	13

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Vermont

Summary

Vermont has adopted the 2009 International Energy Conservation Code (IECC). The code will become effective by January 1, 2011.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.

Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 4 feet.
- 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), though the ducts still have to be sealed.

- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 6.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.40 in Zone 6. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Vermont code and the 2009 IECC

Vermont has adopted the 2009 IECC but it may not be become effective until January 1, 2011. Vermont currently requires the 2000 IECC with extensive amendments. One important difference from the IECC is a whole-house mechanical ventilation system is required. The Vermont code has four basic methods of compliance:

1. A “fast track” compliance method allows the code user to select one of six packages of envelope requirements. There are special packages for log homes.
2. The “trade-off” method which allows different combinations of heating equipment efficiency and window area and U-factors.
3. The VT*check* software program that is a custom version of the RES*check*™ software developed by the U.S. Department of Energy.
4. Home Energy Ratings.

Because of the unique nature of the current Vermont code and because Vermont is moving to the 2009 IECC, no attempt at comparing the energy efficiency of the current Vermont code to the 2009 IECC is made here.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Virginia

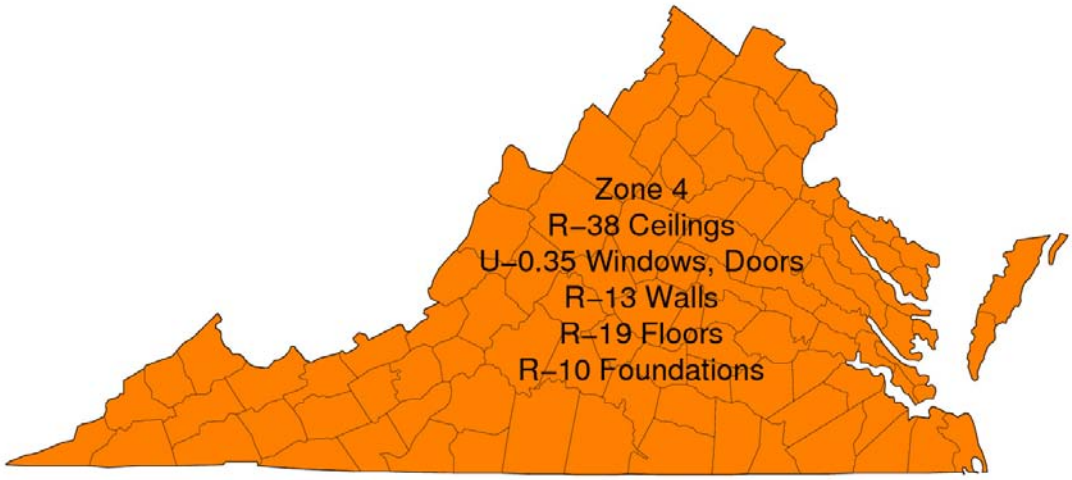
Summary

The 2009 International Energy Conservation Code (IECC) contains several major improvements in energy efficiency over the current state code, the 2006 IRC and IECC. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $225 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC. However, vapor retarders are not required in Virginia.

- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Difference between the Current Virginia Code and the 2009 IECC

Virginia's Uniform Statewide Building Code is the 2006 IRC (for one-and two-family dwellings and townhouses) and the IECC (for other residential).

The 2006 IRC and IECC have the same format (including the same climate zones) and many of the same requirements as the 2009 IECC. The major differences are listed below:

- The current state code 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*™ software and other energy performance analysis tools.)
- A number of thermal envelope requirements have improved in the 2009 IECC. These are highlighted in Table 66.

Table 66. Comparison of Envelope Requirements

Components	Climate Zone 4A	
	VA	2009 IECC
Ceiling	38	38
Skylight U-factor	.60	.60
Fenestration U-factor	**.40**	**.35**
Fenestration SHGC	NR	NR
Wood Frame Wall	13	13
Mass Wall	5/10	5/10
Floor	19	19
Basement Wall	10/13	10/13
Slab	10, 2 ft	10, 2 ft
Crawl Space	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 67 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 67. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. 2006 IRC/IECC*	
	2006 IRC/IECC		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Richmond (CZ 4A)	974	229	845	207	225	15

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Washington

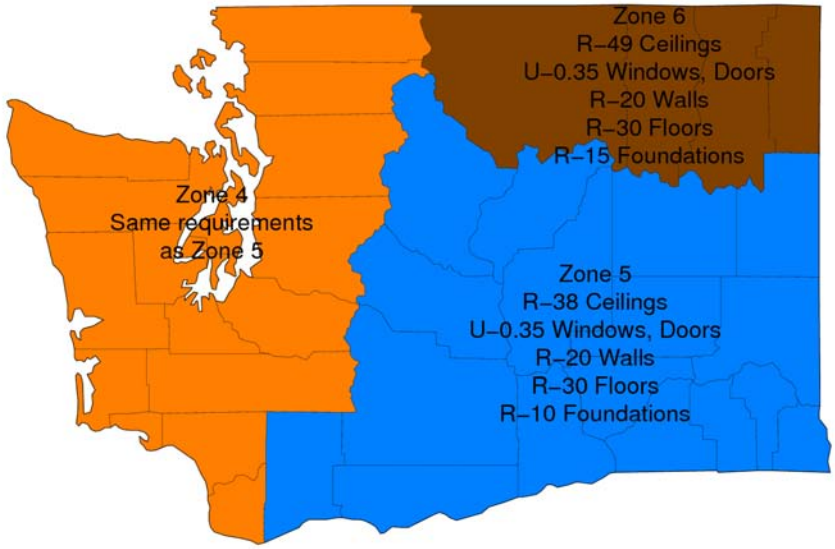
Summary

Washington has a state-developed residential energy efficiency code that has many differences from the 2009 International Energy Conservation Code (IECC). The major differences are summarized below, but a comparison of the overall impacts on energy use for these two codes is not attempted here. Requirements of the 2009 IECC are summarized below.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zones 4 and 5 and 4 feet in Zone 6.
- 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), though the ducts still have to be sealed.

- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5 and 6.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zones 4 and 5 and 0.40 in Zone 6. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Washington Code and the 2009 IECC

The Washington code is not based on the IECC and has many differences from the 2009 IECC, though many of the main requirements are similar or identical. Key differences include the following:

- The Washington code splits the state into two climate zones that do not match the IECC zones.
- Wall insulation requirements are somewhat different between the two codes. Most notably, the Washington code requires R-5 sheathing in addition to R-19 cavity insulation in Zone 2 whereas the IECC does not require sheathing insulation.
- If slab-on-grade foundations have heated slabs, Washington requires R-10 insulation under the slab. The IECC does not require under-slab insulation.
- The Washington code exempts log and solid timber walls with a thickness of at least 3.5 in. from wall insulation requirements if the heating system is other than electric resistance.
- The Washington code requires opaque doors to have a U-factor of 0.20 or lower, whereas the IECC requires U-0.35 or lower. Both codes allow one door to be exempt.
- The Washington code does not have lighting power requirements for most interior lighting. The IECC lighting requirements apply to both interior and exterior lighting.
- The Washington code (effective July 2010) requires 25% to 33% lower duct leakage rates when the post-construction leakage test is used. Washington requires leakage to outdoors of less than or equal to 6 cfm per 100 ft^2 of conditioned floor area (IECC: 8 cfm or less) or a total leakage less than or equal to 8 cfm per 100 ft^2 of conditioned floor area (IECC: 12 cfm or less). Washington allows nondirect vent-type combustion appliances and up to six feet of ductwork in unconditioned space to be exempt from testing. The IECC does not have this exemption.
- The Washington code requires a mechanical ventilation system. The IECC (or the IRC) does not require mechanical ventilation.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in West Virginia

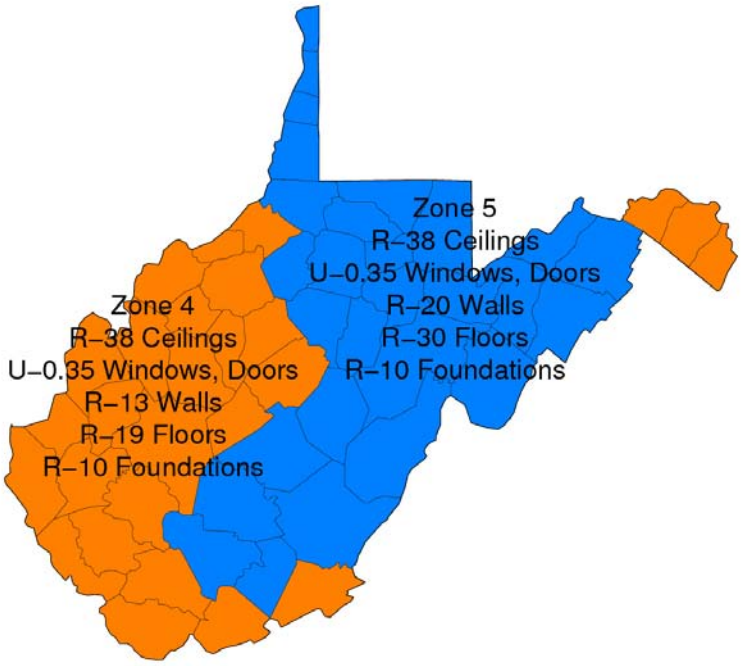
Summary

West Virginia is proceeding with adoption of the 2009 International Energy Conservation Code (IECC) through the State Fire Commission. No energy analysis was conducted here comparing the current West Virginia code to the 2009 IECC for this reason. However, the West Virginia energy code has been one of the weaker codes in the nation and the 2009 IECC would be a major improvement, saving hundreds of dollars per year in energy costs for a typical house.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Wisconsin

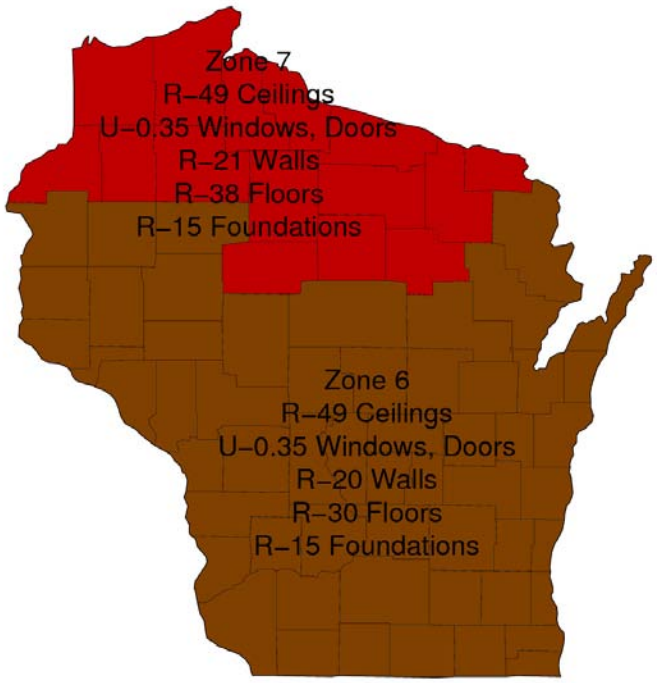
Summary

The energy efficiency requirements in the Wisconsin building code are the 2006 International Energy Conservation Code (IECC) with amendments that increase stringency. The 2009 IECC contains several major improvements in energy efficiency over the 2006 IECC and the Wisconsin code for the total building energy use. The most notable changes are improved duct sealing and efficient lighting requirements. A limited analysis of these changes resulted in estimated savings of $188 to $252 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 4 feet.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 6 and 7.
- Less insulation is allowed for mass walls and more insulation 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.40 in Zones 6 and 7. 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 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 measure 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between the Wisconsin Code and the 2009 IECC

The Wisconsin code is the 2006 IECC with modifications that push the stringency of the Wisconsin code well beyond that of the 2006 IECC. Key modifications include:

- Wisconsin requires a 90% AFUE gas furnace, an 83% oil furnace, or an 84% oil boiler, or alternatively, improved windows, wall, and foundation insulation.
- If slab-on-grade foundations have heated slabs, Wisconsin requires R-10 insulation under the slab. The IECC does not require under-slab insulation.
- Wisconsin requires R-4 pipe insulation, the 2006 IECC requires R-2 (the 2009 IECC requires R-3).
- Replacement furnaces in existing construction must meet duct leakage limits in the Wisconsin code. The 2009 IECC requires duct leakage limits in new buildings and duct system replacements.

A number of thermal envelope requirements are different in the 2009 IECC compared to the Wisconsin code with improved insulation levels (i.e., with baseline furnace/boiler efficiency). These are highlighted in Table 68.

Table 68. Comparison of Envelope Requirements

Components	Climate Zone 6A		Climate Zone 7A	
	WI Code	2009 IECC	WI Code	2009 IECC
Ceiling	49	49	49	49
Skylight U-factor	.60	.60	.60	.60
Fenestration U-factor	**.30**	**.35**	**.30**	**.35**
Fenestration SHGC	NR	NR	NR	NR
Wood Frame Wall	**21**	**20**	21	21
Mass Wall	15/19	15/19	19/21	19/21
Floor	30	30	**30**	**38**
Basement Wall	15/19	15/19	15/19	15/19
Slab	10, 4ft	10, 4ft	10, 4ft	10, 4ft
Crawl Space	10/13	10/13	10/13	10/13

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

- 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

Energy Analysis

A brief energy analysis was conducted comparing the current state code to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to the prescriptive requirements of the current state code, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 69 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 69. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. WI Code*	
	WI Code		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings ($/yr)	Percent Savings
Madison (CZ 6A)	1529	130	1429	134	188	10
Duluth MN (CZ 7A)	2053	65	1882	58	252	10

Analysis of 2009 International Energy Conservation Code Requirements for Residential Buildings in Wyoming

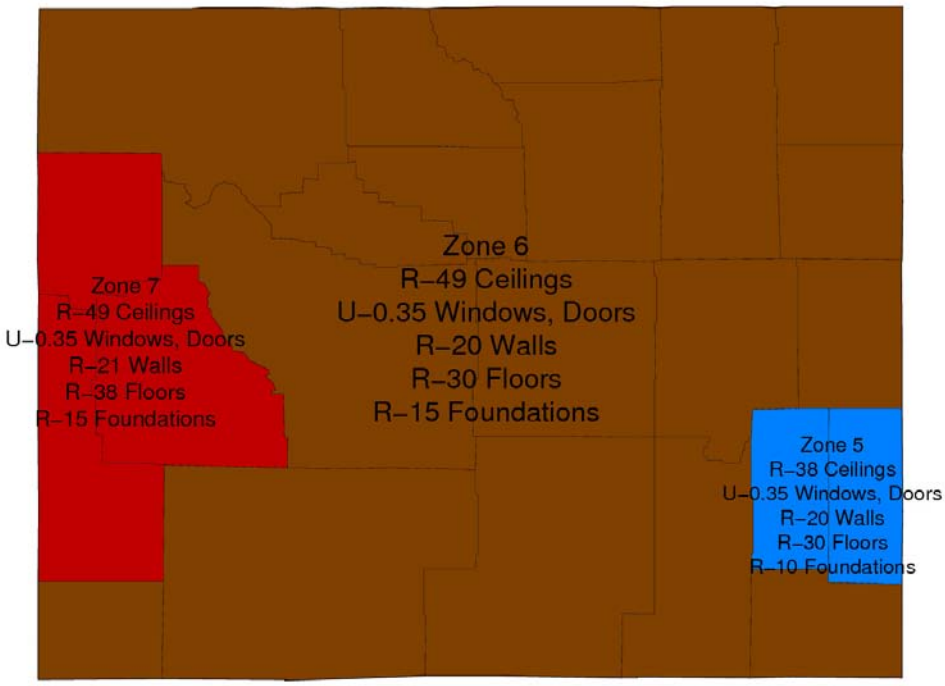
Summary

Wyoming currently does not have a mandatory energy efficiency code. The 2009 International Energy Conservation Code (IECC) would substantially improve energy efficiency in Wyoming homes. A limited analysis of the impact of the 2009 IECC resulted in estimated savings of $369 to $413 a year for an average new house at recent fuel prices.

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 map below shows the primary building envelope requirements for all residential buildings in the 2009 IECC.



Notable requirements in the 2009 IECC:

- Building envelope must be caulked and sealed.
- Slab-on-grade insulation is R-10 to a depth of 2 feet in Zone 5 and 4 feet in Zones 6 and 7.
- 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), though the ducts still have to be sealed.
- Piping for hydronic (boiler) heating systems must be insulated to R-3.
- Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zones 5, 6, and 7.
- 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
- 500 ft^2 or 20% of ceiling area of cathedral ceiling, whichever is less, is allowed to have R-30 insulation

Mandatory Requirements:

Windows can never exceed an area-weighted U-factor of 0.48 in Zone 5 and 0.40 in Zones 6 and 7. 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 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 tradeoff credit for the use of high efficiency space heating, space cooling, or water heating equipment.

Main Differences between Wyoming Current Practice and the 2009 IECC

The state of Wyoming has no mandatory energy efficiency code. We do not have detailed data on current construction techniques related to energy efficiency in Wyoming. Some energy efficient housing may be built to levels at or close to the IECC, others may fall well short of the IECC. Compliance with the 2009 IECC is expected to often result in increased insulation levels, better windows, better insulated and less leaky ducts, and better lighting.

Adoption of the 2009 IECC would likely improve a number of thermal envelope measures in many new houses and other residential construction. These estimated typical improvements are shown Table 70

Table 70. Comparison of Envelope Requirements

Components	Climate Zone 5		Climate Zones 6 and 7	
	Current Practice	2009 IECC	Current Practice	2009 IECC
Ceiling	30	38	38	49
Fenestration U-factor	.50	.35	.40	.35
Wood Frame Wall	19	20	19	20

Energy Analysis

A brief energy analysis was conducted comparing the assumed current practice to the 2009 IECC. The EnergyGauge™ software was used to determine the energy impacts of changes in envelope requirements. EnergyGauge™ is based on the DOE-2 energy simulation software developed by DOE (Lawrence Berkeley National Laboratory 1981).

Two sets of buildings were simulated: one with energy efficiency levels set to current practice, 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 8.5-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 357 ft^2 (15% of the wall area) equally oriented north, south, east, and west. Heating with a natural gas furnace ($1.20/therm) and central electric air conditioning ($.12/kWh) were assumed.

High-efficacy lighting was assumed to increase from 10% to 50% of all lighting within the building, reducing lighting energy use by 26%, or $74 a year. Savings attributable to the lighting requirements in the IECC will decrease as Federal law requires improved light bulbs in 2012 to 2014. Improved duct sealing was assumed to save 10% of the heating and cooling costs. Actual savings will vary depending on many factors, including how well ducts are currently sealed in the absence of any testing requirements.

Table 71 shows the estimated annual energy savings per house that result from meeting the improved requirements in the 2009 IECC. Total savings includes heating, cooling, and lighting and is shown as a percentage of the end-uses covered by the 2009 IECC (heating, cooling and water heating).

Table 71. Energy End Use and Percentage Savings

Climate Zone	*Annual Energy Cost ($)*				*Savings 2009 IECC vs. Current Practice*	
	Current Practice		*2009 IECC*			
	Heating	Cooling	Heating	Cooling	Savings	Percent Savings
Boulder CO (CZ 5B)	1357	145	1029	134	413	23
Cheyenne (CZ 6B)	1621	90	1333	83	369	18

The U.S. Department of Energy's Building Energy Codes Program is an information resource on national model energy codes. We work with other government agencies, state and local jurisdictions, national code organizations, and industry to promote stronger building energy codes and help states adopt, implement, and enforce those codes.

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