AGENDA REQUEST FORM

FOR: COUNCIL MEETING OF June 05, 2012

FROM: **Mayor Lioneld Jordan**
Council Member Matthew Petty
Council Member Sarah Lewis

ORDINANCE TITLE AND SUBJECT:

ADM 11-3655: Residential Energy Code

An ordinance to amend the Residential Energy Code, adopting the 2009 IECC Energy Code for Residential Construction, with the addition of a Home Energy Rating System (HERS) requirement.

APPROVED FOR AGENDA:

Mayor **Lioneld Jordan** — Date: 5/18/12

Council Member **Matthew Petty** — Date: 5/21/2012

Council Member **Sarah Lewis** — Date: 5/21/12

Packet Prepared by:

Jeremy Pate — Date: 05.17.2012
Director of Development Services

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Fayetteville ARKANSAS
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THE CITY OF FAYETTEVILLE, ARKANSAS
DEPARTMENT CORRESPONDENCE

CITY COUNCIL AGENDA MEMO

To: Mayor Lioneld Jordan
City Council

CC: Don Marr, Chief of Staff
Kit Williams, City Attorney
Jeremy Pate, Development Services Director
David Molaschi, Building Official

From: Leif Olson, Associate Planner

Date: May 17, 2012

Subject: ADM 11-3655 Residential Building Codes

PURPOSE

In July of 2011, Mayor Lioneld Jordan and Alderman Matthew Petty co-sponsored Resolution 117-11 to have city staff examine City building codes and recommend amendments to further promote sustainable practices and energy conservation for City Council consideration.

BACKGROUND

The City of Fayetteville, along with the rest of the State, has consistently followed the State of Arkansas' lead on building code adoption to regulate construction practices in the commercial and residential sectors. Currently, the State requires compliance with an amended 2003 International Energy Conservation Code (IECC). Since the State's adoption of the 2003 IECC there have been three IECC updates (2006, 2009 and 2012). Due to Arkansas' rural nature the State Building Codes are not regularly updated to the newer standards, primarily because rural areas may not have the resources to adequately enforce these codes. Unfortunately, that leaves the more urban areas of the State regulating building practices with the older, less energy efficient standards unless a municipality chooses to adopt more stringent standards. In addition, Northwest Arkansas is unique our counterparts in the central, south and east parts of the state in that we are situated in a different climate zone. Many peer urban areas in the climate zone in which Fayetteville is situated (Springfield, Joplin, Columbia, MO; Lawrence, Manhattan, KS; Bowling Green, KY; Nashville, TN) have adopted new energy codes for building construction.

In December 2007, the Mayor's Ad-Hoc Committee on Energy Efficient Construction was assembled with the goal of improving energy efficiency. The Committee quickly narrowed its focus on new residential construction and created the voluntary Residential Energy Efficiency Program (REEP) and the Fayetteville Energy Scorecard. Unfortunately, the voluntary REEP program has not resulted in the widespread adoption of green building practices that the City had hoped for in the 4 years since it was adopted.

On July 5, 2011 the City Council passed Resolution 117-11 directing City Staff to examine Fayetteville's current building codes and recommend possible changes to encourage energy efficiency improvements for City Council consideration. A Residential Building Code Task Force was formed comprised of local home builders, architects and energy performance consultants tasked with researching, modeling and developing a recommendation for the adoption of energy code changes. Included in the staff report is the research and energy modeling analysis conducted by the Residential Building Code Task

Force as well as a report prepared by the U.S. Department of Energy titled "Impacts of the 2009 IECC on Residential Buildings in Arkansas". Together these analyses paint a clear picture of the improvements that can be made upon the existing energy codes for residential construction, and what the cost and benefit will be to the consumer.

RECOMMENDATION

After completing substantial research and home energy modeling, the Residential Building Code Task Force and City staff recommends adopting the 2009 IECC for residential construction with an additional requirement for a Home Energy Rating (HERS) for all new residential structures. After consulting with Home Builders Association membership representatives on multiple occasions, staff is also recommending a delayed implementation date for the HERS and sticker requirement, as this is a new step in the home construction process for some builders.

Included in the staff report are the following resources:

1) Resolution 117-11, adopted by the City Council
2) Committee Summary Analysis of Residential Energy Codes
3) Cost/Benefit Analysis of Residential Energy Codes (3 pages)
4) Dept. of Energy Report, "Impacts of the 2009 IECC for Residential Buildings at State Level"
5) 2009 IECC, Chapter 11 Residential Energy Efficiency

BUDGET IMPACT

None.

Marked-Up Version

The following language is removed:

~~**173.08 Arkansas Energy Code**~~

~~(A) Adoption by reference. The Arkansas Energy Code, its Rules and Regulations as adopted and promulgated by the Arkansas Energy Office, and as may from time to time hereafter may be amended, is hereby adopted by reference pursuant to A.C.A. § 14-55-206 and § 14-55-207.~~

~~(B) The Arkansas Energy Code is amended by adding a provision for an Energy Efficiency Certificate for new home construction.~~

~~The Building Safety Division is authorized to design, approve and may later amend an Energy Efficiency Certificate to be affixed inside the main electrical panel indicating the operational energy efficiency measures incorporated into the building at the time of the completion of its construction.~~

The following language is added:

173.08 Energy Efficiency Code

(A) *Commercial.* The Arkansas Energy Code, its Rules and Regulations as adopted and promulgated by the Arkansas Energy Office, and as may from time to time hereafter may be amended, is hereby adopted by reference pursuant to A.C.A. § 14-55-206 and § 14-55-207.

(B) *Residential.* The 2009 International Energy Efficiency Code (IECC) is hereby adopted by reference for all new residential structures.

(1) The 2009 IECC is hereby amended by adding a provision requiring a Home Energy Rating (HERS) for new home construction. The City of Fayetteville requires that all new residential construction have a Home Energy Rating (HERS) completed by an independent RESNET certified home energy rater, or equivalent, prior to the issuance of a Certificate of Occupancy. Residential developments that utilize the exact same floor plan multiple times are required to have a HERS completed on a minimum of 20% of the residential units.

(2) A sticker shall be posted in a very prominent location near the front door showing the estimated monthly utility cost until the home is sold.

(3) All additions, alterations, renovations or repairs to existing residential structures shall comply with the standards of the 2009 IECC, but shall not be required to provide a HERS or post a sticker. Where it is shown to be impractical to meet the 2009 IECC, the Building Official may consider permitting additions, alterations, renovations or repairs in compliance with the Arkansas Energy Code, its Rules and Regulations as adopted and promulgated by the Arkansas Energy Office, and as may from time to time hereafter may be amended.

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ORDINANCE NO.

AN ORDINANCE TO AMEND §173.08 **ARKANSAS ENERGY CODE** OF THE BUILDING REGULATIONS CHAPTER OF THE U.D.C. TO ADOPT THE 2009 RESIDENTIAL INTERNATIONAL ENERGY EFFICIENCY CODE, WITH AMENDMENTS HEREIN.

WHEREAS, Fayetteville customers spend over $50 million annually for electricity and natural gas services; and

WHEREAS, more efficient buildings can conserve energy, reduce stress on our electricity grid and natural gas supplies while saving money and resources for our citizens; and

WHEREAS, improved building codes emphasizing energy conservation can reduce future energy consumption and the costs associated with energy production; and

WHEREAS, the existing State adopted and amended 2003 International Energy Efficiency Code is inferior in comparison with the 2009 International Energy Efficiency Code;

NOW, THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF FAYETTEVILLE, ARKANSAS:

Section 1. That the City Council of the City of Fayetteville, Arkansas hereby repeals §173.08 **Arkansas Energy Code** of the Unified Development Code and enacts a replacement §173.08 **Energy Efficiency Code** as shown below:

"§173.08 Energy Efficiency Code

(A) *Commercial.* The Arkansas Energy Code, its Rules and Regulations as adopted and promulgated by the Arkansas Energy Office, and as may from time to time hereafter may be amended, is hereby adopted by reference pursuant to A.C.A. § 14-55-206 and § 14-55-207.

(B) *Residential.* The 2009 International Energy Efficiency Code (IECC) is hereby adopted by reference for all new residential structures.

(1) The 2009 IECC is hereby amended by adding a provision requiring a Home Energy Rating (HERS) for new home construction. The City of Fayetteville requires that all new residential construction have a Home Energy Rating (HERS) completed by an independent RESNET certified home energy rater, or equivalent, prior to the issuance of a Certificate of Occupancy. Residential developments that utilize the exact same floor plan multiple times are required to have a HERS completed on a minimum of 20% of the residential units.

(2) A sticker shall be posted in a very prominent location near the front door showing the estimated monthly utility cost until the home is sold.

(3) All additions, alterations, renovations or repairs to existing residential structures shall comply with the standards of the 2009 IECC, but shall not be required to provide a HERS or post a sticker. Where it is shown to be impractical to meet the 2009 IECC, the Building Official may consider permitting additions, alterations, renovations or repairs in compliance with the Arkansas Energy Code, its Rules and Regulations as adopted and promulgated by the Arkansas Energy Office, and as may from time to time hereafter may be amended."

Section 2. That in order to adequately prepare the residential construction industry for the new requirement for a Home Energy Rating (HERS) for new home construction, the effective date for subsections 173.08 (B)(1) and (2) shall be January 01, 2013.

PASSED and **APPROVED** this day of , 2012.

APPROVED: ATTEST:

By: _____ By: _____
LIONELD JORDAN, Mayor **SONDRA E. SMITH**, City Clerk/Treasurer

RESOLUTION NO. 117-11

A RESOLUTION TO REQUEST THAT MAYOR JORDAN HAVE CITY STAFF EXAMINE CITY BUILDING CODES AND RECOMMEND AMENDMENTS TO FURTHER PROMOTE SUSTAINABLE PRACTICES AND ENERGY CONSERVATION FOR CITY COUNCIL CONSIDERATION

WHEREAS, Fayetteville customers spend over $50 million annually for electrical and natural gas services; and

WHEREAS, over 80% of Fayetteville's electrical power is produced from coal imported from Colorado and Wyoming; and

WHEREAS, buildings in the United States consume over 40% of all energy and 70% of all electricity used in the United States; and

WHEREAS, more efficient buildings can conserve energy, reduce stress on our electric grid and natural gas supplies and save money as well as resources; and

WHEREAS, improved building codes emphasizing sustainability and energy conservation can favorably impact future energy consumption and all the costs associated with energy production.

NOW, THEREFORE BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF FAYETTEVILLE, ARKANSAS:

Section 1: That the City Council of the City of Fayetteville, Arkansas hereby requests that Mayor Jordan have his City staff examine Fayetteville's current building codes and recommend possible changes to encourage feasible improvements for increased energy conservation and overall sustainability for City Council consideration.

PASSED and **APPROVED** this 5th day of July, 2011.

APPROVED:

By: _____
LIONELD JORDAN, Mayor

ATTEST:

By: Lisa Branson, Deputy City Clerk for :
SONDRA E. SMITH, City Clerk/Treasurer

CITY CLERK/TREASURER CITY OF FAYETTEVILLE ARKANSAS WASHINGTON COUNTY

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Analysis of Residential Energy Codes

Residential Building Code Task Force
City of Fayetteville Sustainability and Strategic Planning Department
2012

Background: On July 5, 2011 the City Council passed Resolution 117-11 directing City Staff to examine Fayetteville's current building codes and recommend possible changes to encourage energy efficiency improvements for City Council consideration. A Residential Building Code Task Force was formed comprised of local home builders, architects and energy performance consultants tasked with researching, modeling and developing a recommendation for the adoption of energy code changes.

Process: The Residential Building Code Task Force met a total of four times in 2011 and 2012. The Task Force utilized the expertise of its members to model the energy efficiency of a "typical" 1,824 sq. ft. home according to four different sets of building codes; the 2003, 2009 and 2012 International Energy Efficiency Codes (IECC) and the Energy Star Code. The results of this modeling exercise are included in the attached spreadsheets.

Comparison between the 2003, 2006, 2009 and 2012 International Energy Conservation Code (IECC) Building Envelope Requirements:

The IECC is typically published every three years. Each edition has some changes from the previous one. The residential portion of the code was heavily revised in 2004 and climate zones and building envelope requirements were restructured into a different format. This makes the post 2004 IECC codes much more concise and easier to use. However, these changes also complicate comparisons of pre-2004 codes to the newer versions. The changes between the 2006, 2009 and 2012 IECC were mainly to improve energy efficiency and make the code more stringent.

The major building thermal envelope updates to the 2003 IECC are the U-factor and Solar Heat Gain Coefficient (SHGC) requirements for fenestrations (windows) and the insulation *R*-factors for foundations and walls.

The Building Thermal Envelope is defined as what separates the building from unconditioned space. Windows are measured in terms of their thermal transmission, or U-factor. U-factor measures the rate of heat transfer through a product. The lower the U-factor, the lower the amount of heat loss, and the better a product is insulating a building. Solar Heat Gain refers to the increase in temperature in a space, object or structure that results from solar radiation. The amount of solar gain changes with the strength of the sun, and with the ability of any intervening material to transmit or resist the radiation.

The thermal building envelope changes between the 2003, 2006 and 2009 versions of the IECC are shown below:

	2003 IECC adopted by State with amendments	2006 IECC	2009 IECC
Ceiling	*R*-38	*R*-38	*R*-38
Skylight U-factor	N/A	0.60	0.60
Fenestration U-factor	0.41	0.40	0.35
Fenestration SHGC	N/A	N/A	0.45
Wood Frame Wall	*R*-13	*R*-13	*R*-13
Mass Wall	R-8.1	*R*-5	*R*-5/10*
Floor	*R*-19	*R*-19	*R*-19
Basement Wall	*R*-10/13**	*R*-10/13**	*R*-10/13**
Slab	*R*-4	*R*-10,2 ft depth	*R*-10,2 ft depth
Crawlspace Wall	*R*-10/13**	*R*-10/13**	*R*-10/13**

* The second *R*-value applies when more than half the insulation is on the interior of the mass wall.
** The first *R*-value applies to continuous insulation, the second to framing cavity insulation; either insulation meets the requirement.

Additional revisions to the 2009 IECC to improve energy efficiency included:

- The 2009 IECC requires that all sealed ducts located outside of the building's thermal envelope be verified by conducting a duct tightness test. The 2003 and 2006 IECC requires ducts to be sealed but not to a specific leakage rate verified by testing.

- 50% of the lighting lamps in a building have to be high efficiency in the 2009 IECC. The 2006 IECC has no lighting requirement.

- Trade off credit can no longer be obtained for high-efficiency heating, ventilation, and air conditioning (HVAC) equipment in the 2009 IECC. For example, if a high efficiency furnace is used, no reduction in wall insulation is allowed.

- A permanent sticker shall be posted on or in the electrical distribution panel that lists the predominant *R*-values of the insulation in the ceiling/roof, walls, foundation and ducts outside conditioned space. Also, the certificate shall list U-factors for window, the types and efficiencies of heating, cooling, and water heating equipment.

The 2012 IECC continues this trend, with all of the 2009 requirements and heightened requirements for efficiency within the thermal building envelope. Wood frame walls go from R-13 insulation to 20; 75% of lighting fixtures are required to be high-efficiency; and the infiltration standards are much more stringent. Importantly, the mechanical systems within a residence begin to get much more scrutiny. In comparison, the 2003 IECC has no duct infiltration standards, the 2009 has 8 CFM per 100sf standard, and the 2012 IECC allows no more than 4 CFM per 100 sf of infiltration. As noted in the following cost-benefit analysis, the 2012 IECC significantly increases the cost of construction when compared to the current 2003 energy code, therefore the committee chose not to pursue this option further.

Overview of the 2009 IECC with Anticipated Energy Cost/Benefit Analysis

The 2009 IECC is designed to save the consumer in utility costs because the building's thermal envelope and duct system will be tighter allowing for less air infiltration and the solar heat gain will be reduced with the improved window U-factor ratings. The efficient lighting requirements require less energy thereby increasing efficiency. The 2009 IECC scope includes residential single-family housing and multifamily housing three stories or less above-grade, intended for permanent living. The code is intended to apply to new buildings and additions/alterations/ renovations/repairs.

Ceiling	*R*-38
Skylight U-factor	U-0.60
Window U-factor	U-0.35
Wood Frame Wall	*R*-13
Fenestration Solar Heat Gain Coefficient (SHGC)	0.45
Mass Wall	*R*-5/10*
Floor	*R*-19
Basement Wall	*R*-10/13*
Slab	*R*-10, 2 ft depth
Crawlspace Wall	*R*-10/13*

* The first *R*-value applies to continuous insulation, the second to framing cavity insulation; either insulation meets the requirement.

Additional requirements of the 2009 IECC include:

- 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 the building envelope must be insulated to *R*-6.
- All ducts must be sealed and either:
    1. Verified by pressure testing. The duct system is tested and the air leakage out of ducts must be kept to an acceptable maximum level.
    2. All ductwork must be installed entirely within the building envelope. Testing is not required if all ducts are inside the building thermal envelope.
- Less insulation is allowed for mass walls and more insulation is required for steel framing.
- 50% of the lighting in a building must be high efficacy.
- Standard administrative requirements apply (inspections, documentation).
- 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 square feet of window area are exempt.

Mandatory requirements:

Windows can never exceed an area-weighted average solar heat gain coefficient (SHGC) of 0.50.

Compliance Paths:

The 2003, 2006 and 2009 IECC all effectively contain 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 2009 IECC has a single table of requirements for insulation R-values and window and door U-factors and SHGC.

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 measure can fall below code requirements if balanced by other measures that exceed code requirements.

3. Simulated performance path. This path allows compliance if the home has calculated annual energy consumption equal to or less than that of a standard reference design that meets the code's prescriptive requirements. This path allows for crediting energy efficiency measures not accounted for in other paths, such as renewable energy measures. The 2009 performance path differs from previous editions of the IECC in that it allows no trade-off credit for the use of high efficiency space heating, space cooling or water heating equipment.

Cost/Savings Analysis:

The Residential Building Code Task Force performed an analysis comparing the same 1,824 sq. ft. home constructed under both the 2003 IECC and the 2009 IECC and modeled with either gas or electric heat. The resulting analysis estimated an annual energy cost savings of $267 for the gas home and $344 for the electric home. The additional cost for building to the higher efficiency standards of the 2009 IECC was $2,049, or amortized over a 30 year loan, $132 annually. This represents **a net average annual energy savings for the home built to 2009 IECC standards of $135 for the gas heated home and $209 for the electric heated home.**

Overview of the Energy Star Version 3 Code with Cost/Benefit Analysis

The Energy Star Qualified Homes Version 3 goes beyond the requirements of the 2009 IECC. The Energy Star V3 code may be viewed as a stretch code to the 2009 IECC in that it requires higher efficiencies in some of the thermal building envelope requirements, and it promotes higher efficiency HVAC systems and appliances. The primary examples of this are; greater efficiencies for window U-factors, tighter building envelope requirements, tighter duct sealing requirements and increased foundation insulation installation requirements. Additionally, the Energy Star V3 code requires the installation of Energy Star certified appliances.

	2009 IECC	Energy Star Version 3
Ceiling	*R*-38	*R*-38
Skylight U-factor	U-0.60	N/A
Fenestration U-factor	U-0.35	U-0.32
Fenestration SHGC	0.45	0.40
Wood Frame Wall	*R*-13	*R*-13
Floor	*R*-19	*R*-19
Basement Wall	*R*-10/13*	*R*-19
Slab	*R*-10, 2 ft depth	*R*-19
Crawlspace Wall	*R*-10/13	*R*-13

Some additional significant features of the Energy Star Qualified Homes, Version 3 that differentiate it from the 2009 IECC include:

	2009 IECC	Energy Star V-3
HVAC	7.7 HSPF / 13 SEER / 11 EER ASHP – electric backup	8.5 HSPF / 14.5 SEER / 12 EER ASHP – electric backup
Ceiling Insulation Installation	Grade II Installation	Grade I Installation
AG Wall Insulation Installation	Grade III Installation	Grade I Installation
Foundation Insulation Installation	Grade II Installation	Grade I Installation
Infiltration	7.0 ACH50	5.0 ACH50
Water Heater	0.90 EF Electric DHW, 52 Gallons	0.92 EF Electric DHW, 52 Gallons
Dishwasher	Standard Efficiency	Energy Star
Refrigerator	Standard Efficiency	Energy Star
Lighting	50 % Fluorescent	80 % Energy Star Fluorescent
Bathroom Exhaust Fans	Standard Efficiency	Energy Star Exhaust Fans

Energy Star Cost/Saving Analysis:

Energy Star estimates that for a 2,200 sq. ft. all electric home with an unconditioned basement, located in Climate Zone 4 the improved efficiency standards would increase the annual mortgage cost by $264. **The estimated monthly utility savings would be $420, for a net cash flow increase of $156/year for the homeowner.**

Conclusion

The 2003 IECC adopted and amended by the State of Arkansas has been improved on by subsequent code updates in recent years. The 2009 IECC has significantly higher thermal building envelope requirements then the 2003 IECC achieved primarily through higher efficiency windows and doors, better slab insulation, ductwork insulation and sealing requirements to reduce infiltration. The Energy Star V3 code has even higher efficiency requirements then the 2009 IECC and could be considered a stretch code. Both the 2009 IECC and the Energy Star V3 code have been shown to achieve a demonstrable net return on investment for the homeowner.

Recommendation

Based on the analysis performed calculating the cost of implementing the new energy code with the energy savings a homeowner could realize, the Residential Building Code Task Force and Staff recommends that the City adopt the 2009 IECC with the additional requirement for a Home Energy Rating (HERS) for all new residential construction. The HERS would provide a common denominator for all homebuilders and contractors to measure performance and will ensure that the construction techniques for all of these systems are sound. Staff would also recommend that the City require a Home Performance Sticker be placed in a prominent location near the front door showing the estimated monthly utility cost until the home is sold. This provides homebuyers the information needed to make an informed decision when making one of the largest investments a family can make, The Home Performance Sticker can also be a marketing tool for the homebuilders that wish to excel in this area.

IECC Cost Comparison - 1,824 SF Residential Structure

	2003 IECC State Ver.	2009 IECC	Cost	2012 IECC	Cost	Energy STAR Ver. 3	Cost
Ceiling	R-38	R-38	$0	R-49	$ 100.08	R-38	$0
Skylight U-factor	N/A	0.6	N/A	0.55	N/A	N/A	N/A
Fenestration U-factor	0.41	0.35	see windows and doors	0.35	see windows and doors	0.32	see windows and doors
Fenestration SHGC	N/A	0.45		0.4		0.4	
Doors	R-1.3	R-2.9	$ 40.00	R-2.9	$ 40.00	R-4.8	Standard
Wood Frame Wall	R-13	R-13	$ -	20 or 13+5***	$ 1,115.59	R-13	$ -
Mass Wall	R-8.1	R-5/10*	N/A	R-8/13	N/A	Not Specified	N/A
Crawlspace Floor	R-19	R-19	N/A	19	N/A	R-19	N/A
Basement Wall	R-10/13**	R-10/13**	N/A	R-10/13**	N/A	R-19	N/A
Slab	R-4	R-10, 2 ft depth	$ 241.52	R-10, 2 ft depth	$ 241.52	R-10, 2 ft depth	$ 241.52
Crawlspace Wall	R-10/13**	R-10/13**	N/A	R-10/13**	N/A	R-13	N/A
Duct Blaster Test	No	Yes	$ 380.00	Yes	$ 380.00	Yes	$ 380.00
Duct Infiltration	N/A	8CFM per 100 sf		4CFM per 100 sf		4CFM per 100 sf	
Duct Insulation	R-8 Attic/R-5.6 Other	R-8 Attic/R-6 Other	$ 90.00	R-8 Attic/R-6 Other	$ 90.00	R-8 Attic/R-6 Other	$ 90.00
HVAC Specs (Gas)	10 SEER w 78% AFUE	13 SEER w 78% AFUE	N/A	13 SEER 78% AFUE	N/A	13 SEER 90% AFUE	N/A
HVAC Specs (Electric)	6.8 HSPF/10 SEER	7.7 HSPF/13 SEER	$ -	7.7 HSPF/13 SEER	$ -	8.5 HSPF/14.5 SEER	$ 293.00
Trade Off Credits	Allowed	Not Allowed	N/A	Not Allowed	N/A	Not Allowed	N/A
Blower Door Test	No	Yes	$ 380.00	Yes	$ 380.00	Yes	$ 380.00
Infiltration	N/A	7.0 ACH50	$ 528.60	3 ACH50	$ 600.00	5.0 ACH50	$ 565.00
Caulk & Seal	Yes	Yes	$ 100.00	Yes	$ 100.00	Yes	$ 100.00
Lighting	N/A	50% High Efficacy	$ 200.00	75% High Efficacy	$ 300.00	80% Energy STAR	$ 320.00
Programmable Therm	No	Yes	$ 25.00	Yes	$ 25.00	Yes	$ 25.00
Windows SHGC	N/A	0.4	$ 204.16	0.4	$ 204.16	N/A	$ 204.16
Sticker in Panel	No	Yes	Incl. with blower door test	Yes	Incl. with blower door test	N/A	Incl. with blower door test
Dishwasher	Standard	Standard	$ -	Standard	$ -	Energy STAR	Standard
Water Heater	Standard	Standard	$ -	Standard	$ -	Energy STAR	Standard
Refrigerator	Standard	Standard	Not supplied	Standard	Not supplied	Energy STAR	Not supplied
Bathroom Exhaust	Standard	Standard	RCS	Standard	RCS	Energy STAR	$ 50.00
Total			**$ 2,189.28**		**$ 3,576.35**		**# $2,648.48**

Additional items Required for Energy Star Version 3	
Gasketed cover for Attic insulation access or pull-down stairway	$ 124.00
Sheetrock sealed to top plate at all attic/wall interfaces using caulk, foam, or equivalent material.	$ 200.00
Kickout flashing required at bottom of all roof to wall intersections	Standard
Self sealing bituminous membrane at all valleys and roof deck penetrations	$ 50.00
Cement board or equivalent moisture resistant barrier behind all tub and shower enclosures composed of tile or panel assemblies with caulked joints. Paper-faced backerboard **shall not be used.**	$ 35.00
Building Materials with visible water damage or mold **shall not be used.**	Standard
Energy Star Version 3 TOTAL	**$ 3,057.68**

* The second R-value applies when more than half the insulation is on the interior of the mass wall

** The first R-value applies to the continuous insulation, the second to framing cavity insulation; either insulation meets the requirement.

***First value is cavity insulation, second is continuous insulation or insulated siding.

subtotal for Energy star items listed above

CODE VERSION	FUEL TYPE*	UTILITIES $/YR**	DESIGN LOADS Heat/Cool (kBTU/hr)	# TONS	MM BTU/YR	HERS INDEX
2003 IECC AR version	Gas	$1,725	37.8/25.9	2.5	114.5	100
"	Electric	$1,898	37.8/25.9	2.5	69.8	100
2009 IECC	Gas	$1,458	32.6/21.3	2.0	94.6	84
"	Electric	$1,560	32.6/21.3	2.0	61.3	86
2012 IECC	Gas	$1,214	22.9/14.2	1.5	75.7	74
"	Electric	$1,404	22.9/16.4	1.5	51	78
ENERGY STAR v.3	Gas	$1,166	25.3/17.7	1.5	72.1	66
"	Electric	$1,227	25.3/17.7	1.5	44.3	65

*Gas--furnace and water heater: Electric--heat pump and water heater

**Utility rates: $0.09/kWh elec., $1.00/CCF gas

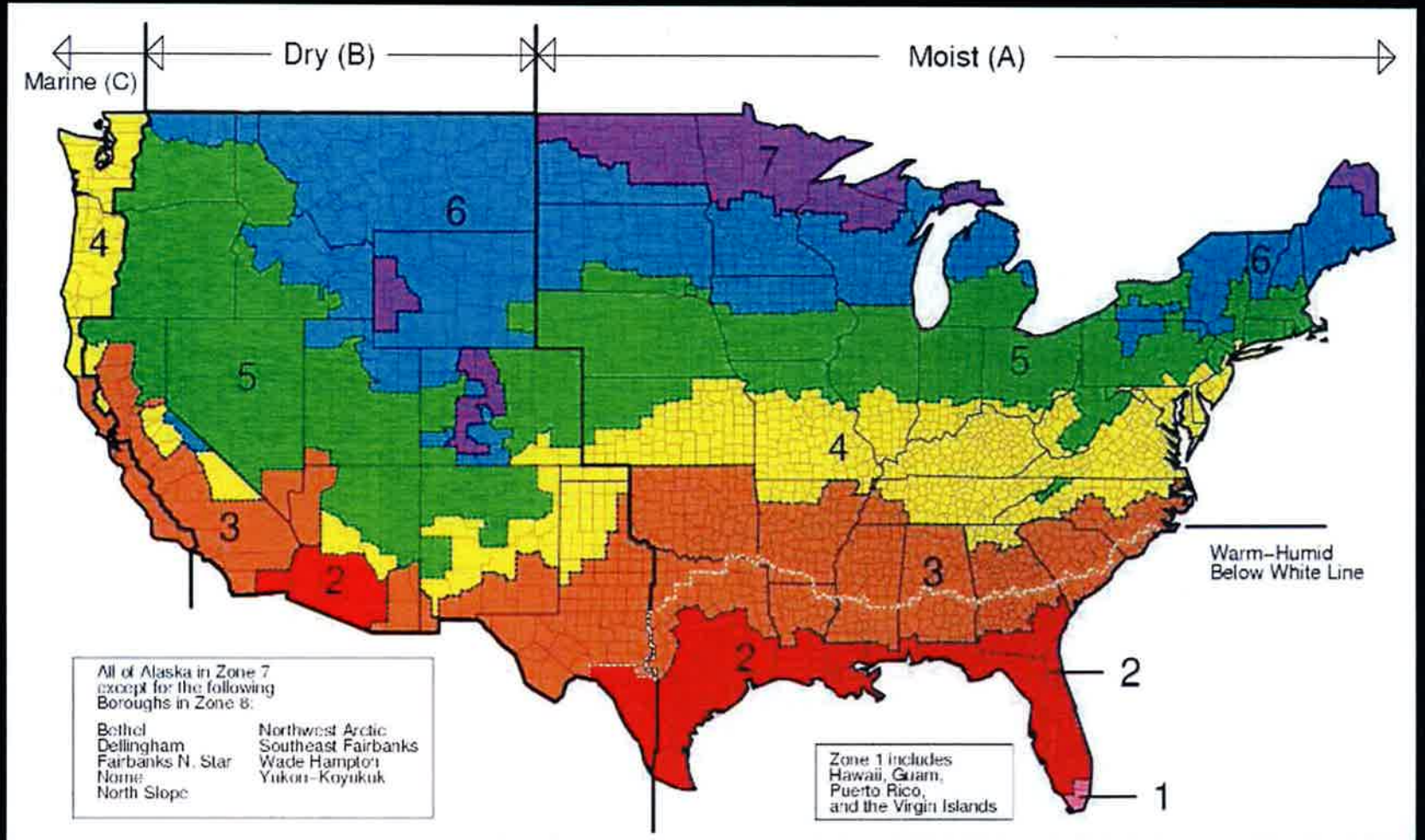
CODE VERSION	FUEL TYPE*	UTILITIES $/YR**	DESIGN LOADS Heat/Cool (kBTU/hr)	# TONS	MM BTU/YR	HERS INDEX	ADDED COST	Avg Monthly Savings	Ammortized Cost/ Monthly Add
2003 IECC AR	Gas	$1,725	37.8/25.9	2.5	114.5	100			
"	Electric	$1,898	37.8/25.9	2.5	69.8	100			
2009 IECC	Gas	$1,458	32.6/21.3	2.0	94.6	84		$ 22.25	
"	Electric	$1,560	32.6/21.3	2.0	61.3	86	$ 2,049.28	$ 28.17	$ 11.00
2012 IECC	Gas	$1,214	22.9/14.2	1.5	75.7	74		$ 42.58	
"	Electric	$1,404	22.9/16.4	1.5	51	78	$ 3,436.35	$ 41.17	$ 18.45
ENERGY STAR v.3	Gas	$1,166	25.3/17.7	1.5	72.1	66		$ 46.58	
"	Electric	$1,227	25.3/17.7	1.5	44.3	65	$ 3,057.68	$ 55.92	$ 16.41

*Gas--furnace and water heater: Electric--heat pump and water heater

**Utility rates: $0.09/kWh elec., $1.00/CCF gas

***30 year fixed mortgage with 5% interest rate

Climate Zones – Chapter 3



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CHAPTER 1
ADMINISTRATION

PART 1—SCOPE AND APPLICATION

SECTION 101
SCOPE AND GENERAL REQUIREMENTS

101.1 Title. This code shall be known as the *International Energy Conservation Code* of [NAME OF JURISDICTION], and shall be cited as such. It is referred to herein as "this code."

101.2 Scope. This code applies to *residential* and *commercial buildings*.

101.3 Intent. This code shall regulate the design and construction of buildings for the effective use of energy. This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve the effective use of energy. This code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances.

101.4 Applicability. Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall govern.

101.4.1 Existing buildings. Except as specified in this chapter, this code shall not be used to require the removal, *alteration* or abandonment of, nor prevent the continued use and maintenance of, an existing building or building system lawfully in existence at the time of adoption of this code.

101.4.2 Historic buildings. Any building or structure that is listed in the State or National Register of Historic Places; designated as a historic property under local or state designation law or survey; certified as a contributing resource with a National Register listed or locally designated historic district; or with an opinion or certification that the property is eligible to be listed on the National or State Registers of Historic Places either individually or as a contributing building to a historic district by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places, are exempt from this code.

101.4.3 Additions, alterations, renovations or repairs. Additions, alterations, renovations or repairs to an existing building, building system or portion thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portion(s) of the existing building or building system to comply with this code. Additions, alterations, renovations or repairs shall not create an unsafe or hazardous condition or overload existing building systems. An addition shall be deemed to comply with this code if the addition alone complies or if the existing building and addition comply with this code as a single building.

Exception: The following need not comply provided the energy use of the building is not increased:

1. Storm windows installed over existing fenestration.
2. Glass only replacements in an existing sash and frame.
3. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation.
4. Construction where the existing roof, wall or floor cavity is not exposed.
5. Reroofing for roofs where neither the sheathing nor the insulation is exposed. Roofs without insulation in the cavity and where the sheathing or insulation is exposed during reroofing shall be insulated either above or below the sheathing.
6. Replacement of existing doors that separate *conditioned space* from the exterior shall not require the installation of a vestibule or revolving door, provided, however, that an existing vestibule that separates a *conditioned space* from the exterior shall not be removed,
7. Alterations that replace less than 50 percent of the luminaires in a space, provided that such alterations do not increase the installed interior lighting power.
8. Alterations that replace only the bulb and ballast within the existing luminaires in a space provided that the *alteration* does not increase the installed interior lighting power.

101.4.4 Change in occupancy or use. Spaces undergoing a change in occupancy that would result in an increase in demand for either fossil fuel or electrical energy shall comply with this code. Where the use in a space changes from one use in Table 505.5.2 to another use in Table 505.5.2, the installed lighting wattage shall comply with Section 505.5.

101.4.5 Change in space conditioning. Any nonconditioned space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code.

101.4.6 Mixed occupancy. Where a building includes both *residential* and *commercial* occupancies, each occupancy shall be separately considered and meet the applicable provisions of Chapter 4 for *residential* and Chapter 5 for *commercial*.

101.5 Compliance. *Residential buildings* shall meet the provisions of Chapter 4. *Commercial buildings* shall meet the provisions of Chapter 5.

101.5.1 Compliance materials. The *code official* shall be permitted to approve specific computer software, worksheets, compliance manuals and other similar materials that meet the intent of this code.

101.5.2 Low energy buildings. The following buildings, or portions thereof, separated from the remainder of the building by *building thermal envelope* assemblies complying with this code shall be exempt from the *building thermal envelope* provisions of this code:

1. Those with a peak design rate of energy usage less than 3.4 Btu/h-ft² (10.7 W/m²) or 1.0 watt/ft² (10.7 W/m²) of floor area for space conditioning purposes.
2. Those that do not contain *conditioned space*.

SECTION 102
ALTERNATE MATERIALS—METHOD OF CONSTRUCTION, DESIGN OR INSULATING SYSTEMS

102.1 General. This code is not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein, provided that such construction, design or insulating system has been *approved* by the *code official* as meeting the intent of this code.

102.1.1 Above code programs. The *code official* or other authority having jurisdiction shall be permitted to deem a national, state or local energy efficiency program to exceed the energy efficiency required by this code. Buildings *approved* in writing by such an energy efficiency program shall be considered in compliance with this code. The requirements identified as "mandatory" in Chapters 4 and 5 of this code, as applicable, shall be met.

PART 2—ADMINISTRATION AND ENFORCEMENT

SECTION 103
CONSTRUCTION DOCUMENTS

103.1 General. Construction documents and other supporting data shall be submitted in one or more sets with each application for a permit. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the *code official* is authorized to require necessary construction documents to be prepared by a registered design professional.

Exception: The *code official* is authorized to waive the requirements for construction documents or other supporting data if the *code official* determines they are not necessary to confirm compliance with this code.

103.2 Information on construction documents. Construction documents shall be drawn to scale upon suitable material. Electronic media documents are permitted to be submitted when *approved* by the *code official*. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include, but are not limited to, as applicable, insulation materials and their *R*-values; fenestration *U*-factors and SHGCs; area-weighted *U*-factor and SHGC calculations; mechanical system design criteria; mechanical and service water heating system and equipment types, sizes and efficiencies; economizer description; equipment and systems controls; fan motor horsepower (hp) and controls; duct sealing, duct and pipe insulation and location; lighting fixture schedule with wattage and control narrative; and air sealing details.

103.3 Examination of documents. The *code official* shall examine or cause to be examined the accompanying construction documents and shall ascertain whether the construction indicated and described is in accordance with the requirements of this code and other pertinent laws or ordinances.

103.3.1 Approval of construction documents. When the *code official* issues a permit where construction documents are required, the construction documents shall be endorsed in writing and stamped "Reviewed for Code Compliance." Such *approved* construction documents shall not be changed, modified or altered without authorization from the *code official*. Work shall be done in accordance with the *approved* construction documents.

One set of construction documents so reviewed shall be retained by the *code official*. The other set shall be returned to the applicant, kept at the site of work and shall be open to inspection by the *code official* or a duly authorized representative.

103.3.2 Previous approvals. This code shall not require changes in the construction documents, construction or designated occupancy of a structure for which a lawful permit has been heretofore issued or otherwise lawfully authorized, and the construction of which has been pursued in good faith within 180 days after the effective date of this code and has not been abandoned.

103.3.3 Phased approval. The *code official* shall have the authority to issue a permit for the construction of part of an energy conservation system before the construction documents for the entire system have been submitted or *approved*, provided adequate information and detailed statements have been filed complying with all pertinent requirements of this code. The holders of such permit shall proceed at their own risk without assurance that the permit for the entire energy conservation system will be granted.

103.4 Amended construction documents. Changes made during construction that are not in compliance with the *approved* construction documents shall be resubmitted for approval as an amended set of construction documents.

103.5 Retention of construction documents. One set of *approved* construction documents shall be retained by the *code official* for a period of not less than 180 days from date of completion of the permitted work, or as required by state or local laws.

SECTION 104
INSPECTIONS

104.1 General. Construction or work for which a permit is required shall be subject to inspection by the *code official*.

104.2 Required approvals. Work shall not be done beyond the point indicated in each successive inspection without first obtaining the approval of the *code official*. The *code official*, upon notification, shall make the requested inspections and shall either indicate the portion of the construction that is satisfactory as completed, or notify the permit holder or his or her agent wherein the same fails to comply with this code. Any portions that do not comply shall be corrected and such portion shall not be covered or concealed until authorized by the *code official*.

104.3 Final inspection. The building shall have a final inspection and not be occupied until *approved*.

104.4 Reinspection. A building shall be reinspected when determined necessary by the *code official*.

104.5 Approved inspection agencies. The *code official* is authorized to accept reports of *approved* inspection agencies, provided such agencies satisfy the requirements as to qualifications and reliability.

104.6 Inspection requests. It shall be the duty of the holder of the permit or their duly authorized agent to notify the *code official* when work is ready for inspection. It shall be the duty of the permit holder to provide access to and means for inspections of such work that are required by this code.

104.7 Reinspection and testing. Where any work or installation does not pass an initial test or inspection, the necessary corrections shall be made so as to achieve compliance with this code. The work or installation shall then be resubmitted to the *code official* for inspection and testing.

104.8 Approval. After the prescribed tests and inspections indicate that the work complies in all respects with this code, a notice of approval shall be issued by the *code official*.

104.8.1 Revocation. The *code official* is authorized to, in writing, suspend or revoke a notice of approval issued under the provisions of this code wherever the certificate is issued in error, or on the basis of incorrect information supplied, or where it is determined that the building or structure, premise, or portion thereof is in violation of any ordinance or regulation or any of the provisions of this code.

SECTION 105
VALIDITY

105.1 General. If a portion of this code is held to be illegal or void, such a decision shall not affect the validity of the remainder of this code.

SECTION 106
REFERENCED STANDARDS

106.1 General. The codes and standards referenced in this code shall be those listed in Chapter 6, and such codes and standards shall be considered as part of the requirements of this code to the prescribed extent of each such reference.

106.2 Conflicting requirements. Where the provisions of this code and the referenced standards conflict, the provisions of this code shall take precedence.

106.3 Application of references. References to chapter or section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section or provision of this code.

106.4 Other laws. The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law.

SECTION 107
FEES

107.1 Fees. A permit shall not be issued until the fees prescribed in Section 107.2 have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

107.2 Schedule of permit fees. A fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.

107.3 Work commencing before permit issuance. Any person who commences any work before obtaining the necessary permits shall be subject to an additional fee established by the *code official*, which shall be in addition to the required permit fees.

107.4 Related fees. The payment of the fee for the construction, *alteration*, removal or demolition of work done in connection to or concurrently with the work or activity authorized by a permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.

107.5 Refunds. The *code official* is authorized to establish a refund policy.

SECTION 108
STOP WORK ORDER

108.1 Authority. Whenever the *code official* finds any work regulated by this code being performed in a manner either contrary to the provisions of this code or dangerous or unsafe, the *code official* is authorized to issue a stop work order.

108.2 Issuance. The stop work order shall be in writing and shall be given to the owner of the property involved, or to the owner's agent, or to the person doing the work. Upon issuance of a stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order, and the conditions under which the cited work will be permitted to resume.

108.3 Emergencies. Where an emergency exists, the *code official* shall not be required to give a written notice prior to stopping the work.

108.4 Failure to comply. Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a vio-

lation or unsafe condition, shall be liable to a fine of not less than [AMOUNT] dollars or more than [AMOUNT] dollars.

SECTION 109
BOARD OF APPEALS

109.1 General. In order to hear and decide appeals of orders, decisions or determinations made by the *code official* relative to the application and interpretation of this code, there shall be and is hereby created a board of appeals. The *code official* shall be an ex officio member of said board but shall have no vote on any matter before the board. The board of appeals shall be appointed by the governing body and shall hold office at its pleasure. The board shall adopt rules of procedure for conducting its business, and shall render all decisions and findings in writing to the appellant with a duplicate copy to the *code official*.

109.2 Limitations on authority. An application for appeal shall be based on a claim that the true intent of this code or the rules legally adopted thereunder have been incorrectly interpreted, the provisions of this code do not fully apply or an equally good or better form of construction is proposed. The board shall have no authority to waive requirements of this code.

109.3 Qualifications. The board of appeals shall consist of members who are qualified by experience and training and are not employees of the jurisdiction.

CHAPTER 4
RESIDENTIAL ENERGY EFFICIENCY

SECTION 401
GENERAL

401.1 Scope. This chapter applies to residential buildings.

401.2 Compliance. Projects shall comply with Sections 401, 402.4, 402.5, and 403.1, 403.2.2, 403.2.3, and 403.3 through 403.9 (referred to as the mandatory provisions) and either:

1. Sections 402.1 through 402.3, 403.2.1 and 404.1 (prescriptive); or
2. Section 405 (performance).

401.3 Certificate. A permanent certificate shall be posted on or in the electrical distribution panel. The certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. The certificate shall be completed by the builder or registered design professional. The certificate shall list the predominant *R*-values of insulation installed in or on ceiling/roof, walls, foundation (slab, *basement wall*, crawlspace wall and/or floor) and ducts outside conditioned spaces; *U*-factors for fenestration and the solar heat gain coefficient (SHGC) of fenestration. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall list the types and efficiencies of heating, cooling and service water heating equipment. Where a gas-fired unvented room heater, electric furnace, or baseboard electric heater is installed in the residence, the certificate shall list "gas-fired unvented room heater," "electric furnace" or "baseboard electric heater," as appropriate. An efficiency shall not be *listed* for gas-fired unvented room heaters, electric furnaces or electric baseboard heaters.

SECTION 402
BUILDING THERMAL ENVELOPE

402.1 General (Prescriptive).

402.1.1 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Table 402.1.1 based on the climate *zone* specified in Chapter 3.

402.1.2 *R*-value computation. Insulation material used in layers, such as framing cavity insulation and insulating sheathing, shall be summed to compute the component *R*-value. The manufacturer's settled *R*-value shall be used for blown insulation. Computed *R*-values shall not include an *R*-value for other building materials or air films.

TABLE 402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[i]	FLOOR *R*-VALUE	BASEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
1	1.2	0.75	0.30	30	13	3/4	13	0	0	0
2	0.65[j]	0.75	0.30	30	13	4/6	13	0	0	0
3	0.50[j]	0.65	0.30	30	13	5/8	19	5/13[f]	0	5/13
4 except Marine	0.35	0.60	NR	38	13	5/10	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.35	0.60	NR	38	20 or 13+5[h]	13/17	30[g]	10/13	10, 2 ft	10/13
6	0.35	0.60	NR	49	20 or 13+5[h]	15/19	30[g]	15/19	10, 4 ft	10/13
7 and 8	0.35	0.60	NR	49	21	19/21	38[g]	15/19	10, 4 ft	10/13

For SI: 1 foot = 304.8 mm.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. R-19 batts compressed into a nominal 2 × 6 framing cavity such that the *R*-value is reduced by R-1 or more shall be marked with the compressed batt *R*-value in addition to the full thickness *R*-value.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.

c. "15/19" means R-15 continuous insulated sheathing on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. "15/19" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulated sheathing on the interior or exterior of the home. "10/13" means R-10 continuous insulated sheathing on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall.

d. R-5 shall be added to the required slab edge *R*-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Zones 1 through 3 for heated slabs.

e. There are no SHGC requirements in the Marine Zone.

f. Basement wall insulation is not required in warm-humid locations as defined by Figure 301.1 and Table 301.1.

g. Or insulation sufficient to fill the framing cavity, R-19 minimum.

h. "13+5" means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25 percent or less of the exterior, insulating sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25 percent of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.

i. The second *R*-value applies when more than half the insulation is on the interior of the mass wall.

j. For impact rated fenestration complying with Section R301.2.1.2 of the *International Residential Code* or Section 1608.1.2 of the *International Building Code*, the maximum *U*-factor shall be 0.75 in Zone 2 and 0.65 in Zone 3.

TABLE 402.1.3
EQUIVALENT *U*-FACTORS[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR[c]
1	1.20	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.65	0.75	0.035	0.082	0.165	0.064	0.360	0.477
3	0.50	0.65	0.035	0.082	0.141	0.047	0.091[c]	0.136
4 except Marine	0.35	0.60	0.030	0.082	0.141	0.047	0.059	0.065
5 and Marine 4	0.35	0.60	0.030	0.057	0.082	0.033	0.059	0.065
6	0.35	0.60	0.026	0.057	0.060	0.033	0.050	0.065
7 and 8	0.35	0.60	0.026	0.057	0.057	0.028	0.050	0.065

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.
b. When more than half the insulation is on the interior, the mass wall *U*-factors shall be a maximum of 0.17 in Zone 1, 0.14 in Zone 2, 0.12 in Zone 3, 0.10 in Zone 4 except Marine, and the same as the frame wall *U*-factor in Marine Zone 4 and Zones 5 through 8.
c. Basement wall *U*-factor of 0.360 in warm-humid locations as defined by Figure 301.1 and Table 301.1.

402.1.3 *U*-factor alternative. An assembly with a *U*-factor equal to or less than that specified in Table 402.1.3 shall be permitted as an alternative to the *R*-value in Table 402.1.1.

402.1.4 Total UA alternative. If the total *building thermal envelope* UA (sum of *U*-factor times assembly area) is less than or equal to the total UA resulting from using the *U*-factors in Table 402.1.3 (multiplied by the same assembly area as in the proposed building), the building shall be considered in compliance with Table 402.1.1. The UA calculation shall be done using a method consistent with the ASHRAE *Handbook of Fundamentals* and shall include the thermal bridging effects of framing materials. The SHGC requirements shall be met in addition to UA compliance.

402.2 Specific insulation requirements (Prescriptive).

402.2.1 Ceilings with attic spaces. When Section 402.1.1 would require R-38 in the ceiling, R-30 shall be deemed to satisfy the requirement for R-38 wherever the full height of uncompressed R-30 insulation extends over the wall top plate at the eaves. Similarly, R-38 shall be deemed to satisfy the requirement for R-49 wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves. This reduction shall not apply to the *U*-factor alternative approach in Section 402.1.3 and the total UA alternative in Section 402.1.4.

402.2.2 Ceilings without attic spaces. Where Section 402.1.1 would require insulation levels above R-30 and the design of the roof/ceiling assembly does not allow sufficient space for the required insulation, the minimum required insulation for such roof/ceiling assemblies shall be R-30. This reduction of insulation from the requirements of Section 402.1.1 shall be limited to 500 square feet (46 m²) or 20 percent of the total insulated ceiling area, whichever is less. This reduction shall not apply to the *U*-factor alternative approach in Section 402.1.3 and the total UA alternative in Section 402.1.4.

402.2.3 Access hatches and doors. Access doors from conditioned spaces to unconditioned spaces (e.g., attics and crawl spaces) shall be weatherstripped and insulated to a level equivalent to the insulation on the surrounding surfaces. Access shall be provided to all equipment that prevents damaging or compressing the insulation. A wood framed or equivalent baffle or retainer is required to be provided when loose fill insulation is installed, the purpose of which is to prevent the loose fill insulation from spilling into the living space when the attic access is opened, and to provide a permanent means of maintaining the installed *R*-value of the loose fill insulation.

402.2.4 Mass walls. Mass walls for the purposes of this chapter shall be considered above-grade walls of concrete block, concrete, insulated concrete form (ICF), masonry cavity, brick (other than brick veneer), earth (adobe, compressed earth block, rammed earth) and solid timber/logs.

402.2.5 Steel-frame ceilings, walls, and floors. Steel-frame ceilings, walls and floors shall meet the insulation requirements of Table 402.2.5 or shall meet the *U*-factor requirements in Table 402.1.3. The calculation of the *U*-factor for a steel-frame envelope assembly shall use a series-parallel path calculation method.

Exception: In Climate Zones 1 and 2, the continuous insulation requirements in Table 402.2.5 shall be permitted to be reduced to R-3 for steel frame wall assemblies with studs spaced at 24 inches (610 mm) on center.

TABLE 402.2.5
STEEL-FRAME CEILING, WALL AND FLOOR INSULATION
(*R*-VALUE)

WOOD FRAME *R*-VALUE REQUIREMENT	COLD-FORMED STEEL EQUIVALENT *R*-VALUE[a]
Steel Truss Ceilings[b]	
R-30	R-38 or R-30 + 3 or R-26 + 5
R-38	R-49 or R-38 + 3
R-49	R-38 + 5
Steel Joist Ceilings[b]	
R-30	R-38 in 2 × 4 or 2 × 6 or 2 × 8 R-49 in any framing
R-38	R-49 in 2 × 4 or 2 × 6 or 2 × 8 or 2 × 10
Steel-Framed Wall	
R-13	R-13 + 5 or R-15 + 4 or R-21 + 3 or R-0 + 10
R-19	R-13 + 9 or R-19 + 8 or R-25 + 7
R-21	R-13 + 10 or R-19 + 9 or R-25 + 8
Steel Joist Floor	
R-13	R-19 in 2 × 6 R-19 + 6 in 2 × 8 or 2 × 10
R-19	R-19 + 6 in 2 × 6 R-19 + 12 in 2 × 8 or 2 × 10

a. Cavity insulation *R*-value is listed first, followed by continuous insulation *R*-value.
b. Insulation exceeding the height of the framing shall cover the framing.

402.2.6 Floors. Floor insulation shall be installed to maintain permanent contact with the underside of the subfloor decking.

402.2.7 Basement walls. Walls associated with conditioned basements shall be insulated from the top of the *basement wall* down to 10 feet (3048 mm) below grade or to the basement floor, whichever is less. Walls associated with unconditioned basements shall meet this requirement unless the floor overhead is insulated in accordance with Sections 402.1.1 and 402.2.6.

402.2.8 Slab-on-grade floors. Slab-on-grade floors with a floor surface less than 12 inches (305 mm) below grade shall be insulated in accordance with Table 402.1.1. The insulation shall extend downward from the top of the slab on the outside or inside of the foundation wall. Insulation located below grade shall be extended the distance provided in Table 402.1.1 by any combination of vertical insulation, insulation extending under the slab or insulation extending out from the building. Insulation extending away from the building shall be protected by pavement or by a minimum of 10 inches (254 mm) of soil. The top edge of the insulation installed between the *exterior wall* and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the *exterior wall*. Slab-edge insulation is not required in jurisdictions designated by the *code official* as having a very heavy termite infestation.

402.2.9 Crawl space walls. As an alternative to insulating floors over crawl spaces, crawl space walls shall be permitted to be insulated when the crawl space is not vented to the outside. Crawl space wall insulation shall be permanently fastened to the wall and extend downward from the floor to the finished grade level and then vertically and/or horizontally for at least an additional 24 inches (610 mm). Exposed earth in unvented crawl space foundations shall be covered with a continuous Class I vapor retarder in accordance with the *International Building Code*. All joints of the vapor retarder shall overlap by 6 inches (153 mm) and be sealed or taped. The edges of the vapor retarder shall extend at least 6 inches (153 mm) up the stem wall and shall be attached to the stem wall.

402.2.10 Masonry veneer. Insulation shall not be required on the horizontal portion of the foundation that supports a masonry veneer.

402.2.11 Thermally isolated sunroom insulation. The minimum ceiling insulation *R*-values shall be R-19 in Zones 1 through 4 and R-24 in Zones 5 through 8. The minimum wall *R*-value shall be R-13 in all zones. New wall(s) separating a sunroom from *conditioned space* shall meet the *building thermal envelope* requirements.

402.3 Fenestration. (Prescriptive).

402.3.1 *U*-factor. An area-weighted average of fenestration products shall be permitted to satisfy the *U*-factor requirements.

402.3.2 Glazed fenestration SHGC. An area-weighted average of fenestration products more than 50 percent glazed shall be permitted to satisfy the SHGC requirements.

402.3.3 Glazed fenestration exemption. Up to 15 square feet (1.4 m²) of glazed fenestration per dwelling unit shall be permitted to be exempt from *U*-factor and SHGC requirements in Section 402.1.1. This exemption shall not apply to the *U*-factor alternative approach in Section 402.1.3 and the Total UA alternative in Section 402.1.4.

402.3.4 Opaque door exemption. One side-hinged opaque door assembly up to 24 square feet (2.22 m²) in area is exempted from the *U*-factor requirement in Section 402.1.1. This exemption shall not apply to the *U*-factor alternative approach in Section 402.1.3 and the total UA alternative in Section 402.1.4.

402.3.5 Thermally isolated sunroom *U*-factor. For Zones 4 through 8, the maximum fenestration *U*-factor shall be 0.50 and the maximum skylight *U*-factor shall be 0.75. New windows and doors separating the sunroom from *conditioned space* shall meet the *building thermal envelope* requirements.

402.3.6 Replacement fenestration. Where some or all of an existing fenestration unit is replaced with a new fenestration product, including sash and glazing, the replacement fenestration unit shall meet the applicable requirements for *U*-factor and SHGC in Table 402.1.1.

402.4 Air leakage (Mandatory).

402.4.1 Building thermal envelope. The *building thermal envelope* shall be durably sealed to limit infiltration. The sealing methods between dissimilar materials shall allow for differential expansion and contraction. The following shall be caulked, gasketed, weatherstripped or otherwise sealed with an air barrier material, suitable film or solid material:

1. All joints, seams and penetrations.

2. Site-built windows, doors and skylights.
3. Openings between window and door assemblies and their respective jambs and framing.
4. Utility penetrations.
5. Dropped ceilings or chases adjacent to the thermal envelope.
6. Knee walls.
7. Walls and ceilings separating a garage from conditioned spaces.
8. Behind tubs and showers on exterior walls.
9. Common walls between dwelling units.
10. Attic access openings.
11. Rim joist junction.
12. Other sources of infiltration.

402.4.2 Air sealing and insulation. Building envelope air tightness and insulation installation shall be demonstrated to comply with one of the following options given by Section 402.4.2.1 or 402.4.2.2:

402.4.2.1 Testing option. Building envelope tightness and insulation installation shall be considered acceptable when tested air leakage is less than seven air changes per hour (ACH) when tested with a blower door at a pressure of 50 pascals (1 psf). Testing shall occur after rough in and after installation of penetrations of the building envelope, including penetrations for utilities, plumbing, electrical, ventilation and combustion appliances.

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed;
2. Dampers shall be closed, but not sealed, including exhaust, intake, makeup air, backdraft and flue dampers;
3. Interior doors shall be open;
4. Exterior openings for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
5. Heating and cooling system(s) shall be turned off;
6. HVAC ducts shall not be sealed; and
7. Supply and return registers shall not be sealed.

402.4.2.2 Visual inspection option. Building envelope tightness and insulation installation shall be considered acceptable when the items listed in Table 402.4.2, applicable to the method of construction, are field verified. Where required by the *code official*, an *approved* party independent from the installer of the insulation shall inspect the air barrier and insulation.

402.4.3 Fireplaces. New wood-burning fireplaces shall have gasketed doors and outdoor combustion air.

402.4.4 Fenestration air leakage. Windows, skylights and sliding glass doors shall have an air infiltration rate of no more than 0.3 cfm per square foot (1.5 L/s/m^2), and swinging doors no more than 0.5 cfm per square foot (2.6 L/s/m^2), when tested according to NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and *listed* and *labeled* by the manufacturer.

Exceptions: Site-built windows, skylights and doors.

402.4.5 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be sealed to limit air leakage between conditioned and unconditioned spaces. All recessed luminaires shall be IC-rated and *labeled* as meeting ASTM E 283 when tested at 1.57 psf (75 Pa) pressure differential with no more than 2.0 cfm (0.944 L/s) of air movement from the *conditioned space* to the ceiling cavity. All recessed luminaires shall be sealed with a gasket or caulk between the housing and the interior wall or ceiling covering.

402.5 Maximum fenestration *U*-factor and SHGC (Mandatory). The area-weighted average maximum fenestration *U*-factor permitted using trade-offs from Section 402.1.4 or 405 shall be 0.48 in Zones 4 and 5 and 0.40 in Zones 6 through 8 for vertical fenestration, and 0.75 in Zones 4 through 8 for skylights. The area-weighted average maximum fenestration SHGC permitted using trade-offs from Section 405 in Zones 1 through 3 shall be 0.50.

SECTION 403
SYSTEMS

403.1 Controls (Mandatory). At least one thermostat shall be provided for each separate heating and cooling system.

403.1.1 Programmable thermostat. Where the primary heating system is a forced-air furnace, at least one thermostat per dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points at different times of the day. This thermostat shall include the capability to set back or temporarily operate the system to maintain zone temperatures down to 55°F (13°C) or up to 85°F (29°C). The thermostat shall initially be programmed with a heating temperature set point no higher than 70°F (21°C) and a cooling temperature set point no lower than 78°F (26°C).

403.1.2 Heat pump supplementary heat (Mandatory). Heat pumps having supplementary electric-resistance heat shall have controls that, except during defrost, prevent supplemental heat operation when the heat pump compressor can meet the heating load.

403.2 Ducts.

403.2.1 Insulation (Prescriptive). Supply ducts in attics shall be insulated to a minimum of R-8. All other ducts shall be insulated to a minimum of R-6.

Exception: Ducts or portions thereof located completely inside the *building thermal envelope*.

403.2.2 Sealing (Mandatory). All ducts, air handlers, filter boxes and building cavities used as ducts shall be sealed.

Joints and seams shall comply with Section M1601.4.1 of the *International Residential Code*.

Duct tightness shall be verified by either of the following:

1. Postconstruction test: Leakage to outdoors shall be less than or equal to 8 cfm (226.5 L/min) per 100 ft² (9.29 m²) of *conditioned floor area* or a total leakage less than or equal to 12 cfm (12 L/min) per 100 ft² (9.29 m²) of *conditioned floor area* when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test.
2. Rough-in test: Total leakage shall be less than or equal to 6 cfm (169.9 L/min) per 100 ft² (9.29 m²) of *conditioned floor area* when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the roughed in system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test. If the air handler is not installed at the time of the test, total leakage shall be less than or equal to 4 cfm (113.3 L/min) per 100 ft² (9.29 m²) of *conditioned floor area*.

Exceptions: Duct tightness test is not required if the air handler and all ducts are located within *conditioned space*.

TABLE 402.4.2
AIR BARRIER AND INSULATION INSPECTION COMPONENT CRITERIA

COMPONENT	CRITERIA
Air barrier and thermal barrier	Exterior thermal envelope insulation for framed walls is installed in substantial contact and continuous alignment with building envelope air barrier. Breaks or joints in the air barrier are filled or repaired. Air-permeable insulation is not used as a sealing material. Air-permeable insulation is inside of an air barrier.
Ceiling/attic	Air barrier in any dropped ceiling/soffit is substantially aligned with insulation and any gaps are sealed. Attic access (except unvented attic), knee wall door, or drop down stair is sealed.
Walls	Corners and headers are insulated. Junction of foundation and sill plate is sealed.
Windows and doors	Space between window/door jambs and framing is sealed.
Rim joists	Rim joists are insulated and include an air barrier.
Floors (including above-garage and cantilevered floors)	Insulation is installed to maintain permanent contact with underside of subfloor decking. Air barrier is installed at any exposed edge of insulation.
Crawl space walls	Insulation is permanently attached to walls. Exposed earth in unvented crawl spaces is covered with Class I vapor retarder with overlapping joints taped.
Shafts, penetrations	Duct shafts, utility penetrations, knee walls and flue shafts opening to exterior or unconditioned space are sealed.
Narrow cavities	Batts in narrow cavities are cut to fit, or narrow cavities are filled by sprayed/blown insulation.
Garage separation	Air sealing is provided between the garage and conditioned spaces.
Recessed lighting	Recessed light fixtures are air tight, IC rated, and sealed to drywall. Exception—fixtures in conditioned space.
Plumbing and wiring	Insulation is placed between outside and pipes. Batt insulation is cut to fit around wiring and plumbing, or sprayed/blown insulation extends behind piping and wiring.
Shower/tub on exterior wall	Showers and tubs on exterior walls have insulation and an air barrier separating them from the exterior wall.
Electrical/phone box on exterior walls	Air barrier extends behind boxes or air sealed-type boxes are installed.
Common wall	Air barrier is installed in common wall between dwelling units.
HVAC register boots	HVAC register boots that penetrate building envelope are sealed to subfloor or drywall.
Fireplace	Fireplace walls include an air barrier.

403.2.3 Building cavities (Mandatory). Building framing cavities shall not be used as supply ducts.

403.3 Mechanical system piping insulation (Mandatory). Mechanical system piping capable of carrying fluids above 105°F (41°C) or below 55°F (13°C) shall be insulated to a minimum of R-3.

403.4 Circulating hot water systems (Mandatory). All circulating service hot water piping shall be insulated to at least R-2. Circulating hot water systems shall include an automatic or readily *accessible* manual switch that can turn off the hot-water circulating pump when the system is not in use.

403.5 Mechanical ventilation (Mandatory). Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

403.6 Equipment sizing (Mandatory). Heating and cooling equipment shall be sized in accordance with Section M1401.3 of the *International Residential Code*.

403.7 Systems serving multiple dwelling units (Mandatory). Systems serving multiple dwelling units shall comply with Sections 503 and 504 in lieu of Section 403.

403.8 Snow melt system controls (Mandatory). Snow- and ice-melting systems, supplied through energy service to the building, shall include automatic controls capable of shutting off the system when the pavement temperature is above 50°F, and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F.

403.9 Pools (Mandatory). Pools shall be provided with energy-conserving measures in accordance with Sections 403.9.1 through 403.9.3.

403.9.1 Pool heaters. All pool heaters shall be equipped with a readily *accessible* on-off switch to allow shutting off the heater without adjusting the thermostat setting. Pool heaters fired by natural gas or LPG shall not have continuously burning pilot lights.

403.9.2 Time switches. Time switches that can automatically turn off and on heaters and pumps according to a preset schedule shall be installed on swimming pool heaters and pumps.

Exceptions:

1. Where public health standards require 24-hour pump operation.
2. Where pumps are required to operate solar- and waste-heat-recovery pool heating systems.

403.9.3 Pool covers. Heated pools shall be equipped with a vapor-retardant pool cover on or at the water surface. Pools heated to more than 90°F (32°C) shall have a pool cover with a minimum insulation value of R-12.

Exception: Pools deriving over 60 percent of the energy for heating from site-recovered energy or solar energy source.

SECTION 404
ELECTRICAL POWER AND LIGHTING SYSTEMS

404.1 Lighting equipment (Prescriptive). A minimum of 50 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps.

SECTION 405
SIMULATED PERFORMANCE ALTERNATIVE (Performance)

405.1 Scope. This section establishes criteria for compliance using simulated energy performance analysis. Such analysis shall include heating, cooling, and service water heating energy only.

405.2 Mandatory requirements. Compliance with this section requires that the mandatory provisions identified in Section 401.2 be met. All supply and return ducts not completely inside the *building thermal envelope* shall be insulated to a minimum of R-6.

405.3 Performance-based compliance. Compliance based on simulated energy performance requires that a proposed residence (*proposed design*) be shown to have an annual energy cost that is less than or equal to the annual energy cost of the *standard reference design*. Energy prices shall be taken from a source *approved* by the *code official*, such as the Department of Energy, Energy Information Administration's *State Energy Price and Expenditure Report*. *Code officials* shall be permitted to require time-of-use pricing in energy cost calculations.

Exception: The energy use based on source energy expressed in Btu or Btu per square foot of *conditioned floor area* shall be permitted to be substituted for the energy cost. The source energy multiplier for electricity shall be 3.16. The source energy multiplier for fuels other than electricity shall be 1.1.

405.4 Documentation.

405.4.1 Compliance software tools. Documentation verifying that the methods and accuracy of the compliance software tools conform to the provisions of this section shall be provided to the *code official*.

405.4.2 Compliance report. Compliance software tools shall generate a report that documents that the *proposed design* complies with Section 405.3. The compliance documentation shall include the following information:

1. Address or other identification of the residence;
2. An inspection checklist documenting the building component characteristics of the *proposed design* as listed in Table 405.5.2(1). The inspection checklist shall show results for both the *standard reference design* and the *proposed design*, and shall document all inputs entered by the user necessary to reproduce the results;
3. Name of individual completing the compliance report; and

4. Name and version of the compliance software tool.

Exception: Multiple orientations. When an otherwise identical building model is offered in multiple orientations, compliance for any orientation shall be permitted by documenting that the building meets the performance requirements in each of the four cardinal (north, east, south and west) orientations.

405.4.3 Additional documentation. The *code official* shall be permitted to require the following documents:

1. Documentation of the building component characteristics of the *standard reference design*.
2. A certification signed by the builder providing the building component characteristics of the *proposed design* as given in Table 405.5.2(1).
3. Documentation of the actual values used in the software calculations for the *proposed design*.

405.5 Calculation procedure.

405.5.1 General. Except as specified by this section, the *standard reference design* and *proposed design* shall be configured and analyzed using identical methods and techniques.

405.5.2 Residence specifications. The *standard reference design* and *proposed design* shall be configured and analyzed as specified by Table 405.5.2(1). Table 405.5.2(1) shall include by reference all notes contained in Table 402.1.1.

405.6 Calculation software tools.

405.6.1 Minimum capabilities. Calculation procedures used to comply with this section shall be software tools capable of calculating the annual energy consumption of all building elements that differ between the *standard reference design* and the *proposed design* and shall include the following capabilities:

1. Computer generation of the *standard reference design* using only the input for the *proposed design*. The calculation procedure shall not allow the user to directly modify the building component characteristics of the *standard reference design*.
2. Calculation of whole-building (as a single *zone*) sizing for the heating and cooling equipment in the *standard reference design* residence in accordance with Section M1401.3 of the *International Residential Code*.
3. Calculations that account for the effects of indoor and outdoor temperatures and part-load ratios on the performance of heating, ventilating and air-conditioning equipment based on climate and equipment sizing.
4. Printed *code official* inspection checklist listing each of the *proposed design* component characteristics from Table 405.5.2(1) determined by the analysis to provide compliance, along with their respective performance ratings (e.g., *R*-value, *U*-factor, SHGC, HSPF, AFUE, SEER, EF, etc.).

405.6.2 Specific approval. Performance analysis tools meeting the applicable sections of Section 405 shall be permitted to be *approved*. Tools are permitted to be *approved* based on meeting a specified threshold for a jurisdiction. The *code official* shall be permitted to approve tools for a specified application or limited scope.

405.6.3 Input values. When calculations require input values not specified by Sections 402, 403, 404 and 405, those input values shall be taken from an *approved* source.

TABLE 405.5.2(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Above-grade walls	Type: mass wall if proposed wall is mass; otherwise wood frame. Gross area: same as proposed *U*-factor: from Table 402.1.3 Solar absorptance = 0.75 Remittance = 0.90	As proposed As proposed As proposed As proposed As proposed
Basement and crawl space walls	Type: same as proposed Gross area: same as proposed *U*-factor: from Table 402.1.3, with insulation layer on interior side of walls.	As proposed As proposed As proposed
Above-grade floors	Type: wood frame Gross area: same as proposed *U*-factor: from Table 402.1.3	As proposed As proposed As proposed
Ceilings	Type: wood frame Gross area: same as proposed *U*-factor: from Table 402.1.3	As proposed As proposed As proposed
Roofs	Type: composition shingle on wood sheathing Gross area: same as proposed Solar absorptance = 0.75 Emittance = 0.90	As proposed As proposed As proposed As proposed
Attics	Type: vented with aperture = 1 ft² per 300 ft² ceiling area	As proposed
Foundations	Type: same as proposed foundation wall area above and below grade and soil characteristics: same as proposed.	As proposed As proposed
Doors	Area: 40 ft² Orientation: North *U*-factor: same as fenestration from Table 402.1.3.	As proposed As proposed As proposed
Glazing[a]	Total area[b] = (a) The proposed glazing area; where proposed glazing area is less than 15% of the conditioned floor area. (b) 15% of the conditioned floor area; where the proposed glazing area is 15% or more of the conditioned floor area. Orientation: equally distributed to four cardinal compass orientations (N, E, S & W). *U*-factor: from Table 402.1.3 SHGC: From Table 402.1.1 except that for climates with no requirement (NR) SHGC = 0.40 shall be used. Interior shade fraction: Summer (all hours when cooling is required) = 0.70 Winter (all hours when heating is required) = 0.85[c] External shading: none	As proposed As proposed As proposed As proposed Same as standard reference design As proposed
Skylights	None	As proposed
Thermally isolated sunrooms	None	As proposed

(continued)

TABLE 405.5.2(1)—continued
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Air exchange rate	Specific leakage area (SLA)[d] = 0.00036 assuming no energy recovery	For residences that are not tested, the same as the standard reference design. For residences without mechanical ventilation that are tested in accordance with ASHRAE 119, Section 5.1, the measured air exchange rate[e] but not less than 0.35 ACH For residences with mechanical ventilation that are tested in accordance with ASHRAE 119, Section 5.1, the measured air exchange rate[e] combined with the mechanical ventilation rate, f which shall not be less than $0.01 \times CFA + 7.5 \times (N_{br}+1)$ where: CFA = conditioned floor area N_{br} = number of bedrooms
Mechanical ventilation	None, except where mechanical ventilation is specified by the proposed design, in which case: Annual vent fan energy use: kWh/yr = $0.03942 \times CFA + 29.565 \times (N_{br} +1)$ where: CFA = conditioned floor area N_{br} = number of bedrooms	As proposed
Internal gains	IGain = $17{,}900 + 23.8 \times CFA + 4104 \times N_{br}$ (Btu/day per dwelling unit)	Same as standard reference design
Internal mass	An internal mass for furniture and contents of 8 pounds per square foot of floor area.	Same as standard reference design, plus any additional mass specifically designed as a thermal storage element[g, f] but not integral to the building envelope or structure
Structural mass	For masonry floor slabs, 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air. For masonry basement walls, as proposed, but with insulation required by Table 402.1.3 located on the interior side of the walls For other walls, for ceilings, floors, and interior walls, wood frame construction	As proposed As proposed As proposed
Heating systems[g, h]	As proposed Capacity: sized in accordance with Section M1401.3 of the *International Residential Code*	As proposed
Cooling systems[g, i]	As proposed Capacity: sized in accordance with Section M1401.3 of the *International Residential Code*	As proposed
Service water heating[b, k]	As proposed Use: same as proposed design	As proposed gal/day = $30 + (10 \times N_{br})$
Thermal distribution systems	A thermal distribution system efficiency (DSE) of 0.88 shall be applied to both the heating and cooling system efficiencies for all systems other than tested duct systems. Duct insulation: From Section 403.2.1. For tested duct systems, the leakage rate shall be the applicable maximum rate from Section 403.2.2.	As tested or as specified in Table 405.5.2(2) if not tested
Thermostat	Type: Manual, cooling temperature setpoint = 75°F; Heating temperature setpoint = 72°F	Same as standard reference

(continued)

TABLE 405.5.2(1)—continued

For SI: 1 square foot = 0.93 m^2; 1 British thermal unit = 1055 J; 1 pound per square foot = 4.88 kg/m^2; 1 gallon (U.S.) = 3.785 L; °C = (°F-3)/1.8, 1 degree = 0.79 rad.

a. Glazing shall be defined as sunlight-transmitting fenestration, including the area of sash, curbing or other framing elements, that enclose conditioned space. Glazing includes the area of sunlight-transmitting fenestration assemblies in walls bounding conditioned basements. For doors where the sunlight-transmitting opening is less than 50 percent of the door area, the glazing area is the sunlight transmitting opening area. For all other doors, the glazing area is the rough frame opening area for the door including the door and the frame.

b. For residences with conditioned basements, R-2 and R-4 residences and townhouses, the following formula shall be used to determine glazing area:

$AF = A_s \times FA \times F$

where:

AF = Total glazing area.

A_s = Standard reference design total glazing area.

FA = (Above-grade thermal boundary gross wall area)/(above-grade boundary wall area + 0.5 × below-grade boundary wall area).

F = (Above-grade thermal boundary wall area)/(above-grade thermal boundary wall area + common wall area) or 0.56, whichever is greater.

and where:

Thermal boundary wall is any wall that separates conditioned space from unconditioned space or ambient conditions.

Above-grade thermal boundary wall is any thermal boundary wall component not in contact with soil.

Below-grade boundary wall is any thermal boundary wall in soil contact.

Common wall area is the area of walls shared with an adjoining dwelling unit.

c. For fenestrations facing within 15 degrees (0.26 rad) of true south that are directly coupled to thermal storage mass, the winter interior shade fraction shall be permitted to be increased to 0.95 in the proposed design.

d. Where leakage area (L) is defined in accordance with Section 5.1 of ASHRAE 119 and where:

$SLA = L/CFA$

where L and CFA are in the same units.

e. Tested envelope leakage shall be determined and documented by an independent party approved by the *code official*. Hourly calculations as specified in the 2001 ASHRAE *Handbook of Fundamentals*, Chapter 26, page 26.21, Equation 40 (Sherman-Grimsrud model) or the equivalent shall be used to determine the energy loads resulting from infiltration.

f. The combined air exchange rate for infiltration and mechanical ventilation shall be determined in accordance with Equation 43 of 2001 ASHRAE *Handbook of Fundamentals*, page 26.24 and the "Whole-house Ventilation" provisions of 2001 ASHRAE *Handbook of Fundamentals*, page 26.19 for intermittent mechanical ventilation.

g. Thermal storage element shall mean a component not part of the floors, walls or ceilings that is part of a passive solar system, and that provides thermal storage such as enclosed water columns, rock beds, or phase-change containers. A thermal storage element must be in the same room as fenestration that faces within 15 degrees (0.26 rad) of true south, or must be connected to such a room with pipes or ducts that allow the element to be actively charged.

h. For a proposed design with multiple heating, cooling or water heating systems using different fuel types, the applicable standard reference design system capacities and fuel types shall be weighted in accordance with their respective loads as calculated by accepted engineering practice for each equipment and fuel type present.

i. For a proposed design without a proposed heating system, a heating system with the prevailing federal minimum efficiency shall be assumed for both the standard reference design and proposed design. For electric heating systems, the prevailing federal minimum efficiency air-source heat pump shall be used for the standard reference design.

j. For a proposed design home without a proposed cooling system, an electric air conditioner with the prevailing federal minimum efficiency shall be assumed for both the standard reference design and the proposed design.

k. For a proposed design with a nonstorage-type water heater, a 40-gallon storage-type water heater with the prevailing federal minimum energy factor for the same fuel as the predominant heating fuel type shall be assumed. For the case of a proposed design without a proposed water heater, a 40-gallon storage-type water heater with the prevailing federal minimum efficiency for the same fuel as the predominant heating fuel type shall be assumed for both the proposed design and standard reference design.

TABLE 405.5.2(2)
DEFAULT DISTRIBUTION SYSTEM EFFICIENCIES FOR PROPOSED DESIGNS[a]

DISTRIBUTION SYSTEM CONFIGURATION AND CONDITION:	FORCED AIR SYSTEMS	HYDRONIC SYSTEMS[b]
Distribution system components located in unconditioned space	—	0.95
Untested distribution systems entirely located in conditioned space[c]	0.88	1
"Ductless" systems[d]	1	—

For SI: 1 cubic foot per minute = 0.47 L/s; 1 square foot = 0.093 m^2; 1 pound per square inch = 6895 Pa; 1 inch water gauge = 1250 Pa.

a. Default values given by this table are for untested distribution systems, which must still meet minimum requirements for duct system insulation.

b. Hydronic systems shall mean those systems that distribute heating and cooling energy directly to individual spaces using liquids pumped through closed loop piping and that do not depend on ducted, forced airflow to maintain space temperatures.

c. Entire system in conditioned space shall mean that no component of the distribution system, including the air handler unit, is located outside of the conditioned space.

d. Ductless systems shall be allowed to have forced airflow across a coil but shall not have any ducted airflow external to the manufacturer's air handler enclosure.

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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BATTELLE
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UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

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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.

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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

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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.

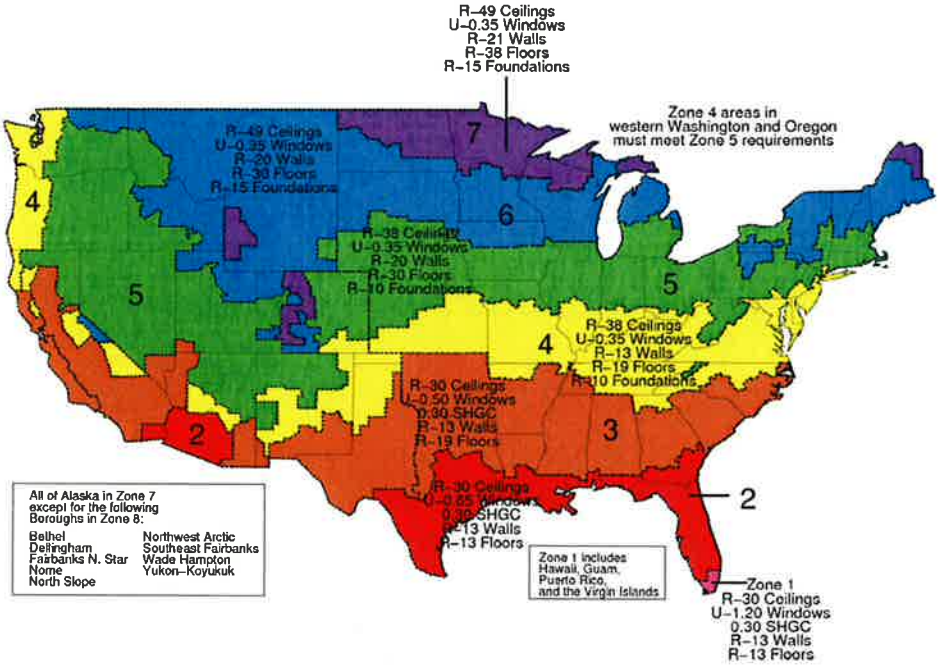

Figure 1. Prescriptive Envelope requirements

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.

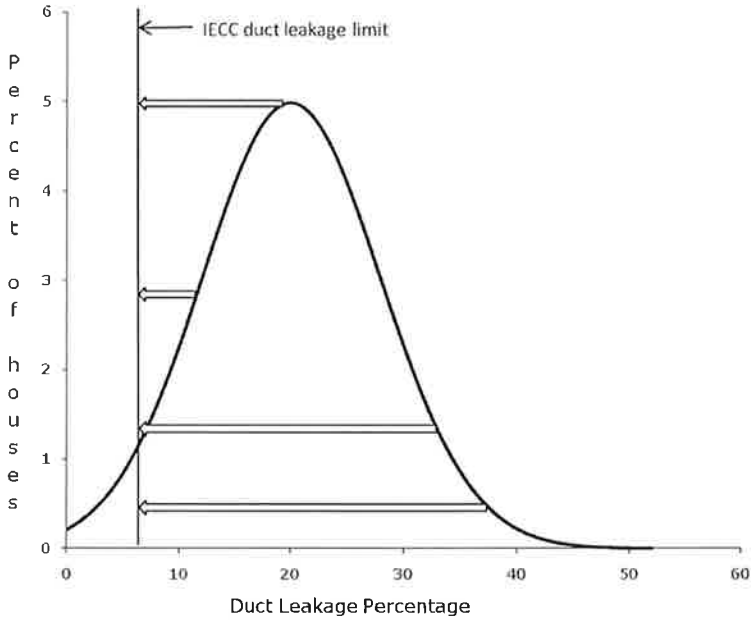

Figure 2. Impact of improved duct sealing. The curve illustrates the approximate distribution of leakage rate in new homes. The arrows show the reduction in duct leakage necessary to meet the code requirement.

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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BUILDING ENERGY CODES PROGRAM

Impacts of the 2009 IECC on Residential Buildings in Arkansas

September 2009

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

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

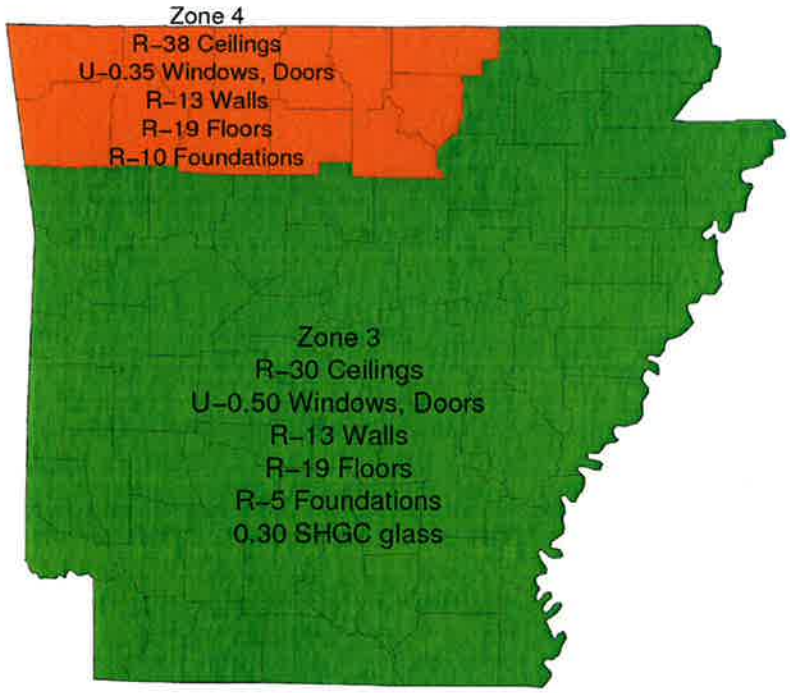
Summary

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 1 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 1. 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

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