IECC
Pathways, Science, and More

Presented by Robby Schwarz

Energy Logic
Helping Colorado Builders Achieve Peak Performance

Agenda

- Intent of the IECC
- Systems Thinking
- The look and layout of the 2018 IECC
- Pathways through the code

Change is Hard ... Change is Good... Change can be Made Easier
Expectation
The fact is that People buying houses don't know that they want to talk about performance

• Largest Purchase
• Least knowledge
The key factor of code development

Adoption

Amendment

- a·mend·ment
- əˈmɛn(d)ˌmɛnt/
- noun
- a minor change in a document.
- a change or addition to a legal or statutory document.
2018 IECC – Intent

This code shall regulate the design and construction of buildings for the effective use and conservation of energy **over the useful life of each building**

- Durability
2018 IECC – Intent

This code is intended to provide flexibility to permit innovative approaches and techniques to achieve this objective

“Learn the rules so you know how to break them properly”

Author: Dalai Lama
Date: Feb 25, 2008

2018 IECC – Intent

The code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances
Energy Code

It's not your Daddy's code?

• No longer building the minimum _ _ _ house allowable!
Look how houses have changed

1910

2017

https://thecraftsmanblog.com/how-to-tell-if-you-have-a-balloon-frame-house/
Applied Building Science

- Holistic approach rather than a component approach.
- Synergy
  - The various parts work together
  - **Achieving** what could not be achieved before!

- Meeting the Expectations
  - Aesthetics
  - Safe
  - Comfort
  - Durable
  - Efficient
  - Environmental
Synergy = Systems Thinking

• 1+1 = 1
  ▪ Fan + Duct = Air flow
• 1+1 = 2
  ▪ Fan + Duct = Air flow + Ventilation
• 1+1 = 3
  ▪ Fan + Duct = Air flow + Ventilation + Durability
• 1+1 = 4
  ▪ Fan + Duct = Air flow + Ventilation + Durability + IAQ

If the House is an Operating System

• There are three parts to the system...
House as a System and Applied Building Science

People Factors

- What do they care about?
- Expectations
  - Safety
  - Energy Efficiency
  - Durability
  - Sustainability
  - Comfort

- People = Need for Systems Thinking

How to take the people out of the equation
Understand

- We are no longer true “builders”
- Leaders of change and innovation
- Understand Systems thinking and applied building science
- Understand performance
- Help educate our trade partners
- Inform the trades of our objectives
- Design – construct – test – review – learn

Warranty
Who is actually using this code?

- Proactive designers
- Market conscience builders
- Building owners who care about their buildings and their costs
- Code Officials who are aware that building owners have expectations

“When I buy a building I **expect** it to stand through a wind storm. I **expect** my roof to hold the snow load. I **expect** the hot water to be hot and the cold water to be cold. I **expect** the building to be durable and I **expect** my next utility bill will not put me out of my next mortgage payment!”

The look and layout of the 2018 IECC

The IECC covers both:

- Commercial (CE) chapters 1-6

  **and**

- Residential (RE) chapters 1-6
The Residential Provisions of the IECC become the energy provisions (Chapter 11) of the IRC.

**Definition of Residential per IECC** is different than that found in the IRC and IBC:

**RESIDENTIAL BUILDING**
- For this code, includes detached one- and two family dwellings and multiple single-family dwellings (townhouses) as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane

**COMMERCIAL BUILDING.** For this code, all buildings that are not included in the definition of "Residential buildings."
Chapter 1: Administration

- Often the Chief Building Official deletes Chapter 1 and inserts their own administrative provisions.

- However, the IECC has code requirements in Chapter 1, so jurisdictions are more apt to amend this chapter rather than delete it.

New since the 2012

**R101.2 Scope**
- Starting with the 2012 IECC, in addition to the code applying to residential buildings, it now also applies to the building sites and associated systems and equipment.
R102.1

• The Code official shall be permitted to approve an alternative material, design or method of construction where the code official finds that the proposed design is satisfactory and complies with the intent of the provision of this code and that the material, method or work offered is for the purpose intended, at least the equivalent of that prescribed in this code.
2018 International Residential Code

Connection to the IECC

R103.1 General

• Construction documents, technical reports and other supporting data shall be submitted in one or more sets with each application for a permit.

• The construction documents and technical reports 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.
R103

Construction Documents

• R103.1 General
  • Construction documents prepared by a design professional
  • i.e. set of plans
  • Different from compliance documents

R103.2 Information on Construction documents

• Details shall include but are not limited to:
  • Insulation location and R-values
  • Window U-value & SHGC
  • Mechanical System design criteria
  • Mechanical and water heater Type, size and efficiency
  • Duct sealing, insulation and location
  • Air sealing details

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Example Details
New in the 2015

• 103.2.1 Building Thermal Envelope depiction:
  • The buildings thermal envelope shall be represented on the construction documents
    • Blue – Exterior air barrier
    • Yellow Thermal Barrier
    • Red Interior air barrier
## IECC Residential Compliance Report

**Component/Location/Value**

<table>
<thead>
<tr>
<th>Location</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat attic</td>
<td>0</td>
<td>To the exterior</td>
</tr>
<tr>
<td>Vented Raftered</td>
<td>0</td>
<td>To the Garage</td>
</tr>
<tr>
<td>Un accessible Bldg</td>
<td>7 NAP</td>
<td>Heating System</td>
</tr>
<tr>
<td>Un vented Raftered</td>
<td>0</td>
<td>Basement</td>
</tr>
<tr>
<td>Wood Framed Walls</td>
<td>0</td>
<td>Attic</td>
</tr>
<tr>
<td>Mass Wall</td>
<td>7</td>
<td>Location</td>
</tr>
<tr>
<td>Insulation</td>
<td>0</td>
<td>Location</td>
</tr>
<tr>
<td>Insulation</td>
<td>7</td>
<td>Location</td>
</tr>
<tr>
<td>Insulation</td>
<td>10</td>
<td>Location</td>
</tr>
<tr>
<td>Insulation</td>
<td>0</td>
<td>Location</td>
</tr>
<tr>
<td>Insulation</td>
<td>0</td>
<td>Location</td>
</tr>
<tr>
<td>Insulation</td>
<td>0</td>
<td>Location</td>
</tr>
</tbody>
</table>

**Hot Water**

- Type: NA
- R-value: 0
- Energy Factor: 11 to 64 U/F
- Insulation System Type: Open-conduction / 4 vents (theven 10gkg)
- Insulation: Insulated
- Air Code: Applies

**Foundation**

- R-value: 0
- Supplemental Heat: 0
- Unvented room heater: NA
- Insulation: Yes
- Vapor Management: Tightly sealed and well insulated

**EnergyLogic** certifies that the best of our knowledge the information contained on this document is true and complete.

**Date:**

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## ENERGY COMPLIANCE FOR A NEW SINGLE FAMILY RESIDENCE AT 442 SOUTH VINE STREET

1. Project shall comply with the 2018 IECC residential provisions and the 2018 IRC, Chapter 11.
2. All mandatory requirements in IECC Sections R301 through R404 and IRC Sections R1101.1 through N1104 shall be met.
3. Compliance shall be shown using Method 2 (Simulated Performance Alternative, IECC Section R404 and IRC Section N1105).
4. The energy compliance submittal shall include:
   A. Compliance Report submitted by:
      EnergyLogic
      Rocky Software
      720 83rd Avenue
      Denver, CO 80221
   B. Energy Compliance Certificate, R.S. Sheet A101X
   C. Building sections showing the building thermal envelope, R.S. Sheet A101X
   D. Air Sealing Details and Notes, R.S. Sheet A101X
   E. HVAC Manuals, N.S. 1 and 3
5. Upon completion of the building, a compliance report based on the as-built condition of the building shall be submitted to the building official. Before a Certificate of Occupancy can be issued, the compliance report must include all requirements outlined in IECC Section R404.2 and IRC Section N1101.14. A permanent certificate shall be completed by the building inspector and posted on a wall in the building. The certificate must be posted by the time of the building's final inspection and shall use the included energy compliance certificate for posting.

**Please Note:** In addition to the air-sealing details shown on sheet A101X, the following construction methods shall be employed where applicable to comply with the requirements of IECC R402.1.1 and R402.2.1:

1. 2 or 3 stud insulated corners
2. Lumber blocking WHERE INTERIOR WALLS MEET EXTERIOR WALLS TO FULLY INSULATE THEM
3. Insulated headers
4. Sealing the drywall to the top plate adjacent to the vented attic
5. Raised heel truss to ensure that insulation can fully cover the top plate
R105 Inspections – New in the 2015 IECC

- Construction or work for which a permit is required shall be subject to inspection
- The code official or his/her agent shall inspect....

- Footing and foundation
- Framing and rough-in inspection
- Plumbing rough-in inspection
- Mechanical rough-in inspection
- Final inspection
- Re-inspection

Required Inspections

R105.2.2 Framing and rough-in inspection
- Inspections at framing and rough-in shall be made before application of interior finish and shall verify compliance with the code as to types of insulation and corresponding R-values and their correct location and proper installation; fenestration properties (U-factor and SHGC) and proper installation; and air leakage controls as required by the code and approved plans and specifications.

R105.2.4 Mechanical rough-in inspection
- Inspections at mechanical rough-in shall verify compliance as required by the code and approved plans and specifications as to installed HVAC equipment type and size, required controls, system insulation and corresponding R-value, system air leakage control, programmable thermostats, dampers, whole-house ventilation, and minimum fan efficiency.
Focus on House Performance

Fundamental Questions

- Is It There?
- Does It Work?
Fundamental Questions

- Is It There?
- Does It Work?
Fundamental Questions

Is It There?  Does It Work?

R105.4 Approved Inspection Agency

- The code official is authorized to accept reports of third party inspection agencies not affiliated with the building design or construction, provided such agencies are approved as to qualifications and reliability relevant to the building components and systems they are inspecting.

- Becomes important for the Energy Rating Path
Chapter 2: Definitions

Sometimes words are defined within IECC Chapter 2

- **BUILDING THERMAL ENVELOPE**
  - The basement walls, exterior walls, floors, ceiling, roofs and any other building element assemblies that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.

- **CONTINUOUS AIR BARRIER**
  - A combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

- **ERI REFERENCE DESIGN**
  - A version of the rated design that meets the minimum requirements of the 2006 International Energy Conservation Code.

Sometimes words are defined in other codes but used in the IECC

- **JOINT.** The opening in or between adjacent assemblies that is created due to building tolerances, or is designed to allow independent movement of the building in any plane caused by thermal, seismic, wind or any other loading.

Chapter 3: General

Chapter 3 discusses

- climate zones
- Design conditions
- General info and requirements that apply to materials, systems, and equipment

R302.1 Interior design conditions

- The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F (22°C) for heating and minimum of 75°F (24°C) for cooling

R303.1.1 Building thermal envelope insulation

- The insulation installer shall provide a certification listing the type, manufacture, and R-value of insulation installed in each element of the building thermal envelope

R303.2 Installation

- Materials, systems and equipment shall be installed in accordance with the manufacturer’s instructions and the International Building Code or International Residential Code, as applicable
Important things in Chapter 3

R303.1.1 Building thermal envelope insulation.

- An R-value identification mark shall be applied by the manufacturer to each piece of building thermal envelope insulation.
- Alternately, the insulation installers shall provide a certification listing the type, manufacturer and R-value of insulation installed in each element of the building thermal envelope.

What is the R-Value?
R401.3 Certificate (Mandatory)

- A permanent certificate shall be completed and posted on or in the electrical distribution panel by the builder or registered design professional.
- The certificate shall list:
  - R-values of insulation
  - R-values of ducts outside conditioned spaces
  - Window U-value and SHGC
  - Results of duct system and building envelope air leakage testing
  - Types and efficiencies of heating, cooling and service water heating equipment.
Chapter 4: Residential Energy Efficiency

Specific and technical requirements for the:

- Building Thermal Envelope
- Mechanical Systems
- Service Hot Water Systems
- Electrical Power and Lighting Systems
Pathways = Flexibility/Options

Code Compliance Paths

Prescriptive Path  UA Compliance Path  Simulated Performance Path  Energy Rating Index Path
Cost Effective

Value?
- Cost of construction
- Payback
  - Simple payback
  - Investment paid for in a loan
- Cost of ownership
- Ability to build the house that I want to build
- Opportunity cost

Regardless of the Pathway

International Energy Conservation Code

Mandatory Requirements
Terminology

• **Mandatory requirements**
  • Requirements that must be met by every building unless there is a specific exception in the code

• **Prescriptive requirements**
  • Requirements that must be met by every building unless an approved tradeoff is utilized or unless there is a specific exception in the code

• **Performance approach**
  • An overall performance requirement for the building that replaces the individual prescriptive requirements for building systems and components

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**Prescriptive Path**

- Most restrictive path
  - Only option is to do better
- No compliance Tool
- Must declare that this is your method of compliance
- Permitting plan document
SECTION R402 BUILDING THERMAL ENVELOPE
Prescriptive path ways through code (3 choices)

• R402.1 General (Prescriptive).
  • The building thermal envelope shall meet the requirements of Sections R402.1.1 through R402.1.4.
• Sections R402.1.3
  • R-value table specification
• Section R402.1.4
  • U-Value table specification
• Section R402.1.5
  • Total UA Alternative Approach

• R402.1.3 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 (Attics)
  • Computed R-values shall not include an R-value for other building materials or air films

2018 Prescriptive R-value Table Compliance Specification
Declare to the Code official that the pathway for compliance is the prescriptive path

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-VALUE IN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRAWL SPACE WALL UF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WALL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WALL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Only looking at Cavity or component R-value/U-value
Floor Systems

• Best Practices
  • Insulation must be in contact with the surface it is intended to insulate
  • Insulation completely fills the cavity

• R402.2.8 Floors.
  • Floor insulation shall be installed to maintain permanent contact with the underside of the subfloor decking
  • R-30 climate zone 5

Ducts in Garage Ceiling

Old Installation methods

What about obstructions in the floor system
Ducts in Garage Ceiling

**Code requirements**
- Insulation in complete contact with subfloor
- Insulation encapsulates duct
- IECC Table 402.1.2 footnote G
- Minimum R-19 below duct

**R402.1.4 U-factor Alternative**

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR</th>
<th>SKYLIGHT U-FACTOR</th>
<th>CEILING U-FACTOR</th>
<th>FRAME WALL U-FACTOR</th>
<th>MASS WALL U-FACTOR</th>
<th>FLOOR U-FACTOR</th>
<th>BASEMENT WALL U-FACTOR</th>
<th>CRAWLSPACE WALL U-FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.50</td>
<td>0.75</td>
<td>0.035</td>
<td>0.064</td>
<td>0.197</td>
<td>0.064</td>
<td>0.360</td>
<td>0.477</td>
</tr>
<tr>
<td>2</td>
<td>0.40</td>
<td>0.65</td>
<td>0.030</td>
<td>0.064</td>
<td>0.165</td>
<td>0.064</td>
<td>0.360</td>
<td>0.477</td>
</tr>
<tr>
<td>3</td>
<td>0.32</td>
<td>0.55</td>
<td>0.030</td>
<td>0.056</td>
<td>0.138</td>
<td>0.056</td>
<td>0.360</td>
<td>0.477</td>
</tr>
<tr>
<td>4 except Marine</td>
<td>0.32</td>
<td>0.55</td>
<td>0.026</td>
<td>0.060</td>
<td>0.086</td>
<td>0.047</td>
<td>0.059</td>
<td>0.065</td>
</tr>
<tr>
<td>5 and Marine 4</td>
<td>0.30</td>
<td>0.55</td>
<td>0.026</td>
<td>0.060</td>
<td>0.082</td>
<td>0.047</td>
<td>0.059</td>
<td>0.065</td>
</tr>
<tr>
<td>6</td>
<td>0.30</td>
<td>0.55</td>
<td>0.026</td>
<td>0.060</td>
<td>0.060</td>
<td>0.033</td>
<td>0.050</td>
<td>0.055</td>
</tr>
<tr>
<td>7 and 8</td>
<td>0.30</td>
<td>0.55</td>
<td>0.026</td>
<td>0.060</td>
<td>0.057</td>
<td>0.038</td>
<td>0.050</td>
<td>0.055</td>
</tr>
</tbody>
</table>

- **An assembly** with a U-factor equal to or less than that specified in Table R402.1.4 shall be permitted as an alternative to the R-value in Table R402.1.2
- Example: Climate zone 5 framed wall
  - U-0.060 = R-16.67
  - R-value table requires cavity insulation at R20 or 13+5
  - 1/20 = U.05 Plus sheathing, air film, etc. = U.06
All other paths us a software

UA Compliance Path  Simulated Performance Path  Energy Rating Index Path

What is a Reference Design

- Reference Design
  - A standard set of house specifications that generate a specific level of quantifiable energy performance

- The concept Code uses to show compliance with the UA Trade Off (ResCheck), Simulated Performance Path, and ERI Path

The Actual built homes performance will be less than or equal to the performance of the code standard reference design

The Standard reference design for code is the prescriptive path of compliance built in Table 405.5.2 (1)
Twin Houses

2018 IECC reference design house vs. Builder’s desired house
- Geometric Twin
- 2015 IECC prescriptive envelope U-values in (Table 402.1.4)
- Geometric Twin
- Envelope U-values based on Builder’s Specification

If the Builder’s house has the same or lower area weighted U-values then it meets the intent of code

R402.1.5 Total UA alternative
- A method for performing conductive energy trade offs
  - Trading off the R-values and U-values in the thermal envelope
  - Mathematically making the R-value and U-value paths
R402.1.5 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 R402.1.4 (multiplied by the same assembly area as in the proposed building), the building shall be considered in compliance with Table R402.1.1.

- The UA calculation shall include the thermal bridging effects of framing materials.

Example

<table>
<thead>
<tr>
<th>Component</th>
<th>Assembly</th>
<th>Gross Area</th>
<th>Cond. Insulation R-Value</th>
<th>Cont. Insulation R-Value</th>
<th>U-Factor</th>
<th>UA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling 1</td>
<td>Tile Ceiling or Soffit</td>
<td>400</td>
<td>R2</td>
<td>0.0</td>
<td>0.025</td>
<td>18</td>
</tr>
<tr>
<td>Wall 1</td>
<td>Stud/Framed</td>
<td>400</td>
<td>R2</td>
<td>20</td>
<td>0.082</td>
<td>48</td>
</tr>
<tr>
<td>Window 1</td>
<td>Vinyl/Frame/Double Pane</td>
<td>64</td>
<td>R2</td>
<td>30</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Door 1</td>
<td>Solid</td>
<td>20</td>
<td>R2</td>
<td>0.6</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Floor 1</td>
<td>AAS Wood Joint/Tongue &amp; Groove</td>
<td>400</td>
<td>R2</td>
<td>30</td>
<td>0.0</td>
<td>0.047</td>
</tr>
</tbody>
</table>

Compliance: Passes | Max UA: 134 | Your UA: 128 | 4.5% Better Than Code
Compliance Certificate

Project

Energy Code: 2018 IECC
Location: [location]
Construction Type: Single-Family
New Construction
Conditioned Year Area: 3,495 sq ft
Climate Zone: 5 (Indianapolis IN)
Square Footage: 3,495 sq ft

Construction Site:

Designer/Contractor: [designer/contractor]
Bedford, IN 46220

Compliance: Passes using UA trade-off

Compliance: 3.2% Better Than Code

Maximum UA: 375
Your UA: 363

This % Better or Worse Than Code index reflects how close to compliance the House is based on code trade-off rules. It does not provide an estimate of energy use or cost relative to a minimum-code home.

Envelope Assemblies

<table>
<thead>
<tr>
<th>Assembly</th>
<th>U-value</th>
<th>R-value</th>
<th>Scoring</th>
<th>Code</th>
<th>Factor</th>
<th>UA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling</td>
<td>0.020</td>
<td>50.0</td>
<td>4</td>
<td>0.020</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Wall</td>
<td>0.040</td>
<td>25.0</td>
<td>4</td>
<td>0.040</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Door</td>
<td>0.300</td>
<td>3.3</td>
<td>3</td>
<td>0.300</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Window</td>
<td>0.500</td>
<td>2.0</td>
<td>3</td>
<td>0.500</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

2018 IECC Building UA Compliance

Property: Best Builder In America Homes
8205 Race to Live
Denver, CO 80238

Builder: Best Builder In America

Building UA

<table>
<thead>
<tr>
<th>Elements</th>
<th>As Designed</th>
<th>As Built</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceilings</td>
<td>142.4</td>
<td>142.4</td>
</tr>
<tr>
<td>Above-Ground Walls</td>
<td>150.0</td>
<td>150.0</td>
</tr>
<tr>
<td>Windows, Doors and Skylights</td>
<td>37.3</td>
<td>37.3</td>
</tr>
<tr>
<td>Stair Treads</td>
<td>58.4</td>
<td>63.7</td>
</tr>
<tr>
<td>Basement Walls</td>
<td>58.4</td>
<td>63.7</td>
</tr>
<tr>
<td>R-values</td>
<td>Overall Ua (Design must be equal or lower):</td>
<td>453.6</td>
</tr>
</tbody>
</table>

Mandatory Requirements

Design exceeds requirements for IECC 2015 Prescriptive compliance by 2%.
### Envelope Sample Inspection Checklist

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Compliance?</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>402.1.1 (F-101a)</td>
<td>Slab edge insulation</td>
<td>Yes</td>
<td>Not Observable</td>
</tr>
<tr>
<td>402.2 (F-102)</td>
<td>Slab edge insulation installed per manufacturer’s instructions</td>
<td>Yes</td>
<td>Not Observable</td>
</tr>
<tr>
<td>402.1.1 (F-103)</td>
<td>Slab edge insulation depth/thickness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>402.1.1 (F-104)</td>
<td>Condensed basement wall insulation R-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>402.2 (F-105)</td>
<td>Condensed basement wall insulation installed per manufacturer’s instructions</td>
<td>Yes</td>
<td>Not Observable</td>
</tr>
<tr>
<td>402.2.1 (F-106)</td>
<td>Condensed basement wall insulation depth of center or distance from top of wall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>402.2.2 (F-110)</td>
<td>A protective covering is installed to protect exposed exterior insulation and extends a minimum of 6 in. below</td>
<td>Yes</td>
<td>Not Observable</td>
</tr>
<tr>
<td>423.8 (F-119)</td>
<td>Snow and ice melting system control assisted</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Code Compliance Paths

- **Prescriptive Path**
- **UA Compliance Path**
- **Simulated Performance Path**
- **Energy Rating Index Path**
Simulated performance alternative 405 Performance

• This section establishes criteria for compliance using simulated energy performance analysis.
• Such analysis shall include
  • Heating
  • Cooling,
  • Service water heating energy only.
• Compliance with this Section requires that the *(Mandatory)* items still be met.

R405 Performance-based compliance

• Energy Analysis
  • A method for performing whole house performance energy trade offs
    • **Conduction** - Trading off R-values and U-values
    • **Convection** – Energy moving with air infiltration and exfiltration
    • **Radiation** – Trade offs created by energy moving form areas of high concentrations to low concentration through open space.
Building Science built into the code

The Reference Home/Twin Home Concept
Used by modeling software for Code

2018 reference design house
Built from table 405.5.2(1)

• The reference home is the geometric twin of the rated home configured to a standard set of thermal performance characteristics

VS.

Rated Home: Builders desired house

• Geometric Twin
• Envelope R/U-values based on Builder’s Specification
Energy Costs?

• **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.

SECTION R405
SIMULATED PERFORMANCE ALTERNATIVE (PERFORMANCE)

• **R405.3 Performance-based compliance.**
  • 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*

• **R405.4.2 Compliance report**
  • Batch sampling of buildings to determine energy code compliance shall only be allowed for stacked multiple-family units
By Product
Not a code compliance document
Submittal Documents

• Need to release building permit
• Document the predicted performance of the proposed design
Compliance Documents
Needed to release the certificate of occupancy
IECC 2016 Performance Compliance

Property
Ekotrope
123 Fake St
Aiken, SC 29801

Certified Rating: Confirmed Rating

Organization
Ekotrope Rating Co.
Test Rater

HERS Rating Information
Rate: 64.4

Builder
Ekotrope

Annual Energy Cost

<table>
<thead>
<tr>
<th>Description</th>
<th>IECC 2016 Performance</th>
<th>As Designed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>$2,452</td>
<td>$2,452</td>
</tr>
<tr>
<td>Cooling</td>
<td>$277</td>
<td>$195</td>
</tr>
<tr>
<td>Water Heating</td>
<td>$277</td>
<td></td>
</tr>
<tr>
<td>BackUp Load for determinate compliance</td>
<td>$2,988</td>
<td></td>
</tr>
<tr>
<td>Lights &amp; Appliances</td>
<td>$1,980</td>
<td>$1,984</td>
</tr>
<tr>
<td>Other generation</td>
<td>$30</td>
<td>$30</td>
</tr>
<tr>
<td>Total</td>
<td>$4,939</td>
<td>$4,929</td>
</tr>
</tbody>
</table>

Design exceeds requirements for IECC 2016 Performance compliance by 1.9%.

Name: Test Rater
Organization: Ekotrope Rating Co.
Signature: Jan 05, 2017

123 Fake St
Ekotrope

THIS HOME IS CERTIFIED TO MEET THE 2015 INTERNATIONAL ENERGY CONSERVATION CODE

Building Features

Ceiling: R-60
Duct: Supply R-8.0, Return R-8.0

Above Grade Walls: R-21
Duct Leakage to Outside: 0.0 CFM @ 25 Pa

Foundation Walls: R-11
Total Duct Leakage: 0.0 CFM @ 25 Pa

Framed Floor: R-0

Slab: R-10.0 Perimeter, R-0.0

Infiltration: 0.00 CFM/1000

Window: U-10bar: 0.31 SHGC; 0.25

The organization below certifies that the proposed building design described herein is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the 2015 IECC requirements in compliance with Chapter 4 based on Climate Zone 5 and with all mandatory requirements.

Name: Test Rater
Organization: Ekotrope Rating Co.
Signature: Jan 05, 2017
2018 • IECC Certificate
1234 Place to Live, Denver, CO 80221

Building Envelope Insulation

- Ceiling: R-49.0
- Above Grade Walls: R-20.0
- Foundation Walls: R-15.0
- Exposed Floor: R-30.0
- Slab: R-8.0 Edge, R-6.0 Under
- Infiltration: Htg: 3.00 Cig: 3.00 ACH50
- Duct: Uninsulated
- Total Duct Leakage: 80.00 CFM @ 25 Pascals

Window Data

- Window: U-Factor 0.320, SHGC 0.320

Mechanical Equipment

- HEAT: Fuel-fired air distribution, Natural gas, 92.1 AFUE.
- COOL: Air conditioner, Electric, 13.0 SEER.
- DHW: Conventional, Natural gas, 0.62 EF, 40.0 Gal.

Builder or Design Professional

Signature

REM/Rate • Residential Energy Analysis and Rating Software v14.6

Code Compliance Paths

- Prescriptive Path
- UA Compliance Path
- Simulated Performance Path
- Energy Rating Index Path
Section R406 of the 2015 and 2018 IECC Energy Rating Index Compliance Alternative

What is an Energy Rating Index

Section R406 of the 2018 IECC Energy Rating Index Compliance Alternative

Home Energy Rating Certificate

HERS* Index Score:
47

Annual Savings:
$5,912

Home:
7213 S. 121st St, Gretna, NE

Builder:
JG Construction

This home meets or exceeds the criteria of the following:
Energy Star v5.1
2009 International Energy Conservation Code
2009 International Energy Conservation Code
2012 International Energy Conservation Code
2015 International Energy Conservation Code

Rating Completed by:
HERS Rater: Dan Grissim
Rating Company: Ekotrope Rating Co.

Rater Provided By Ekotrope Provider

** The Home Energy Rating Standard Measure for this resource is available from the rating provider.**
Quantifying Energy Use
ERI vs. HERS

- ERI Index Score = HERS Index Score

### HERS® Index

![HERS Index Diagram]

Code Book misprint and the Errata

**err·ra·tum**

i´râtəm,-´rā-,´rat-/ noun
plural noun: errata
An error in printing or writing.
A list of corrected errors appended to a book or published in a subsequent issue of a journal.

- **R406.2 Mandatory requirements.** Compliance with this section requires that the mandatory provisions identified in Sections R401.2 R401 through R404 labeled as ‘mandatory’ and Section R403.5.3 be met. The building thermal envelope shall be greater than or equal to levels of efficiency and Solar Heat Gain Coefficient in Table 402.1.2 or 402.1.4 of the 2009 International Energy Conservation Code.
Mandatory sections of the 2018 IECC

- R401.1 Mandatory Requirements
  - Section R402.4 Air Leakage
    - R402.4.1.2 Testing
      - Air leakage rate not exceeding 5 air changes per hour in Climate Zones 1 and 2, and 3 air changes per hour in Climate Zones 3 through 8
      - Table R402.4.1.1 Air barriers and Insulation
  - Section R403 Systems
  - Section R404 Electrical Power and Lighting Systems
  - Prescriptive requirements in R403.5.3
    - Hot water pipe insulation

R406.2 Mandatory Requirements

- The building thermal envelope shall be greater than or equal to levels of efficiency and Solar Heat Gain Coefficient in Table 402.1.1 or 402.1.3 of the 2009 International Energy Conservation Code.

2018 IECC

- If Solar is installed on a home using the ERI path, builders must also meet the minimum prescriptive envelope efficiency measures in the 2015 IECC

- If there is no solar on the home then the builders must also meet the minimum prescriptive envelope efficiency measures in the 2009 IECC
### 2009 IECC vs. 2015 IECC Prescriptive Table

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Window U-Factor</th>
<th>Window SHGC</th>
<th>Ceiling R-Value</th>
<th>Wood Framed Wall R-Value</th>
<th>Mass Wall R-Value</th>
<th>Floor R-Value</th>
<th>Basement Wall R-Value</th>
<th>Slab R-Value and Depth</th>
<th>Crawl Space Wall R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.2</td>
<td>NR</td>
<td>0.30</td>
<td>0.25</td>
<td>R-30</td>
<td>R-3/4</td>
<td>R-13</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0.65</td>
<td>0.40</td>
<td>0.30</td>
<td>0.25</td>
<td>R-30</td>
<td>R-4/6</td>
<td>R-13</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0.35</td>
<td>0.38</td>
<td>0.30</td>
<td>0.25</td>
<td>R-30</td>
<td>R-5/8</td>
<td>R-19</td>
<td>0</td>
<td>R-5/13</td>
</tr>
<tr>
<td>4 except Marine</td>
<td>0.35</td>
<td>NR</td>
<td>0.38</td>
<td>0.25</td>
<td>R-38</td>
<td>R-13</td>
<td>20 or 13+5</td>
<td>0</td>
<td>R-10/13</td>
</tr>
<tr>
<td>5 and Marine-4</td>
<td>0.35</td>
<td>NR</td>
<td>0.38</td>
<td>0.25</td>
<td>R-38</td>
<td>R-49</td>
<td>R-20 or 13+5</td>
<td>0</td>
<td>R-10/13</td>
</tr>
<tr>
<td>Climate Zone 6</td>
<td>0.35</td>
<td>NR</td>
<td>0.38</td>
<td>0.25</td>
<td>R-49</td>
<td>R-20</td>
<td>20 or 13+5 or 13+10</td>
<td>0</td>
<td>R-15/20</td>
</tr>
<tr>
<td>Climate Zone 7 &amp; 8</td>
<td>0.35</td>
<td>NR</td>
<td>0.38</td>
<td>0.25</td>
<td>R-49</td>
<td>R-21</td>
<td>20+5 or 13+10</td>
<td>0</td>
<td>R-15/19</td>
</tr>
</tbody>
</table>

| Climate Zone 6 | 0.35 | NR          | 0.38            | 0.25                     | R-49             | R-20         | 20+5 or 13+10 or 13+10 | 0                      | R-15/20                  | 15/19                    |
| Climate Zone 7 & 8 | 0.35 | NR          | 0.38            | 0.25                     | R-49             | R-21         | 20+5 or 13+10 or 13+10 | 0                      | R-15/19                  | 15/19                    |

**Why create a backstop**

- 100 meets the minimum requirements of the 2006 International Energy Conservation Code prescriptive requirements
## Why create a backstop?

### 2006 IECC compliant
- 2 story
- 2800 Square Feet
- Single Family Detached
- Conditioned basement
- **HERS Index**
  - HERS 98

### House Specs
- Foundation R-10
- Slab R-0
- Floor over garage **R-30 Grade 3**
- Rim R-19 **Grade 3**
- Walls blown R-19 **Grade 3**
- Windows U-0.35/SHGC 0.35
- Doors R-5/ R-2.2
- Attic R-38 flat R-30 edge
- Furnace 80 AFUE w/ 200 CFM LTO & 20% return in attic R-6 /20% supply in garage ceiling
- Water Heater .54 EF
- AC 12 Seer
- 7 ACH50 & Exhaust Ventilation
- Default appliances 10% CFL

## Why create a backstop?

### 2009 IECC compliant
- 2 story
- 2800 Square Feet
- Single Family Detached
- Conditioned basement
- **HERS Index**
  - HERS 95
- 6.4K PV system = 55

### House Specs
- Foundation R-10
- Slab R-0
- **Floor over garage R-30 Grade 1**
- Rim R-19 **Grade 1**
- Walls blown R-19 **Grade 1**
- Windows U-0.35/SHGC 0.35
- Doors R-5/ R-2.2
- Attic R-38 flat R-30 edge
- Furnace 80 AFUE w/ 200 CFM LTO & 20% return in attic R-6 /20% supply in garage ceiling
- Water Heater .54 EF
- AC 12 Seer
- 7 ACH50 & Exhaust Ventilation
- Default appliances 10% CFL
R406.3.1 ERI reference design

2015 IECC
• The *ERI reference design* shall be configured such that it meets the minimum requirements of the 2006 *International Energy Conservation Code* prescriptive requirement.

2018 IECC
• The Energy Rating Index will be developed in accordance with ANSI/RESNET/ICC 301-2014

• The proposed residential building shall be shown to have an annual total normalized Modified Loads that are less than or equal to the annual total Loads of the *ERI reference design*.

Twin Houses

**ERI reference design house** vs. **Builder's desired house**

- Geometric Twin
- 2006 IECC prescriptive requirements
- Geometric Twin
- Mandatory 2009 IECC Envelope R-Values
- 2015 IECC Mandatory Requirements

The Builder’s house must have the Energy Rating Index Required by code, or lower, to meet the intent of code.
### Table R406.4 Maximum Energy Rating Index

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>2015 IECC Energy Rating Index</th>
<th>2018 IECC Energy Rating Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52</td>
<td>57</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
<td>57</td>
</tr>
<tr>
<td>3</td>
<td>51</td>
<td>57</td>
</tr>
<tr>
<td>4</td>
<td>54</td>
<td>62</td>
</tr>
<tr>
<td>5</td>
<td>55</td>
<td>61</td>
</tr>
<tr>
<td>6</td>
<td>54</td>
<td>61</td>
</tr>
<tr>
<td>7</td>
<td>53</td>
<td>58</td>
</tr>
<tr>
<td>8</td>
<td>53</td>
<td>58</td>
</tr>
</tbody>
</table>

- Compliance based on an ERI analysis requires that the *rated design* be shown to have an ERI less than or equal to the appropriate value listed in Table R406.3, when compared to the *ERI reference design*.

### Features that Impact the ERI

(Lower the score)

- Mechanical equipment
  - High efficiency furnace
  - High efficiency AC
  - High efficiency water heater
- More R-value than required by the 2009 IECC
- House orientation with the ERI
- House tightness below 3 ACH50
- Duct leakage to the outside
- Duct location
- Whole house fan
- CFL or LED Lighting above 75%
- High efficiency appliances
- Solar
ERI Calculation includes

- Internal gains
- Internal mass
- Structural mass
- Heating and cooling systems
  - Equipment efficiencies and sizing
  - Air-and ground-source heat pumps
  - Solid fuel combustion
- Service water heating systems
- Thermal distribution systems
- Thermostat
- Lighting, appliance and miscellaneous loads

R406.6 Documentation

- Documentation of the software used to determine the ERI and the parameters for the residential building in accordance with Sections R406.6.1 through R406.6.3
  - Compliance software tools
  - Compliance report
  - Additional Documentation
Will the ERI path be used?

- In 2015
  - 190,180 homes were rated
  - Average HERS Index 62

- In 2016
  - 206,583 homes were rated
  - Average HERS Index 61

End Goal
## Base Case Compliance

### 2018 Compliance Reality
- 2 story
- 2800 Square Feet
- Single Family Detached
- Conditioned basement
- UA Alternative
  - Pass by 6.3%
- Simulate Performance
  - Pass by 1.8%
- Corresponding HERS Index
  - HERS 72

### House Specs
- Foundation R-15
- Slab R-0
- Floor over garage R-30
- Rim R-19
- Walls blown R-20
- Windows U-32/SHGC.32
- Doors R-5/ R-2.2
- Attic R-49 flat R-38 edge
- Furnace 80 AFUE w/ 150 CFM LTO & 10% in attic R-8
- Water Heater 62 EF
- AC 13 Seer
- 3 ACH50 & Exhaust Ventilation
- Default appliances 75% CFL

## Typical Code House in Colorado

### 2018 Compliance Reality
- 2 story
- 2800 Square Feet
- Single Family Detached
- Conditioned basement
- UA Alternative
  - Pass by 3%
- Simulate Performance
  - Pass by 6.9%
- Corresponding HERS Index
  - HERS 61

### House Specs
- Foundation R-11
- Slab R-0
- Floor over garage R-50
- Rim R-19
- Walls blown R-23
- Windows U-34/SHGC.32
- Doors R-5/ R-2.2
- Attic R-38 flat R-30 edge
- Furnace 92.5 AFUE w/ 50 CFM LTO & 10% in attic R-8
- Water Heater 62 EF
- AC 13 Seer
- 2.5 ACH50 & Exhaust Ventilation
- Default appliances 100% CFL
Which Pathway to use?

Section R406 Simulated Performance Path
HERS Index is a by product

Four Steps of IECC Performance Compliance
Simulated Performance Path or Energy Rating Index

Step 1
From Plan Analysis:
• Demonstrates that the proposed design will comply with the IECC.
• Determine the most cost effective way to comply with the IECC.
• Develop required permitting submittal documents.
• Assistance with other required documents such as air sealing details.

Step 2
Rough Inspection:
• Perform IECC required rough inspections for compliance, quality assurance, and builder risk.
• Inspections allow 3rd Party to generate final documentation that is needed to obtain the certificate of occupancy.
• Insulation, air barrier, windows, HVAC, Duct leakage, moisture management and more will be inspected.
• Action item reporting after each inspection.
Four Steps of IECC Performance Compliance Simulated Performance Path or Energy Rating Index

**Step 3**
Final Inspection:
- Diagnostics - Blower door air tightness and duct leakage to outside
- Attic and foundation insulation
- Controlled whole house mechanical ventilation / Spot Ventilation
- Action item reporting after each inspection.

**Step 4**
Modeling and Certification
- Making the from plans analysis address and lot/site specific including the details of what has been inspected at rough and final
- Generate required code compliance certificates and reports for C.O
- Homes using the Simulated Performance Path receive a cost compliance report, and other required reports
- ERI Score is a byproduct on code compliance using the SPP
### Home Energy Rating Certificate

**Projected Report**

**HERS® Index Score:** 63  
**Your home’s HERS score is a relative performance score. The lower the number, the more energy efficient the home. To learn more, visit www.HERSindex.com**

**Annual Savings:** $1,597  
**Home:** 8525 Place for live, Denver, CO  
**Builder:** Best Builders by America Homes

<table>
<thead>
<tr>
<th>Use (MWh)</th>
<th>Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>$626</td>
</tr>
<tr>
<td>Cooling</td>
<td>$69</td>
</tr>
<tr>
<td>Hot Water</td>
<td>$572</td>
</tr>
<tr>
<td>Lights/Appliances</td>
<td>$1,260</td>
</tr>
<tr>
<td>Service Charges</td>
<td>$50</td>
</tr>
<tr>
<td>Generation (e.g. Solar)</td>
<td>$0</td>
</tr>
<tr>
<td>Total</td>
<td>$1,936</td>
</tr>
</tbody>
</table>

**Home Feature Summary:**
- **Home Type:** Single Family Detached
- **Conditioned Floor Area:** 2,250 sq. ft.
- **Number of Bedrooms:** 4
- **Primary Heating System:** Natural Gas - 95 AFUE
- **Primary Cooling System:** Air Conditioner - Single Zone 13 SEER
- **Primary Water Heater:** Water Heater - Natural Gas - 60 Gallon Energy Factor 0.92

**This home meets or exceeds the criteria of the following:**
- Energy Star v3
- 2006 International Energy Conservation Code
- 2009 International Energy Conservation Code
- 2012 International Energy Conservation Code

**Rating Completed by:**
- Energy Rate/Test Rater  
- Rating Company: Ekotrope Rating Co.
- Rating Provider: Ekotrope Rating Co.

---

### Home Energy Rating Certificate

**Confirmed Report**

**HERS® Index Score:** 47  
**Your home’s HERS score is a relative performance score. The lower the number, the more energy efficient the home. To learn more, visit www.HERSindex.com**

**Annual Savings:** $5,912  
**Home:** 123 Fake St, Anytown, CO  
**Builder:** Best Builders

<table>
<thead>
<tr>
<th>Use (MWh)</th>
<th>Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>$1,182</td>
</tr>
<tr>
<td>Cooling</td>
<td>$55</td>
</tr>
<tr>
<td>Hot Water</td>
<td>$340</td>
</tr>
<tr>
<td>Lights</td>
<td>$2,441</td>
</tr>
<tr>
<td>Service Charges</td>
<td>$94</td>
</tr>
<tr>
<td>Generation (e.g. Solar)</td>
<td>$-2,699</td>
</tr>
<tr>
<td>Total</td>
<td>$5,780</td>
</tr>
</tbody>
</table>

**Home Feature Summary:**
- **Home Type:** Single Family Detached
- **Conditioned Floor Area:** 4,500 sq. ft.
- **Number of Bedrooms:** 4
- **Primary Heating System:** Natural Gas - 95 AFUE
- **Primary Cooling System:** Air Conditioner - Single Zone 13 SEER
- **Primary Water Heater:** Water Heater - Natural Gas - 60 Gallon Energy Factor 0.92

**This home meets or exceeds the criteria of the following:**
- Energy Star v3
- 2006 International Energy Conservation Code
- 2009 International Energy Conservation Code
- 2012 International Energy Conservation Code

**Rating Completed by:**
- Energy Rate/Test Rater  
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