Nebraska's Residential Energy Code

Requirements and Best Practices

Nebraska Energy Code Training Program

Instructor: Matt Belcher

April 11, 2024

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About MEEA

- MEEA is a nonprofit membership organization with 160+ members, including:
  - Utilities
  - Research institutions
  - State and local governments
  - Energy efficiency-related businesses
- MEEA helps stakeholders understand and implement cost-effective energy efficiency strategies

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About the Nebraska Training Program

- Goal: prepare the Nebraska workforce for upcoming changes in construction best practices
  - Residential and Commercial Energy Code
  - Building Science
  - Practical Solutions

- Focused on providing training to builders, code officials, design professionals, public officials and students

- For more information, visit: https://www.mwalliance.org/nebraska-energy-codes-training-program

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About Matt/Verdatek Solutions

- 40+ Years in the Building Industry
- Certified NRC Level II Nuclear Inspector
- Building Codes Official for St. Louis County MO
- Director of University of Missouri Columbia High Performance Buildings Research Center. Created and Instructed Curriculum for Students and Industry Professionals.
- Currently Assisting University of Missouri Science & Technology in Building and Energy Code Curriculum and Policy.
- Missouri Technical School (Linn MO) Advisory Board.
- ICC Member serving on 2012, 2015, 2018 and 2024 Energy Code Development Committee. 2021& 2027 Building Code-General Committee
- NAHB Approved Instructor for Advanced Building Science, Advanced Business Management

Introduction Poll

- What is your profession?
  - Code Official
  - Home Builder
  - State/local government
  - Energy Rater/Consultant
  - Architect/Engineer
  - Non-profit
  - Academic
  - Utility
  - Other

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Training Objectives

- What is the 2018 Energy Code?
- Inside the Energy Code:
  - Building Envelope
  - Interior Comfort/Health
  - Remodeling
- Marketing Energy Efficient/High Performance Buildings

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Today's Agenda

- Code Requirements in the 2018 IECC
- Moisture Management
- Air Movement
- Heat Transfer
- Performance Testing
- HVAC System
- Key Takeaways

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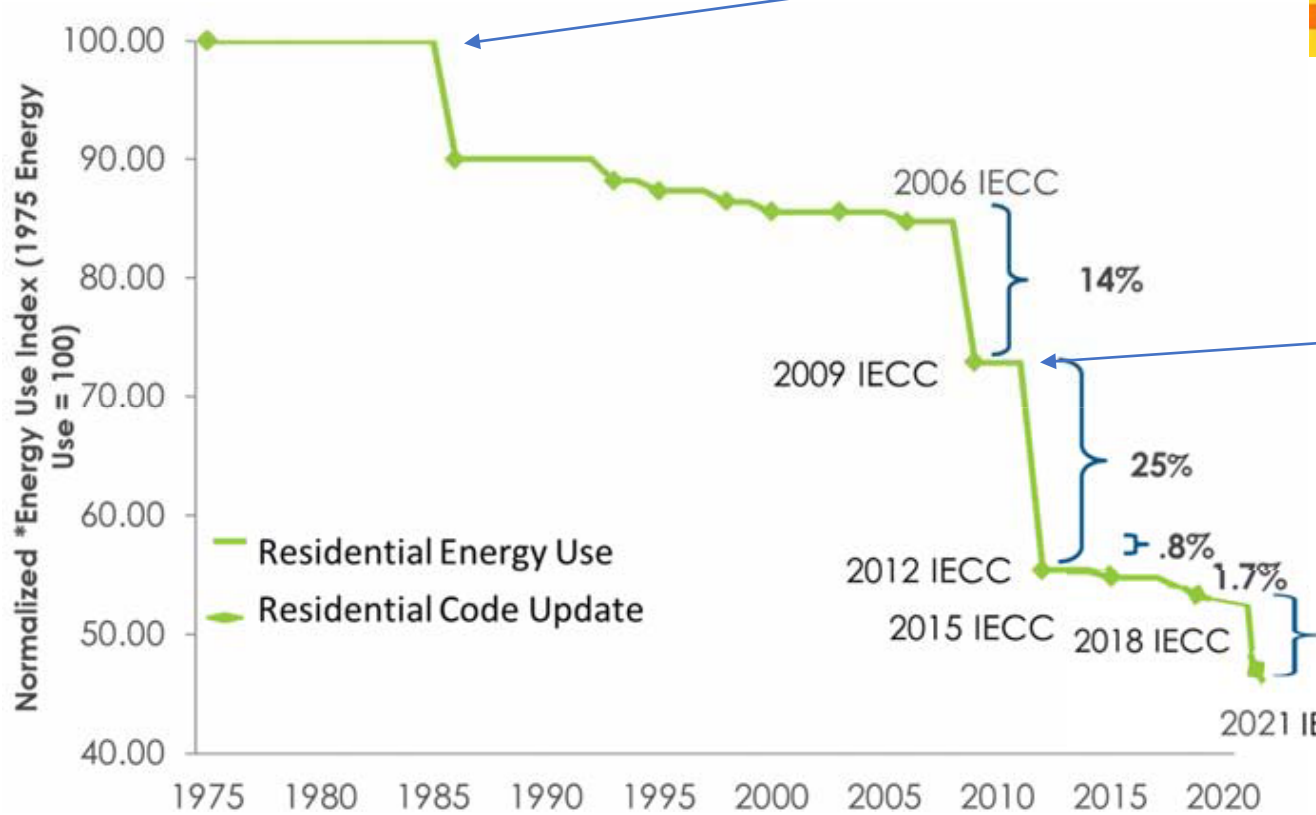
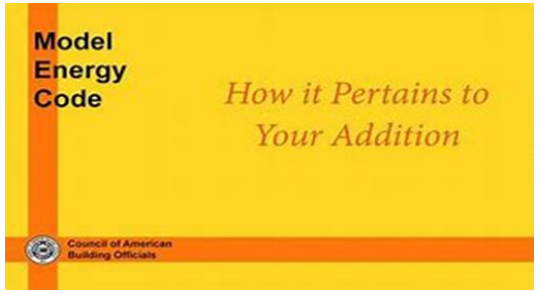
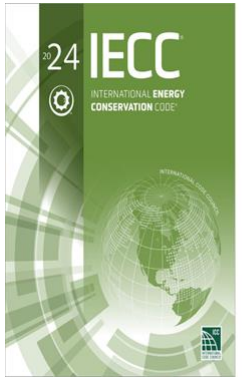
What is the 2018 IECC?

Energy Code Background







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Nebraska Residential Field Study

- Conducted in 2017 by **Nebraska Department of Environment and Energy.** 2009 IECC was the baseline.
- Collected and analyzed several data points for new homes, including:
  - Envelope air leakage
  - Efficacy in lighting
  - Duct leakage
  - Ceiling & exterior wall insulation
  - Basement & slab insulation
  - Windows

For More Information and Data:

https://www.energycodes.gov/sites/default/files/documents/Nebraska_Residential_Compliance_Evaluation_final.pdf

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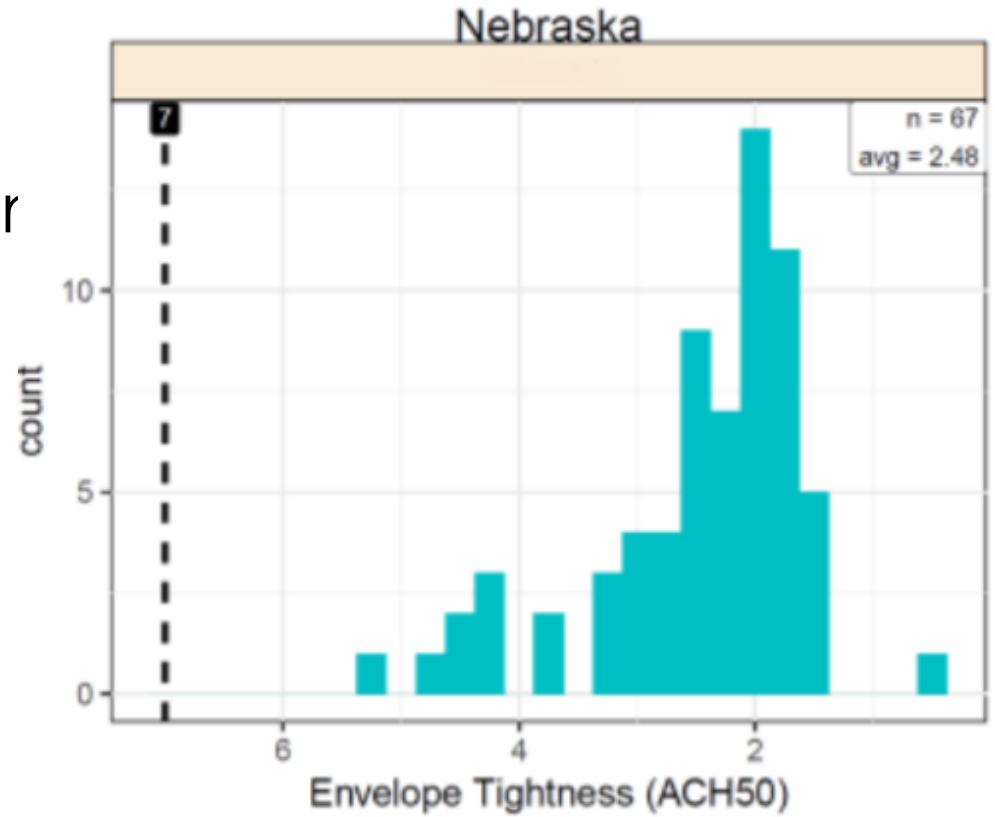
Nebraska Residential Field Study - Results

- Overall, not too bad! But room to improve.
  - **Envelope Air Leakage**: Better thar code(7 ACH50)
    - Not all would meet 2018 IECC
  - **Efficacy in Lighting**: Average; some good, some not
  - **Duct Leakage**: Ugh!
    - Needs significant improvement to meet 2018 IECC
  - **Ceiling Insulation**:
    - Amount: Good+ (Average: R-42.5)
    - Install: Not as good. Reduces compliance (R-factor)



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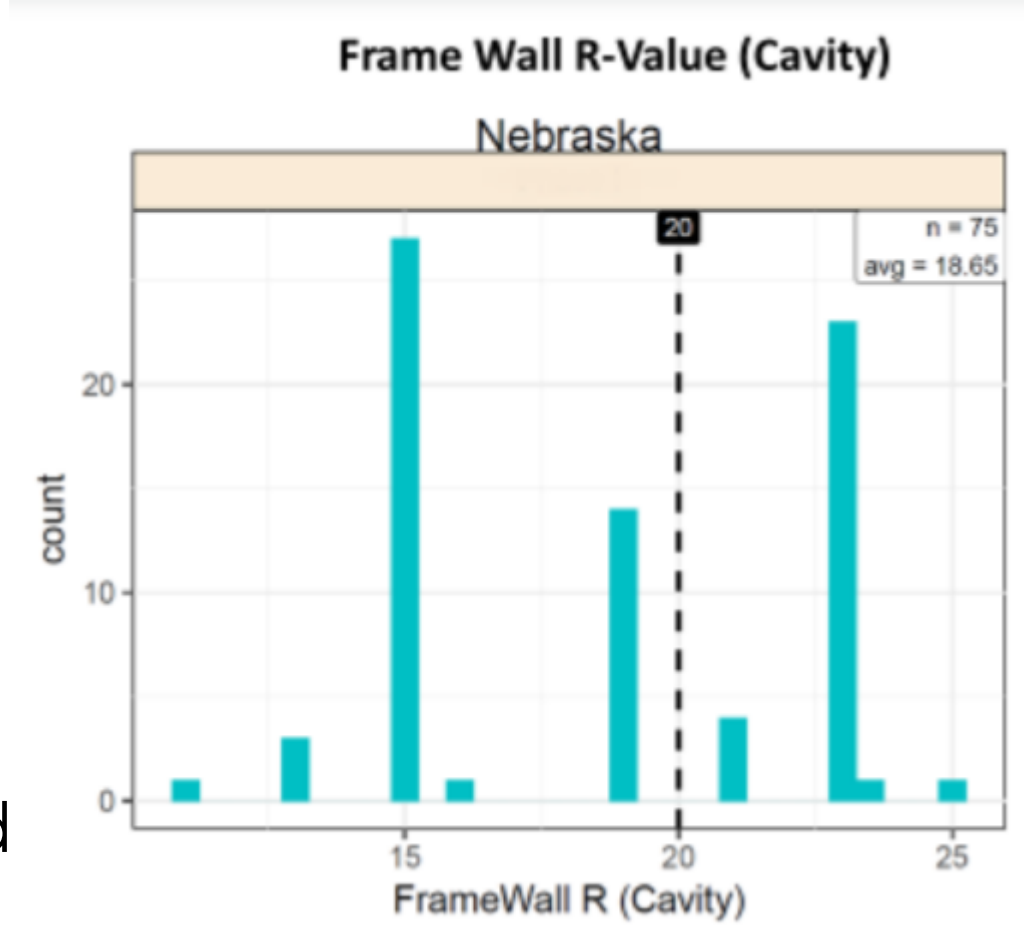
Nebraska Residential Field Study - Results

- Frame Wall Insulation: Most common installation was below code
  - Even continuous insulation < Code
  - Quality of Installation an issue
- Basement Insulation: Meets code(average), but room to improve
- Slab insulation: Meets or exceeds code
- Windows: Meets code but will need to upgrade to meet 2018 IECC



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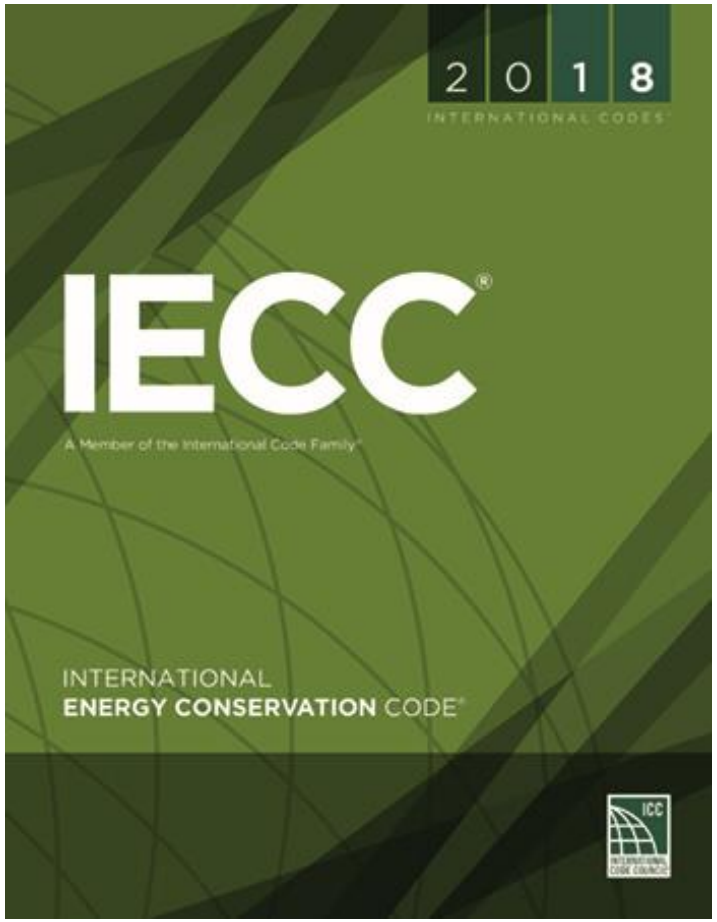
So, What's Changed since 2009?



2018 IECC / IRC Section 11

- Creates a Residential Energy Code separate from the Commercial Energy Code
- Adds testing and verification requirements
- Promotes Innovation through Energy Ratings Index (ERI)
  - Uses a HERS-type index as an "equivalent" for residential applications
  - Mandatory requirements still apply

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2018 IECC Mandatory Requirements

Energy Certificate

- Energy Certificate located on circuit breaker box includes key energy efficiency measures and is signed by the builder

Air Sealing

- All holes between floors and through exterior walls/ceilings have been sealed in **accordance with table R402.4.1.1**
- Building or dwelling unit is **tested to verify air leakage rate of ≤ 3 Air Changes per Hour (ACH)**
- Building or dwelling unit must have continuous air barrier installed

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2018 IECC Mandatory Requirements

Ducts

- All ducts are sealed with approved materials (e.g. mastic or UL 181 tape) - duct tape is not acceptable
- All ducts outside conditioned space are tested to verify duct leakage with a total duct leakage or leakage to the outside test
- Supply & return ducts in attic insulated to ≥ R-6 when ducts are outside conditioned space and ≥ R-8 when ducts are outside the building thermal envelope

Building Cavities

- **Building framing cavities shall not be used as supply ducts or plenums**

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2018 IECC Mandatory Requirements

Heating and Cooling

- Controls: Programmable thermostat installed
- Equipment sized per ACCA Manuals S & J

Lighting

- Minimum of **90% high-efficacy lamps** installed
- Recessed lighting in thermal envelope IC-rated and airtight

Mechanical Ventilation

- **Installed according to requirements in the International Mechanical Code**
- **Required for all homes ≤ 5 ACH per Section M303.4 (3 ACH is a 2018 IECC mandatory requirement)**

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2018 IECC Mandatory Requirements

Other requirements

- Wood-burning fireplaces have tight flue dampers or doors, and outdoor combustion air
- Mechanical system piping insulated to min R-3 for fluids >105° F or <55° F
- Circulating hot water systems shall be insulated to at least R-2. Systems shall include an automatic, or readily accessible, off-switch.

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Energy Code Compliance Pathways

Prescriptive Method Requirements

- All mandatory and prescriptive requirements must be met

Total UA Method Requirements

- All mandatory and prescriptive requirements (other than Table R402.1.2) must be met
- Include documentation to demonstrate compliance with the UA Trade-off method. Compliance software submittal must include completed compliance form, inspection checklist and certificate demonstrating compliance with 2018 IECC levels

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Energy Code Compliance Pathways

Simulated Performance Requirements (Section R405)

- All mandatory requirements must be met
- Submit an energy cost analysis report which demonstrates that the proposed design (as built) home is more efficient than the standard reference design home

Energy Rating Index Requirements (Section R406)

- All Mandatory requirements met. Meet or exceed 2009 IECC prescriptive envelope requirements
- ERI score of 61 or lower. Submit report demonstrating compliance

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2018 IECC Prescriptive Requirements

Indicates Change

Table R402.1.2 Insulation Requirements By Component

Requirement	2009 IECC	2018 IECC
Ceiling R-value	R-38	**R-49**
Wall R-value	R-20 or R-13+5	R-20 or R-13+5
Floors over unconditioned space	R-30	R-30
Basement R-value	10/13	**15/19**
Slab R-value and depth	10, 2 ft.	10, 2 ft. ***R-5 insulation shall be provided under the full area of a heated slab**
Crawl space wall R-value	10/13	**15/19**

2018 IECC Prescriptive Requirements

Indicates Change

Table R402.1.2 Fenestration Requirements By Component

Requirement	2009 IECC	2018 IECC
Fenestration U-factor (windows, glass, opaque and swinging doors with <50% glazing)	.35	**0.30**
Skylight U-factor	.60	**0.55**

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2018 IECC Prescriptive Requirements

Indicates Change

Requirement	2009 IECC	2018 IECC
Eave Baffle	NO REQUIREMENT	For air permeable insulations in vented attics, **a baffle shall be installed adjacent to soffit and eave vents**. Baffles shall maintain an opening equal or greater size than the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material. (402.2.3)
Hot water pipe insulation	NO REQUIREMENT	**Insulated to R-3,** ¾ or larger pipes with exceptions (403.5.3)

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2018 IECC Prescriptive Requirements

Indicates Change

Requirement	2009 IECC	2018 IECC
Duct Insulation	Supply ducts in attics shall be insulated to a minimum of R-4. Exception: Ducts or portions thereof in conditioned space (403.2.1)	Supply and Return ducts in attics shall be insulated to a **minimum of R-6 or R-8**, depending on diameter. All other ducts shall be insulated to a **minimum of R-6 or R-4.** Exception: Ducts or portions in conditioned space (403.3.1)
Duct Testing	Post construction: Leakage to Outdoors: 8 cfm/100 sq. ft. Total Leakage: 12 cfm/100 sq. ft. Rough-in: Total Leakage: 6 cfm/100 sq. ft. Exception: Duct tightness test not required if most ducts located entirely within building envelope. (403.2.2)	Ducts tested to the following leakage rates: Post construction: Total Leakage: **4 cfm/100 sq. ft.** Rough-in: Total Leakage: **4 cfm/100 sq. ft.** Exception: Duct tightness test not required if all ducts located entirely within building envelope. (403.3.4)

Other changes in the 2018 IECC

Indicates Change

Requirement	2009 IECC	2018 IECC
Thermally Isolated sunroom U-factor	Maximum fenestration U-factor shall be 0.50 and maximum skylight U-factor shall be 0.75. (402.3.5)	Maximum fenestration **U-factor shall be 0.45** and maximum skylight U-factor shall be 0.70. (402.3.5)
Buried Ducts in Attic	Not referenced	Ducts tested to have a maximum leakage rate of 1.5 cfm25/100 sq. ft. to the outside, are insulated with ≥ R-8 insulation, and have at least R-19 insulation above and to the sides of the ducts, **count as being in conditioned space**. (403.3.6)

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Performance Testing

A Great Benefit
(and a new code requirement)

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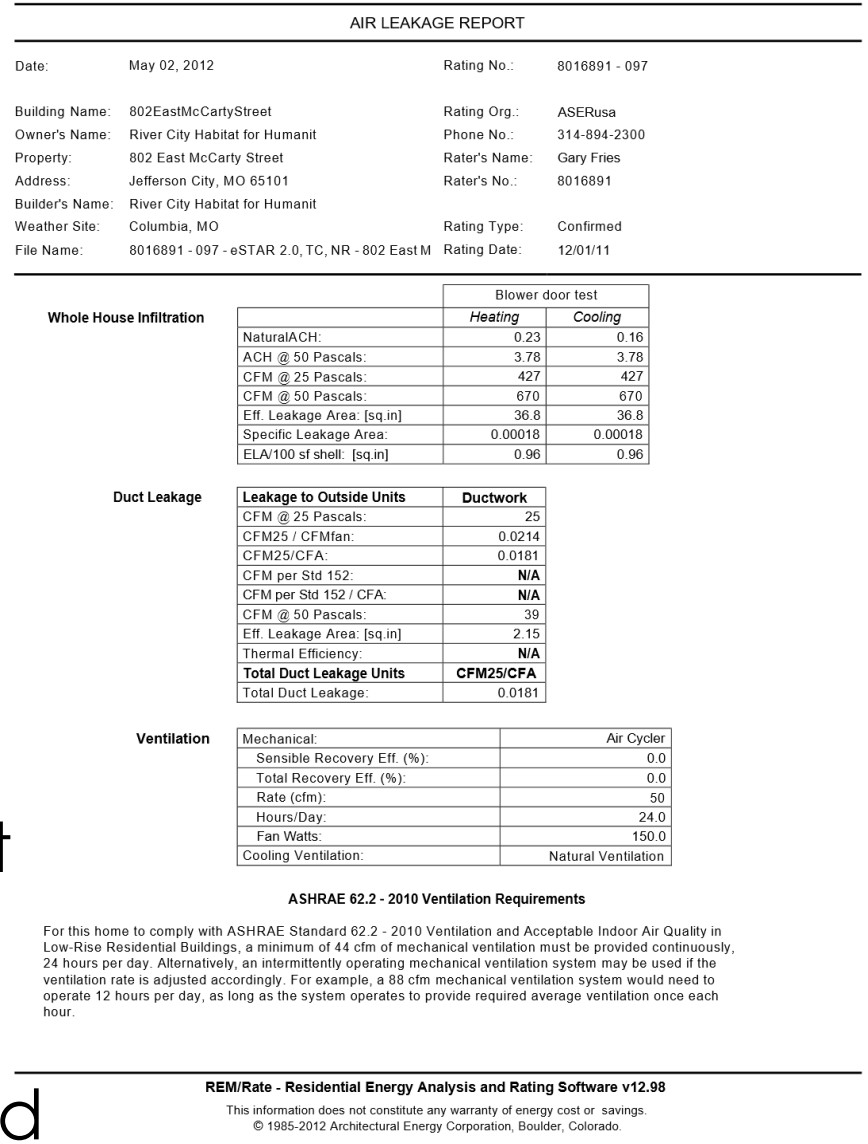
Air Leakage Report

- Blower door test documents a home's air leakage performance
- Required by code
- Third party verification (some areas; performed by Inspectors)
- Provides solid data for final equipment adjustment and energy use/cost forecast
- Great liability protection for all involved



AIR LEAKAGE REPORT

Date:	May 02, 2012	Rating No.:	8016891 - 097
Building Name:	802EastMcCartyStreet	Rating Org.:	ASERusa
Owner's Name:	River City Habitat for Humanit	Phone No.:	314-894-2300
Property:	802 East McCarty Street	Rater's Name:	Gary Fries
Address:	Jefferson City, MO 65101	Rater's No.:	8016891
Builder's Name:	River City Habitat for Humanit		
Weather Site:	Columbia, MO	Rating Type:	Confirmed
File Name:	8016891 - 097 - eSTAR 2.0, TC, NR - 802 East M	Rating Date:	12/01/11

Whole House Infiltration

	Blower door test	
	Heating	*Cooling*
NaturalACH:	0.23	0.16
ACH @ 50 Pascals:	3.78	3.78
CFM @ 25 Pascals:	427	427
CFM @ 50 Pascals:	670	670
Eff. Leakage Area: [sq.in]	36.8	36.8
Specific Leakage Area:	0.00018	0.00018
ELA/100 sf shell: [sq.in]	0.96	0.96

Duct Leakage

Leakage to Outside Units	**Ductwork**
CFM @ 25 Pascals:	25
CFM25 / CFMfan:	0.0214
CFM25/CFA:	0.0181
CFM per Std 152:	**N/A**
CFM per Std 152 / CFA:	**N/A**
CFM @ 50 Pascals:	39
Eff. Leakage Area: [sq.in]	2.15
Thermal Efficiency:	**N/A**
Total Duct Leakage Units	**CFM25/CFA**
Total Duct Leakage:	0.0181

Ventilation

Mechanical:	Air Cycler
Sensible Recovery Eff. (%):	0.0
Total Recovery Eff. (%):	0.0
Rate (cfm):	50
Hours/Day:	24.0
Fan Watts:	150.0
Cooling Ventilation:	Natural Ventilation

ASHRAE 62.2 - 2010 Ventilation Requirements

For this home to comply with ASHRAE Standard 62.2 - 2010 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, a minimum of 44 cfm of mechanical ventilation must be provided continuously, 24 hours per day. Alternatively, an intermittently operating mechanical ventilation system may be used if the ventilation rate is adjusted accordingly. For example, a 88 cfm mechanical ventilation system would need to operate 12 hours per day, as long as the system operates to provide required average ventilation once each hour.

REM/Rate - Residential Energy Analysis and Rating Software v12.98

This information does not constitute any warranty of energy cost or savings.

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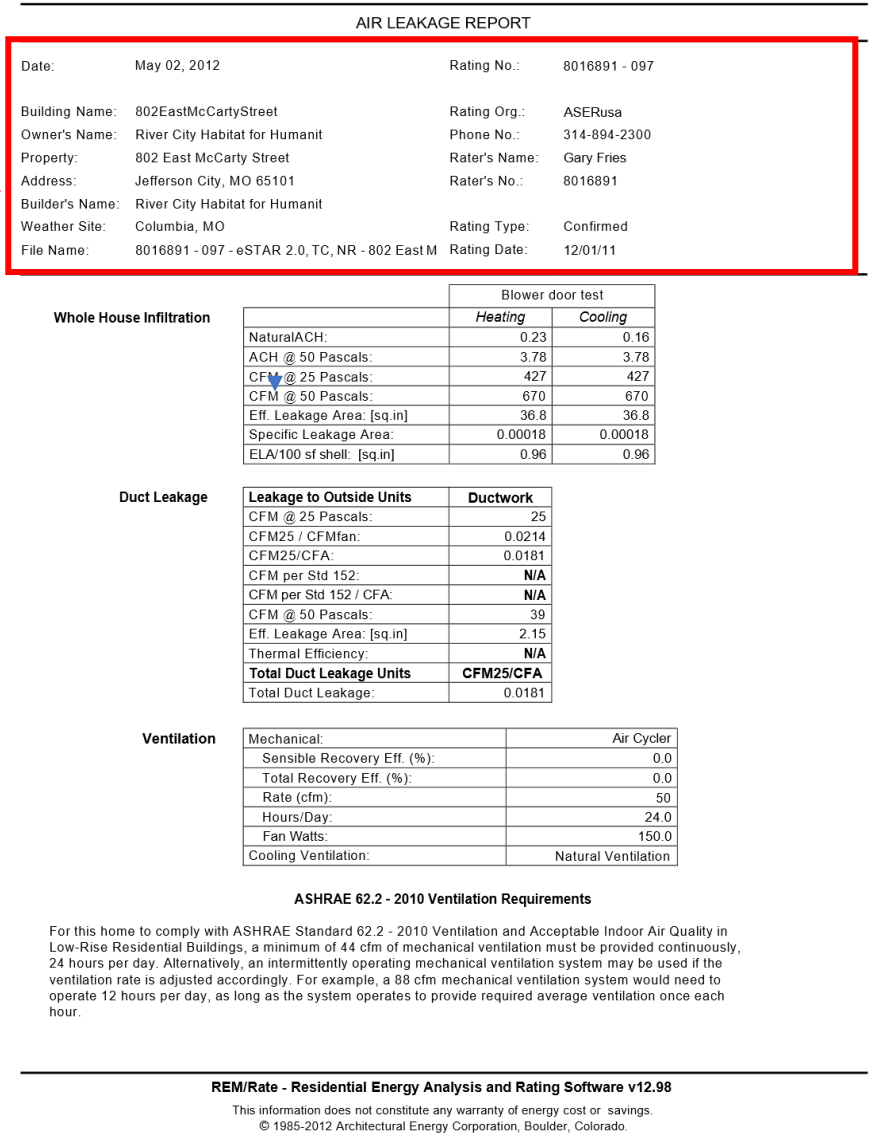
Air Leakage Report

Date:	May 02, 2012	**Rating No.:**	81158891-901
Building Name:	123 Main Street	**Rating Org.:**	Raters USA
Owners Name:	Jane Smith	**Phone:**	555-555-5555
Property Address:	123 Main Street Omaha, NE 68007	**Rater's Name:**	John Williams
Builder's Name:	ABC Construction	**Rater's No:**	1234567
Weather Site:	Omaha, NE	**Rating Type:**	Confirmed
File Name:	101682391-097 eSTAR	**Rating Date:**	12/01/20



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Whole House Infiltration

	Blower door test	
	Heating	*Cooling*
NaturalACH:	0.23	0.16
ACH @ 50 Pascals:	3.78	3.78
CFM @ 25 Pascals:	427	427
CFM @ 50 Pascals:	670	670
Eff. Leakage Area: [sq.in]	36.8	36.8
Specific Leakage Area:	0.00018	0.00018
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Duct Leakage

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Ventilation

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Rate (cfm):	50
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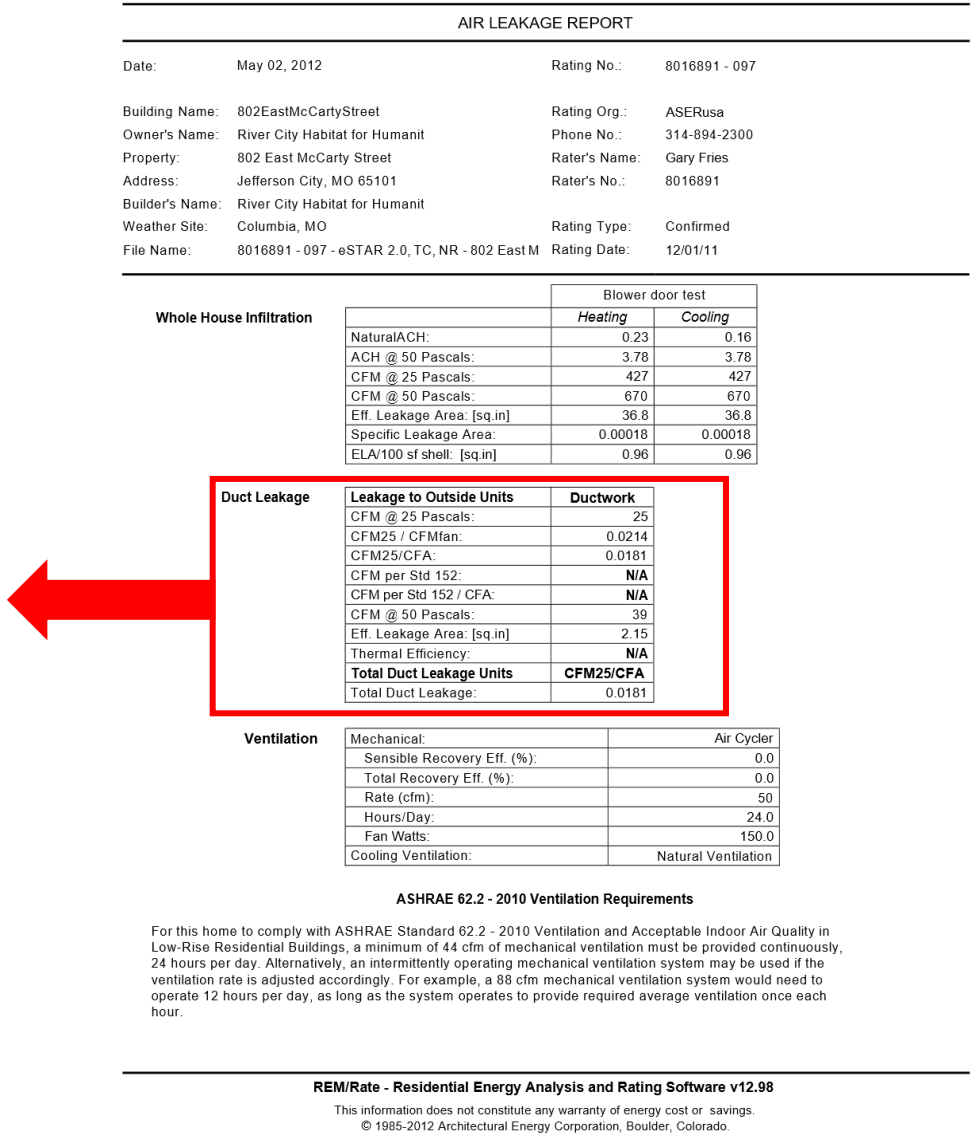

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Date:	May 02, 2012	Rating No.:	8016891 - 097
Building Name:	802EastMcCartyStreet	Rating Org.:	ASERusa
Owner's Name:	River City Habitat for Humanit	Phone No.:	314-894-2300
Property:	802 East McCarty Street	Rater's Name:	Gary Fries
Address:	Jefferson City, MO 65101	Rater's No.:	8016891
Builder's Name:	River City Habitat for Humanit		
Weather Site:	Columbia, MO	Rating Type:	Confirmed
File Name:	8016891 - 097 - eSTAR 2.0, TC, NR - 802 East M	Rating Date:	12/01/11

Whole House Infiltration

	Blower door test	
	Heating	*Cooling*
NaturalACH:	0.23	0.16
ACH @ 50 Pascals:	3.78	3.78
CFM @ 25 Pascals:	427	427
CFM @ 50 Pascals:	670	670
Eff. Leakage Area: [sq.in]	36.8	36.8
Specific Leakage Area:	0.00018	0.00018
ELA/100 sf shell: [sq.in]	0.96	0.96

Duct Leakage

Leakage to Outside Units	Ductwork
CFM @ 25 Pascals:	25
CFM25 / CFMfan:	0.0214
CFM25/CFA:	0.0181
CFM per Std 152:	**N/A**
CFM per Std 152 / CFA:	**N/A**
CFM @ 50 Pascals:	39
Eff. Leakage Area: [sq.in]	2.15
Thermal Efficiency:	**N/A**
Total Duct Leakage Units	**CFM25/CFA**
Total Duct Leakage:	0.0181

Ventilation

Mechanical:	Air Cycler
Sensible Recovery Eff. (%):	0.0
Total Recovery Eff. (%):	0.0
Rate (cfm):	50
Hours/Day:	24.0
Fan Watts:	150.0
Cooling Ventilation:	Natural Ventilation

ASHRAE 62.2 - 2010 Ventilation Requirements

For this home to comply with ASHRAE Standard 62.2 - 2010 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, a minimum of 44 cfm of mechanical ventilation must be provided continuously, 24 hours per day. Alternatively, an intermittently operating mechanical ventilation system may be used if the ventilation rate is adjusted accordingly. For example, a 88 cfm mechanical ventilation system would need to operate 12 hours per day, as long as the system operates to provide required average ventilation once each hour.

REM/Rate - Residential Energy Analysis and Rating Software v12.98

This information does not constitute any warranty of energy cost or savings.

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Air Leakage Report

Ventilation

Mechanical:	Air Cycler
Sensible Recovery Eff (%):	0.0
Total Recovery Eff (%):	0.0
Rate (cfm):	50
Hours/Day:	24
Fan Watts:	150.0
Cooling Ventilation:	Natural Ventilation

AIR LEAKAGE REPORT

Date:	May 02, 2012	Rating No.:	8016891 - 097
Building Name:	802EastMcCartyStreet	Rating Org.:	ASERusa
Owner's Name:	River City Habitat for Humanit	Phone No.:	314-894-2300
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	Heating	*Cooling*
NaturalACH:	0.23	0.16
ACH @ 50 Pascals:	3.78	3.78
CFM @ 25 Pascals:	427	427
CFM @ 50 Pascals:	670	670
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Specific Leakage Area:	0.00018	0.00018
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Ventilation and I.A.Q.

Building Envelope +

Air Sealing Package +

HVAC Design, Equipment & Installation +

ERV/HRV +

Water Heating Design

= Occupant Comfort

Any questions?

Part II: All about the 2018 IECC, 2021 IECC, and Beyond Learning Objectives

In this Part you will:

1. **Learn about the major changes to the 2021 IECC**
2. **Understand what is coming in the 2024 IECC and potential requirements**
3. **Understand the impacts on materials, best practices, and how that will affect Building in Nebraska**

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Biggest Changes in IECC 2021

- Redrawn Climate Zones (No Change in NE)
- Improved Window U-factors & Wall and Ceiling R-values
- Attic pull-down stairs – R-13 okay for CZ1-4
- Floor insulation – 3 options
- Basement option details
- Sunrooms and heated garage separation

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Biggest Changes in IECC 2021 (Cont.)

- Ducts Testing on all systems
- Ducts inside, < 8% Total Leakage
- Ducts outside, < 4% Total Leakage
- Verified fan (kitchen, bath, whole house) airflow
- All efficient lighting and controls (100%)
- Must choose your Additional Efficiency Package

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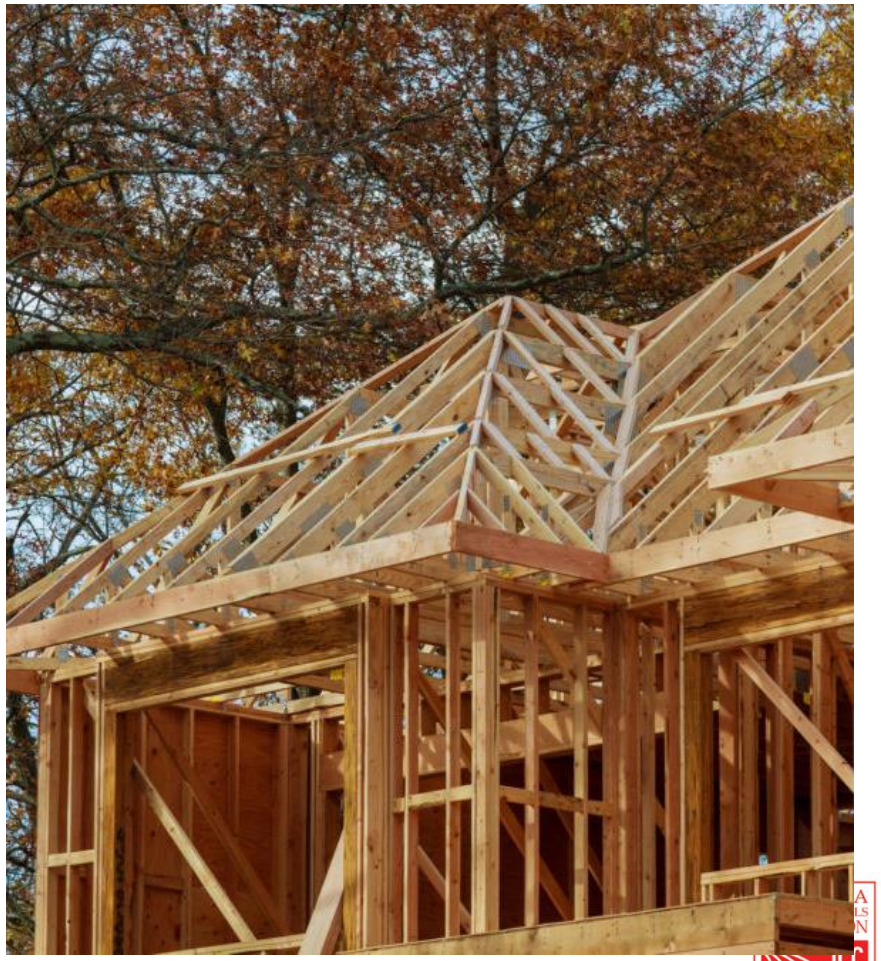
The Energy Code is Everywhere

- Unlike most other codes, the energy code directly impacts the work of many disparate building trades and systems, including:
  - Framing/Envelope
  - Plumbing
  - HVAC
  - Electric
  - Moisture management
  - Concrete
  - Caulking



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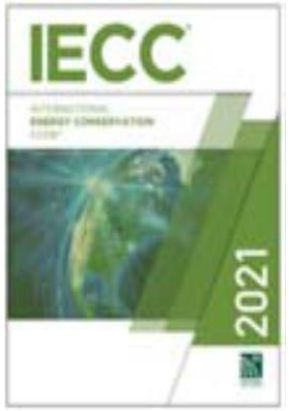
Changes in IECC 2021



- **Definitions Added/Modified:**

- *Lighting Definition Modification*
- Information Technology Equipment (ITE)
- Internal Curtain System
- *On-Site Renewable Energy*
- *Renewable Energy Resources*
- *Testing Unit Enclosure Area*
- *Thermal Distribution Efficiency (TDE)*
- *Vegetative Roof*
- *Visible Transmittance*

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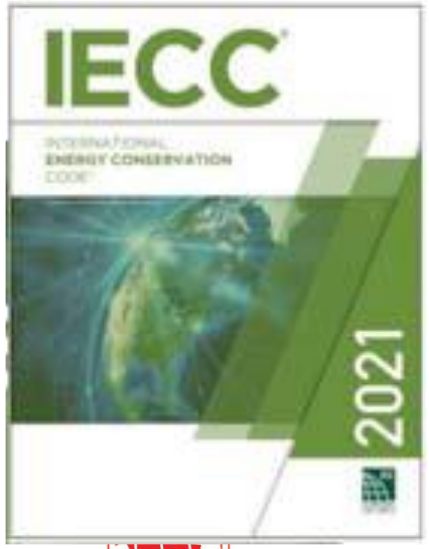
Key Energy Code Components

- Insulation R-value (ceiling, wall, foundation)
- Insulation installation quality
- Continuous air barrier/sealing and testing
- Efficient windows
- Mechanical ventilation
- HVAC system sizing location detailing
- Envelope testing
- Efficient lighting & verification testing



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2021 IECC / IRC Section 11

Basics:

- Updated +/- 3% above 2018 IECC
- Testing and verification.
- Continues to Promote Innovation through Criteria: Energy Ratings Index (ERI) and 3 other alternative methods
- Biggest Changes:
  - -R 60 attic Insulation
  - -More focus on future electrification

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IECC - Residential Provisions (All-Electric)

- **Chapter 1 – Scope and Application R101 SCOPE AND GENERAL REQUIREMENTS**
- **R101.3 Intent:**

Intent has been modified to include consideration of greenhouse gas emissions as well as both production and storage of energy.

- **R103 CONSTRUCTION DOCUMENTS**
- **R103.2.3 Solar-ready system**

Revisions to this section incorporate critical elements of solar readiness to be clearly identified on the construction documents. This code language has been migrated and amended from the 2021 IECC Appendix RB Solar-Ready Provisions.

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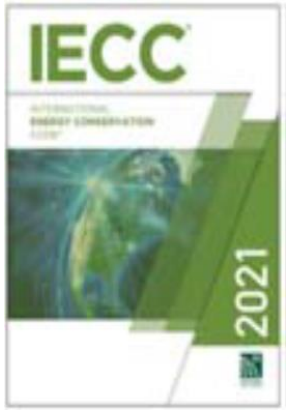
Changes in IECC 2021



- **Administrative**
- R102: More Authority for Code Official to approve alternative material(s). (or not!)
- More definition for Code Officials Approval of Above Code Programs. (or not!)
- Information on Construction Documents must include: Energy Compliance Path and Air Sealing Details and Location of Air Barrier.

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IECC - Residential Provisions (All-Electric) (Cont.)

- **R105 INSPECTIONS**
- **R105.2.3 Plumbing rough-in inspection.**

Revisions to this section incorporate critical elements of solar readiness used for service water heating.

- **R105.2.5 Electrical rough-in inspection.**

Current 2021 IECC inspections do not require dedicated electrical inspections.

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IECC - Residential Provisions (All-Electric) (Cont.)

- **Chapter 4 – Residential Energy Efficiency**
- **R401 GENERAL**
- **R401.2 Application. Residential buildings shall be *all-electric buildings*.**

The change in application requires that new construction be all-electric. Where a jurisdiction does not wish to require electrification of specific end uses but wants to advance electric buildings further than electric-readiness, exception language can be added.

R401.3 Certificate. *Where a solar-ready zone is provided, the certificate shall indicate the location, dimensions, and capacity reserved on the electrical service panel.*

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IECC - Residential Provisions (Mixed-Fuel)

- **Chapter 4 – Residential Energy Efficiency**
- **R401 GENERAL**
- For all-electric buildings
- For mixed-fuel buildings
- For buildings complying with the Energy Rating Index

- **R402 BUILDING THERMAL ENVELOPE**

Low energy buildings are currently exempt from thermal envelope requirements. This revision applies the same intention of low greenhouse gas impact that was given to low energy use impact when these buildi types were exempted.

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IECC - Residential Provisions (Mixed-Fuel)

- **R404.4.1.2 Obstructions.** Solar-ready zones shall be free from obstructions, including but not limited to vents, chimneys, and roof-mounted equipment.
- **R404.4.1.3 Electrical service reserved space.** The main electrical service panel shall have a reserved space to allow installation of a dual pole circuit breaker for future solar electric installation and shall be labeled "For Future Solar Electric." The reserved space shall be positioned at the opposite (load) end from the input feeder location or main circuit location.

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IECC - Residential Provisions (Mixed-Fuel)

- **R404.5 Electric vehicle charging infrastructure**. Electric infrastructure for the current and future charging of electric vehicles shall be installed in accordance with this section. EV ready spaces are permitted to be counted toward meeting minimum parking requirements.

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IECC - Residential Provisions (Mixed-Fuel)

- **R404.6.4 Combustion clothes drying.**
- A dedicated 240-volt branch circuit with a minimum capacity of 30 amps shall terminate within 6 feet (1829 mm) of natural gas clothes dryers and shall be accessible with no obstructions. Both ends of the branch circuit shall be labeled with the words "For Future Electric Clothes Drying" and be electrically isolated.

- **R404.6.5 Combustion cooking**.

A dedicated 240-Volt, 40A branch circuit shall terminate within 6 feet (1829 mm) of natural gas ranges, cooktops and ovens and be accessible with no obstructions. Both ends of the branch circuit shall be labeled with the words "For Future Electric Range" and be electrically isolated.

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IECC and IMC

- Whole-house mechanical ventilation required by energy code
- Ventilation rate and equipment requirements in the International Mechanical Code (IMC)

HVAC Design and Loads

- Properly designed HVAC systems rely on scientific criteria and a systematic method to match the loads required for health and comfort:
  - *ACCA Manual J – Residential Load Calculation*
  - *ACCA Manual S – Residential Equipment Selection*
  - *ACCA Manual D – Residential Duct Systems*
- Reports should be submitted with permit application

HVAC Design and Loads

Oversized systems:

- Less comfort
- Less efficient
- Poorly handles moisture
- Premature equipment failure

Right-sized systems:

- Better operating efficiencies
- Greater comfort
- Healthier indoor environments
- Better moisture control

Moisture Management

It Connects EVERYTHING!

The Major "Damage Functions"

- Liquid water (bulk and capillary)
- Air-borne water
- Vapor
- Radiation (UV degradation)
- Pests
- People

Moisture Flows Four Ways: Air Transported Moisture

- Uncontrolled / unknown holes that allow air into or out of a building have a negative impact on the building and its occupants.
  - 1/3 quart of water through solid gypsum board but 30 quarts through 1 in^2 hole!
- Minimizing envelope air leakage must be a primary goal of the building envelope.
- Energy efficient buildings have a low leakage rate.
- Controlled ventilation / fresh air intake from a known source improves indoor air quality and contributes to occupant health.

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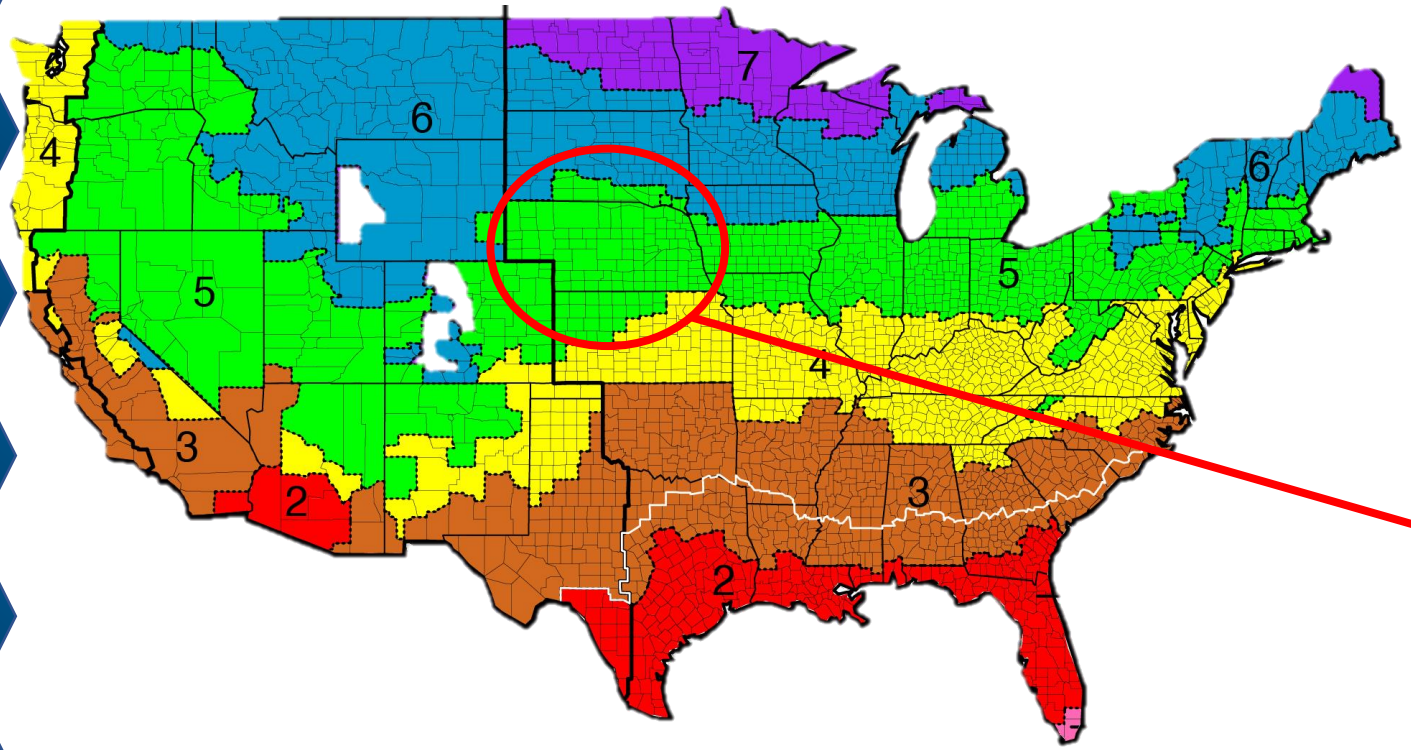
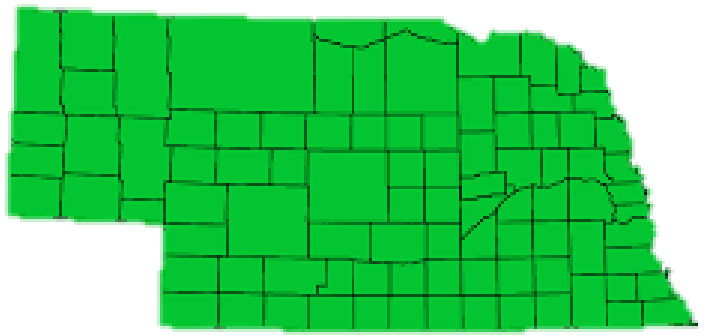
Climate Zones



- Nebraska has only one climate zone – 5A
- Cold & Moist climate



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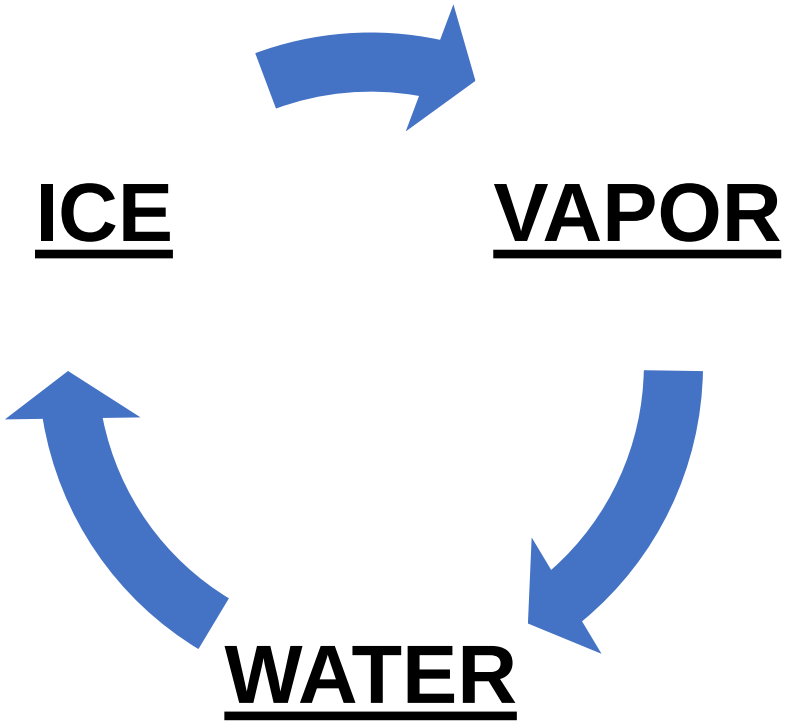
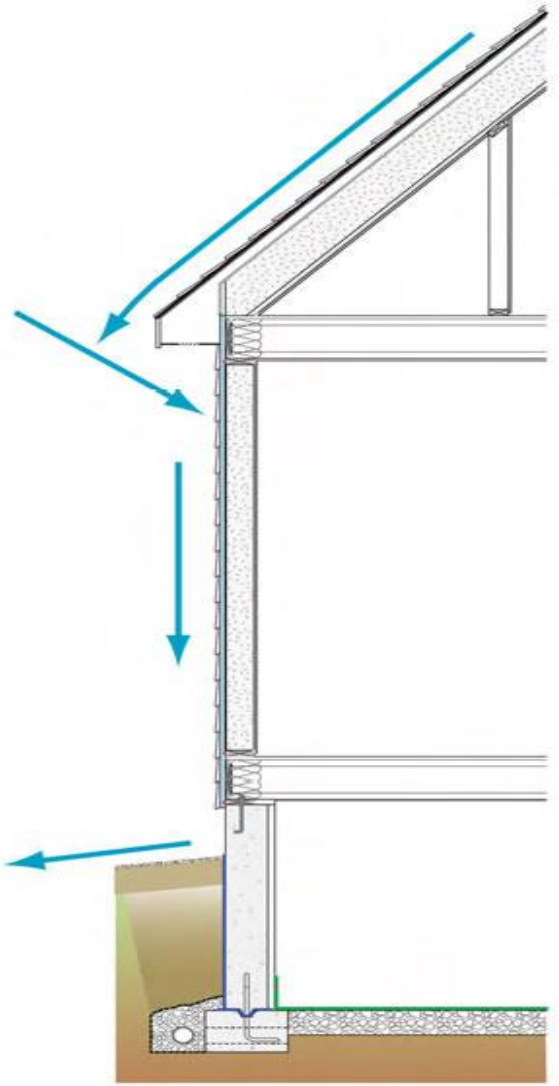
Prioritizing Moisture Movement

#1 – Bulk Water
#2 – Capillary Water
#3 – Air-Transported Moisture
#4 – Diffusive Moisture Movement



Bulk Water Management – Priority #1

The key is proper
drainage!



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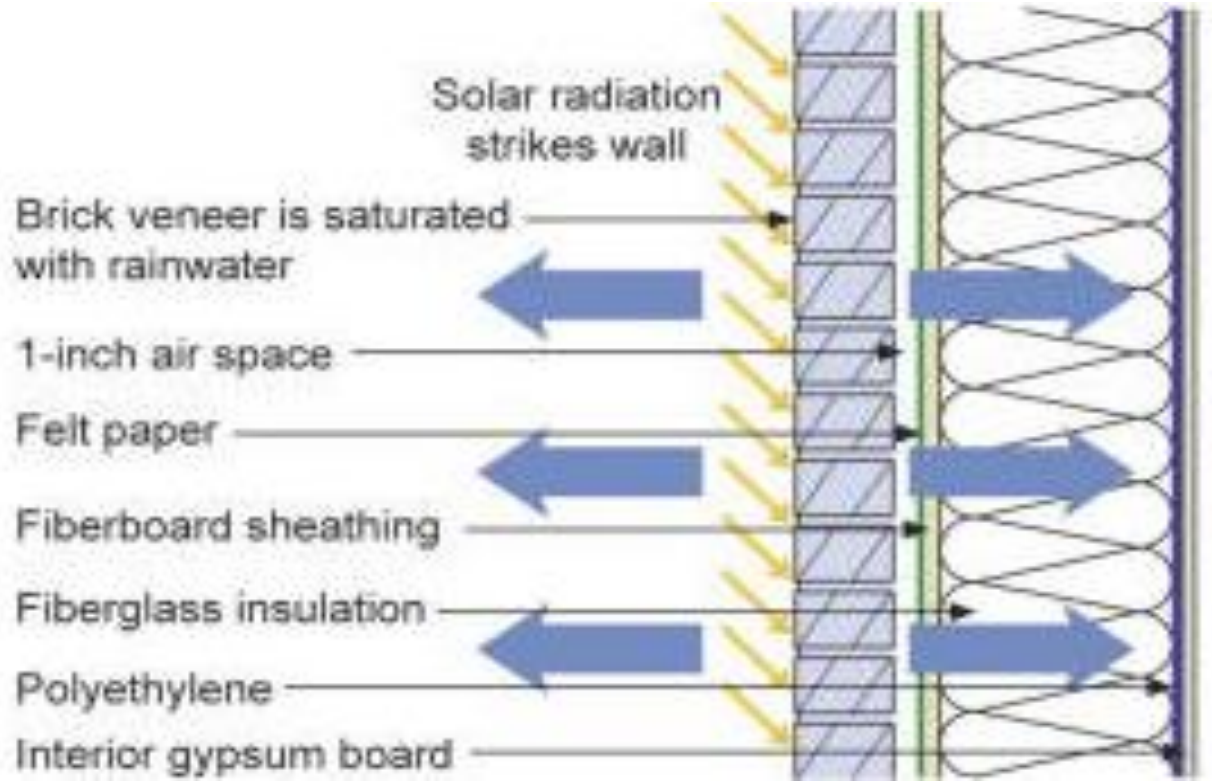
Always Allow For Drying

Exterior Conditions
Temperature: 80° F
Relative Humidity: 75%
Vapor Pressure: 2.49 kPa

Conditions Within Cavity
Temperature: 120° F
Relative Humidity: 100%
Vapor Pressure: 11.74 kPa

Interior Conditions
Temperature: 75° F
Relative Humidity: 60%
Vapor Pressure: 1.82 kPa

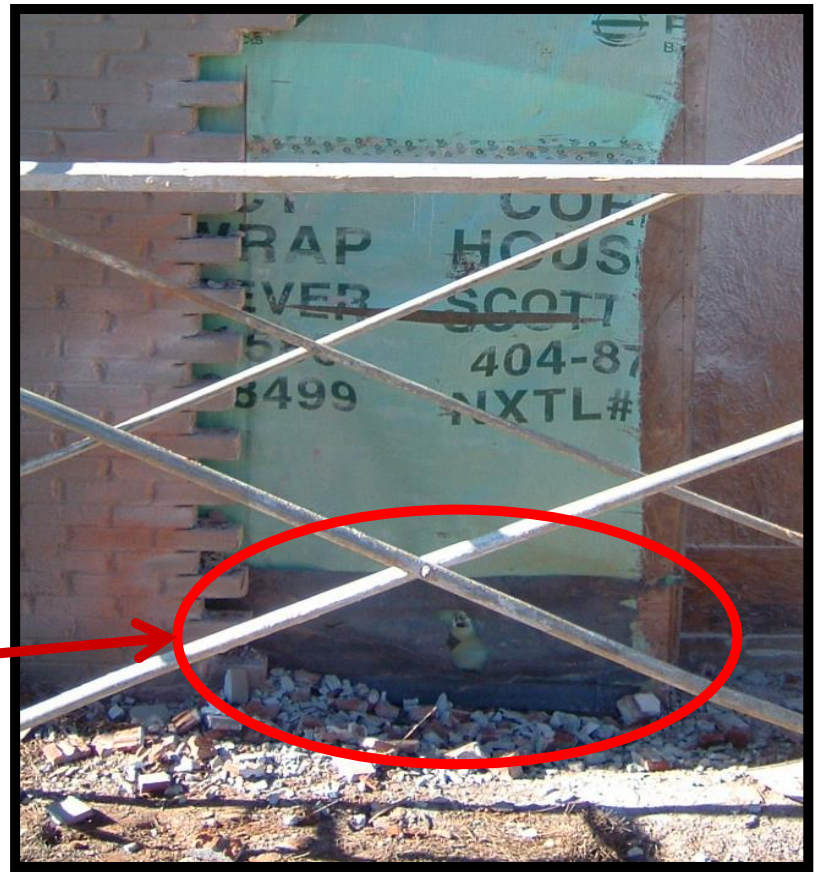


Vapor is driven both inward and outward by a high vapor pressure differential between the brick and interior and the brick and exterior

Image by Building Science Corp.

Properly Lap Flashing

- The mason's flashing (black) was installed after and in front of the house wrap (green). This is reverse flashing that will trap any drain water that gets past the brick veneer.



Direct Water Away From Corners

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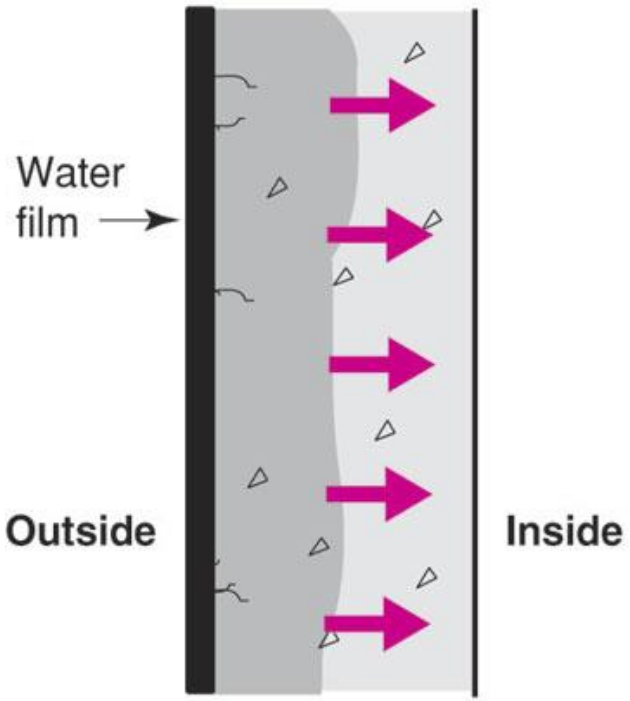
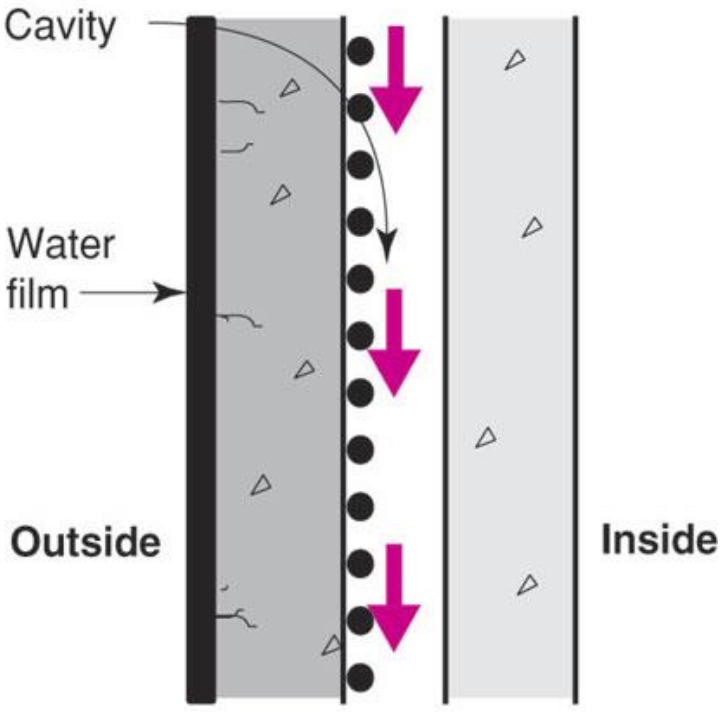
Capillary Moisture Flows - Priority #2



Capillary suction draws water into porous material and tiny cracks



Cavity acts as capillary break and receptor for capillary water interrupting flow

Image courtesy of Building Science Corp.

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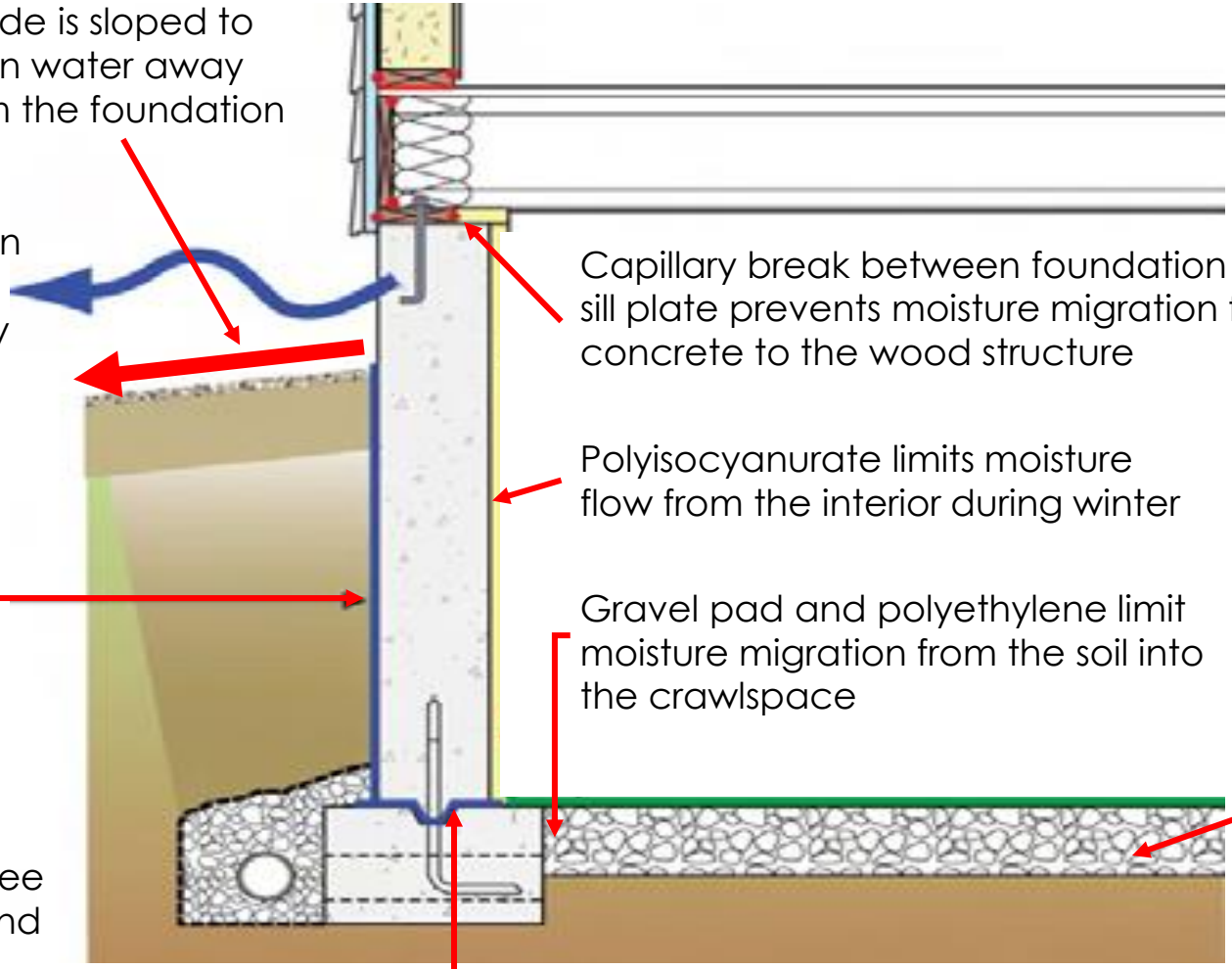
Foundation Moisture Management



Grade is sloped to drain water away from the foundation

Exposed portion of foundation wall able to dry to exterior

Capillary break between foundation wall and sill plate prevents moisture migration from the concrete to the wood structure

Polyisocyanurate limits moisture flow from the interior during winter

Damp-proofing limits moisture flow from soil

Gravel pad and polyethylene limit moisture migration from the soil into the crawlspace

Gravel pad is connected to the perimeter drain through pipes cast into the footing

Water against the foundation wall drains down the free draining backfill and out the perimeter drain at the footing

Capillary break between footing and foundation wall

Sill Plates Need Capillary Breaks

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Air Transport of Moisture – Priority #3

- Air carries a ***lot*** of water
- Air leakage
  - Moisture flow
    - 4X8 Drywall
    - 70 F
    - 40% RH
    - 1 square inch hole
- Flow quantity
  - 30 Quarts of water!!

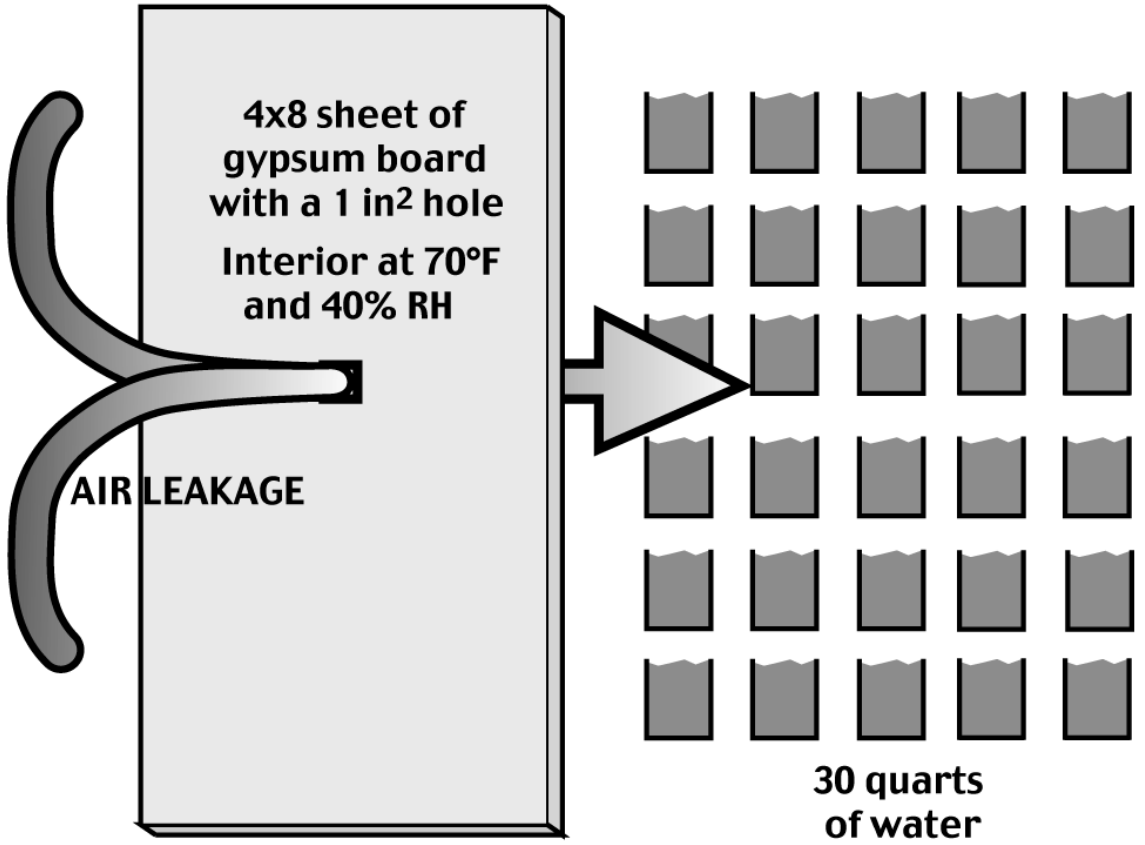


Image courtesy of Building Science Corp.

Diffusion – Priority #4

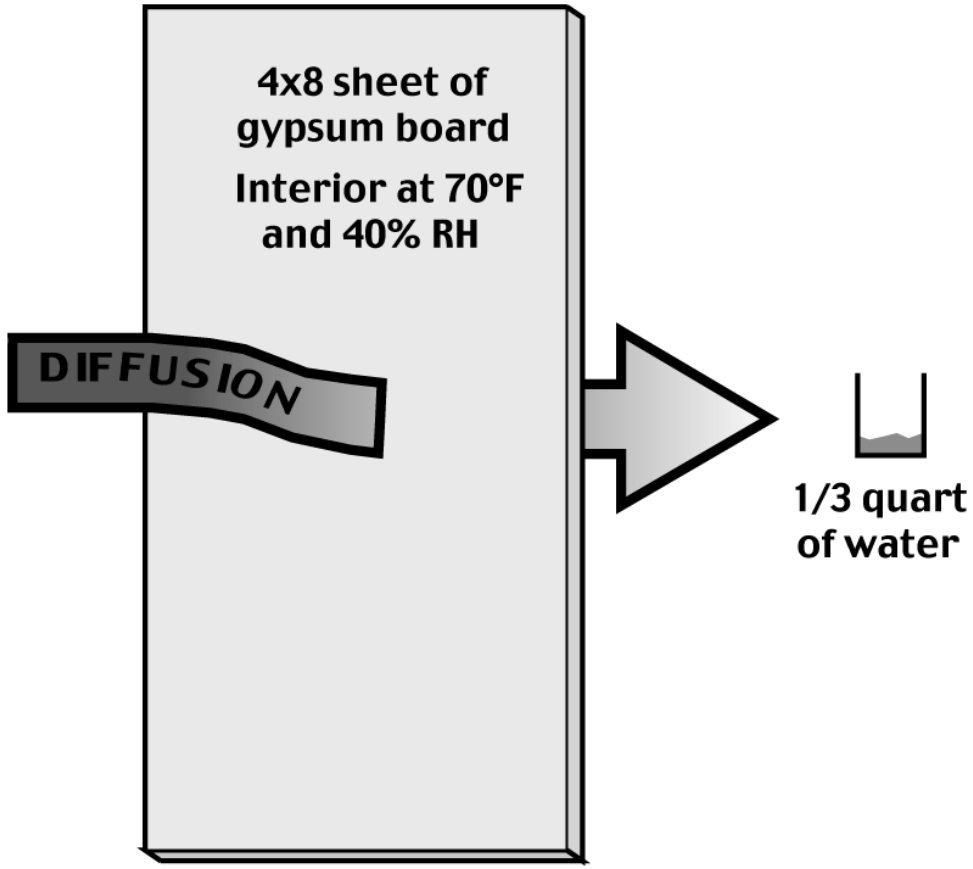


Image courtesy of Building Science Corp.

- Migration of moisture by means of vapor pressure differential
- Occurs in either direction based on climate conditions and exterior/interior levels of humidity
- Different building materials have different permeability

Air Movement

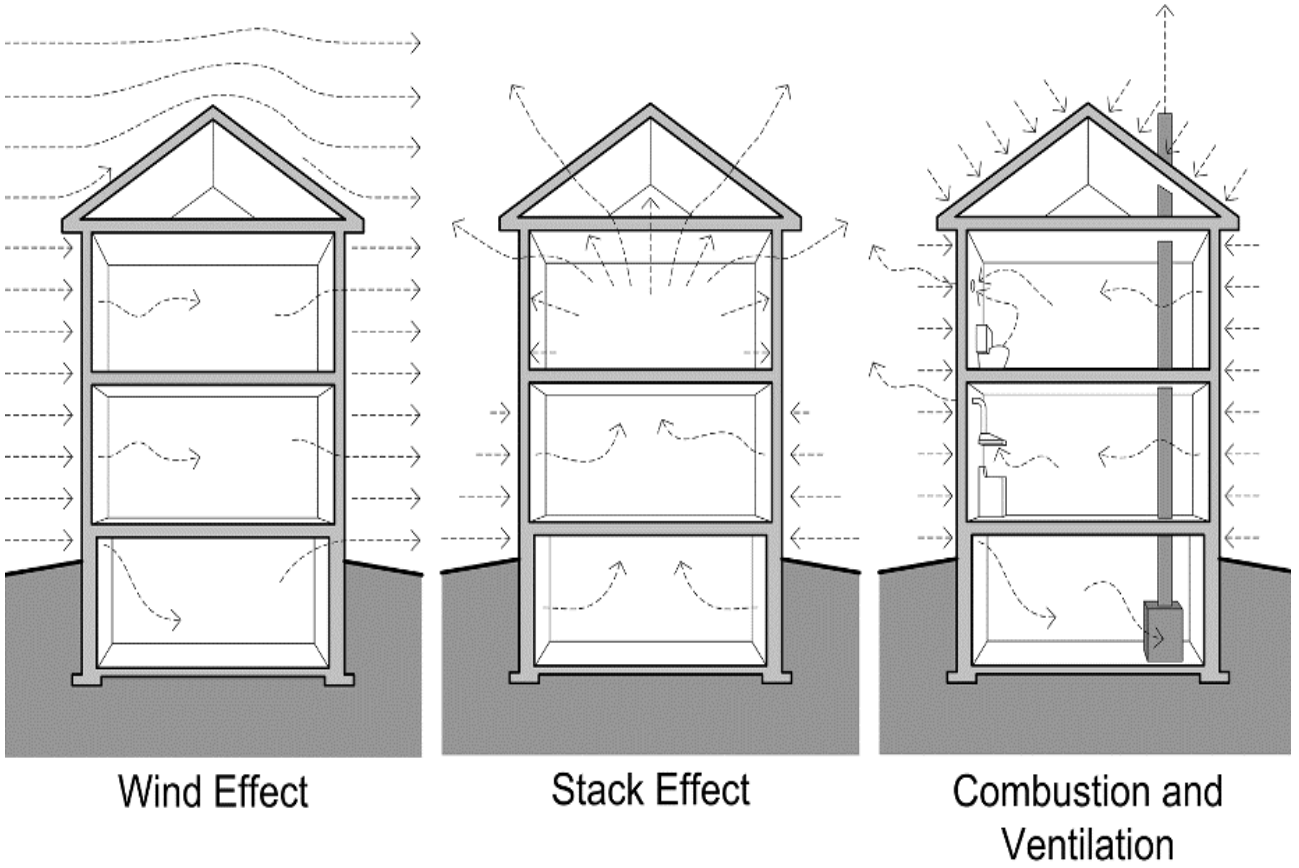
Air Movement Seeks Balance

How Does Air Get Around?

Air In = Air Out

For air movement you need:

- A hole
- A driving force
- Another hole



Internally Generated Air Pressure

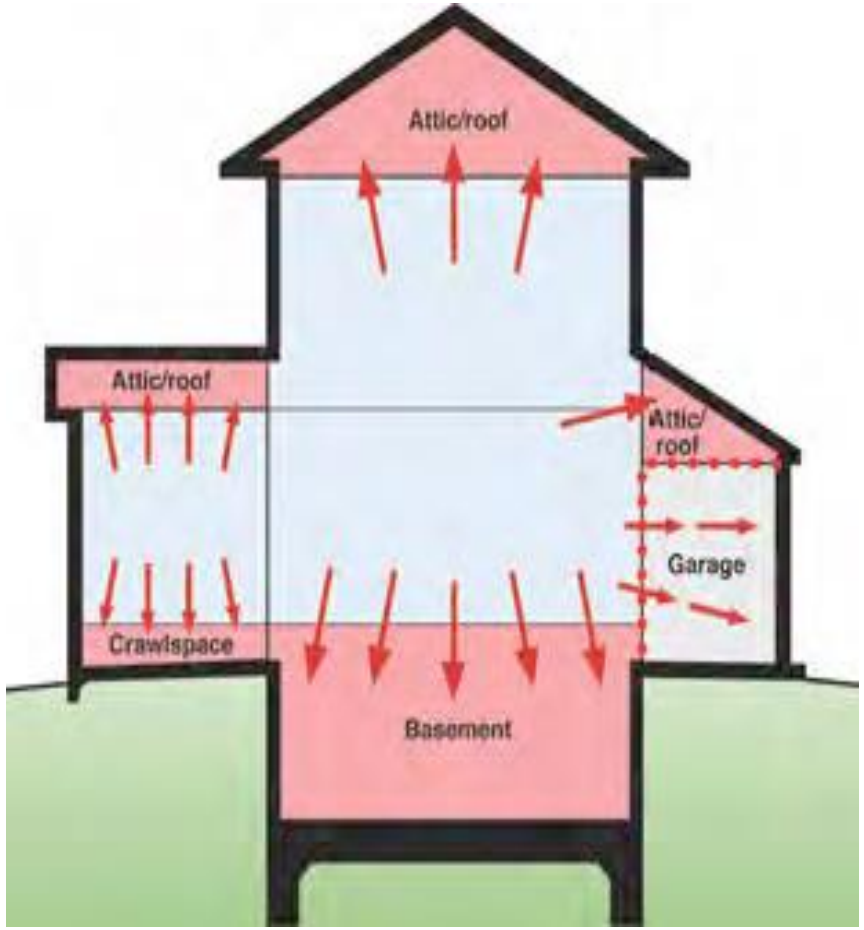


Image by Belcher Homes

Expansion of Conditioned Space

- Conditioned space boundaries moving towards exterior surfaces of building
- Garage isolated from house by air barrier/pressure boundary
- Garage ventilated and conditioned independently of rest of conditioned spaces

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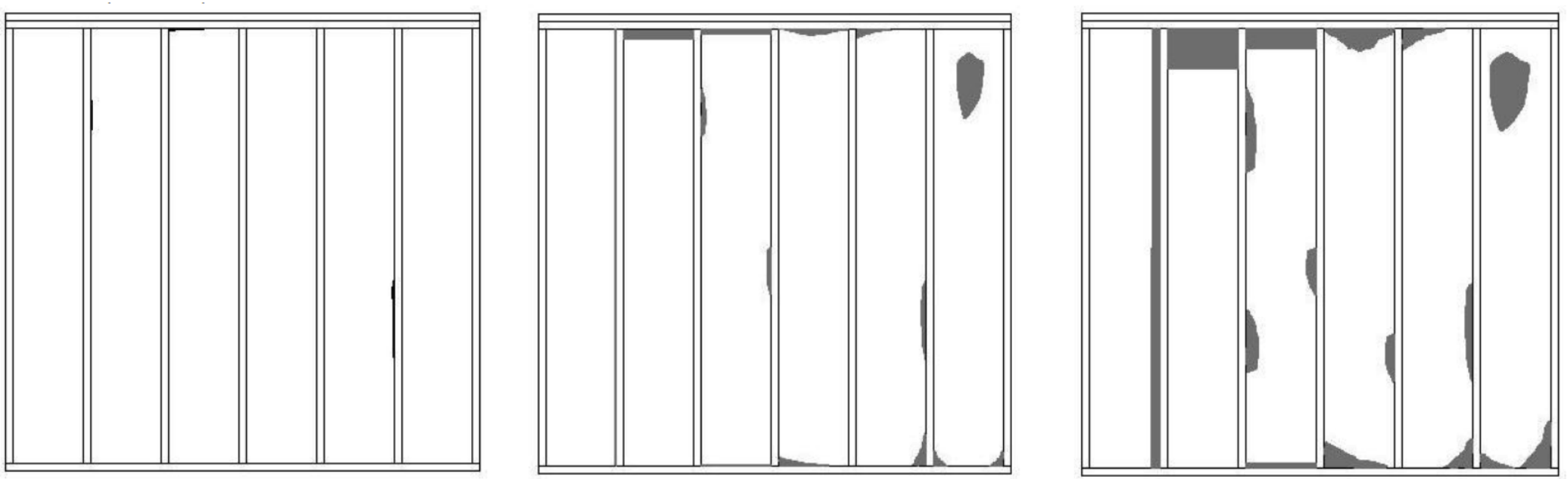
Batt Insulation Grading

Code Compliant ——— **Not Acceptable** ———



Grade I: Almost no gaps

Grade II: Up to 2%

Grade III: 2% - 5%

RESNET protocol for the effect of missing insulation on installation grade

Diagrams from the HERS Standards

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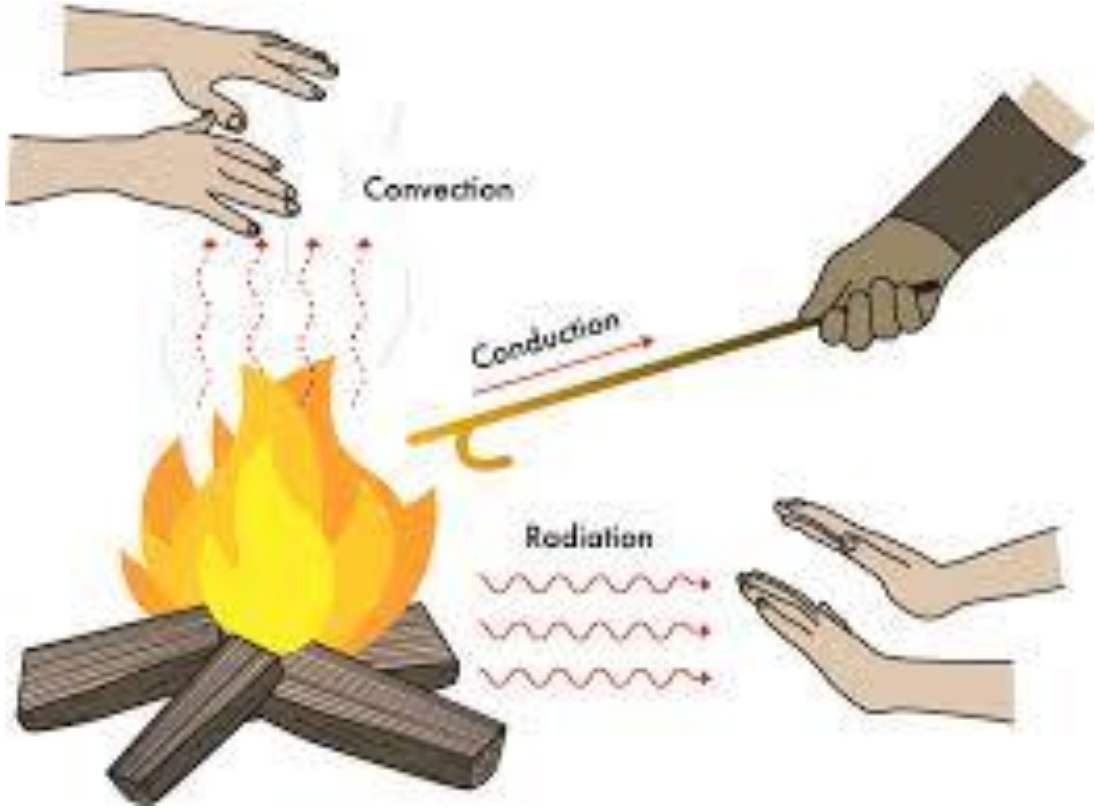
Heat Transfer

A Triple Threat

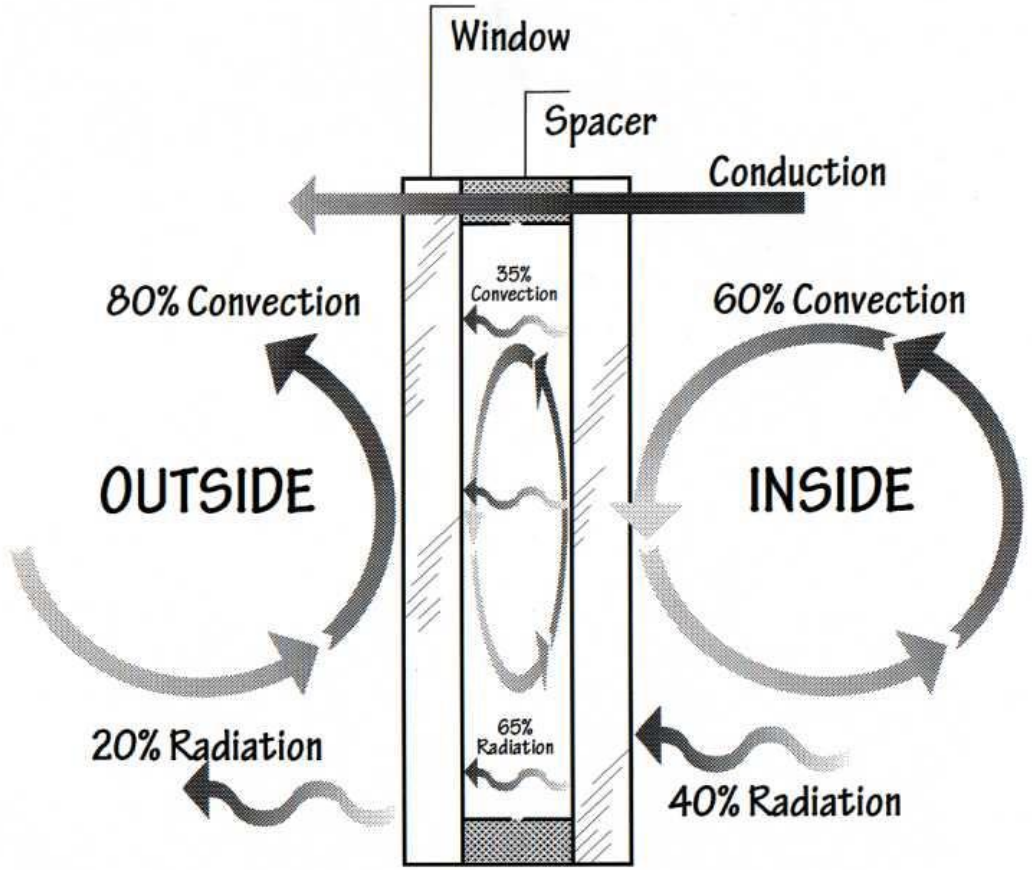
Heat Transfers in 3 Ways

- ***Convection*** - Through fluids (liquid or gas)
- ***Conduction*** - Through solids
- ***Radiation*** - Mostly windows



Practical Application - Windows

- Heat always moves from hot to cold
- Always a mix of transfers
- Different rates of transfer can be important



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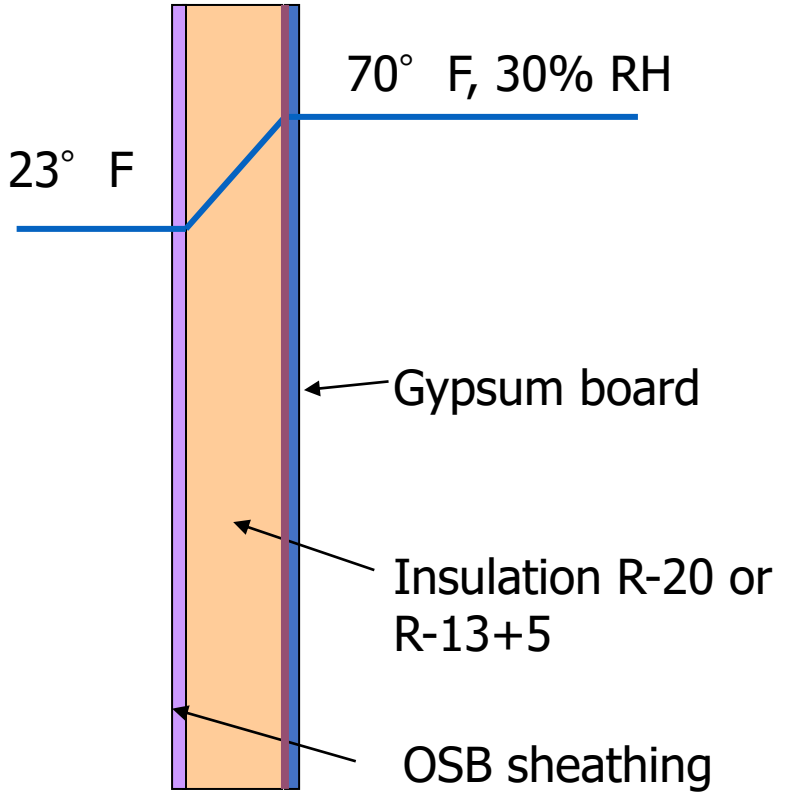
Condensing Surface Temperatures

- Dewpoint of interior air = 37°F
- Where will condensation occur?
  Inside surface of exterior sheathing
- One Solution?
  Interior vapor retarder, but what type and at what "cost?"



Major Building Envelope Protection Systems

- Water Barrier
- Air Barrier
- Thermal Barrier
- Vapor Profile (not just the designated vapor retarder)
- Maintenance documents

“You don’t get what you expect, you get what you inspect!”

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HVAC System

*Don't Forget the **"V"***

Ventilation
Section C403.2.2 (Mandatory)

- **Natural and mechanical ventilation to be provided in accordance with Chapter 4 of the IMC**

- **If mechanical: system to provide the capability to reduce outdoor air supply to minimum required by IMC Chapter 4**

HVAC Design and Loads

- Properly designed HVAC systems rely on scientific criteria and a systematic method to match the loads required for health and comfort:
  - *ACCA Manual J – Residential Load Calculation*
  - *ACCA Manual S – Residential Equipment Selection*
  - *ACCA Manual D – Residential Duct Systems*
- Reports should be submitted with permit application

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HVAC Load Calculations
Section C403.1.1 (Mandatory)

Heating and cooling load sizing calculations required:

- ASHRAE/ACCA Standard 183

- OR -

- Other approved computation procedures – defined in Chapter 3
  - Interior design conditions specified by Section C302
    - ≤ 72°F for heating load
    - ≥ 75°F for cooling load
- Loads reduced from energy recovery systems utilized in the HVAC system shall be accounted for in accordance with the ASHRAE HVAC Systems and Equipment Handbook

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HVAC Design and Loads

Today's homes risk health problems for occupants because:

- They are not properly ventilated:
  - < 3 ACH
- More chemicals and products are used in and around a house:
  - Concentration levels are often 2 to100 times higher than outside.

HVAC Design and Loads

Oversized systems:

- Less comfort
- Less efficient
- Poorly handles moisture
- Premature equipment failure

Right-sized systems:

- Better operating efficiencies
- Greater comfort
- Healthier indoor environments
- Better moisture control

Balanced Ventilation

- Blows air into and out of the house
- Is cost effective by reclaiming energy from exhaust and supply airflows (60%-80%!)
- Balances exhaust and supply flows (minimizes pressure differential)
- Maintains the Minimum Ventilation Guideline automatically with proper set-up

Air Sealing, Testing & Ventilation | R402.4

- **2009 IECC** Requirement: 7 ACH50 (testing optional)
  - Mechanical Ventilation not required
- **2015 IECC** Requirement: 5 ACH50 (testing Required)
- **2018 IECC** Requirement: 3 ACH50 (testing required)
  - Mechanical ventilation required and is critical!
    - Exhaust, Supply or Balanced Ventilation
    - As simple as a continuous bath fan
- ✓ **2021 IECC** Requirement: 3 ACH50 (No Real Change)

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Ventilation and Air Sealing

- Both natural and mechanical ventilation provide fresh air that can dilute and remove indoor pollutant levels
- Per the IMC/IRC, mechanical ventilation is required when homes are <5 ACH 50
  - Need to do a blower door test to determine leakage rate
  - **Liability concerns when not performed**
- A blower door test measures a building's existing air leakage
- Can not design a code compliant system without knowing air leakage

Courtesy of AC Tool Supply, Inc.

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Appraisals and Resale Value

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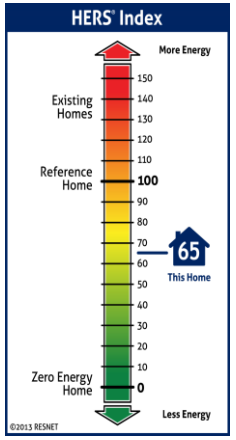
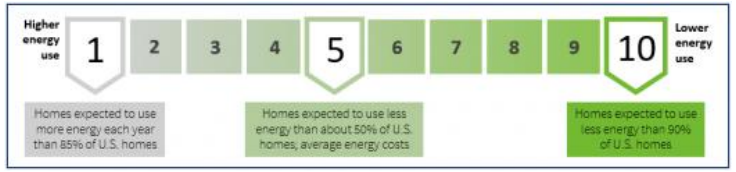
Qualified Appraisers

- Unlike granite countertops, energy efficiency investments are not always visible at a glance
- Utilize certifications, labels, ratings, and scores
- Make sure appraisers are accurately valuing sustainable properties
  - *Residential Green and Energy Efficient Addendum* - Assists appraisers in analyzing residential "Energy efficient" features and properties.

LEED FOR HOMES



HOME PERFORMANCE WITH ENERGY STAR



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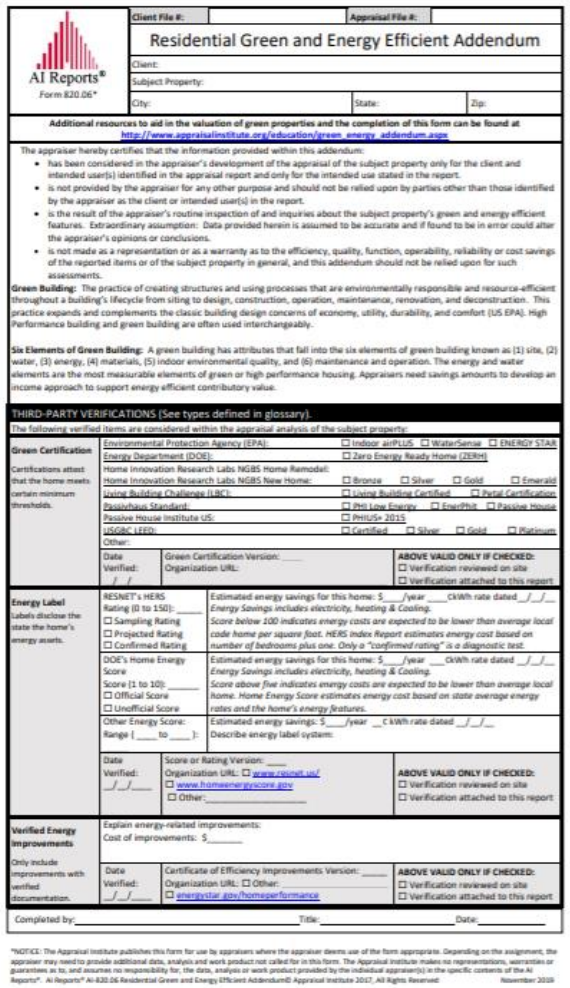
Residential Green and Energy Efficient Addendum!

- Resources for realtors and appraisers on properly valuing energy efficiency/green features
  - Educational materials
  - List of designated appraisers
  - Trainings

- For more information: http://www.appraisalinstitute.org/education/green_energy_addendum.aspx



AI Reports®
Form 820.06*

Residential Green and Energy Efficient Addendum

Client File #: | Appraisal File #:

Client:

Subject Property:

City: | State: | Zip:

Additional resources to aid in the valuation of green properties and the completion of this form can be found at http://www.appraisalinstitute.org/education/green_energy_addendum.aspx

The appraiser hereby certifies that the information provided within this addendum:

- has been considered in the appraiser's development of the appraisal of the subject property only for the client and intended user(s) identified in the appraisal report and only for the intended use stated in the report.
- is not provided by the appraiser for any other purpose and should not be relied upon by parties other than those identified by the appraiser as the client or intended user(s) in the report.
- is the result of the appraiser's routine inspection of and inquiries about the subject property's green and energy efficient features. Extraordinary assumption: Data provided herein is assumed to be accurate and if found to be in error could alter the appraiser's opinions or conclusions.
- is not made as a representation or as a warranty as to the efficiency, quality, function, operability, reliability or cost savings of the reported items or of the subject property in general, and this addendum should not be relied upon for such assessments.

Green Building: The practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's lifecycle from siting to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and complements the classic building design concerns of economy, utility, durability, and comfort (US EPA). High Performance building and green building are often used interchangeably.

Six Elements of Green Building: A green building has attributes that fall into the six elements of green building known as (1) site, (2) water, (3) energy, (4) materials, (5) indoor environmental quality, and (6) maintenance and operation. The energy and water elements are the most measurable elements of green or high performance housing. Appraisers need savings amounts to develop an income approach to support energy efficient contributory value.

THIRD-PARTY VERIFICATIONS (See types defined in glossary).

The following verified items are considered within the appraisal analysis of the subject property:

Green Certification — Certifications attest that the home meets certain minimum thresholds.

- Environmental Protection Agency (EPA): ☐ Indoor airPLUS ☐ WaterSense ☐ ENERGY STAR
- Energy Department (DOE): ☐ Zero Energy Ready Home (ZERH)
- Home Innovation Research Labs NGBS Home Remodel:
- Home Innovation Research Labs NGBS New Home: ☐ Bronze ☐ Silver ☐ Gold ☐ Emerald
- Living Building Challenge (LBC): ☐ Living Building Certified ☐ Petal Certification
- Passivhaus Standard: ☐ PHI Low Energy ☐ EnerPHit ☐ Passive House
- Passive House Institute US: ☐ PHIUS+ 2015
- USGBC LEED: ☐ Certified ☐ Silver ☐ Gold ☐ Platinum
- Other:

Date Verified: / / | Green Certification Version: ____ Organization URL: | ABOVE VALID ONLY IF CHECKED: ☐ Verification reviewed on site ☐ Verification attached to this report

Energy Label — Labels disclose the state the home's energy assets.

RESNET's HERS Rating (0 to 150): ____
☐ Sampling Rating
☐ Projected Rating
☐ Confirmed Rating

Estimated energy savings for this home: $____/year ____ckWh rate dated __/__/__
Energy Savings includes electricity, heating & Cooling.
Score below 100 indicates energy costs are expected to be lower than average local code home per square foot. HERS Index Report estimates energy cost based on number of bedrooms plus one. Only a "confirmed rating" is a diagnostic test.

DOE's Home Energy Score
Score (1 to 10): _____
☐ Official Score
☐ Unofficial Score

Estimated energy savings for this home: $____/year ____ckWh rate dated __/__/__
Energy Savings includes electricity, heating & Cooling.
Score above five indicates energy costs are expected to be lower than average local home. Home Energy Score estimates energy cost based on state average energy rates and the home's energy features.

Other Energy Score: Range (____ to ____): | Estimated energy savings: $____/year ____ckWh rate dated __/__/__ Describe energy label system:

Date Verified: __/__/____ | Score or Rating Version: ____ Organization URL: ☐ www.resnet.us/ ☐ www.homeenergyscore.gov ☐ Other:_____ | ABOVE VALID ONLY IF CHECKED: ☐ Verification reviewed on site ☐ Verification attached to this report

Verified Energy Improvements — Only include improvements with verified documentation.

Explain energy-related improvements.
Cost of improvements: $_____

Date Verified: __/__/____ | Certificate of Efficiency Improvements Version: ____ Organization URL: ☐ Other: ☐ energystar.gov/homeperformance | ABOVE VALID ONLY IF CHECKED: ☐ Verification reviewed on site ☐ Verification attached to this report

Completed by:_____ Title:_____ Date:_____

NOTICE: The Appraisal Institute publishes this form for use by appraisers where the appraiser deems use of the form appropriate. Depending on the assignment, the appraiser may need to provide additional data, analysis and work product not called for in this form. The Appraisal Institute makes no representations, warranties or guarantees as to, and assumes no responsibility for, the data, analysis or work product provided by the individual appraiser(s) in the specific contents of the AI Reports®. AI Reports® AI-820.06 Residential Green and Energy Efficient Addendum® Appraisal Institute 2017. All Rights Reserved November 2019

Form 820.04

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S 4671

US Senate S. 4671 which addresses accurate energy appraisals in connection with residential mortgage loans.

The proposed legislation requires that the federal secondary mortgage institutions of Fannie Mae, Freddie Mac, FHA, VA, Ginnie Mae, and the Rural Housing Service of the Department of Agriculture to provide written disclosure to loan applicants:

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S 4671 cont.

A statement that the "prospective borrower or current homeowner may provide an energy report, or any information in such report, regarding the property subject to the covered loan to the creditor or to a qualified appraiser or other interested party for consideration during a home appraisal or application for a covered loan."

A statement that "the prospective borrower under the covered loan has the right to request an energy report regarding the property subject to the covered loan."

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S4671

A statement that in developing an appraisal in connection with such covered loan—

- a qualified appraiser will take the information in the report into consideration; and
- the appraisers' final opinion of the value of the property may be higher, lower, or no different than if the energy report had not been available for the appraiser to review."

A statement that "as with any other data considered by the appraiser that affects the appraiser's opinion of the value of a property, consideration of such data may help or hurt the ability of the prospective borrower to obtain a covered loan."

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Marketing High Performance homes

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High Performance Homes

- High-performing homes cost less to heat and cool, are more comfortable, and are healthier for their occupants.
- 69% of real estate agents said promoting energy efficiency in listings was very or somewhat valuable
- Immediate benefits – energy savings, comfort, and health
- Long term-benefits – higher selling price

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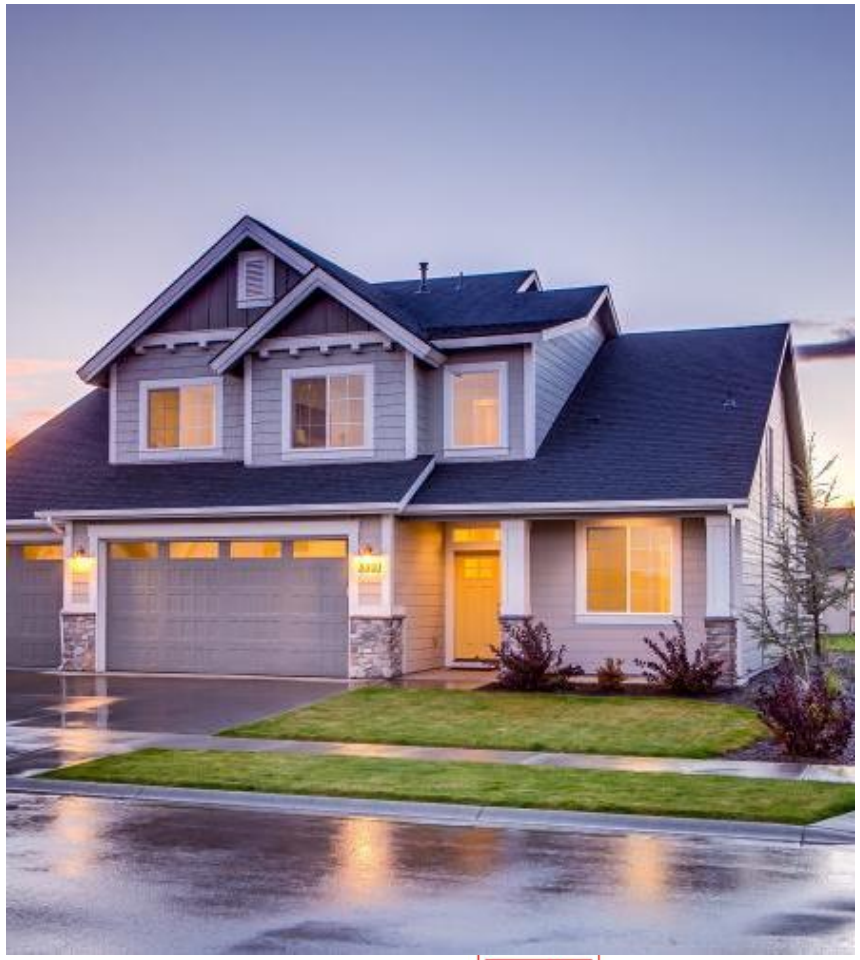
Energy Efficiency is a Must-Have for Home Buyers

- A survey done by the NAHB in 2018 showed 46% of builders reported that **marketing green homes was easier** than marketing non-green homes
- Energy efficient homes also **keep residents in their homes longer** and **sell more quickly** than non-energy efficient homes.
- Green certified homes have a **higher market value** than less efficient homes
- The odds of **mortgage default are also one-third less** for ENERGY STAR rated homes



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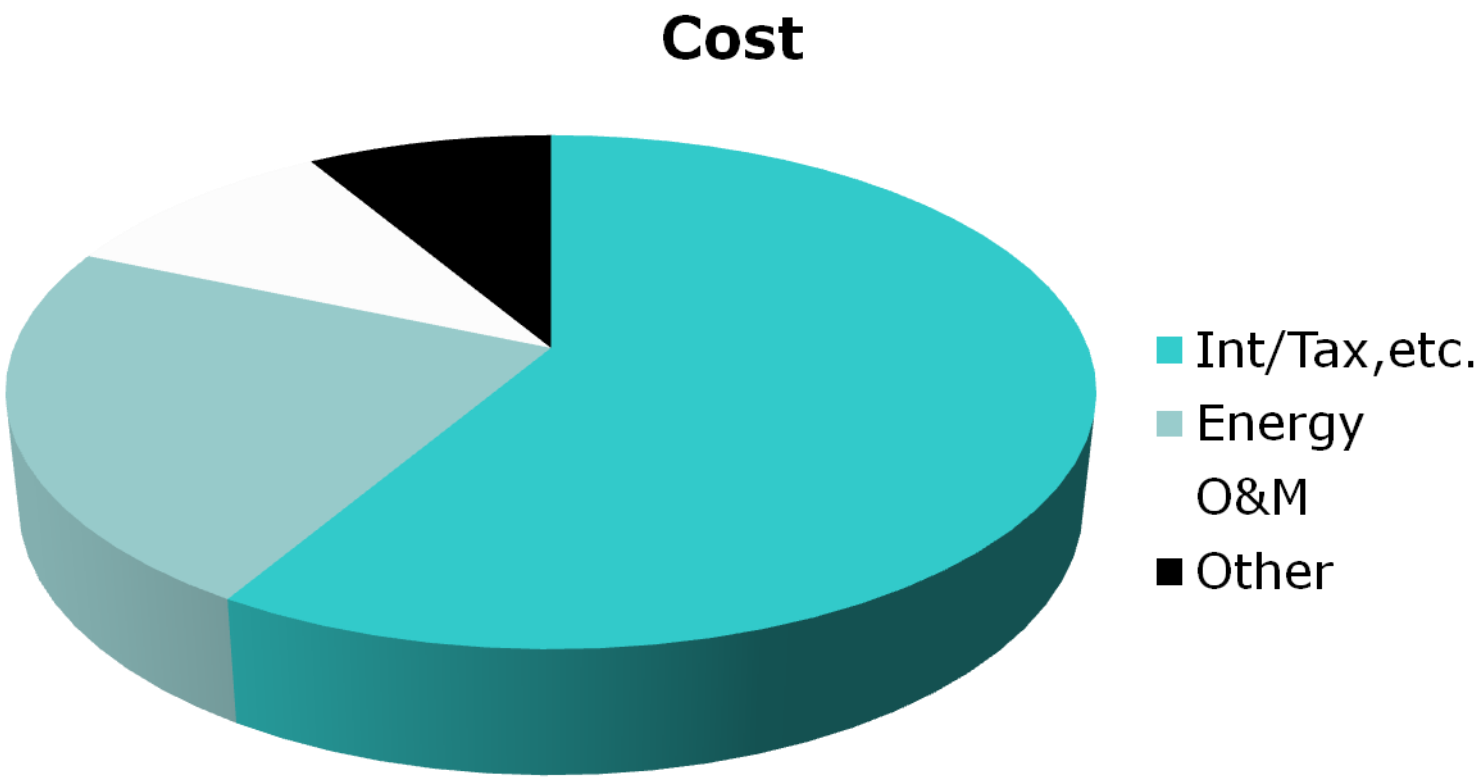
Equity!



Monthly Payment

Key Takeaways

- 2018 IECC has requirements for:
  - Air sealing
  - Duct sealing
  - U-Factor
  - R-Values
  - Performance Testing
- Controlling moisture is *critical*
  - Proper air sealing is key
  - Right-sizing HVAC is required
  - Mechanical ventilation must be installed and takes on new importance

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Key Takeaways

- 2018/2021 IECC has new requirements for:
  - Duct sealing
  - U-Factor
  - R-Values (R 60)
  - Performance Testing Unchanged

- Controlling moisture is ***critical***. *Always has been, Always will be!*
  - Proper air sealing is key
  - Right-sizing HVAC is required
  - Mechanical ventilation must be installed and takes on new importance

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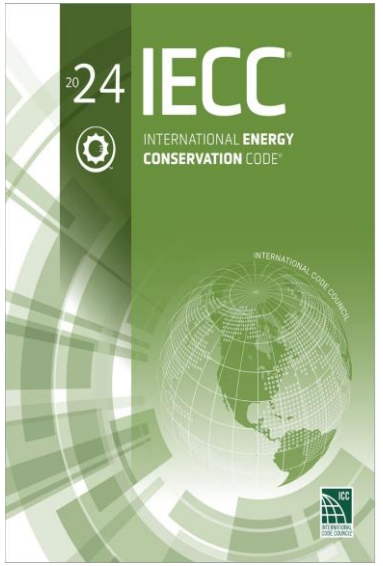
2024 National Energy Standard

- In Process since November ’21 ***Final Approval 3/24!***
- Use ‘21 Energy Code as Basis and Improvements from there.
- Many more stakeholders than IECC Development
- Glide slope to Net Zero by 2030
- Expanded Appendices
- Carbon Impact/Credits



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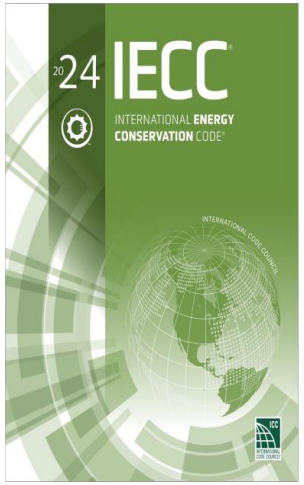
2024 National Energy Standard (Cont.)

- *More* focus on Electrification
- Tables for Envelope and Fenestrations (402/403)updated
- More reliance of high performance
- More focus on testing/verification
- More intent to move appendices items forward in 2027 & 2030 versions



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2024 IECC The final result is a code that:

- Wall insulation and ceiling insulation issues from 2021 IECC – this was the biggest issue with the 2021 IECC
- Expanded the performance path to include equipment trade-offs, duct location trade-offs, and very reasonable envelope backstops
- Includes a much-slimmed down version of the electrification readiness measures in an appendix that would have been if it wasn't for the omnibus

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2024 IECC The final result is a code that:

- Added a wide range of reasonable options for compliance with R408
- Fixed the ERI path
- Recognizes federal preemption challenges with both electrification and higher levels of stringency

2024 Energy Standard

- Many of these “advanced” technologies and practices have actually been in use for a number of years.
- As newer technologies and components come along, they are easier to incorporate
- They all require the “basics” to be done properly!
- They are all systems part of a larger system!

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Key Takeaways

- 2024 Energy Standard has new requirements for:
  - Electrification
  - EV Charging
  - Solar
  - Grid Interaction
  - Carbon
- Using & Understanding Guides and formulas is *critical*
  - Good Design!!!
  - Proper envelope construction is key
  - Right-sizing HVAC is required
  - Documenting construction and certification

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Thank you!

Questions?

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