DOE Zero Energy Ready Home

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

Zero Energy Ready Home Training

SAM RASHKIN
Chief Architect
Building Technologies Office

Outline

Zero Energy Ready Home:

- Why ‘0’ in 3
- Translating Value
- Technical Specifications
- Recognition

Zero Energy Ready Home

Why ‘0’ in 3

Why ‘0’ in 3

Risk
Management

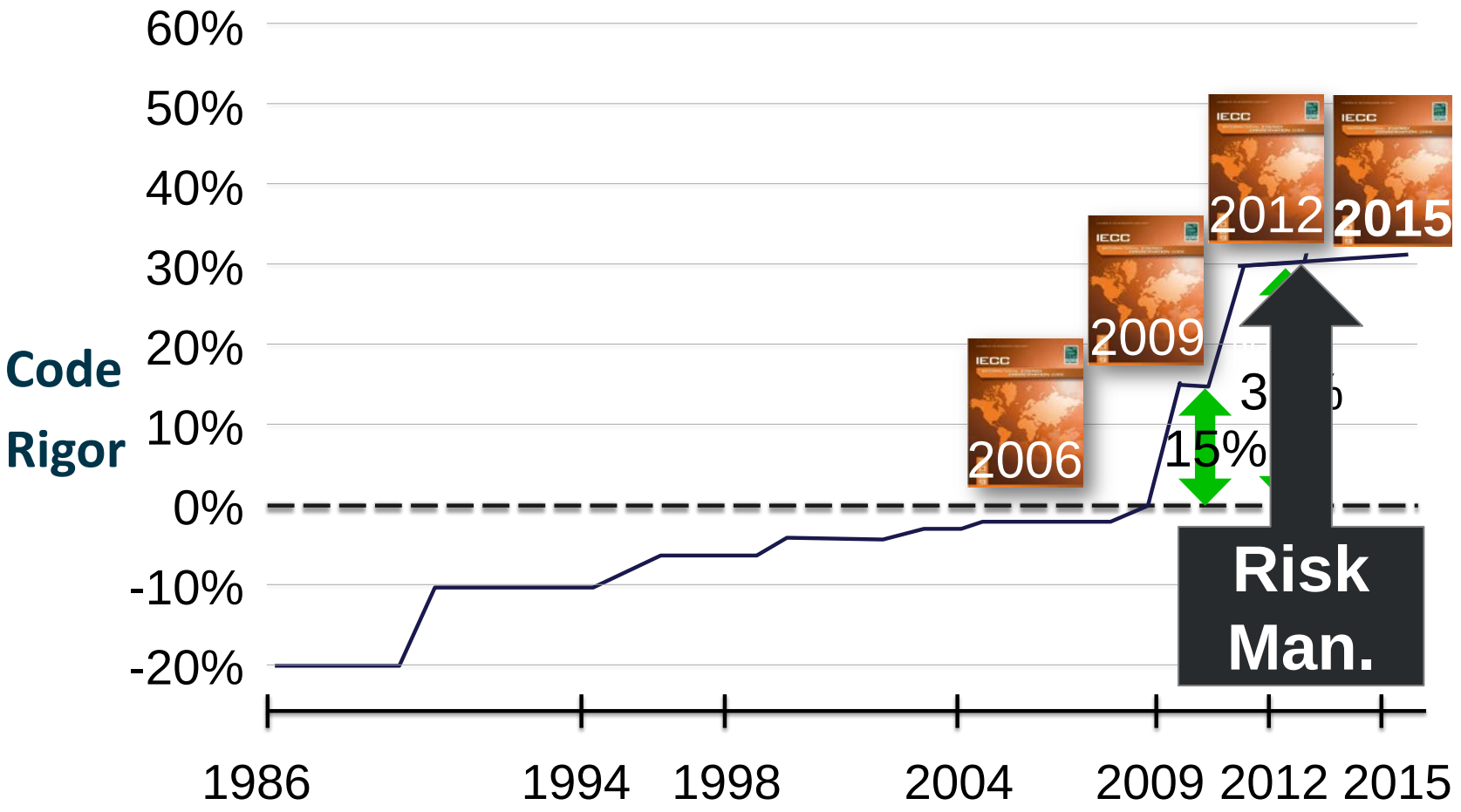
Differentiation
Opportunity

Innovation
Imperative

The Building Science Ceiling

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

Risk | **Differentiation** | **Innovation**



Risk Driver

Risk | Differentiation | Innovation

More Rigorous Specs:

- Latest Energy Codes
- Low HERS Scores

Adv. Thermal Enclosure:

- Adv. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Advanced Windows
- More Air Tightness

Risk Management 1:
Ensured Comfort

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

Risk | **Differentiation** | **Innovation**

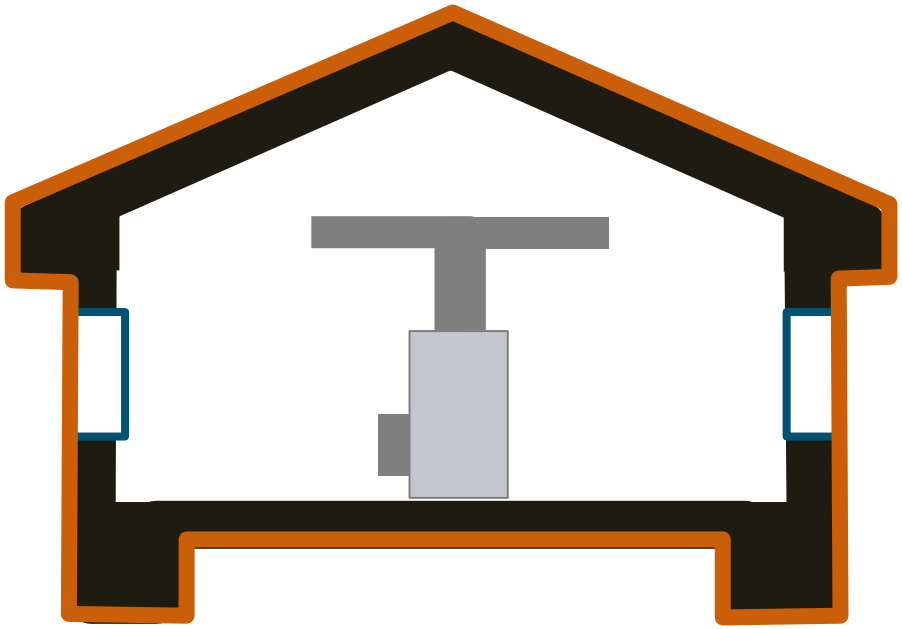
Ultra Low HVAC Loads:

- Lower Air Flow/Mixing
- Longer Swing Seasons
- Less Humidity Control

Advanced Enclosure:

- Adv. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Advanced Windows
- More Air Tightness

Risk | **Differentiation** | **Innovation**



Ultra Low HVAC Loads:

- Lower Air Flow/Mixing
- Longer Swing Seasons
- Less Humidity Control

Optimized Low-Load Comfort System

- Right-Sized
- Properly Installed
- Complete (Htg., Clg. + RH)
- Tested

Risk Management 2:
Moisture Management

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

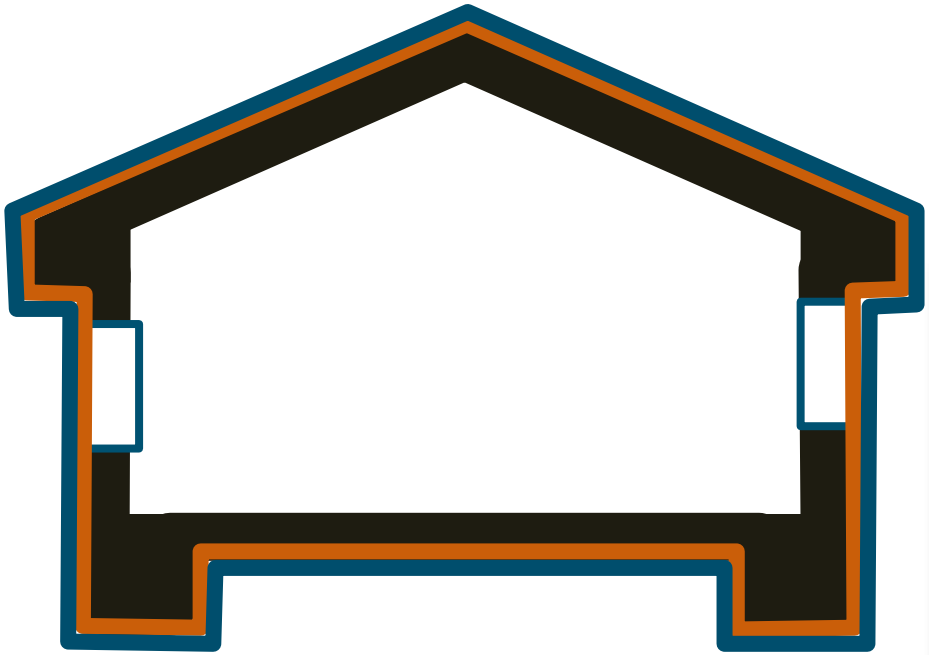
Risk | **Differentiation** | **Innovation**

More Wetting Risk

- Colder Surfaces
- Less Drying Potential

Advanced Enclosure:

- Adv. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Advanced Windows
- More Air Tightness

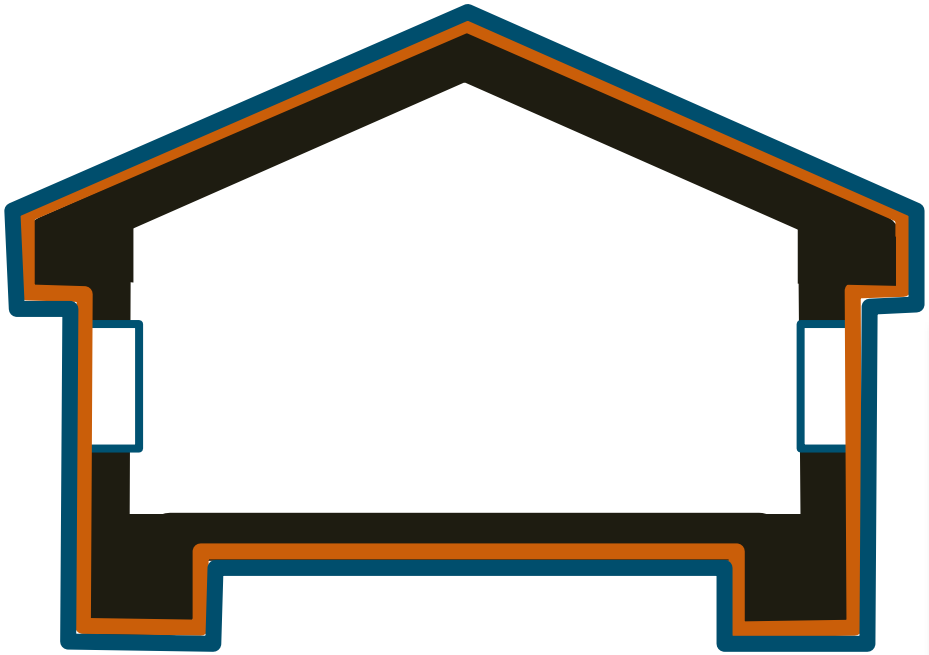


More Wetting Risk

- Colder Surfaces
- Less Drying Potential

Comprehensive Water Protection

- Roofs
- Walls/Openings
- Site/Foundation
- Materials

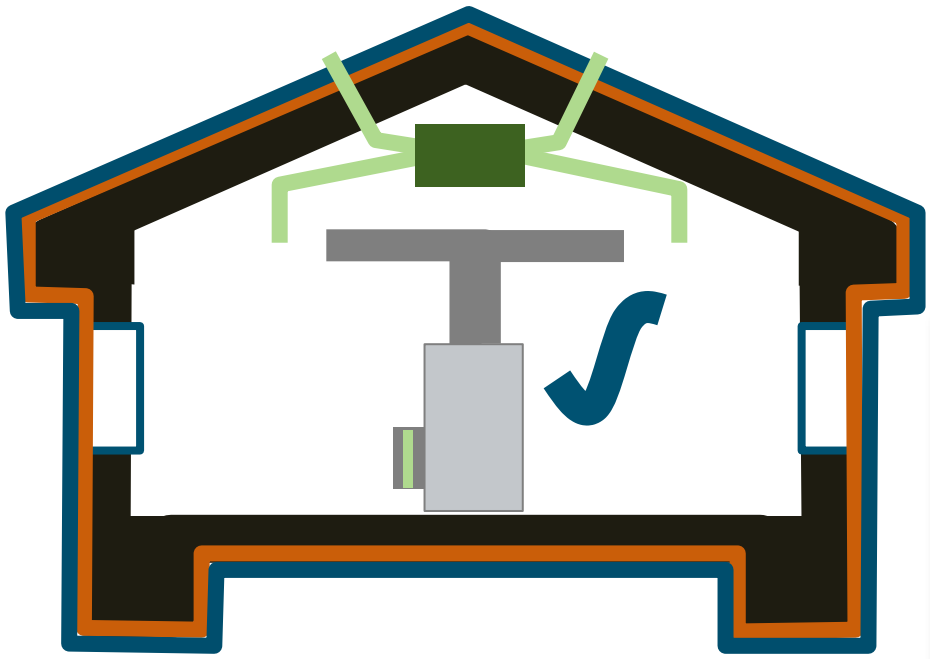


More IAQ Risk:

- Less Dilution
- Less Filtration

Advanced Enclosure:

- Adv. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Advanced Windows
- More Air Tightness



More IAQ Risk:

- Less Dilution
- Less Filtration

Comprehensive IAQ System:

- Contaminant Control
- Fresh Air System
- High-Capture Filtration

Differentiation Opportunity

- Next Generation of Buyers
- The Competition
- The Interest in Health
- Interest in Zero

Next Generation Homebuyers

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

Risk | **Differentiation** | **Innovation**

78 Million Gen-Y’ers

What We Know About Gen-Y

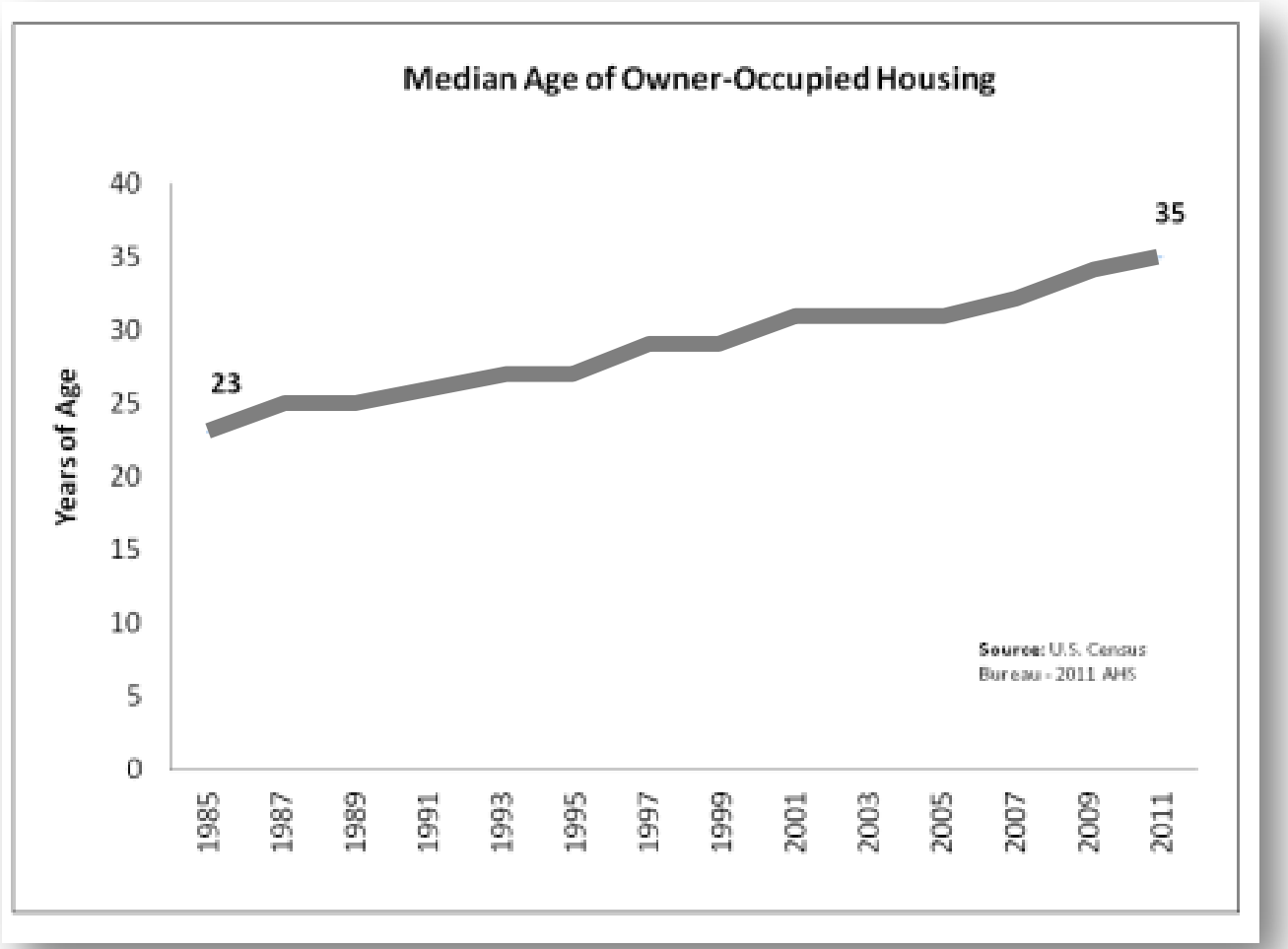
- Debt
- Sharing Economy
- Delayed Commitment
- Crash Experience
- Innovation Junkies

  (Willing to
  Pay More for a
  Better Experience)

The Competition

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

Risk | **Differentiation** | **Innovation**



The Competition

Risk | **Differentiation** | Innovation

Aging Housing Stock with:

- High Utility Bills
- Poor Comfort
- Health Risks
- Moisture Problem Risks
- Excessive Bugs/Pests
- Durability Issues
- Obsolete Technology

Meet 85% of Your Competition

Increasing Health Concerns

$40 Billion

$20 Billion

Increasing Health Concerns

Indoor vs. Outdoor Air Pollutants:

On average **2-5 times greater**

Up to **100 times greater**

While Americans Spend

90% of time indoors

Source: EPA

Increasing Health Concerns

"If your child doesn't use an inhaler, consider yourself a lucky parent because,

1 in 10 children in the U.S. suffers from asthma."

Source: Remarks for Administrator McCarthy, Announcement of Clean Power Plan, Washington, DC, June 2, 2014

Gen-Y Vested in Zero

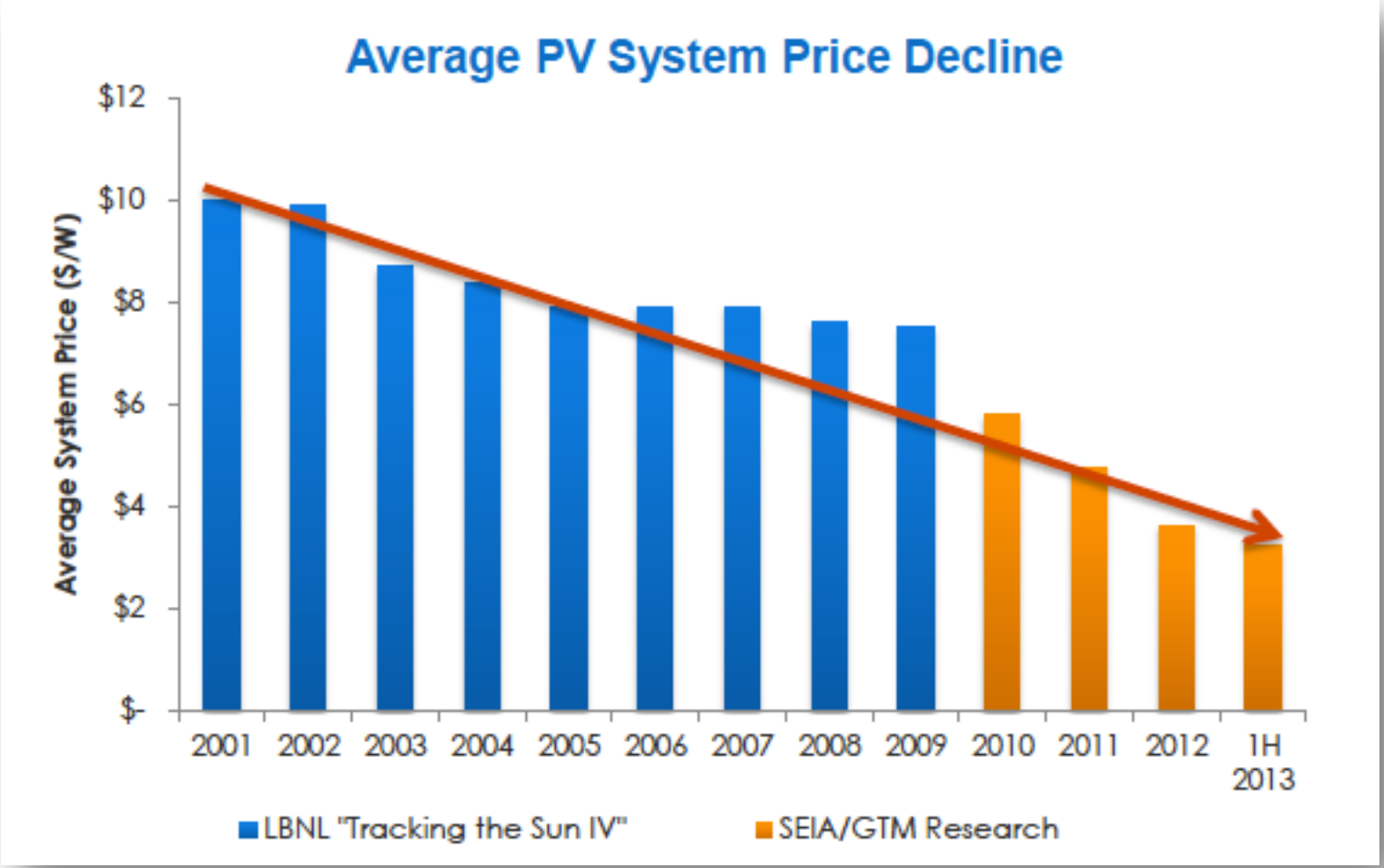
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Risk | **Differentiation** | **Innovation**

Zero Cost-Effectiveness

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

Risk | **Differentiation** | **Innovation**



Differentiation Opportunity 1: Obsolescence

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

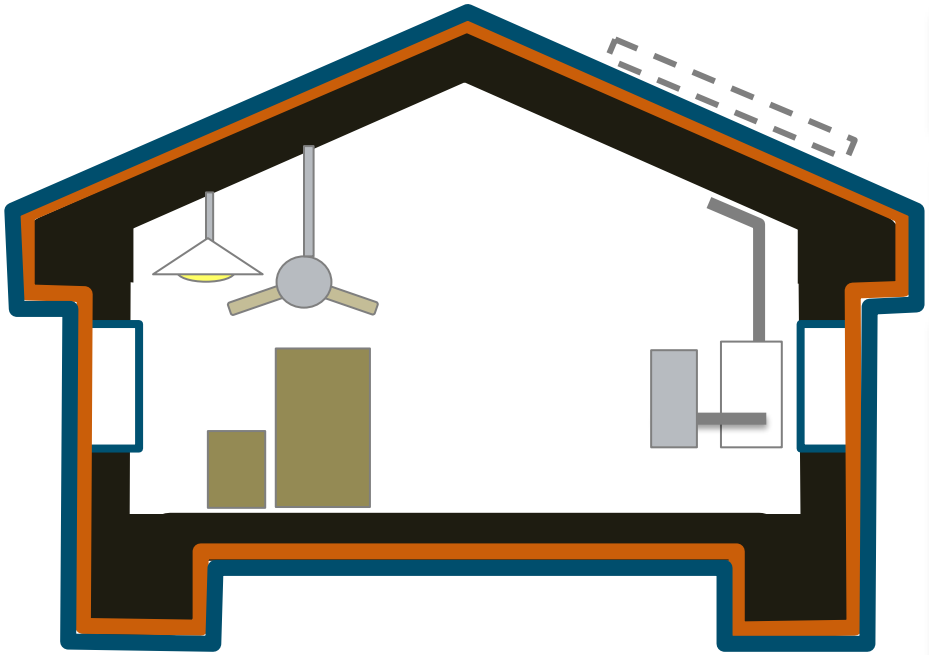
Risk | **Differentiation** | Innovation

House of the Future:

- Meets or Exceeds Future Code/Expectations

Optimized Enclosure:

- Opt. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Optimized Windows
- Optimized Air Tightness



Solar Ready Home

Efficient Components:

Ultra Low HVAC Loads

Optimized Enclosure:

- Opt. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Optimized Windows
- Optimized Air Tightness

Zero Energy Ready Home Spec

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

Risk | **Differentiation** | **Innovation**

Advanced Enclosure

Risk Management:

Optimized Comfort System

Complete Water Protection

Comprehensive IAQ System

Differentiation:

Comprehensive IAQ System

Optimized Enclosure

Efficient Components

Solar Ready Construction

ZERH Spec = Clear Definition

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

Risk | **Differentiation** | **Innovation**

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

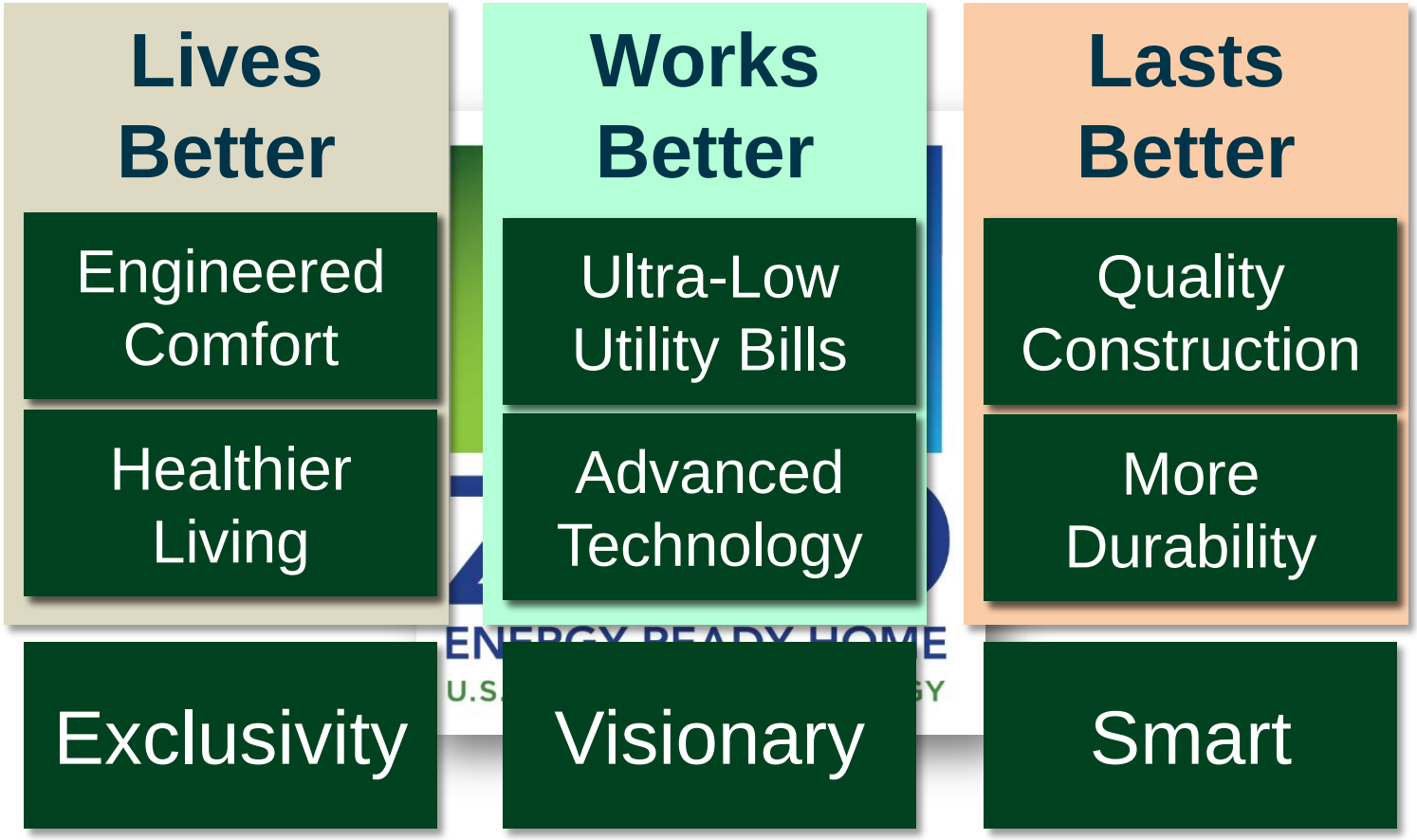
A Zero Energy Ready Home is a…

High-performance home, so **energy efficient,** all or most annual energy consumption can be offset by renewable energy.

ZERH Spec = Value

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

Risk | **Differentiation** | **Innovation**



Change Imperative

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

Risk | **Differentiation** | **Innovation**

"**Accelerating rate of change is as certain** as the sun rising in the east…

It's going to sweep across our landscape like the technological tsunami it is….

It will disrupt catastrophically every aspect of every industry…

—***except for those who see it coming***."

Daniel Burrus, ***"Flash Foresight"***

Change in Housing…Not So Much

…it can take 10 to 25 years for a new housing technology to achieve full market penetration.

Source: '*The Diffusion of Innovation in the Residential Building Industry*,' Center for Housing Research Virginia Tech and NAHB Research Center. January 2004

More Informed Consumers

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

Risk | Differentiation | **Innovation**

BY JANN SWANSON

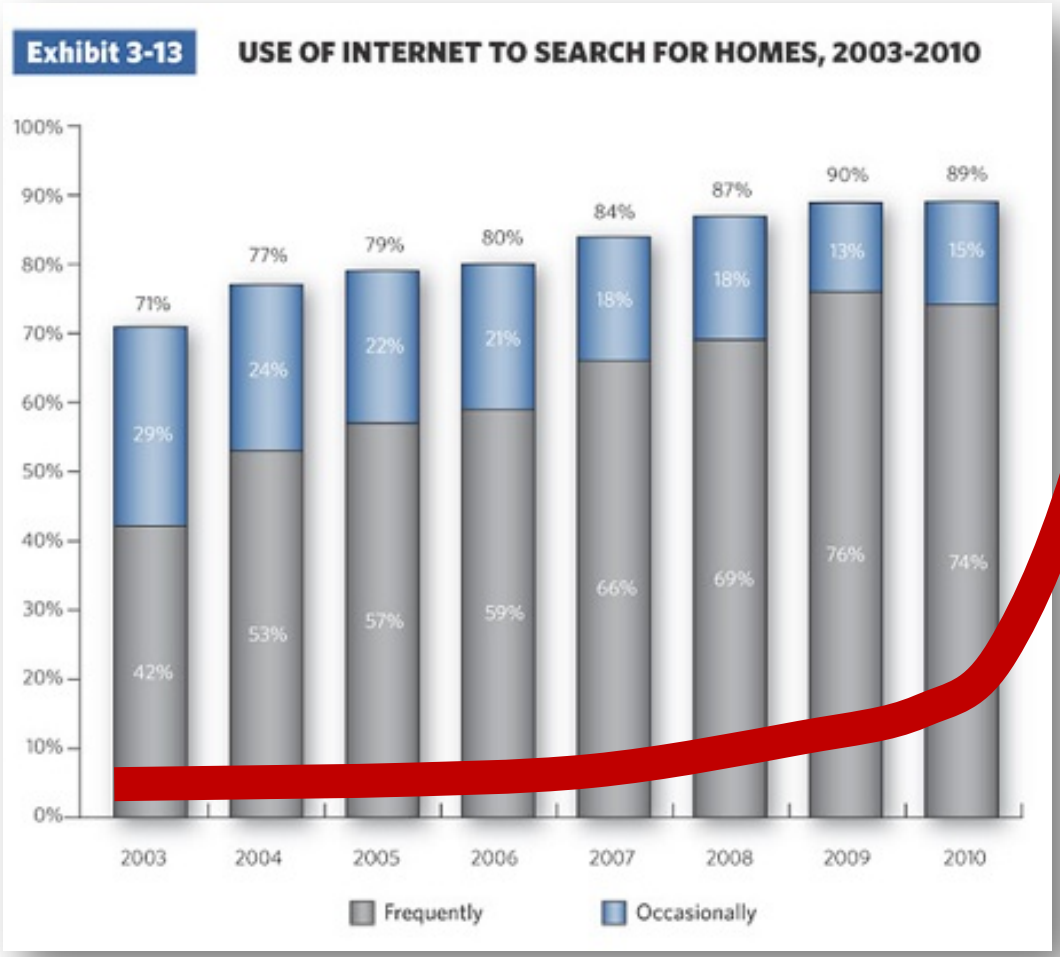
Real Estate Web Searches Climb 253% in Four Years as 90% of Homebuyers Use Internet as Primary Research

Jan 7 2013, 3:50PM Text +

Home-shopping consumers are not only exponentially increasing their **reliance on the Internet** but are also developing distinct patterns for using it in their housing searches. **Google** and the **National Association of**

More Informed Consumers

Risk | **Differentiation** | **Innovation**



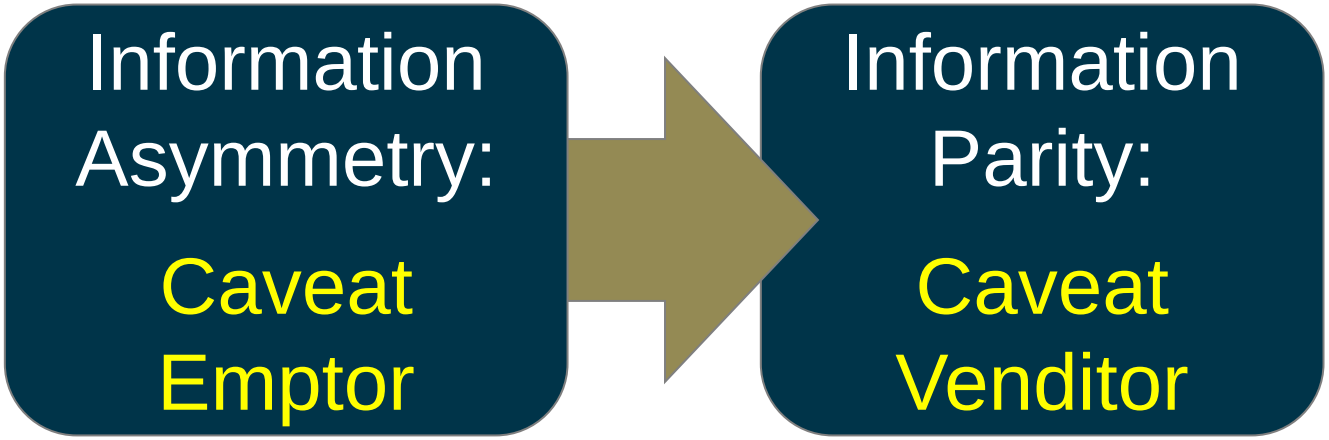
Internet Content Available

SOURCE: National Association of Realtors® - Profile of Home Buyers and sellers 2010

More Informed Consumers

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

Risk | **Differentiation** | **Innovation**



What Car Buyers Know

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

Change | **Information** | Innovation

- **Design**
  - Appearance
  - Size
  - Function
- **Performance**
  - Energy Efficiency (MPG)
  - Acceleration/Handling
  - Safety/Crash Test Ratings
- **Cost**
  - Invoice Price
  - 'Great/Good/Fair' Price
  - Resale Value
  - Maintenance Cost
- **Durability**
  - Repair Record
  - Recalls
  - Warranty
- **Value**
  - Awards/Special Recognition
  - Professional Reviews
  - Owner Reviews

What Home Buyers Will Know

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

Change | **Information** | Innovation

- **Design**
  - Appearance
  - Size
  - Function
- **Performance**
  - Energy Efficiency (HERS)
  - Comfort
  - Health
- **Cost**
  - Sticker Price
  - Ownership Cost (PITI + E)
  - Resale Value
  - Maintenance Cost
- **Durability**
  - Repair Record
  - Disaster Resistance
  - Warranty
- **Value**
  - Awards/Special Recognition
  - Professional Reviews
  - Owner Reviews

With more informed buyers…

Rules*:

1. If it can be done, it ***will*** be done.
2. If you don't do it, ***someone else*** will.

* Daniel Burrus, ***"Flash Foresight"***

Innovation Graveyard

Disruption Ignoring New Business Model:

- Kodak
- Polaroid
- Motorola
- Palm
- Circuit City (and a host of other retailers)
- American Car Manufacturers
- TWA and other Legacy Airlines
- Converse Sneakers
- and the list goes on…

Media and Housing Innovation

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

Risk

An air conditioner that anticipates your needs
PAGE 59

Solar panels that eliminate your energy bills
PAGE 76

A door that can sense your approach
PAGE 59

A sprinkler that tracks the weather
PAGE 80

Differentiation

Innovation

Walls that can weather a hurricane
PAGE 66

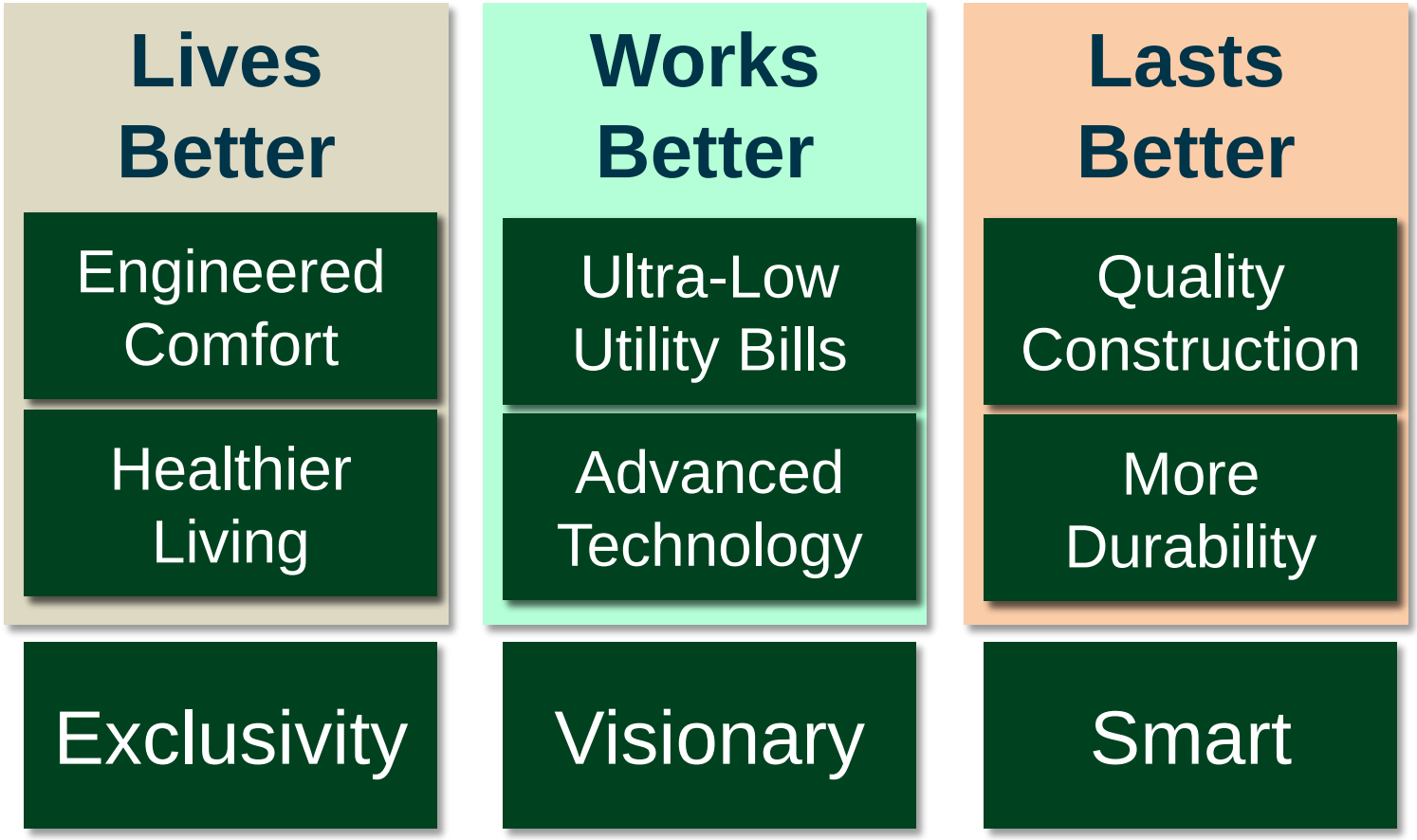
A car that can power your house
PAGE 79

A garden that filters your air
PAGE 87

Zero Energy Ready Home
Why Build:

Translating Value

Zero Energy Ready Home Value



Zero Energy Ready Home

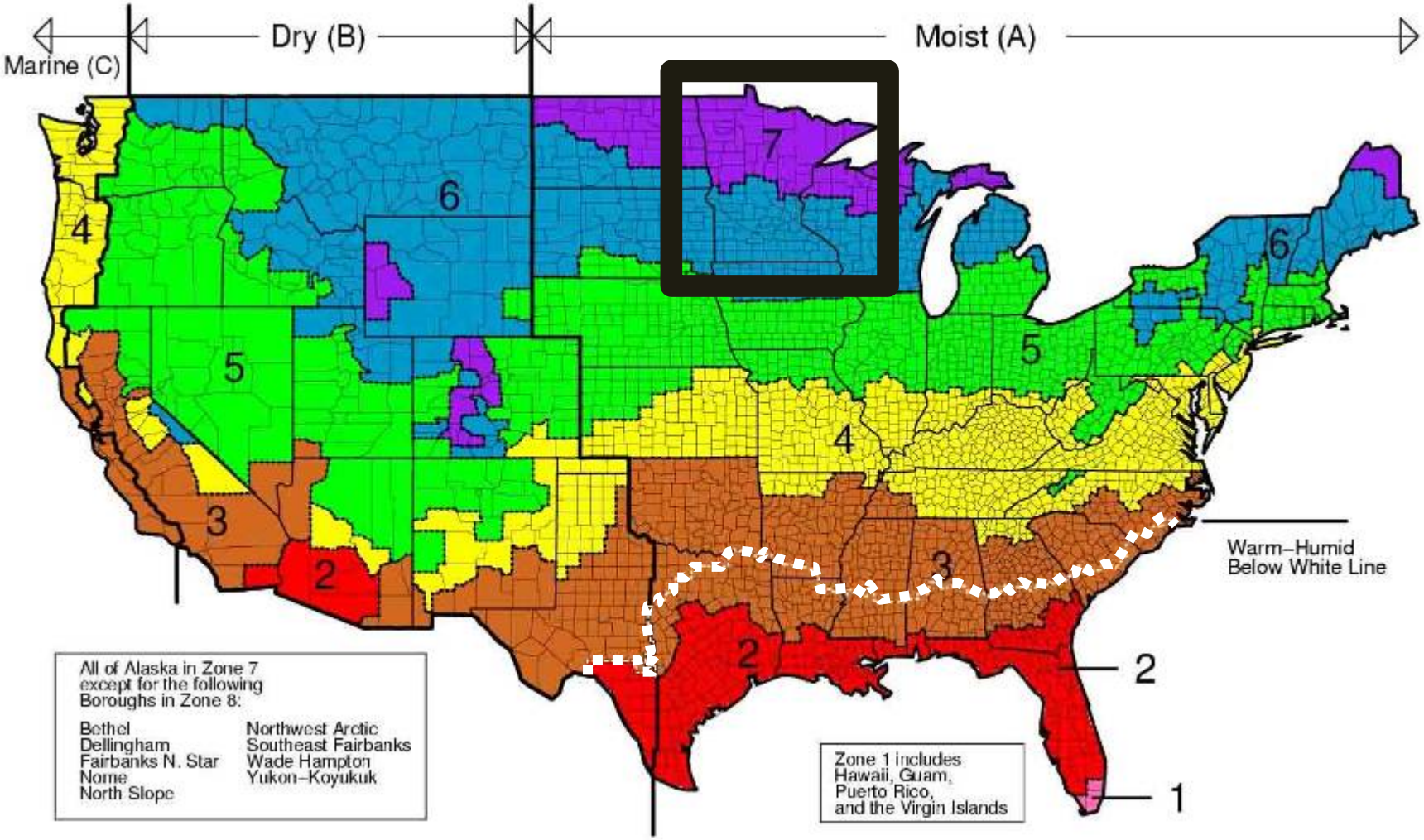
Technical Specifications

Technical Specifications

- ENERGY STAR Certified Homes v3
- Advanced Windows
- Air-Tight Construction
- 2012 IECC Insulation
- Energy Efficient Components
- Efficient Hot Water Distribution
- Indoor Air Quality
- Renewable Ready Construction

For Webinars: www.buildings.energy.gov/zero/

IECC Climate Zones



Key Strategy

Align with ENERGY STAR for Homes v3:

- Comprehensive Building-Science System
- Variable vs. Fixed HERS Index Score
- House Size Adjustment to HERS Score

DOE ZERH Framework

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

Mandatory Reqts.

Must Comply

'Target Home' Specs

Trade-Off Flexibility

Size Adjust. Factor

Identical to Energy Star

Exhibit 1: DOE Challenge Home Mandatory Requirements for All Labeled Homes

Area of Improvement	Mandatory Requirements
1. ENERGY STAR for Homes Baseline	☐ Certified under ENERGY STAR Qualified Homes Version 3[9]
2. Envelope[6]	☐ Fenestration shall meet or exceed latest ENERGY STAR requirements[7, 8] ☐ Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels[9]
3. Duct System	☐ Ducts located within the home's thermal and air barrier boundary[10]
4. Water Efficiency	☐ Hot water delivery systems shall meet efficient design requirements[11]
5. Lighting & Appliances[12]	☐ All installed refrigerators, dishwashers, and clothes washers are ENERGY STAR qualified. ☐ 80% of lighting fixtures are ENERGY STAR qualified or ENERGY STAR lamps (bulbs) in minimum 80% of sockets ☐ All installed bathroom ventilation and ceiling fans are ENERGY STAR qualified
6. Indoor Air Quality	☐ EPA Indoor airPLUS Verification Checklist and Construction Specifications[13]
7. Renewable Ready[14]	☐ EPA Renewable Energy Ready Home Solar Electric Checklist and Specifications[15] ☐ EPA Renewable Energy Ready Home Solar Thermal Checklist and Specifications[16]

Exhibit 2: DOE Challenge Home Target Home [3, 17]

HVAC Equipment[18]			
	Hot Climates (2012 IECC Zones 1,2) [19]	Mixed Climates (2012 IECC Zones 3, 4 except Marine)	Cold Climates (2012 IECC Zones 4 Marine 5,6,7,8)
AFUE	80%	90%	94%
SEER	18	15	13
HSPF	8.2	9	10[20]
Geothermal Heat Pump	ENERGY STAR EER and COP Criteria		
ASHRAE 62.2 Whole-House Mechanical Ventilation System	1.4 cfm/W; no heat exchange	1.4 cfm/W; no heat exchange	1.2 cfm/W; heat exchange with 60% SRE
Insulation and Infiltration			
• Insulation levels shall meet the 2012 IECC and achieve Grade 1 installation, per RESNET standards. • Infiltration[21] (ACH50): 3 in CZ's 1-2 | 2.5 in CZ's 3-4 | 2 in CZ's 5-7 | 1.5 in CZ 8			
Windows[22, 23, 24]			
	Hot Climates (2012 IECC Zones 1,2,)	Mixed Climates (2012 IECC Zones 3, 4 except Marine)	Cold Climates (2012 IECC Zones 4 Marine 5,6,7,8)
SHGC	0.25	0.27	any
U-Value	0.4	0.3	0.27
Homes qualifying through the Prescriptive Path with a total window-to-floor area greater than 15% shall have adjusted U-values or SHGCs.[25]			
Water Heater			
ENERGY STAR minimum; for heating oil water heaters use EF = 0.60			

Effective for Homes Revised 07/01/2012 Page 2 of 8

Exhibit 3: Benchmark Home Size[26]

Bedrooms in Home to be Built	1	2	3	4	5	6	7	8
Conditioned Floor Area Benchmark Home	1,000	1,600	2,200	2,800	3,400	4,000	4,600	5,200

Zero Energy Ready Home

Technical Specifications Mandatory Requirements:

Mandatory Requirements

Exhibit 1: DOE Challenge Home Mandatory Requirements for All Labeled Homes

Area of Improvement	Mandatory Requirements
1. ENERGY STAR for Homes Baseline	☐ Certified under ENERGY STAR Qualified Homes Version 3[5]
2. Envelope[6]	☐ Fenestration shall meet or exceed latest ENERGY STAR requirements[7,8] ☐ Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels[9]
3. Duct System	☐ Ducts located within the home's thermal and air barrier boundary[10]
4. Water Efficiency	☐ Hot water delivery systems shall meet efficient design requirements[11]
5. Lighting & Appliances[12]	☐ All installed refrigerators, dishwashers, and clothes washers are ENERGY STAR qualified. ☐ 80% of lighting fixtures are ENERGY STAR qualified or ENERGY STAR lamps (bulbs) in minimum 80% of sockets ☐ All installed bathroom ventilation and ceiling fans are ENERGY STAR qualified
6. Indoor Air Quality	☐ EPA Indoor airPLUS Verification Checklist and Construction Specifications[13]
7. Renewable Ready[14]	☐ EPA Renewable Energy Ready Home Solar Electric Checklist and Specifications[15] ☐ EPA Renewable Energy Ready Home Solar Thermal Checklist and Specifications[16]

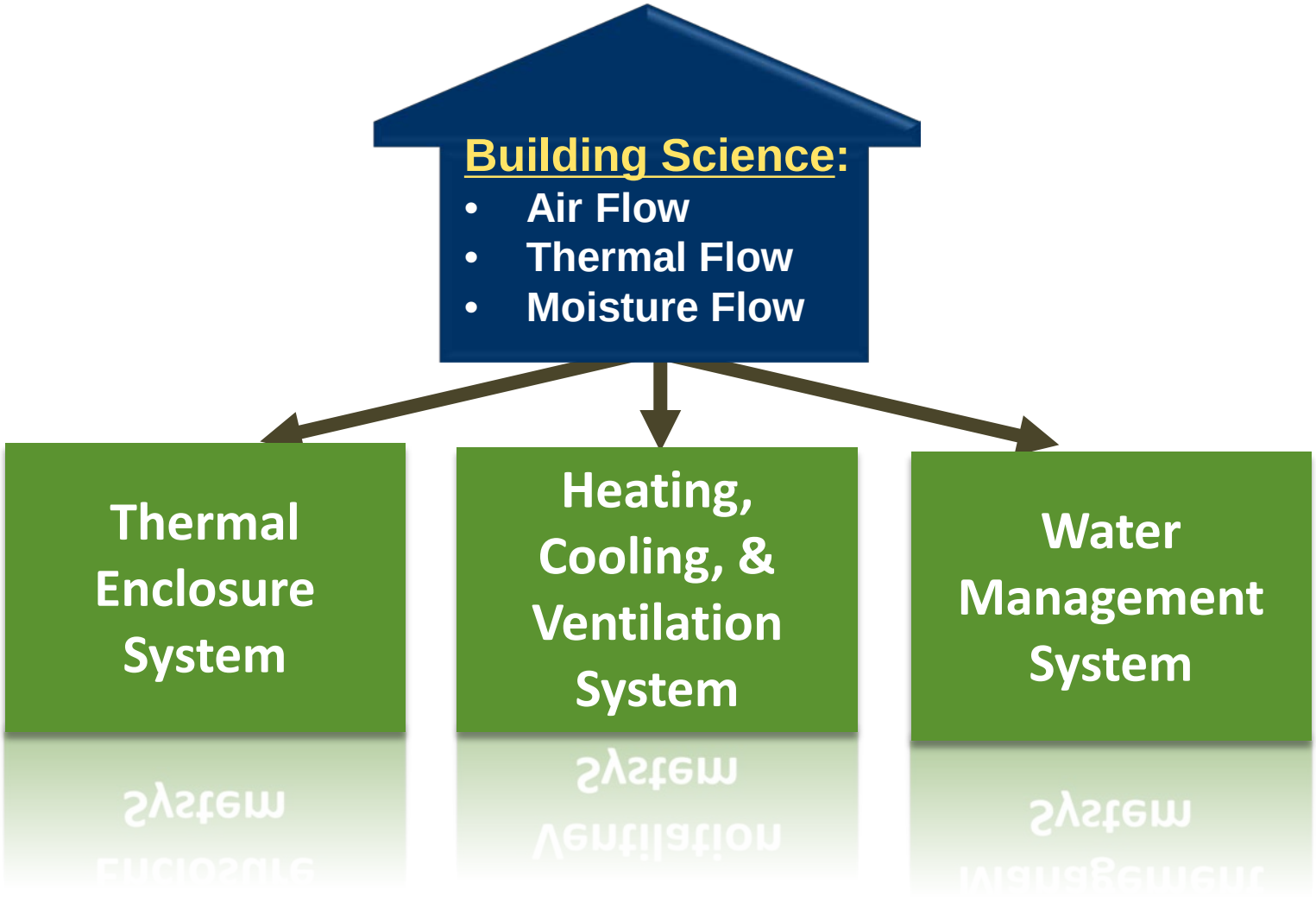
Encouraged:

- WaterSense Label (indoor and outdoor)
- Disaster Resistance (IBHS Fortified Home)
- Quality Management

Zero Energy Ready Home

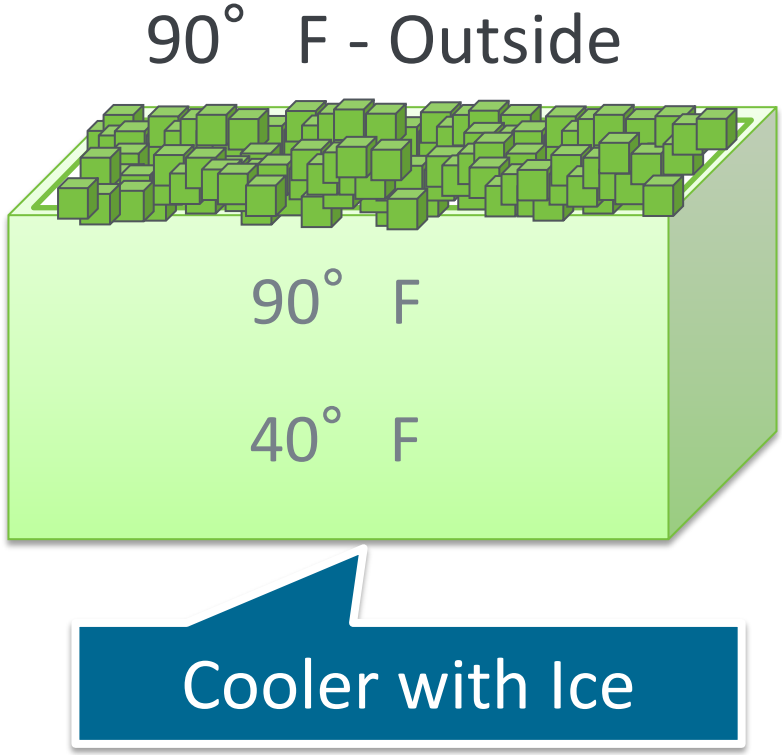
Technical Specifications Mandatory Requirements: ENERGY STAR for Homes Version 3 Baseline

What is Building Science

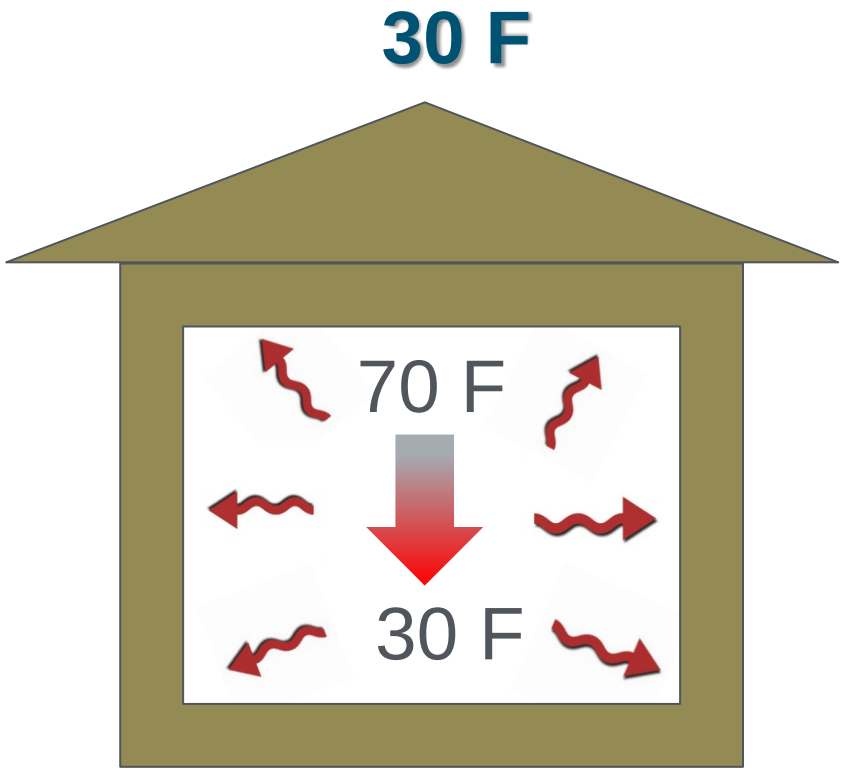


A well-insulated and air-sealed home, with good windows and doors, reduces the amount of energy needed to keep the home comfortable.

1. Energy moves from more to less.



1. Energy moves from more to less.



2. Heat Transfer is quantified in British Thermal Units (BTU's)

1 Btu is approximately equal to the energy in a single match.

What We're Trying to Avoid

Attic air infiltration into the wall

Drywall Sealed at Top Plates

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

Thermal Enclosure | Heating, Cooling & Ventilation | Water Management

Default: Foam

Alternative: Sill sealer

Alternative: Constr. Adhesive

Air and Thermal Flow Control

Thermal Enclosure | Heating, Cooling & Ventilation | Water Management

- **Air Sealing**
- **Air Barriers**
  - Thermal Bypass
  - Wind Intrusion
- **Insulation**
  - Adequate Quantity
  - Proper Installation
  - Minimum Thermal Bridging
- **Adv. Windows**

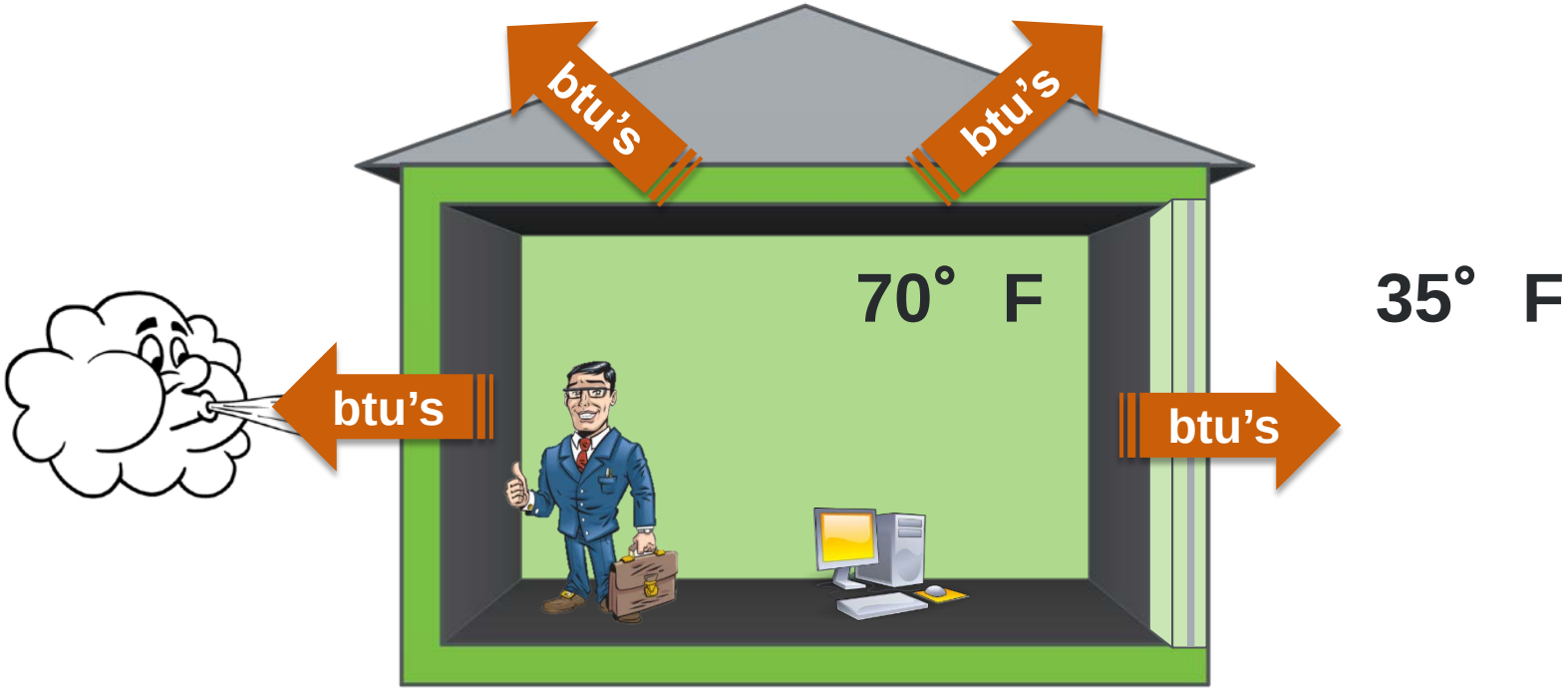
Thermal Enclosure Checklist

- **Heating and Cooling Equipment**:
  - High efficiency
  - Properly designed and installed
  - Combined with a duct system that's insulated, sealed, and balanced

  … Maintain comfort with less energy.
- **Ventilation System:**
  - Remove low-quality air
  - Provide outdoor air
  - Filter contaminants to improve IAQ

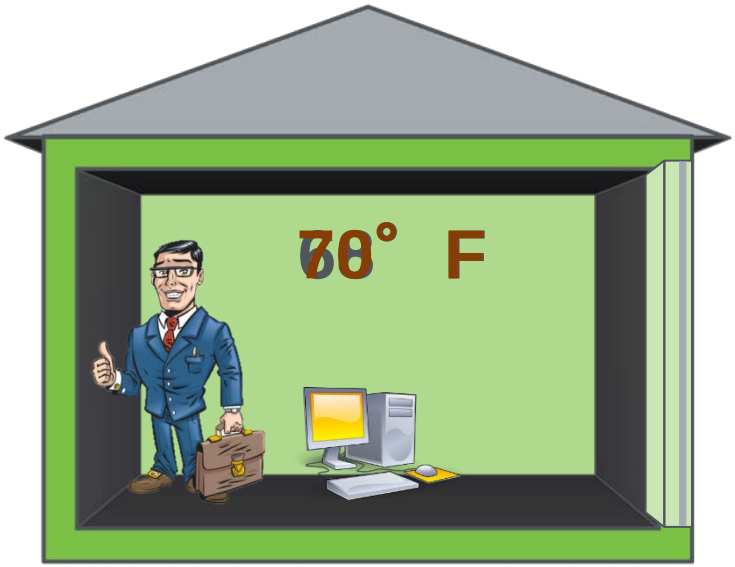
Calculating Heating & Cooling Load

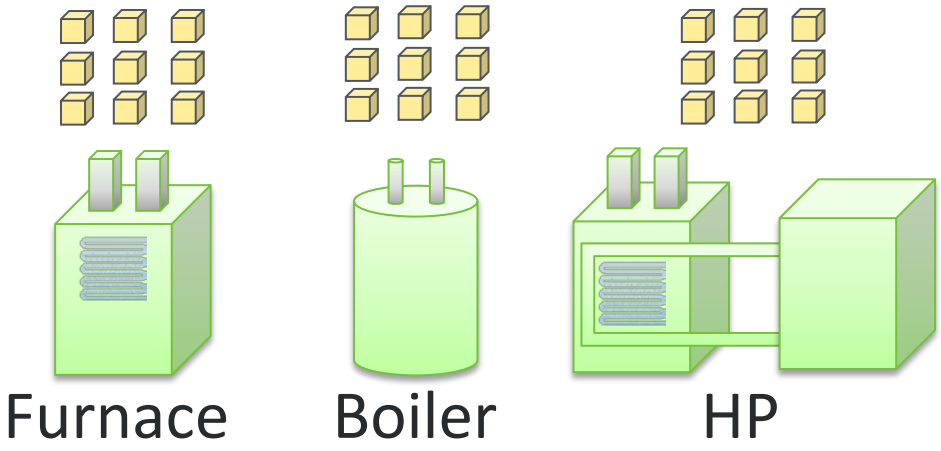
- Heating Load varies for each hour of the year.
- Heating Peak Load: Maximum energy lost in a single hour, which must be added back to maintain temperature.



Calculating Heating & Cooling Load

- Cooling & heating equipment are “btu machines” that add or remove btu’s to offset the load
- Load = number of btu’s equipment has to remove or add
- Load independent of *type* of equipment used

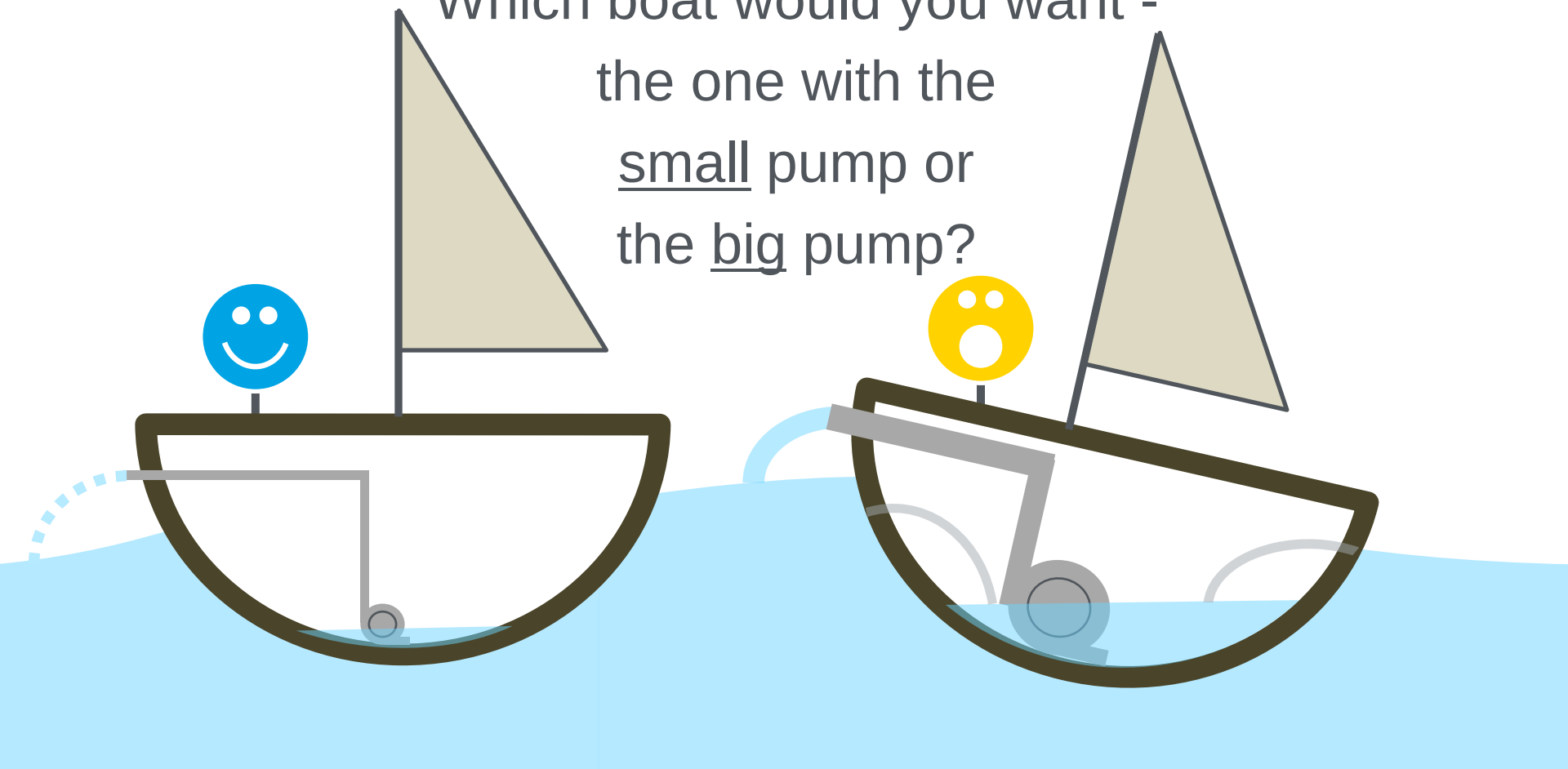




What We're Trying to Avoid

Thermal Enclosure | **Heating, Cooling & Ventilation** | **Water Management**

Which boat would you want - the one with the small pump or the big pump?

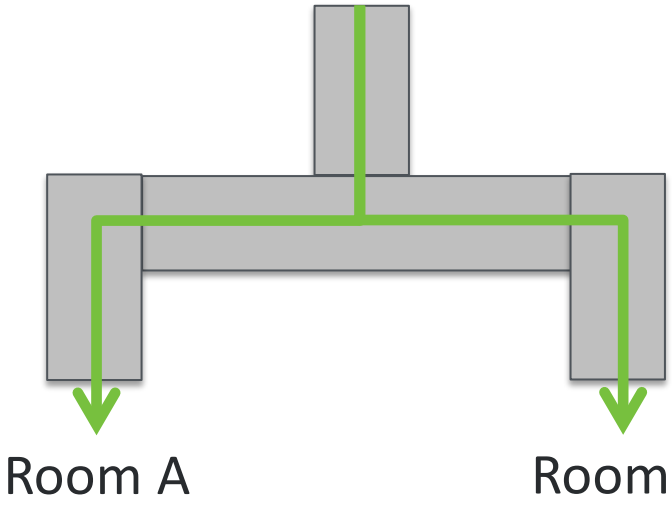


HVAC-C (3.12); HVAC-R (1.2.9)

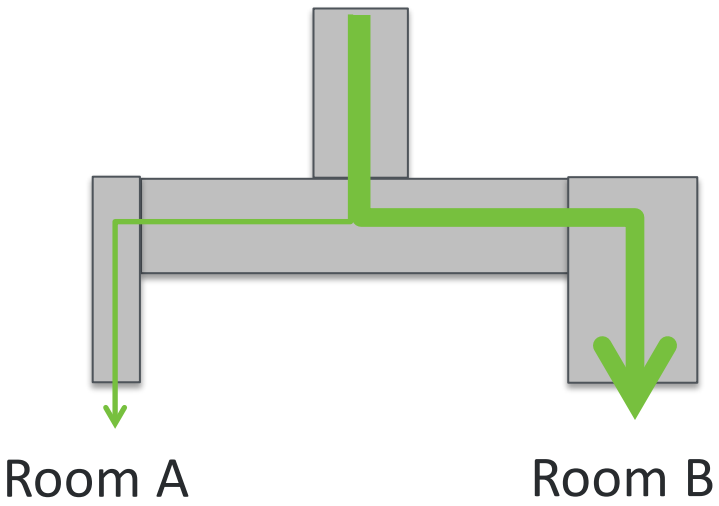
Verify that the equipment capacity is right-sized relative to the heating and cooling load.

Duct System Design

1. Air follows the path of least resistance.



Equal resistance, equal flow

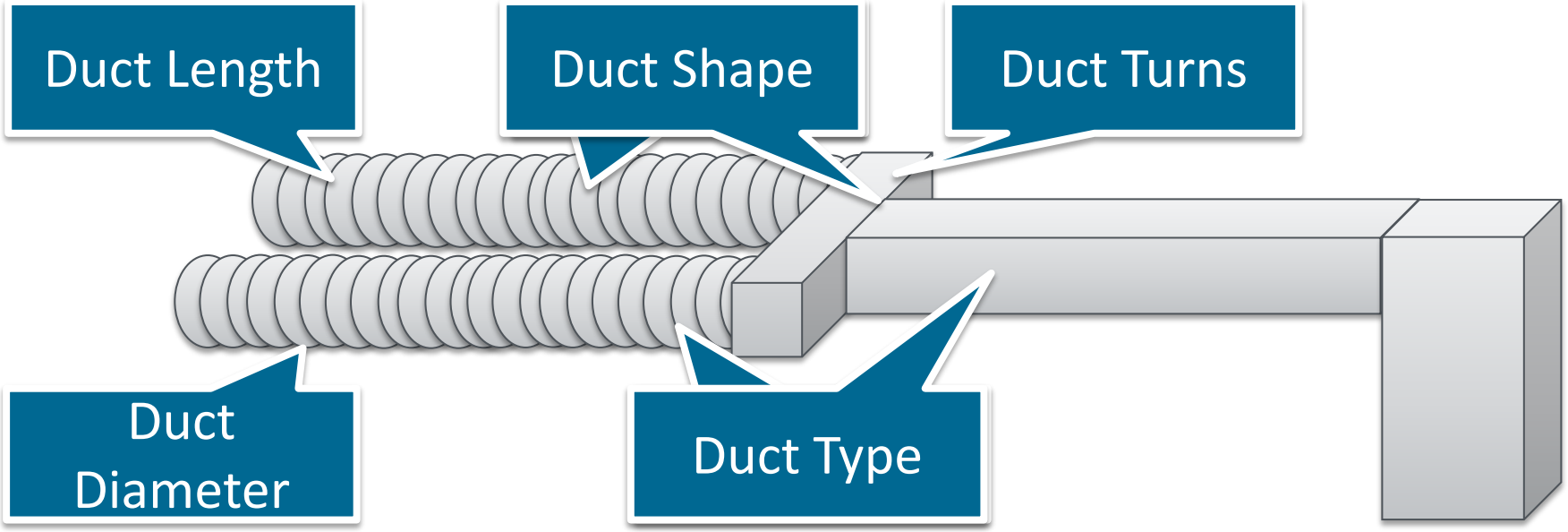


Higher resistance, less flow

Duct System Design

Factors that influence the airflow of the ducts:

- Duct Length
- Duct Size
- Duct Shape
- Duct Type
- Duct Turns
- Other Components (e.g., Filters)



What We Are Trying to Avoid

Thermal Enclosure | **Heating, Cooling & Ventilation** | **Water Management**

HVAC-R Item 1.4, Sections 2,3, & 4

Verify that the ducts are balanced, insulated, tight, and installed without major defects.

Thermal Enclosure | **Heating, Cooling & Ventilation** | Water Management

Design:

1. Calculate Heating/Cooling Loads
2. Select Equipment that Meets Loads
3. Design Duct System that Gets Air from Equipment to Rooms and Back

Commission:

A. Check Airflow at Air Handler
B. Check Refrigerant Charge
C. Measure Airflow at Registers/Exhaust

HVAC QI Contractor Checklist

Rater Field Checklist

Moisture Vapor (Air Flow)

- Air Sealing
- Air Barriers
- Vapor Barriers/Retarders

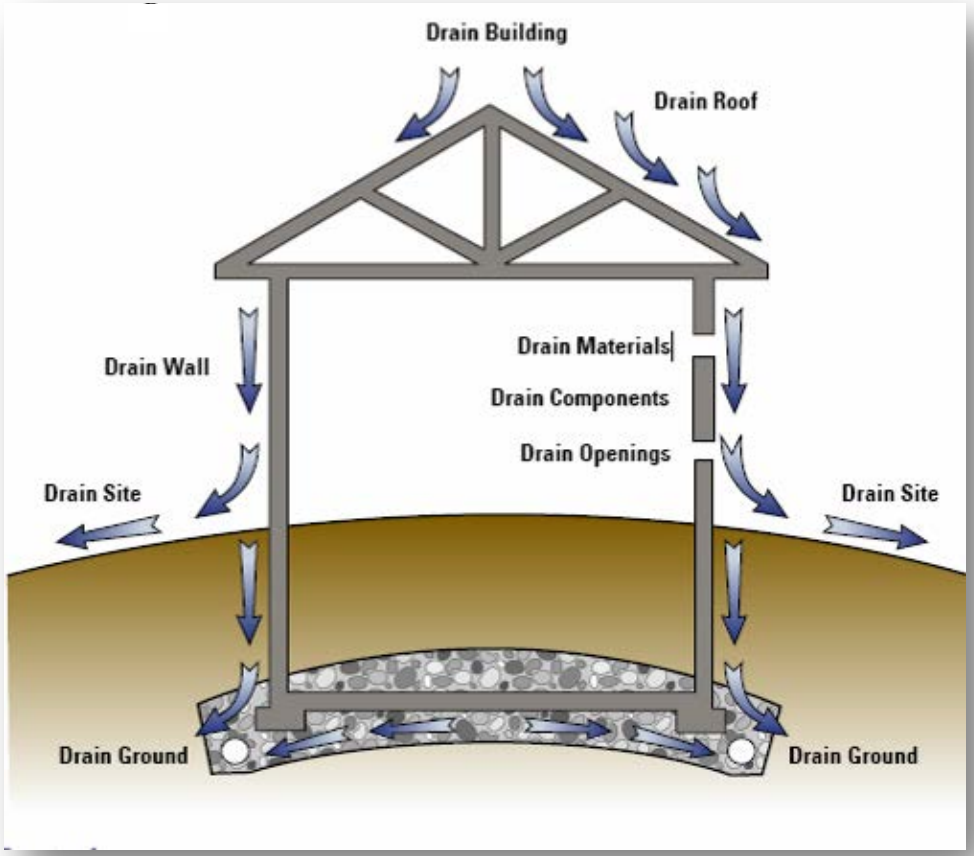
→ Thermal Enclosure Checklist

- HVAC Quality Installation
- Whole-House Ventilation
- Spot Ventilation

→ HVAC Quality Installation Checklist

Basic Concept

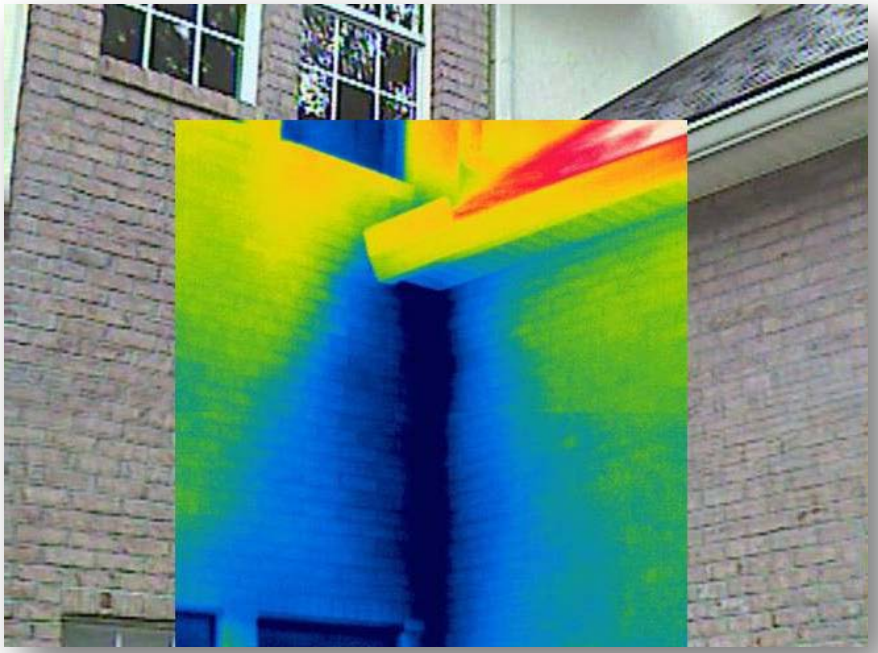
Thermal Enclosure	Heating, Cooling & Ventilation	Water Management



Basic Concept

- Many materials used in building homes are not durable when wet.
- Especially important in high performance homes, regardless of whether ENERGY STAR certified.

What We're Trying to Avoid



Missing step & kick-out flashing

Step and Kick-Out Flashing (3.1)

- Step and kick-out flashing at all roof-wall intersections, extending ≥ 4” on wall surface about roof deck and integrated with drainage plane above.
- Step flashing goes behind water barrier on wall and under shingles on the roof.

Bulk Moisture Control

Bulk Moisture

- weather resistant barriers
- flashing
- capillary breaks

Water Management Checklist

Thermal Enclosure	Heating, Cooling & Ventilation	Water Management

ENERGY STAR for Homes v3:

- ✓ Rater Plan Review Checklist
- ✓ Rater Field Checklist
  - Thermal Enclosure
  - HVAC QI
- ✓ HVAC QI Contractor Checklist
- ✓ Water Management Checklist

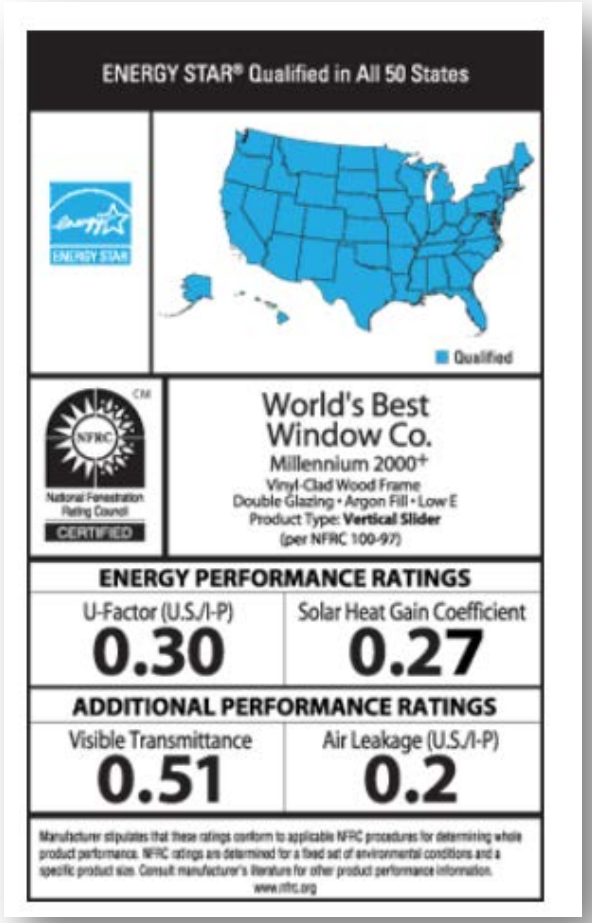
Zero Energy Ready Home

Technical Specifications Mandatory Requirements

Envelope: Advanced Windows

ENERGY STAR Windows

- Assures beyond-code window performance
- Fenestration used for passive solar design are exempt from the U-factor and SHGC requirements
- Area-weighted averages for U-factor, SHGC permitted



Good, Better, Best Windows

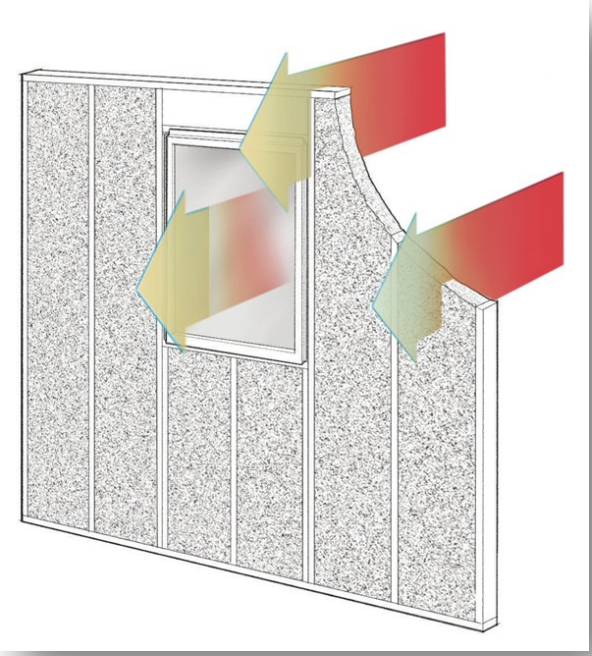
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

	Hot Climates IECC CZ 1-2		Mixed Climates IECC CZ 3-4 except Marine		Cold Climates IECC CZ 5-8 and 4 Marine	
	SHGC	U-value	SHGC	U-value	SHGC	U-value
Mandatory: ENERGY STAR	0.27	0.60	[4] 0.40 [3] 0.30	[4] 0.32 [3] 0.35	Any ≥0.35 ≥0.40	0.30 0.31 0.32
Performance: Target Home	0.25	0.4	0.27	0.3	Any	0.27
Encouraged: R-5	0.22	0.21	0.25	0.21	Any	0.21

Windows Are a Big Deal

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

Window 15% of Wall Area	Wall R-Value with Windows w/Varied Wall Insulation Levels			
U-Value	**R-0**	**R-18**	**R-39**	**R-60**
0.30	R-5	R-11	R-15	R-17
0.20	R-5	R-13	R-19	R-23
0.15	R-5	R-14.5	R-23	R-28
0.10	R-5.5	R-16	R-27	R-34



Sources:

"*Holes in the Wall: To Improve the Energy Performance of Walls, Look at the Total R-Value*," Journal of Light Construction, February 2014;
Multi-Assembly R-Value / U-Value Calculator – Cascadia Windows and Doors;
Michael Blasnik Presentation, 2014 ACI Conference

Zero Energy Ready Home

Technical Specifications: Best Practices Air-Tight Construction

Why Air-Tight Construction

- 16 to 50% of HVAC Loads
- Moisture Problems
- Comfort Problems
- Indoor Air Quality

Target Home Air-Tightness

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

	ACH50 Requirements/Targets			
Climate Zones	**Zero Energy Ready Home**	**ENERGY STAR V3**	**2012 IECC**	**Passive House**
1-2	3.0	6.0	5. 0	0.6
3-4	2.5	5.0	3.0	0.6
5-7	2.0	4.0	3.0	0.6
8	1.5	3.0	3.0	0.6

Seal Usual Suspects

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

Penetrations:

- Plumbing
- Wiring
- Recessed Lights
- Vents
- HVAC Duct Boots

Shafts:

- Flues
- Ducts
- Plumbing

Cracks:

- Sill Plates
- Windows & Doors
- Drywall at Top Plate
- Access Panels
- Sheathing Joints
- Foundation/Framing

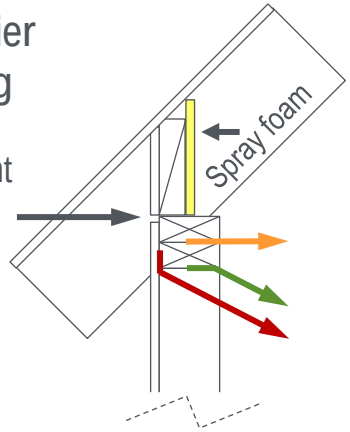
Odd Geometry:

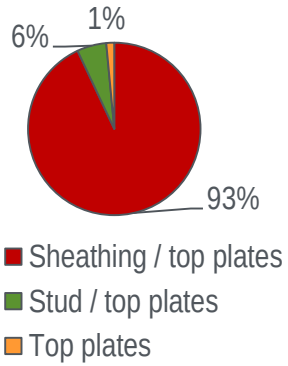
- Cantilevers
- Knee-walls

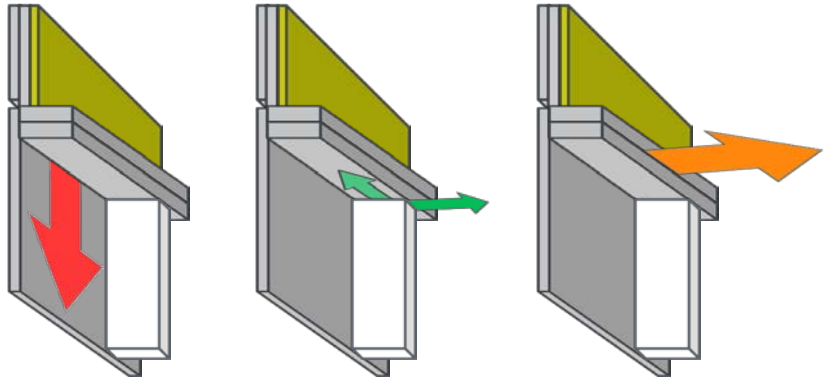
Air Leakage Distribution

Exterior air barrier
Cathedral ceiling

Sheathing / roof joint
1.1 cfm/ft @ 50 Pa



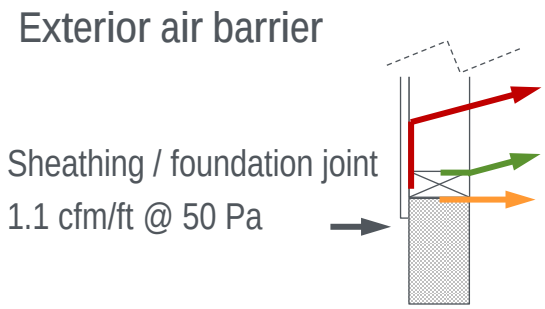


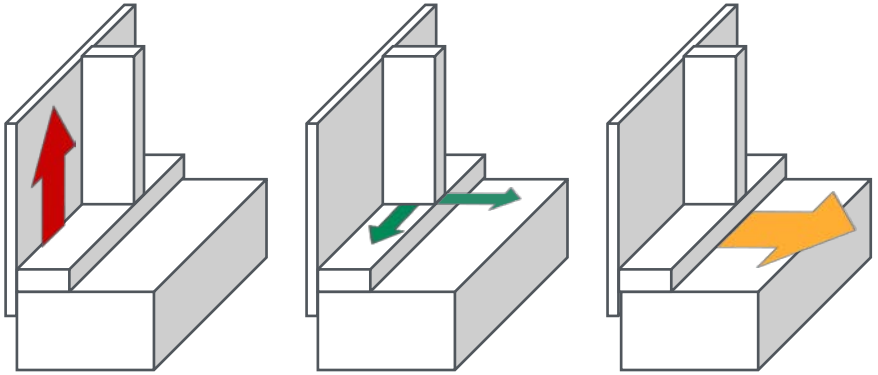


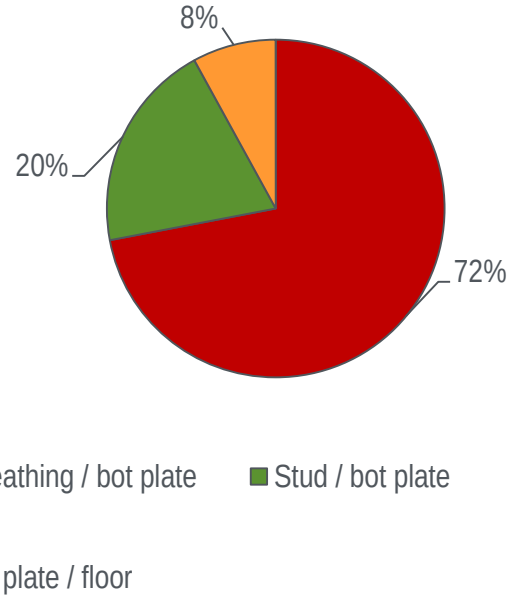
2-Story house (Floor area = 2,000 ft^2)
Sheathing / roof joint unsealed ≅ 0.5 ACH$_{50}$

Zones	DOE Challenge Home		IECC 2012	
	Requirement	Contribution to requirement (%)	Requirement	Contribution to requirement (%)
1 – 2	3	17	5	10
3 – 4	2.5	20	3	17
5 – 7	2	25	3	17
8	1.5	33	3	17

Air Leakage Distribution







2-Story house (Floor area = 2,000 ft^2)

Sheathing / foundation joint unsealed ≅ 0.5 ACH$_{50}$

Zones	DOE Challenge Home		IECC 2012	
	Requirement	Contribution to requirement (%)	Requirement	Contribution to requirement (%)
1 – 2	3	17	5	10
3 – 4	2.5	20	3	17
5 – 7	2	25	3	17
8	1.5	33	3	17

1.5”ϕ ID Capped PVC Pipe



- **~ 1/4” perimeter gap**
- **~ 12 cfm @ 50 Pa**
- **Perimeter gap sealed**
  - Effectively with one-component polyurethane foam
  - Effectively with caulk
  - Somewhat effectively with tape

Rectangular Electrical Box



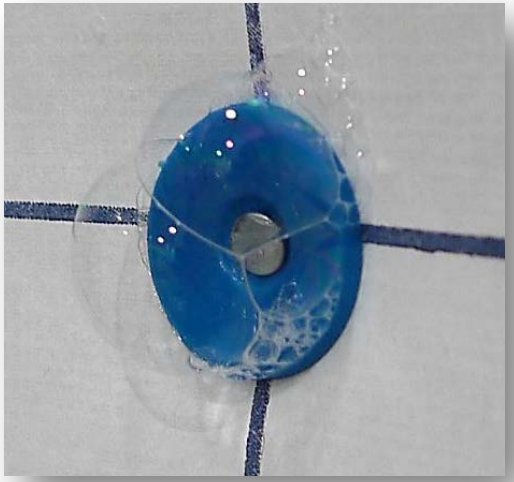


- **1/8” to 1/4” perimeter gap**
- **~ 12 cfm @ 50 Pa**
- **Perimeter gap sealed**
  - Somewhat effectively with one-component polyurethane foam
  - Effectively with caulk
- **Wire holes ≥ 50% of leakage**

4”ϕ Circular Electrical Box

- **1/8” to 1/4” perimeter gap**
- **~ 16 cfm @ 50 Pa**
- **Perimeter gap sealed effectively**
  - One-component polyurethane foam
  - Caulk
- **Wire holes ≥ 50% of leakage**

Fasteners



Air leaked at nailed fasteners

Repeat test with screwed fasteners

Air Leakage Contribution Estimates

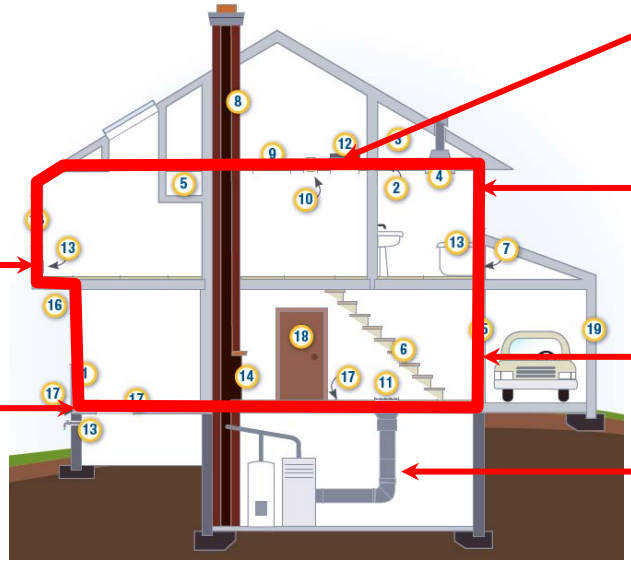
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Exterior Air Barrier:

2-Story House (2,000 sq. ft.)

(4) Elect. Outlets = 0.17 ACH_{50}

Exterior Sheathing/Foundation = 0.51 ACH_{50}



(5) Lights = 0.29 ACH_{50}

Ext. Sheathing/Roof = 0.51 ACH_{50}

Air barrier

Duct ≅ 0.22 ACH_{50}

1. Sheathing/Foundation Joint Unsealed = 0.51
2. Sheathing/Roof Joint Unsealed = 0.51
3. (4) Electrical Outlets = 0.17
4. (5) Ceiling Lights = 0.29
5. Return Duct = 0.22

1.7 ACH_{50}

Air Sealing with Aerosol

You've probably seen this:

AEROSEAL
Duct Sealing From The Inside

Air Sealing with Aerosol

But now we are going to investigate this…

Engineer Curtis Harrington taping off areas in preparation for sealing.

Connecting controls for blower door, setting u compressor for aerosol injection and monitorli software.

Aerosol sealant sealed this leak between this electrical outlet and the wall.

Photos from wcec.ucdavis.edu

Zero Energy Ready Home

Technical Specifications Mandatory Requirements: Envelope: 2012 IECC Insulation

2012 IECC Insulation

- Compliance with next generation code
- Three Options:
  - ✓ Prescriptive
  - ✓ Alternative equivalent U-factor
  - ✓ Total UA calculation
    [allows window to be included]
- Allowances for ceilings without attic spaces
  [up to 500 square feet or 20% of roof area, whichever is smaller]

2012 IECC Insulation

	Climate Zone 6	Climate Zone 7
Walls	R-20+5 or R-13+10	
Ceiling	R-49	
Floor	R-30	R-38
Basement	R-15/19	
Crawl Space	R-15/19	
Slab	R-10/4’ Deep	

Zero Energy Ready Home

High-R Walls

High-R Wall Options

- Advanced Framing with Thicker Wall
- Rigid Insulation Exterior Sheathing
  - Continuous Rigid Insulation w/Sheathing
  - Continuous Rigid Insulation w/o Sheathing
  - Continuous Rigid Insulation w/Recessed Studs
- Structural Insulated Panels (SIPs)
- Insulated Concrete Forms (ICFs)
- Double Wall
- Structural Engineered Panel w/ETMMS

Adv. Framing w/Thicker Walls

- R-17 – R-21
- Higher Framing Factor (~12-15%)
- Blanket Insulation Issues:
  R-19 is 6” Thick, which results in
  R-17 Compressed in 2x6 Wall

  R-21 is 5.5” Thick, which results in
  R-21 in 2x6 Wall
- Blown-In Insulation Issues:
  Settling and Proper Density (Bag Count)
- Spray Foam Issues:
  High Cost
  Closed Cell Enhances Structure Perf.
  Still Need to Ensure Quality installation

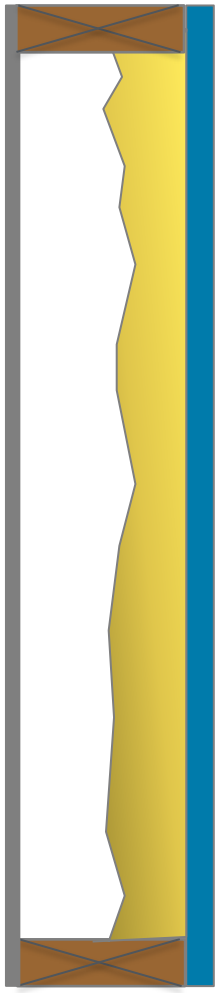
Rigid Insulation w/Sheathing

- R-18 Wall
- Complete Thermal Break
- Exterior Condensation Surface
- Can Combine Sheathing w/ Weather Resistant Barrier
- Installation Issues:
  ≤ 1.5” Thick, Nails Okay
  > 1.5” Thick, Screws Needed

Rigid Insulation w/o Sheathing

BASF Wall Assembly:

- R-17 Wall
- Complete Thermal Break
- Enhanced Racking Strength and Impact Resistance with CCSpf Enables No Sheathing
- Rigid Insulation Sheathing serves as Weather Resistant Barrier w/Liquid Membrane at Joints and Pan Flashing
- Substantially Reduced Framing including Single Plates
- BASF Claims Net Cost Competitive with Conventional Wall



Rigid Insulation w/Recessed Studs

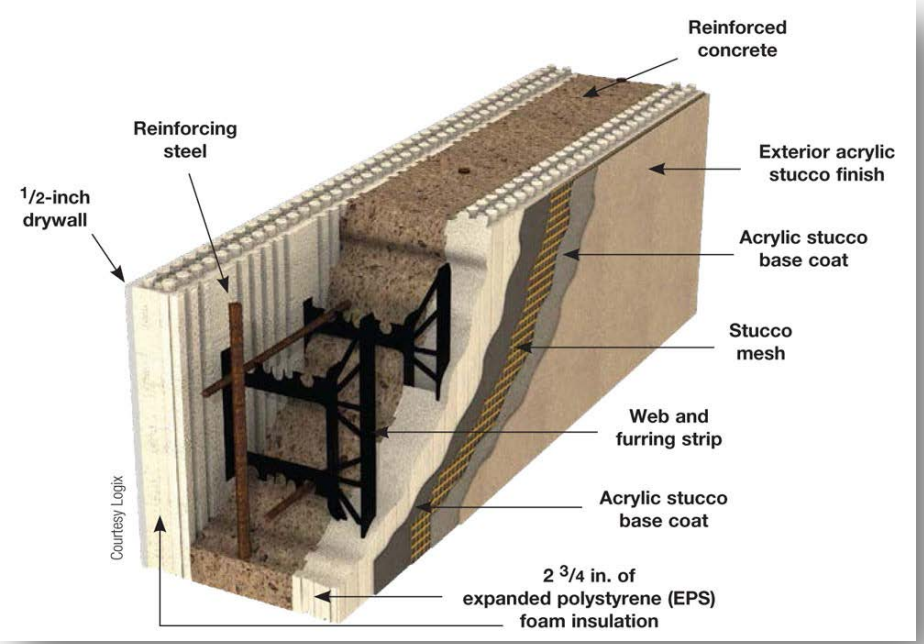
- R-18 Wall
- 2x4 Studs with 2x6 Plates
- Sheathing Attached to Plates for Near Full Racking Strength
- Complete Thermal Break Except for Top and Bottom Plates
- Condensation Surface Inside Assembly, so Must Control Air Flow
- Much Easier Installation of Cladding

Structural Insulated Panels (SIPs)

- R-20 Walls (6”)
- Substantial Thermal Break (3 – 8% Framing Factor)
- Special Construction Practices Required
- Foundation has to be Perfectly Level
- Significantly Reduced Time-of-Construction
- Reduced Dimensional Variation Corrections
- Killer Applications

Insulated Concrete Forms (ICFs)

- ~R-24 Walls
- Complete Thermal Break
- Useful Thermal Mass
- Foundation has to be Perfectly Level
- Longer Time-of-Construction
- Maximum Disaster Resist.
- Termite Resistant
- Reduced Dimensional Variation Corrections
- Much More Costly



Double-Wall

- R-26 Walls
- Studs Offset to Ensure Complete Thermal Break
- Coldest Outside Sheathing Surface Suggests Plywood Rather Than OSB to Ensure Drying
- Uses Exact Same Framing Techniques Already Understood by Trade Partners

University of MN Display: 4 Walls

Wall 1: Super ICF

- High level of insulation
- Minimal thermal bridging
- Resilient to wind & water

Wall 2: Low Envir. Impact Wall

- Natural materials (limited materials from fossil fuels)
- High overall R-value
- Limit thermal bridging
- High moisture storage and drying potential

Wall 3: Opti-MN

- Developed by the U of MN Student Team
- Robust, high performance wall optimized for current construction methods
- Single water, air, and vapor barrier
- Two-way drying potential

Wall 4: SEP-ETMMS

- Innovative & Affordable
- Based on the perfect wall, using a “studless” structural engineered panel
- Single water, air, and vapor control layer
- Recent experience has demonstrated it can be built for less than a standard wood-frame wall system

Step 1: Put the structure on the inside

- Light-frame construction
- Timber frame
- Concrete masonry
- SEP = Structural Engineered Panel (studless construction)

Step 2: Put the thermal and moisture control layers on the outside.

- Perfect Wall
  (Lstiburek, w/credit to bright Canadians in CBDs)
- PERSIST (Makepeace)
- REMOTE (Alaskans)
- PERFORM (Texans)
- Out-sulation (???)
- Exterior Thermal & Moisture Management System (ETMMS)

- Build the entire structure;
  - foundation, floor systems, walls, and roof
- Wrap the entire envelope with a “peel & stick” membrane integrated with openings / penetrations
- Add rigid foam insulation
  - 2 to 3” on foundation
  - 3 to 4” on walls
  - 6 to 8” on the roof
- Add furring strips, overhangs, etc.
- Install trim; siding; roof sheathing and roofing


L S
722 2345


GRACE
Bituthene
GRACE
Perm-A-Barrier
GRACE VYCOR PLUS
GRACE VYCOR


GRACE
Bituthene


METROPOLITAN

Foundation Insulation Solution Sets

- Option 1: Customized Approach
  - Based on a holistic assessment of:
    - site conditions,
    - basement conditions,
    - foundation construction details, and
    - interior conditions.
- Option 2: Universal Approach
  - Do we have one-size fits all designs for both liquid active and not liquid active walls?

Foundation Insulation Solution Sets

Universal Approaches

- Existing wall is (or likely to be) liquid water active
  - No exterior water proofing or capillary break
  - Signs of water staining and efflorescence
  - Most CMU walls

- Existing wall is not liquid water active
  - Good waterproofing and capillary break
  - Very dry soil and site conditions

Foundation Insulation Solutions (liquid water active; exterior)

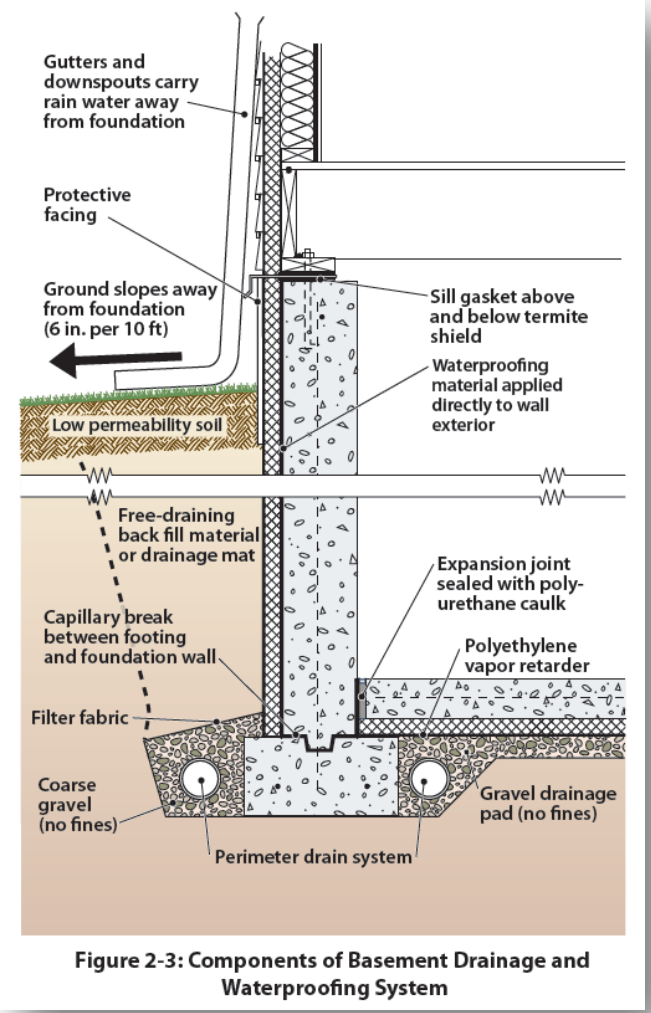


Figure 2-3: Components of Basement Drainage and Waterproofing System

Source: Oak Ridge National Laboratory

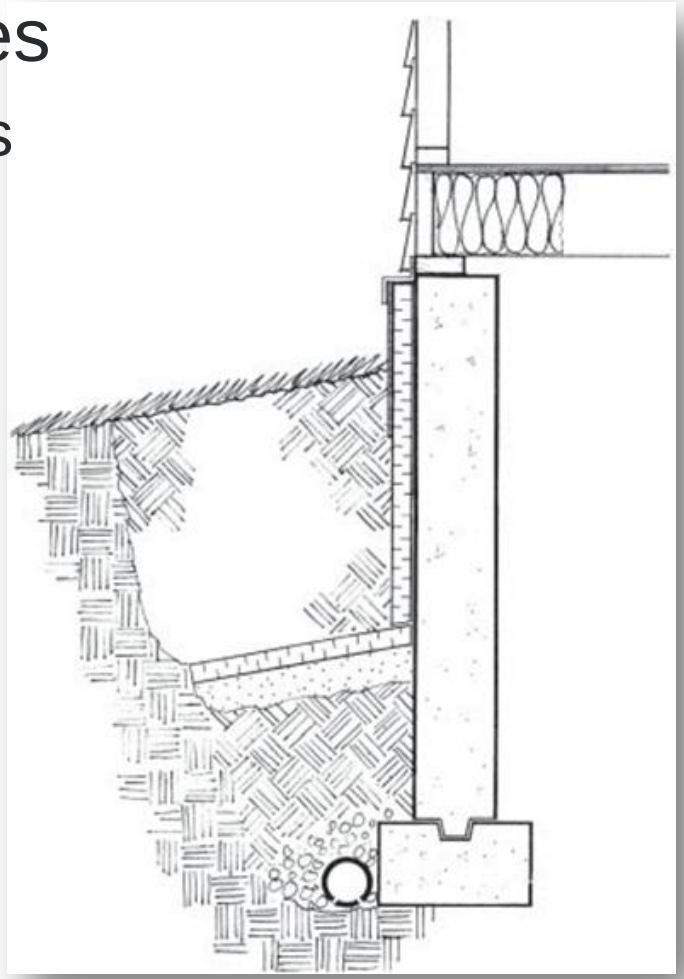
Foundation Insulation Solutions
Walls Not Liquid Water Active

- Exterior options are pretty much wide open
  - Even partial insulation-only options may be viable
- Interior options may work
  - Generally requires a semi-impermeable insulation
  - but must be airtight and limit exterior wetting

Foundation Insulation Solutions (not liquid water active; exterior)

Existing Basements Alternatives

- Partial exterior insulation systems
  - Partial depth
  - With or without skirt
- Current cautions
  - Material choices
  - Moisture impacts



Foundation Insulation Solutions (not liquid water active; interior)

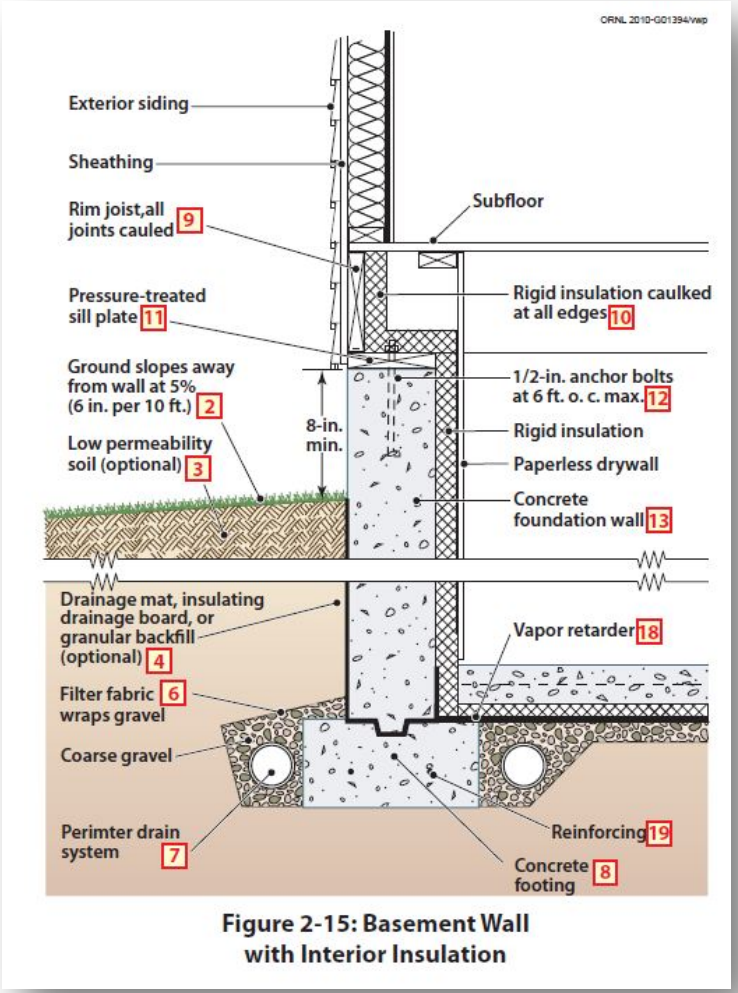
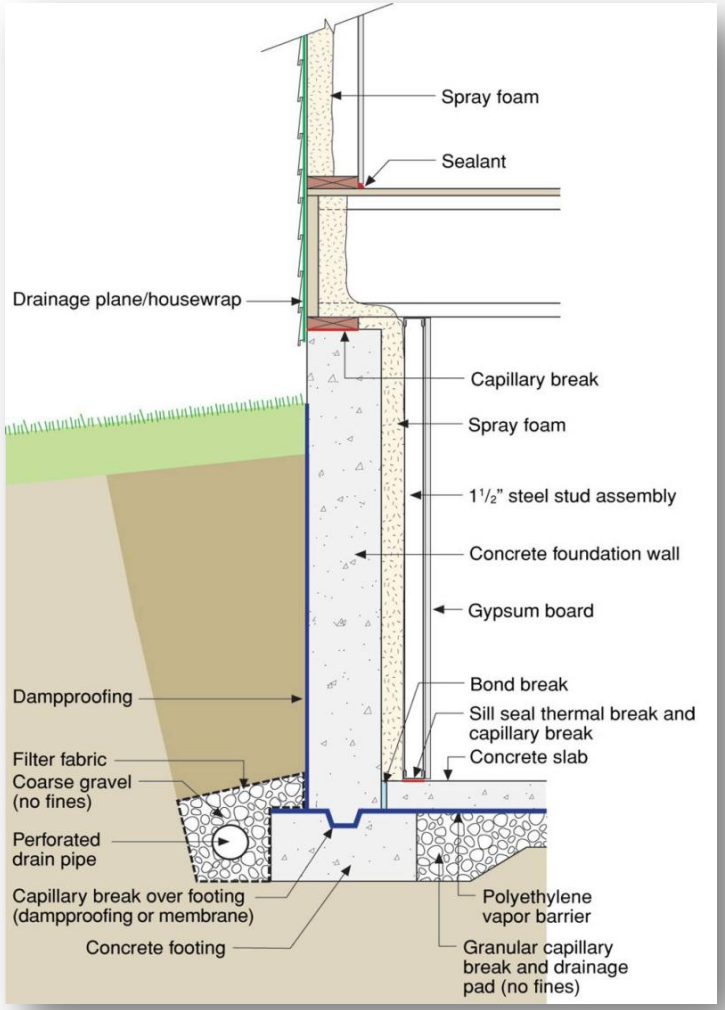


Figure 2-15: Basement Wall with Interior Insulation

Source: Oak Ridge National Laboratory

Foundation Insulation Solutions (not liquid water active; interior)



Source: Building Science Corporation

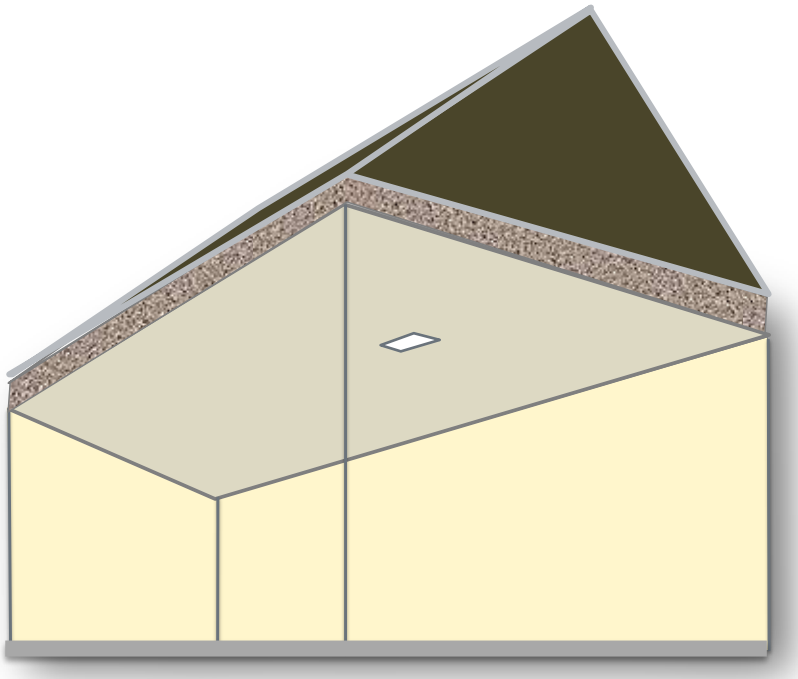
Foundation Insulation Solutions
Liquid Water Active Walls

- Exterior options
  - Most will work very well
  - Rarely will increase risks
  - Can mitigate bulk water issues
- Interior options
  - Generally more risky
  - Will likely require a water separation plane

Zero Energy Ready Home

High-R Roofs

Why Thermal Holes Are a Big Deal



1, 000 sq. ft. R-38 Attic
U = .026

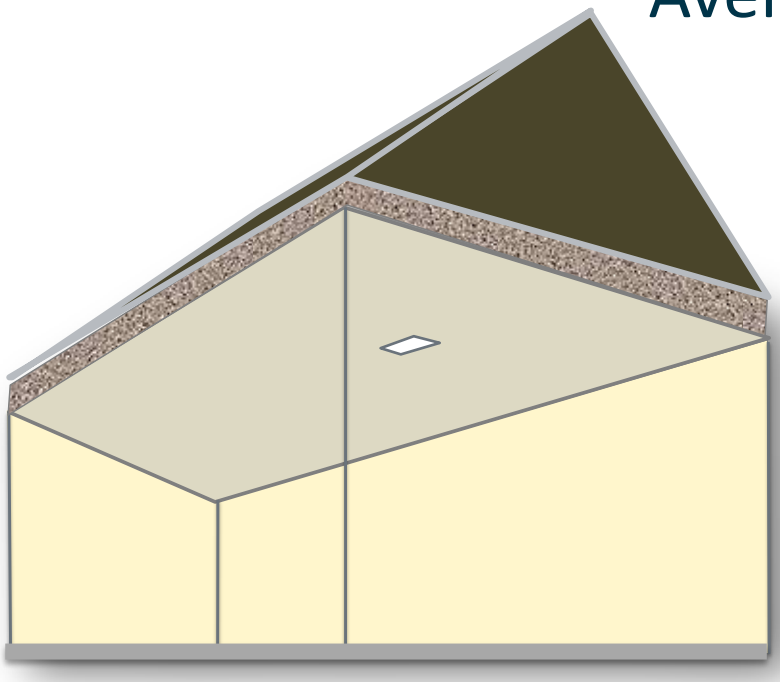
Drop-Down Stair = R-1

R-1, U = 1.0

10 sq. ft. = 1% of area

What Percent Loss in Attic R-Value?

Why Thermal Holes Are a Big Deal



$$\text{Average U} = \frac{U1 \times A1 + U2 \times A2 + \ldots}{\text{Total Area (A)}}$$

$$= \frac{(.026 \times 990) + (1 \times 10)}{1{,}000}$$

$$= \frac{35.74}{1{,}000} = .036$$

$$= \mathbf{R\text{-}28}$$

$$= \mathbf{27\% < R\text{-}38}$$

1% Hole Results in 27% Loss of R-Value

Why Thermal Holes Are a Big Deal

Assume 50° F temperature difference across attic ceiling

$$\text{Heat Flow} = \frac{(\text{Delta T}) \times \text{Area}}{R}$$

$$\text{Heat Flow (w/o Hole)} = \frac{(50) \times 1000}{38} = \frac{50{,}000}{38} = \textbf{1316 Btu/hr}$$

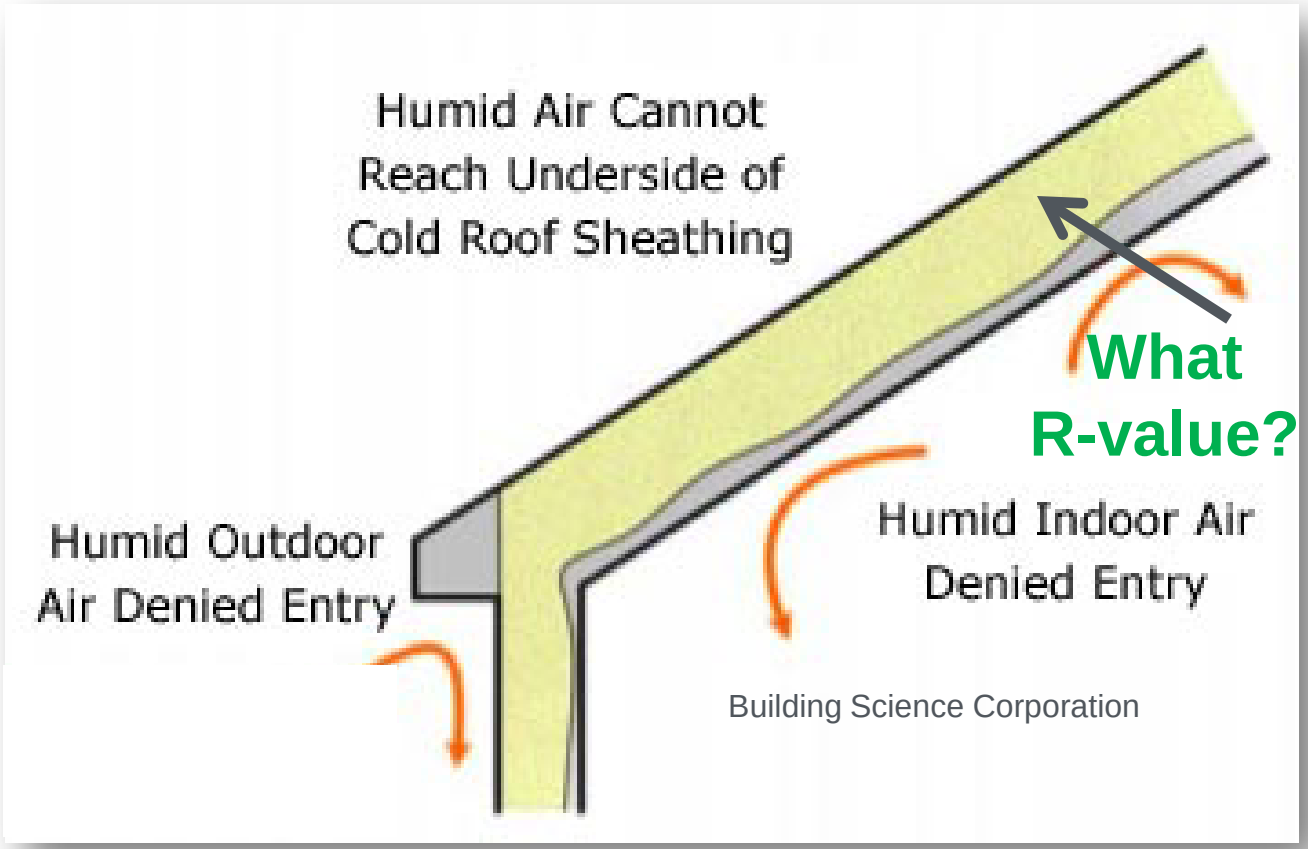
$$\text{Heat Flow (w/hole)} = \frac{(50) \times 1000}{28} = \frac{50{,}000}{28} = \textbf{1786 Btu/hr}$$

33%+ Greater Heat Flow with 1% Hole

Air Impermeable Insulation

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

5.1 AIR-IMPERMEABLE: In direct contact with the underside of the sheathing



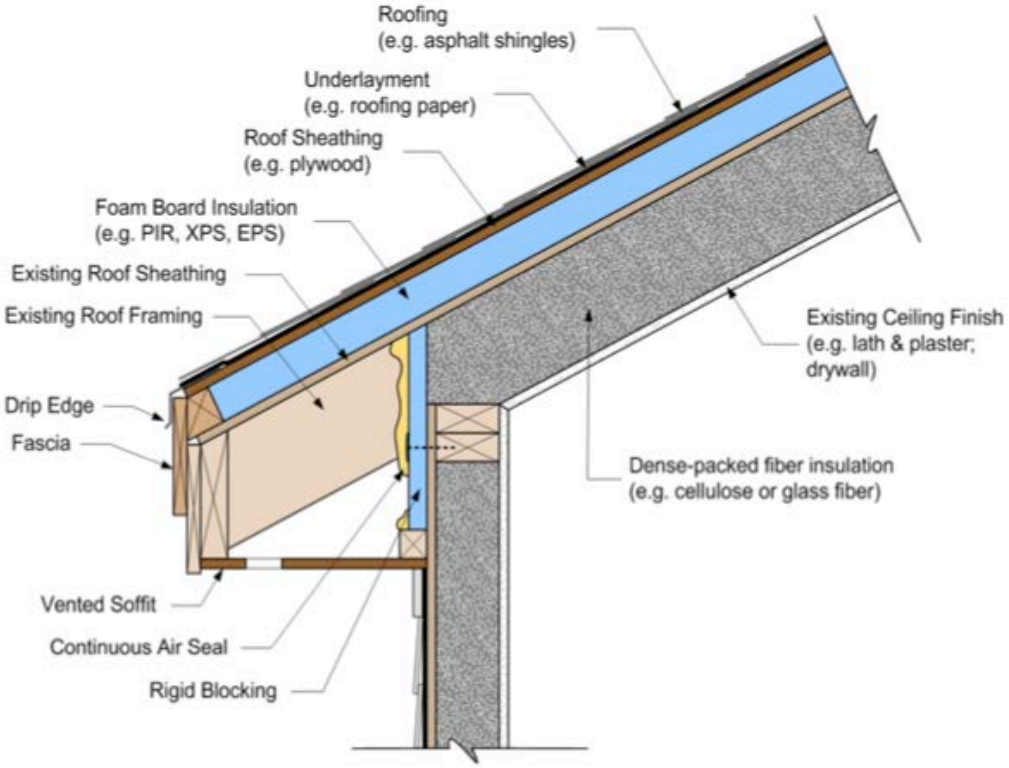
Minimum R-value of Impermeable Insulation

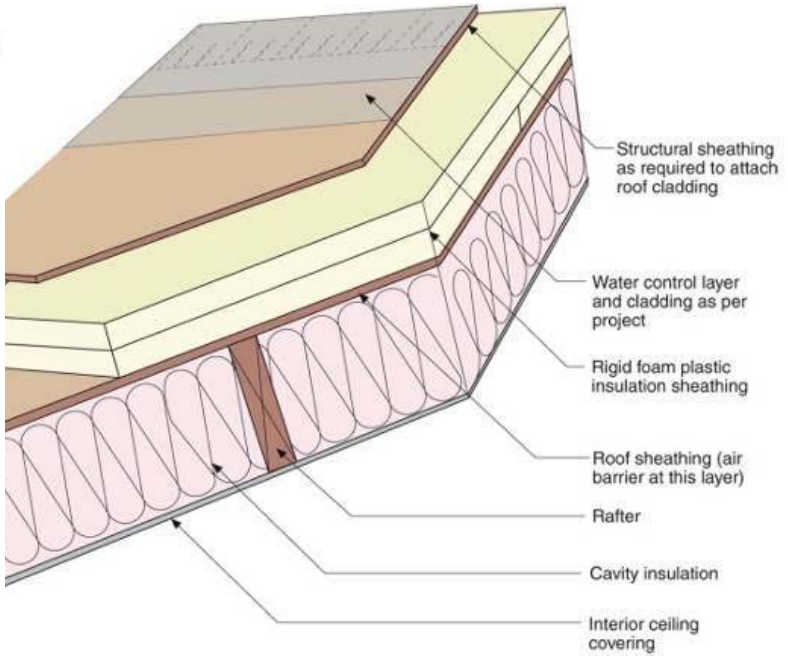
Climate Zone	Minimum Impermeable Insulation R-Value*	2012 IECC Ceiling R-Values
2B and 3B Tile Roof	None Required	30
1, 2A, 2B, 3A, 3B, 3C	R-5	38
4C	R-10	38
4A, 4B	R-15	49
5	R-20	49
6	R-25	49
7	R-30	49
8	R-35	49

*contributes but doesn't supersede 2012 IECC insulation requirements

Top Insulated Roof Deck

Building Science Corporation





Sequence of Retrofit:

1) Remove existing roofing and underlayment; Inspect existing roof deck and framing and repair as necessary.

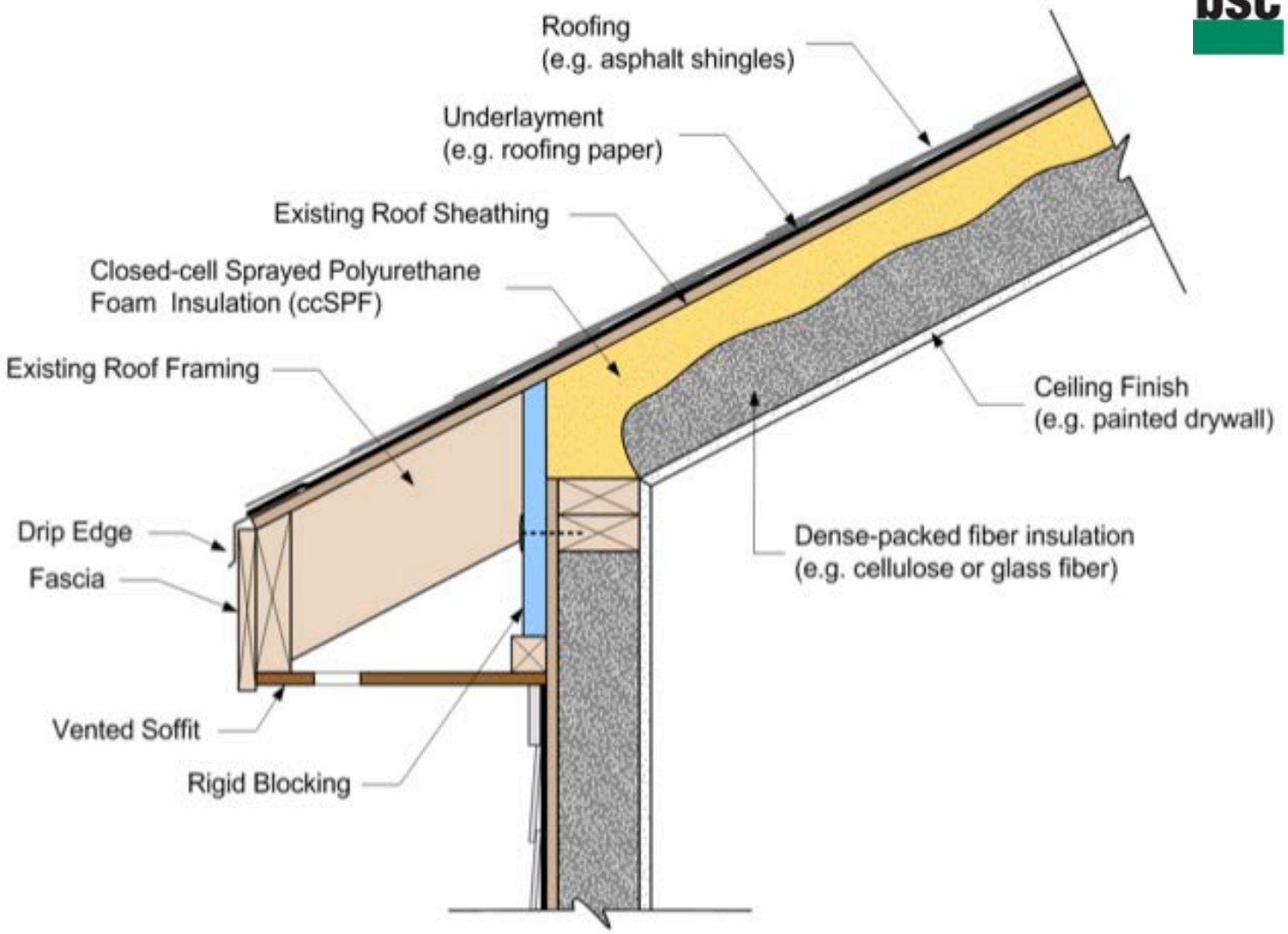
2) Install new exterior foam board insulation, roof sheathing, underlayment, flashings and roofing.

3) Remove existing soffit and install rigid blocking to prevent loose-fill fiber insulation from blowing into soffit; Install continuous air seal at all joints and interfaces in blocking; Replace soffit.

4) Dense-pack rafter cavities using approved cellulose or glass fiber insulation and following insertion tube techniques described in BPI RBE-WHALCI 2012.

Guidance for Dense Pack Roof Assemblies

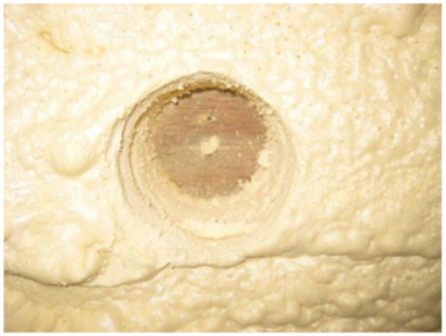
Building Science Corporation

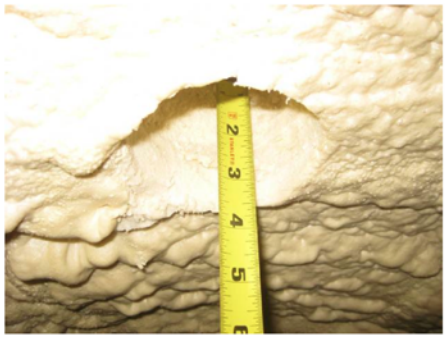


Guidance for Spray Foam Under Roof Decks

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

Building Science Corporation





Description
- Built 2009
- Cathedralized attic
- R21 - ~3.5" ccSPF below OSB roof sheathing

Exploration Findings
- All sheathing locations investigated are within safe moisture content readings

Exploration Location 1 – North Lower
- 6% moisture content reading
- No visible signs of moisture damage

Exploration Location 2 – West Upper
- 7.5% moisture content reading
- No visible signs of moisture damage

Exploration Location 3 – East Upper
- 6.5% moisture content reading
- No visible signs of moisture damage

Exploration Location 4 – West Lower
- 7.0% moisture content reading
- No visible signs of moisture damage

This information correlates well to modeling of warm locations with drives that enhance drying and have limited wetting.

Figure 1 – New Orleans, LA – June 2012 Collection of Sample of Spray Foam Under Roof Assembly in an Attempt to Compare Actual Performance with Idealized Performance

Figure 2 – Minneapolis, MN – July 2012

Description
- 1941, Retrofit 2012
- Catherdralized attic
- R21 - ~3.5" ccSPF below 1x board roof

Exploration Findings
- All sheathing locations investigated are within safe moisture content readings

Exploration Location 1 – North West Lower
- 9.2% moisture content reading
- No visible signs of moisture damage

Exploration Location 2 – South West Lower
- 6.9% moisture content reading
- No visible signs of moisture damage

Zero Energy Ready Home

Technical Specifications Mandatory Requirements: Ducts in Conditioned Spaces

Why Ducts in Conditioned Space?

- **Significant Thermal Losses:**
  - Thermal losses triple for ducts in unconditioned vs. conditioned space
  - Total thermal losses can range from 10-45%
  - Extensive unconditioned space penetrations
- **Significant Performance Impacts:**
  - IAQ
  - Comfort
  - Durability

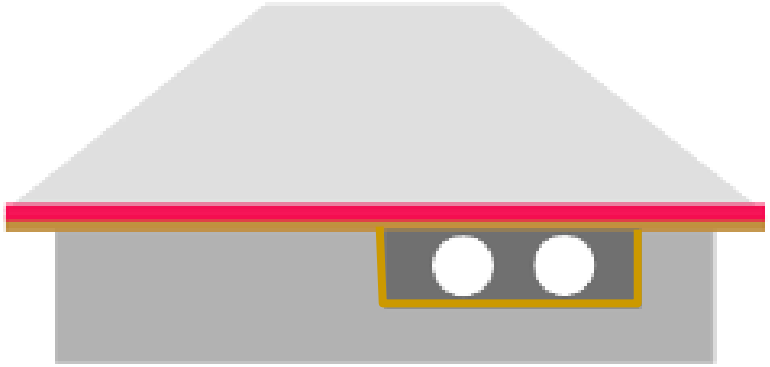
Ducts in Condit. Space Exemptions

- **Short Duct Run**
  up to 10’ of total length is permitted to be outside of the home’s thermal and air barrier boundary.
- **Jump Ducts**
  may be located in attics if all joints, including boot-to-drywall, are fully air sealed with mastic
- **Ductless HVAC system**

Ducts in Condit. Space Options

- **Conditioned Floor Space [3 options]**
  within the thermal boundary
- **Unvented Crawl Space/Basement**
  which is within the home's thermal boundary
- **Unvented Attic**
  regardless of whether conditioned with a supply register
- **Vented Attic**
  equivalent option where other locations in conditioned space are impractical, expensive, don't work well in specific climates, or increase envelope loads

Ducts in Conditioned Floor Space Option 1: Dropped Ceiling

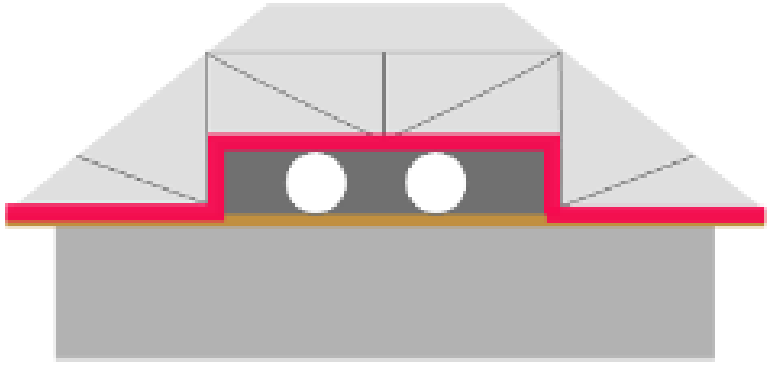


Ducts in dropped ceiling

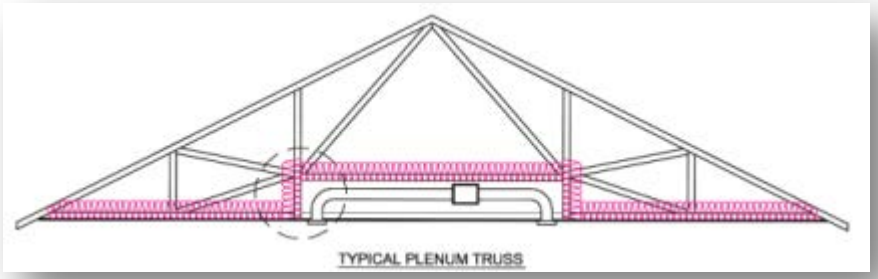
Issues:

- Architectural Integration
- Good Fit w/Simple Plans
- Longer Throws (ACCA Man T)

Ducts in Conditioned Floor Space Option 2: Modified Attic Truss



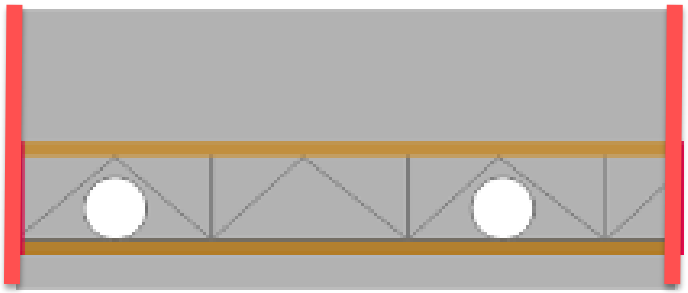
Ducts in modified truss in attic



Issues:

- Design Integration
- Good Fit w/Narrow Plans
- Sealed Air Barrier Critical

Ducts Between Floors



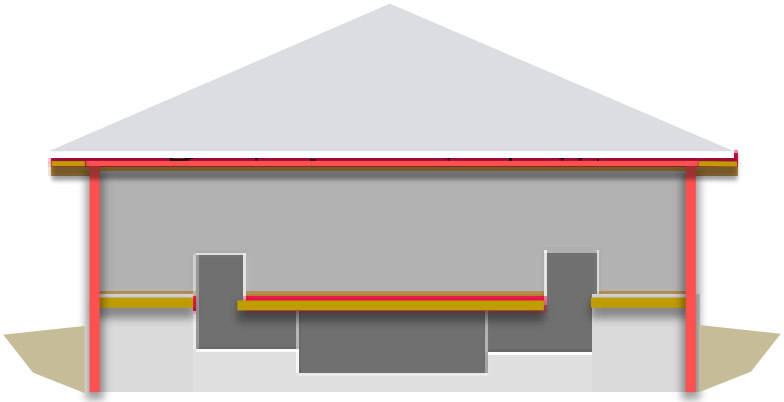
Ducts between floors

Issues:

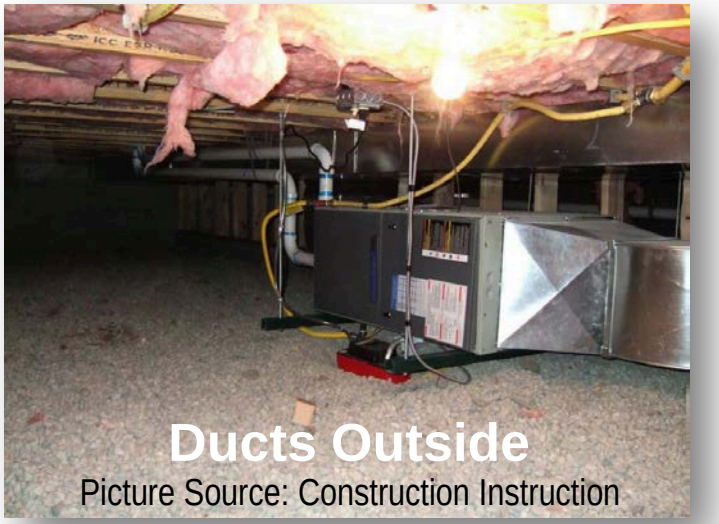
- Simple Installation
- Design Flexibility
- Cost-Effective
- Floor Registers Likely

Ducts in Conditioned Floor Space Option 3: Ducts Between Floors

Unvented Crawl Space/Basement

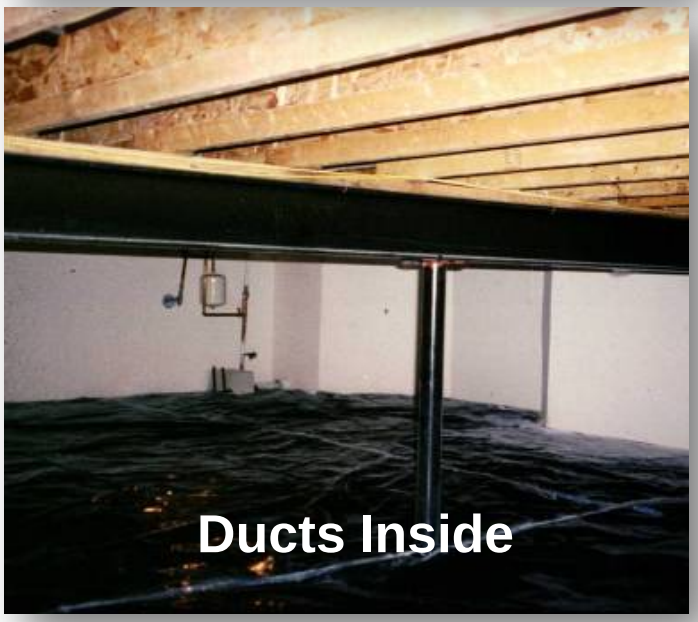


Ducts in unvented crawl space or basement



Ducts Outside

Picture Source: Construction Instruction

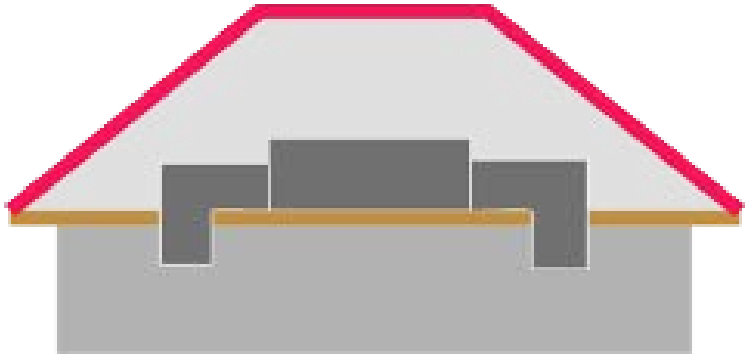


Ducts Inside

Issues:

- Simple Installation
- Design Flexibility
- Cost-Effective
- Floor Registers Likely

Ducts in Unvented Attic

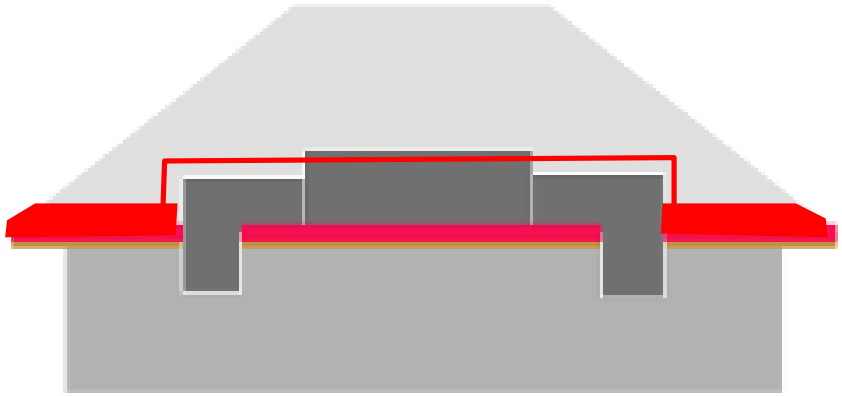


Ducts in unvented attic

Issues:

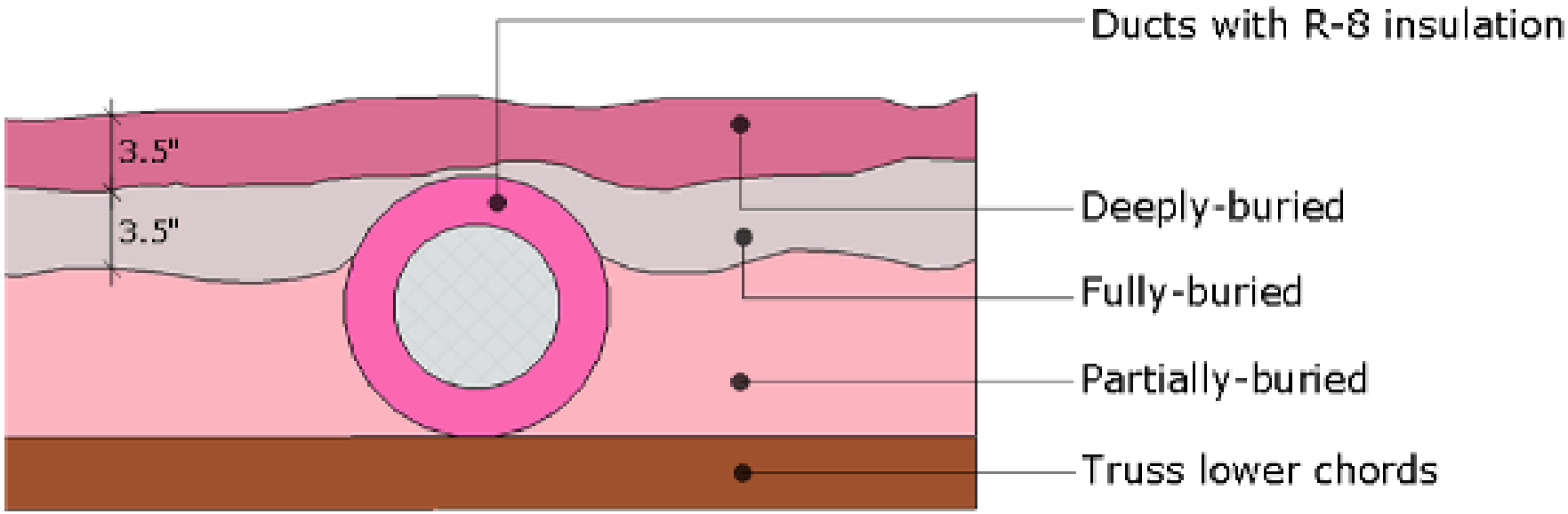
- CZ 5+, air impermeable plus a Class II VT or Class III VT in direct contact
- No Class I VR on attic floor

Ducts in Vented Attic: Dry CZs



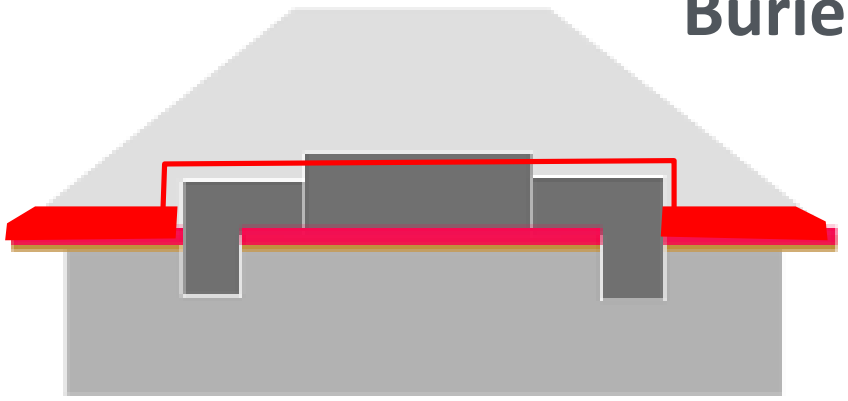
Ducts in vented attic

Buried Ducts

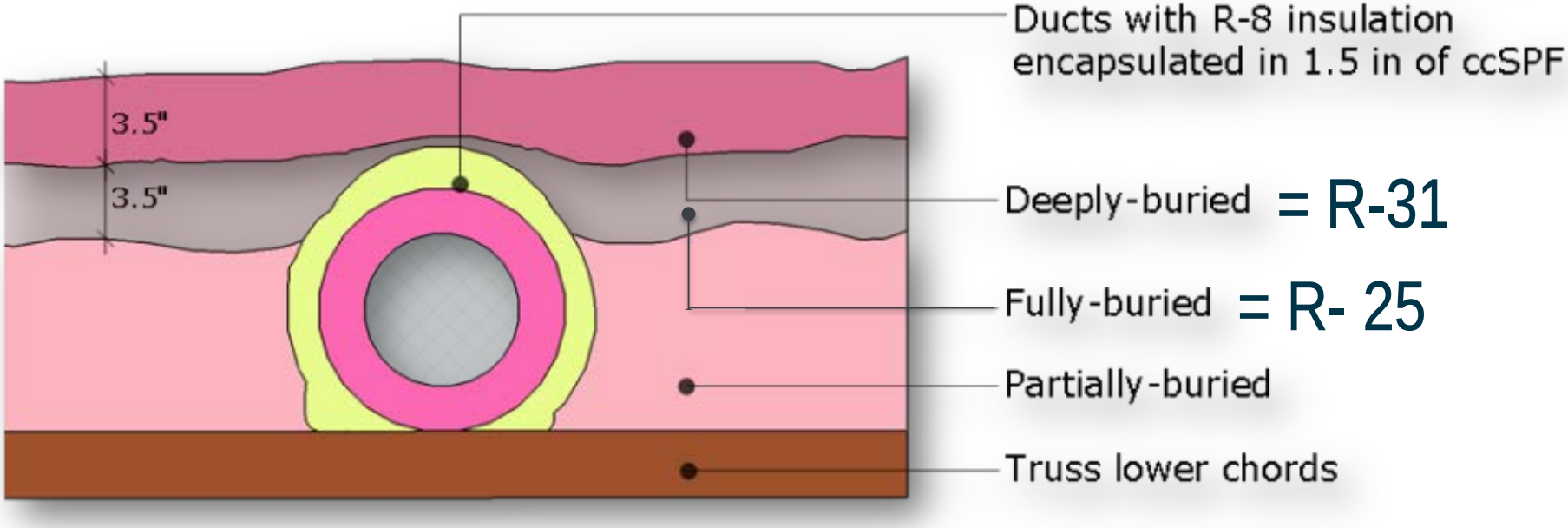


Ducts in Vented Attic: Humid CZs

Buried Encapsulated Ducts (BEDs)

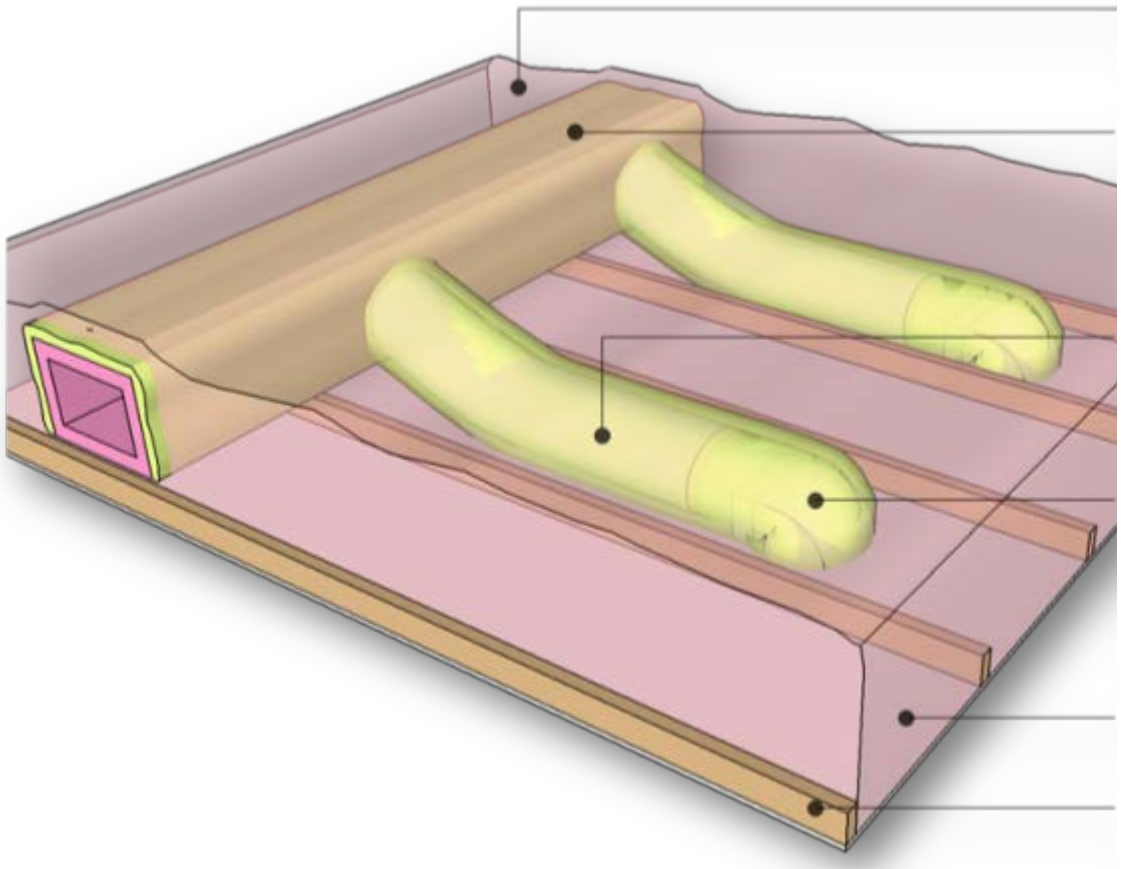


Ducts in vented attic



Buried Encapsulated Duct (BED)

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



- Ducts buried under loose-fill insulation
- R-8 ducts encapsulated in 1.5” ccSPF
- R-8 flex duct encapsulated in 1.5” ccSPF
- Duct boot connection encapsulated in 1.5” ccSPF
- Drywall ceiling
- Truss lower chords

Building America Resources

Zero Energy Ready Home

Technical Specifications Mandatory Requirements: Efficient Hot Water Distribution

Water Efficiency as a System

- **Indoor Fixtures**
  - Plumbing Fixtures
  - Appliances and Other Equipment
- **Distribution**
  - Service Pressure
  - Metering (for Multi-Family Homes)
  - Leak Prevention
  - **Hot Water Distribution**
- **Outdoor**
  - Landscape Design
  - Irrigation (if installed)

Efficient Hot Water Distribution

- "Must Have" for zero net-energy ready homes
- Based on EPA WaterSense Specifications:
  - No more than 0.5 gallons of water in any piping/manifold between the hot water source and any hot water fixture.
  - No more than 0.6 gallons of water shall be collected from the hot water fixture before hot water delivered.
  - Timer- and temperature-based recirculating systems shall not be used to meet the criteria.

Hot Water Distribution

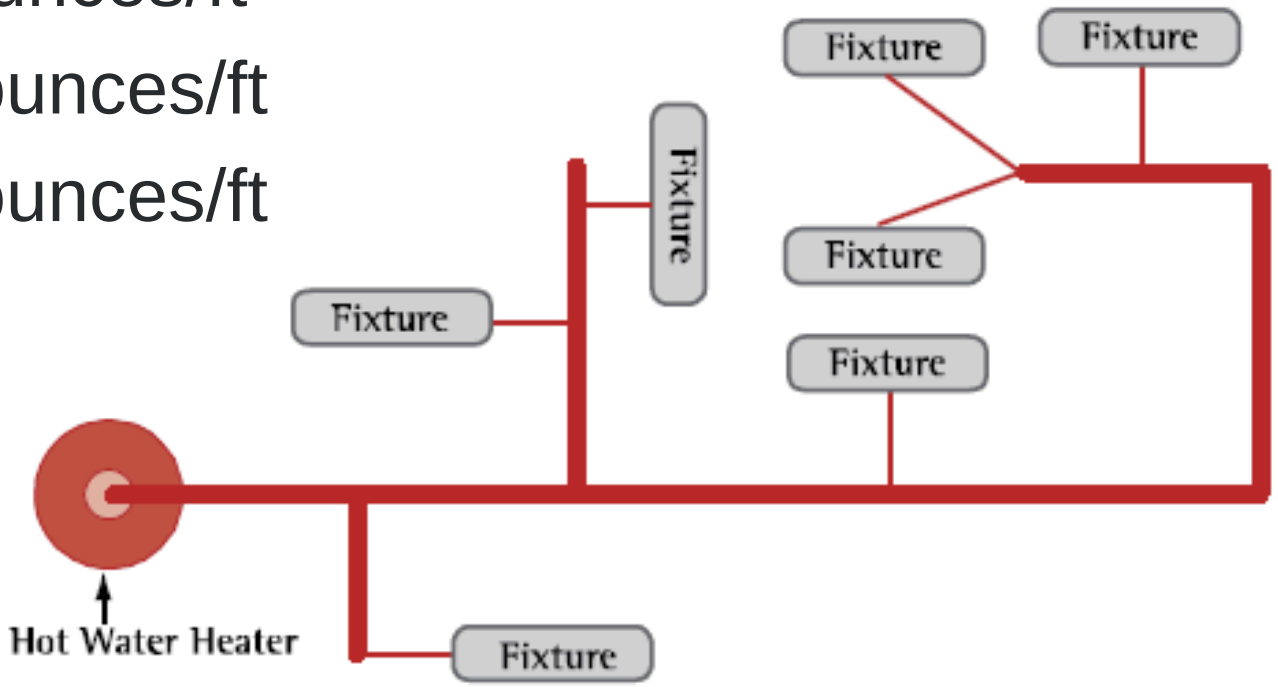
Built for when water was free and energy was cheap!

Copper L piping:

- 1” = 5.53 ounces/ft
- ¾” = 3.22 ounces/ft
- ½” = 1.55 ounces/ft

Stored Volume:
1.6 gallons
30’ trunk
10’ branch
3’ twig
2 GPM showerhead

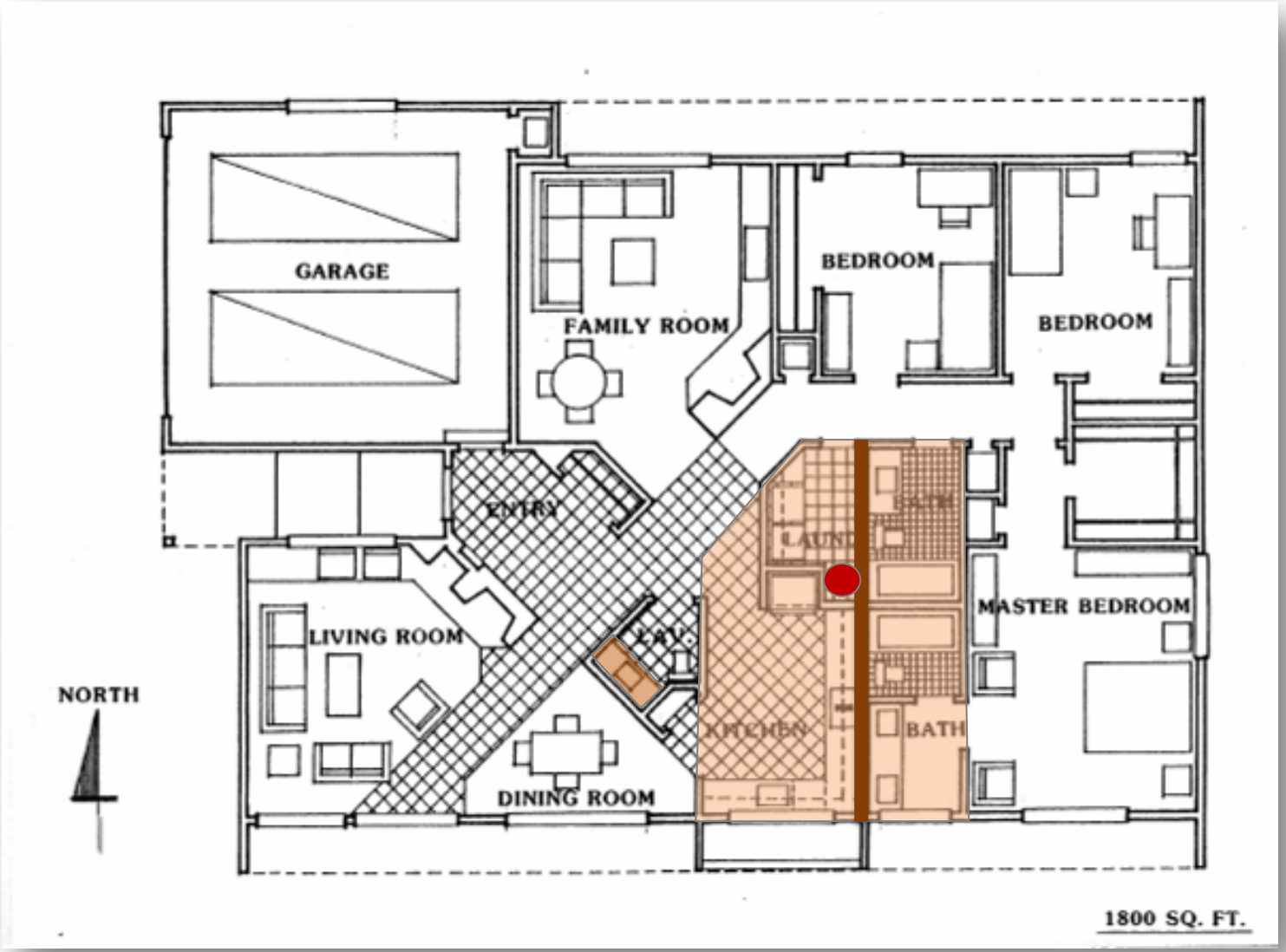
Example:
Stored Volume:
1.6 gallons
30’ trunk
10’ branch
3’ twig
Wait Time: 1 – 1.5 minutes
2 GPM showerhead



Hot Water Distribution Options

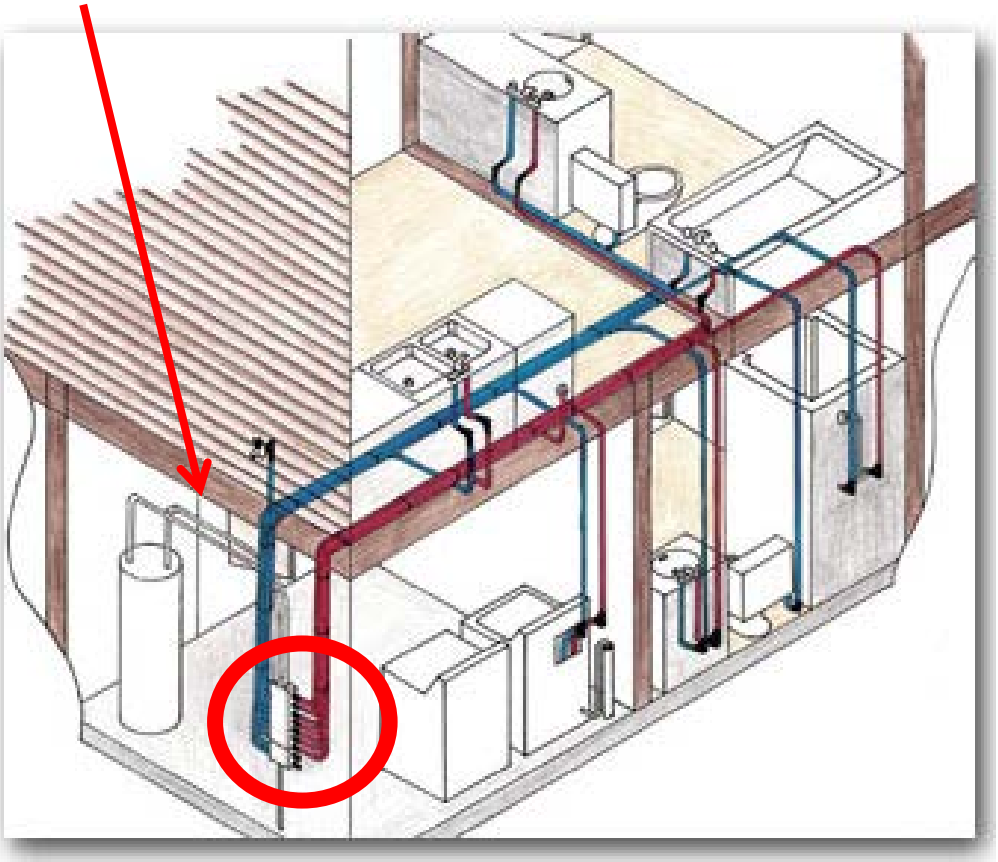
- Core Plumbing Layout (wet wall)
- Manifold System
- Demand Pumping System

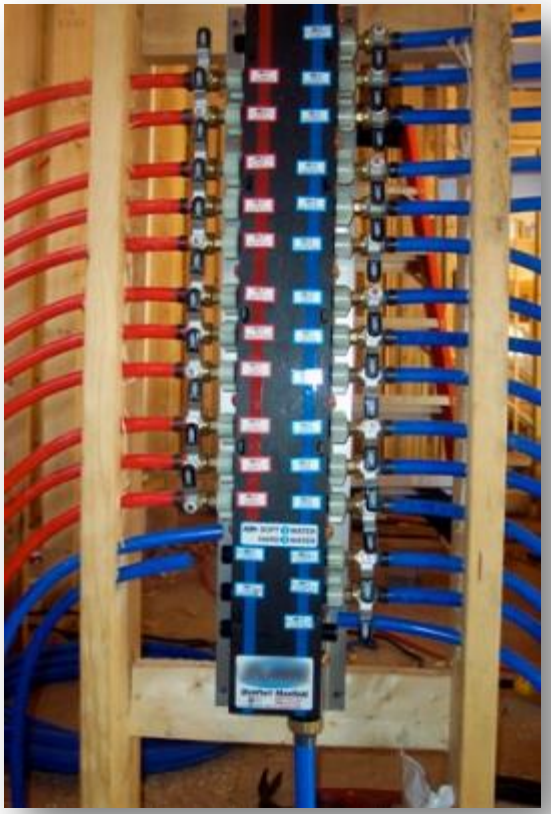
Core Plumbing Layout



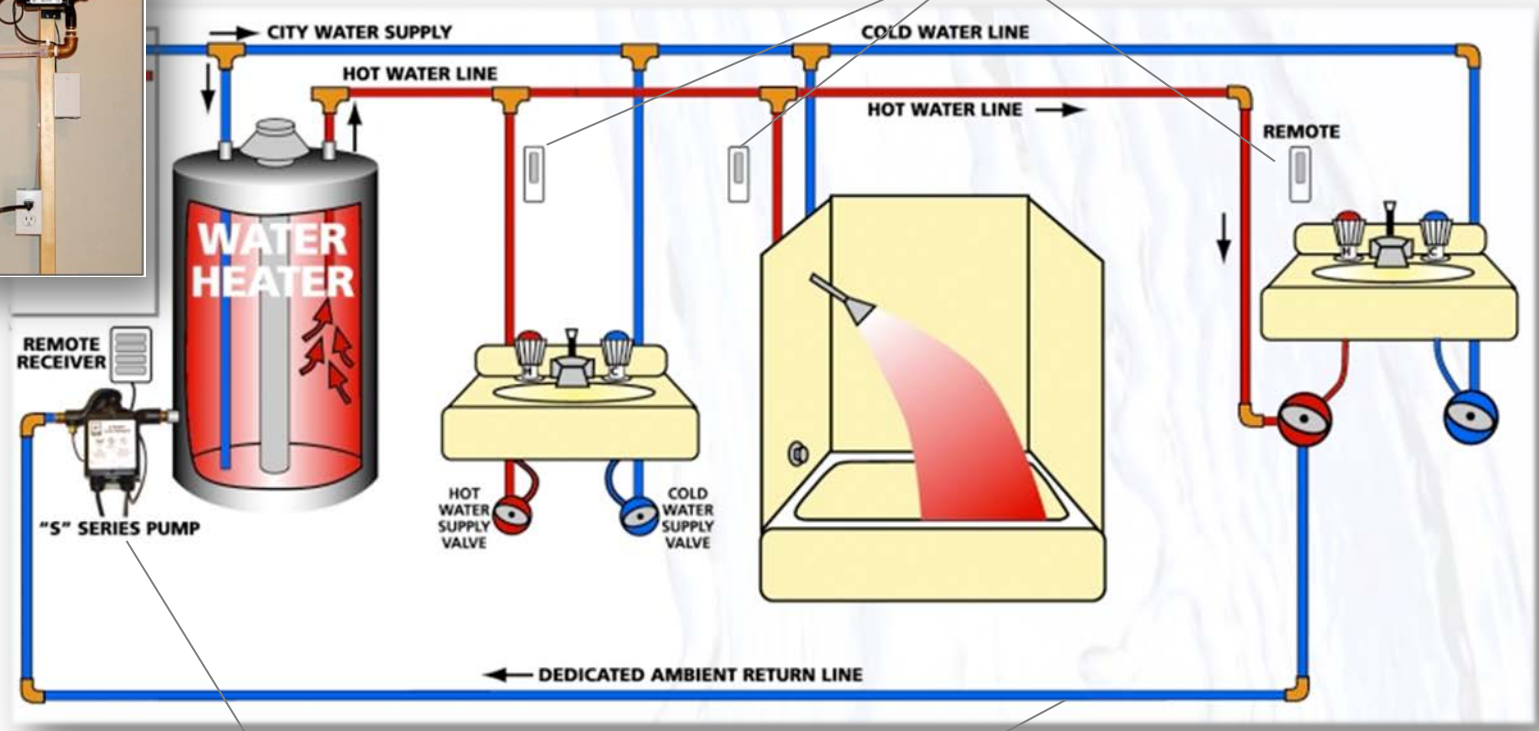
Manifold Plumbing System

10’ Max





Demand Pumping System



Sensor or Controls

Demand Pump

Dedicated Return

Zero Energy Ready Homes

Technical Specifications Mandatory Requirements: Efficient Components: Lighting, Appliances, & Fans

Efficient Components

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

Components and MEL's are increasingly Important in Low-Load Homes (~25 to 40%). Therefore, Challenge Home requires:

- **ENERGY STAR Certified Appliances:*** refrigerators, dishwashers, clothes washers
- **ENERGY STAR Certified Fans*:** bathroom ventilation, ceiling fans
- **ENERGY STAR Certified Lighting:** Min. 80% of fixtures or lamps (CFL or LED)

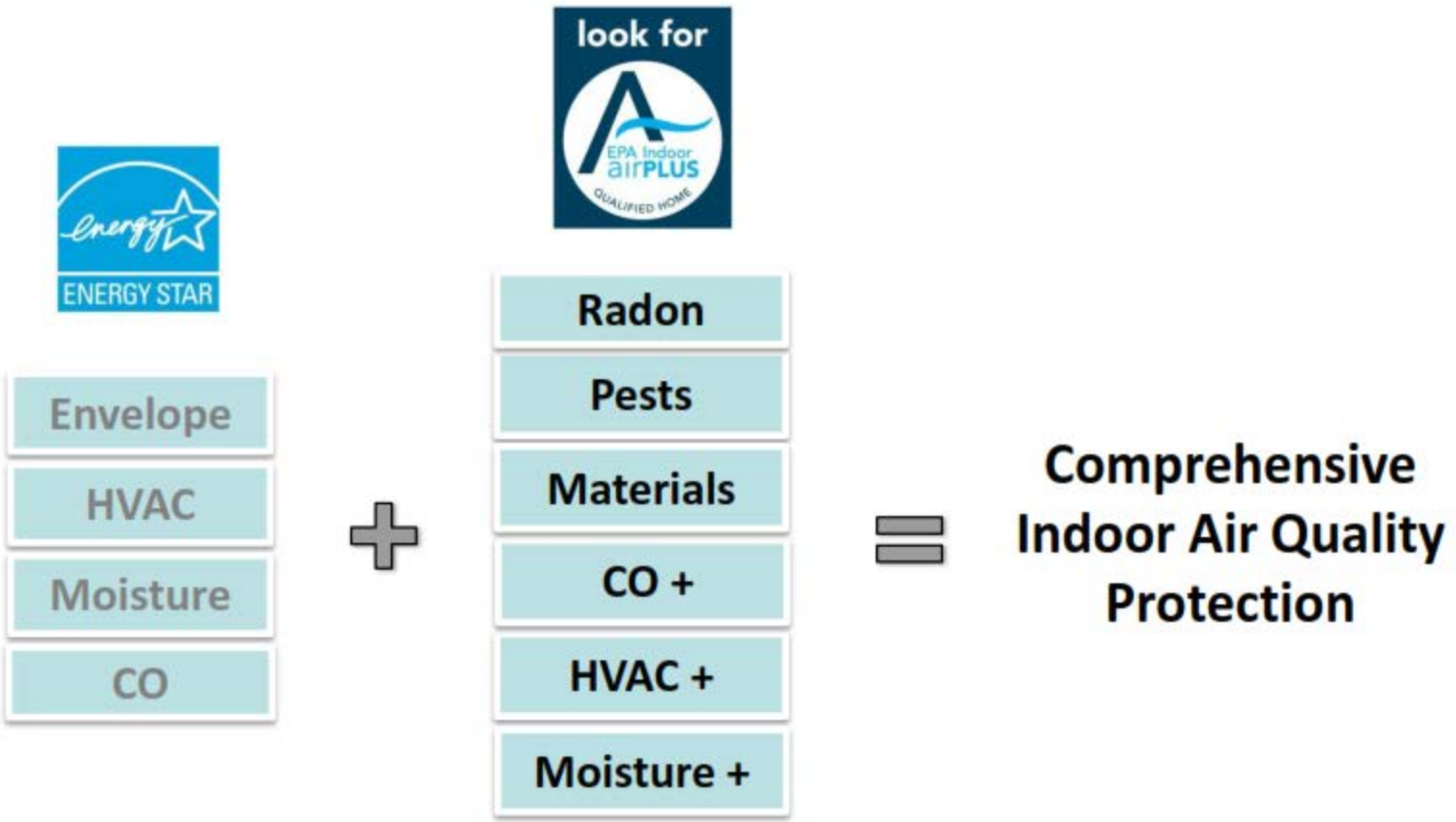
*Only where installed by builder

Zero Energy Ready Home

Technical Specifications Mandatory Requirements: Indoor Air Quality

Addressing Health Concerns

ENERGY STAR + Indoor airPLUS



Why IAQ is NOT A La Carte?

- 2000 SF Home
- 8.5’ Ceilings
- 3 ACH50 Air Tightness
- 200 cfm Exhaust
  (e.g. dryer, range hood)

- 5 Pa depressurization

- Dust Mites –asthma
- ~40% households with significant respiratory issue

- Radon Control

Indoor Air Quality **as a System**

- Source Control
- Dilution
- Filtration

Practices & Product Selection That Limit Moisture, Radon, Chemicals, Combustion By-Products, Biological Contaminants

HVAC Quality Installation System

Moisture Control System

- Moisture Vapor:
  - Air Sealing
  - Air Barriers

Thermal Enclosure System

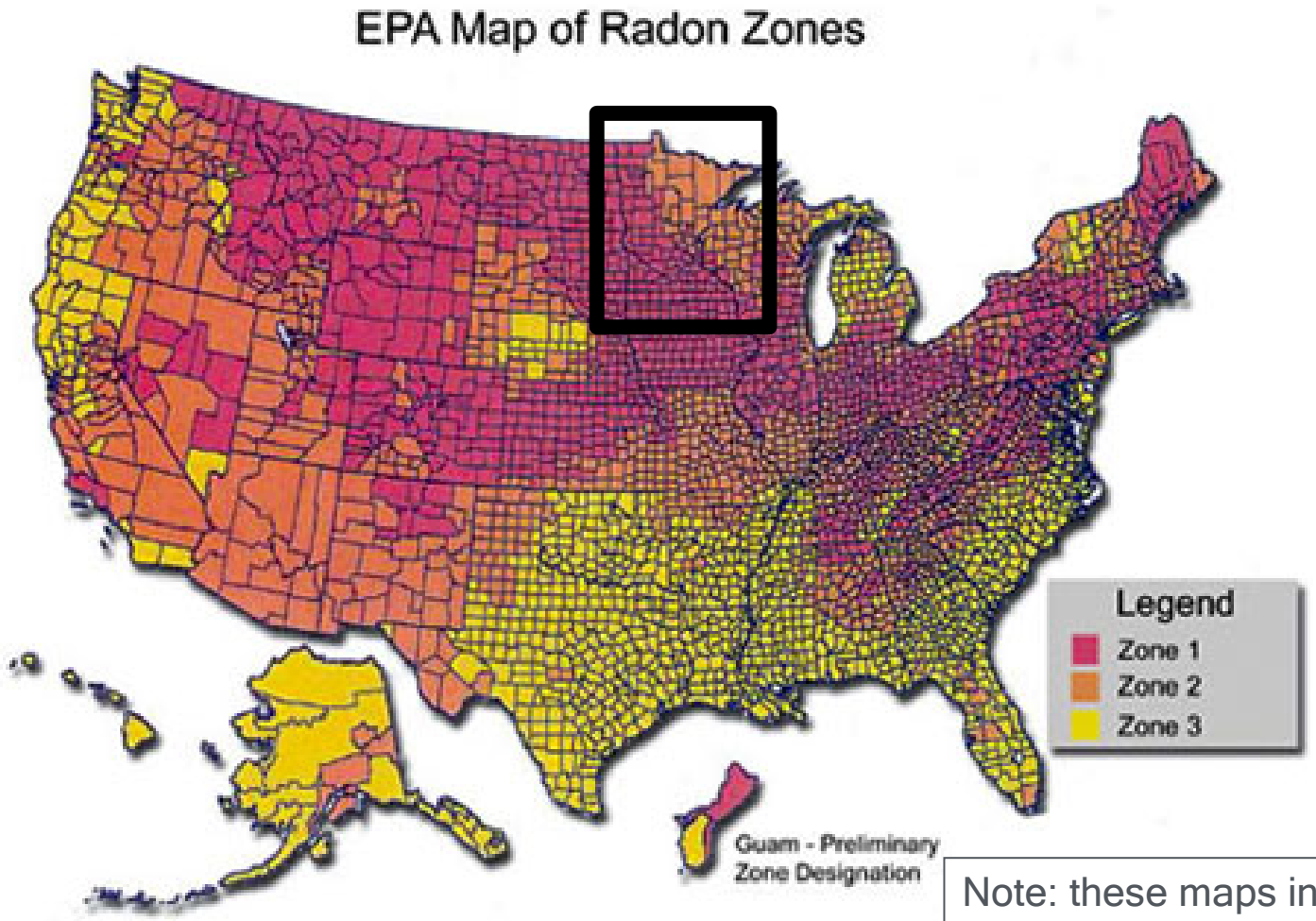
- Bulk Moisture:
  - Water-Managed Roofs
  - Water-Managed Walls/Openings
  - Water Manage Foundation/Site
  - Water Managed Materials

Water Managed Construction

- Dehumidification [Warm-Humid Climates]

HVAC System or Supplemental

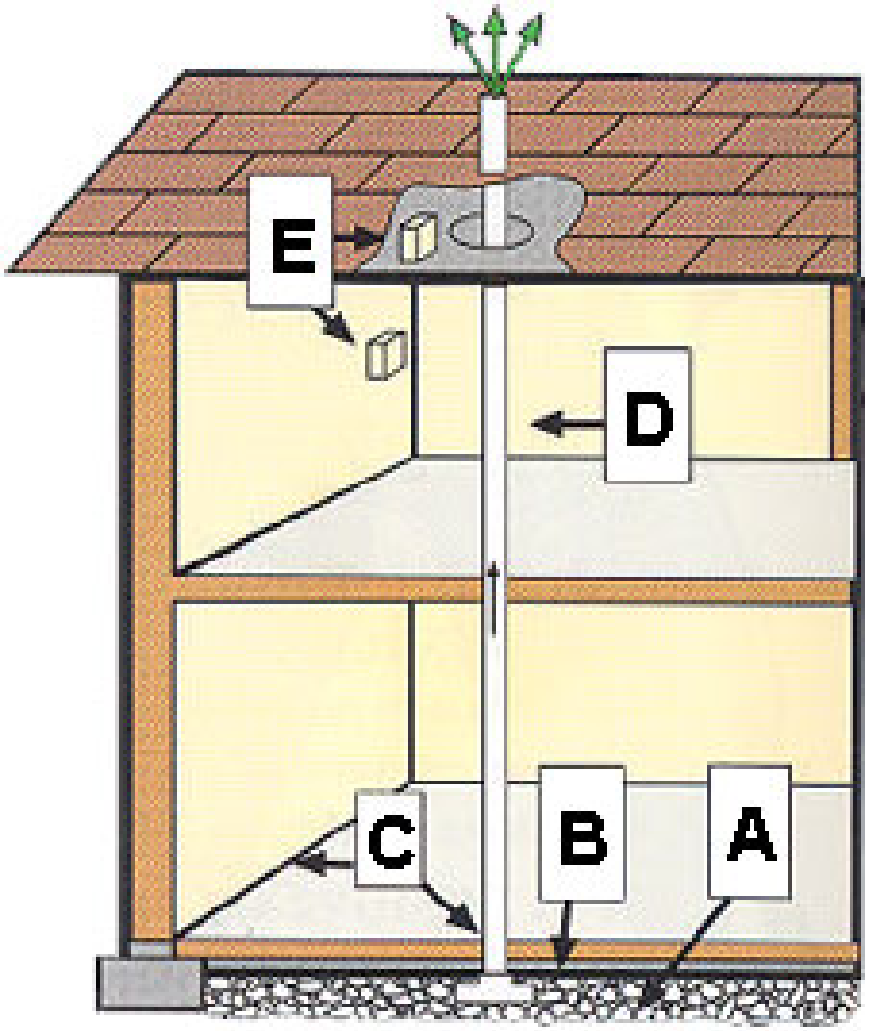
Radon Zones in U.S.



Surgeon General's Warning: Radon Causes Lung Cancer

Note: these maps indicate average risk by county. However, **High levels of Radon can be found in any home**.

Radon Resistant Construction



Required for Moisture Control:

A. Gas Permeable Layer
(min. 4” clean gravel)

B. Plastic Sheeting
(under slab)

C. Sealing and Caulking
(all openings in concrete floor)

D. Vent Pipe
(3 or 4 inch PVC pipe)

E. Junction Box
(if fan needed later)

Radon Test Kits Not Required

Pests

Screened Openings for Pests

Corrosion-proof rodent/bird screens for openings (e.g., copper or stainless steel mesh)

Exception: clothes dryer vent

Foundation Sealing

Sealed Sump Pump

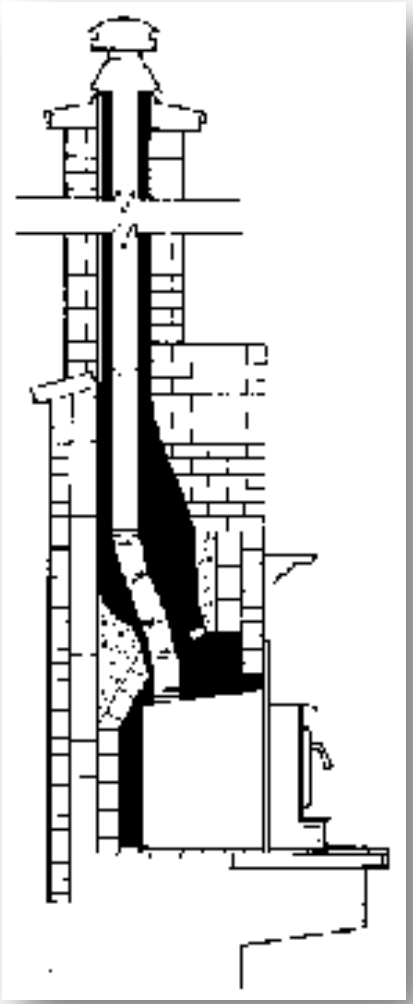
Air Sealing

Power/Direct Vent Equipment

Power Vented Water Heater

Direct-Vent Furnace

Certified Fireplaces & Stoves



- Vented to outdoors
- Adequate Combustion and Ventilation Air
- Gas fireplace power or direct vented
- Meet Specified Standards

Certified CO Alarms

CO Alarm in each bedroom area

CO Alarm

Combined CO & Smoke Alarm

c UL us LISTED

Enforceable policy in Multi-family buildings

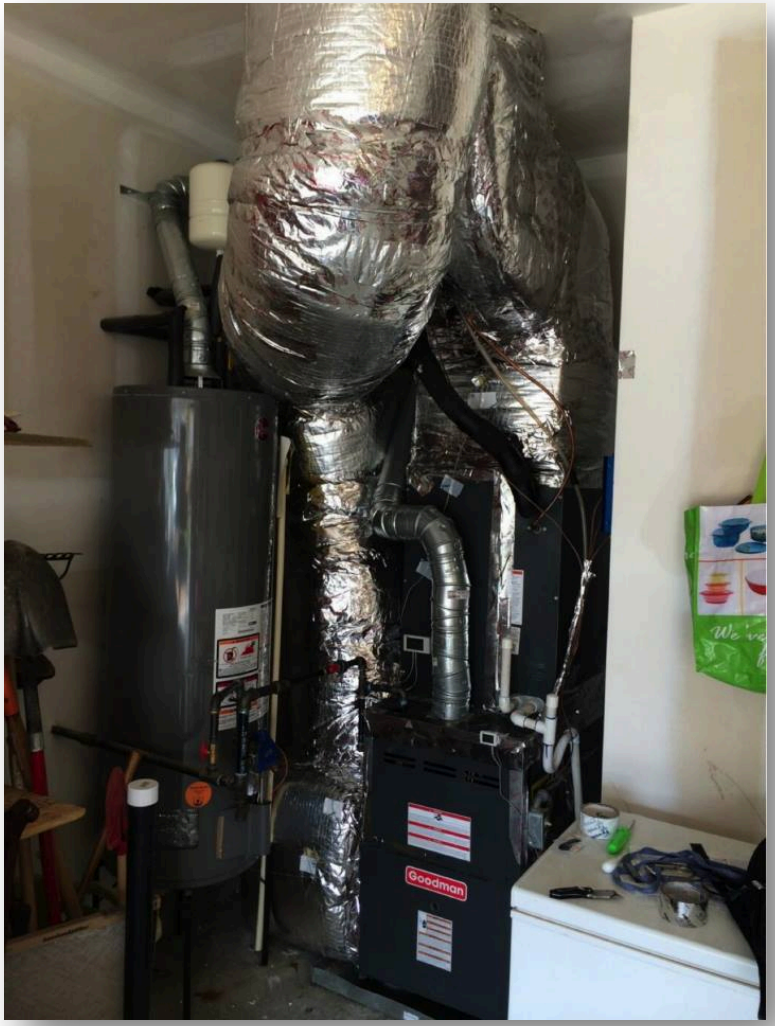
Attached Garage Isolation

Air Sealing & Gasketed Door

Exhaust Fan Optional

Attached Garage Isolation

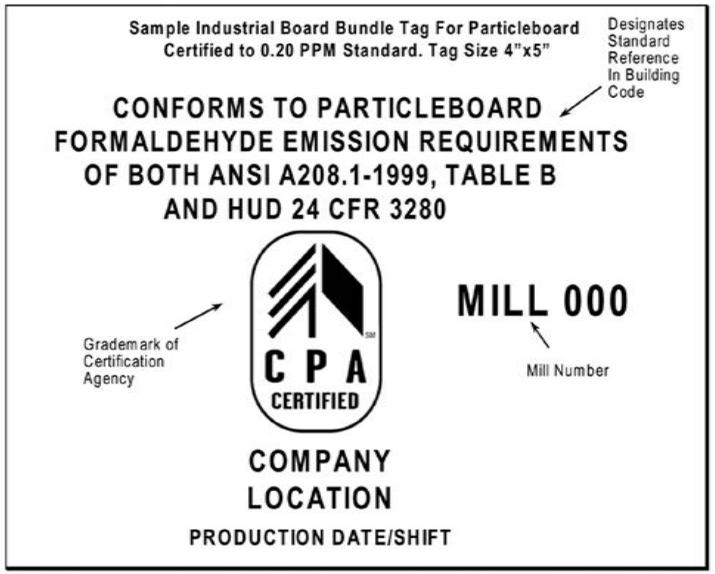
No Air Handler in the Garage



Picture Source: Construction Instruction

Low Formaldehyde Pressed Wood

MDF & Particleboard



Why Low VOC

Health Hazards of VOCs

VOLATILE Organic Compounds

Immediate

- Eye & Respiratory Tract Irritation
- Headaches
- Dizziness
- Visual Disorders
- Memory Impairment

Up to 6 years

- Eye, Nose, and Throat Irritation
- Headaches
- Loss of Coordination
- Nausea
- Damage to Liver, Kidney, and Central Nervous System
- Cancer

Low VOC Paints

Interior paints and finishes, including 90% or more of such products applied to interior surfaces of homes, shall be certified low-VOC or no-VOC by one of the following:

- Green Seal Standard GS-11, OR
- Greenguard Certification for Paints and Coatings, OR
- Scientific Certification Systems (SCS) Standard EC-10.2-2007, Indoor Advantage Gold, OR
- Master Painters Institute (MPI) Green Performance Standards GPS-1 or GPS-2, OR
- A third-party low-emitting product list based on CA Section 01350, e.g., the CHPS List at chps.net/manual/lem_table.htm.

Low VOC Carpet, Padding, Adhesives

Carpets and carpet adhesives shall be labeled with, or ***otherwise documented as meeting, the Carpet & Rug Institute (CRI) Green Label Plus or Green Label testing program criteria.*** Carpet cushion (i.e., padding) shall similarly be certified to meet the CRI Green Label testing program criteria.

Whole-House Ventilation

Three Options:

- Exhaust-Only
- Supply-Only
- Balanced

ASHRAE 62.2 2010 Continuous Ventilation Rate:

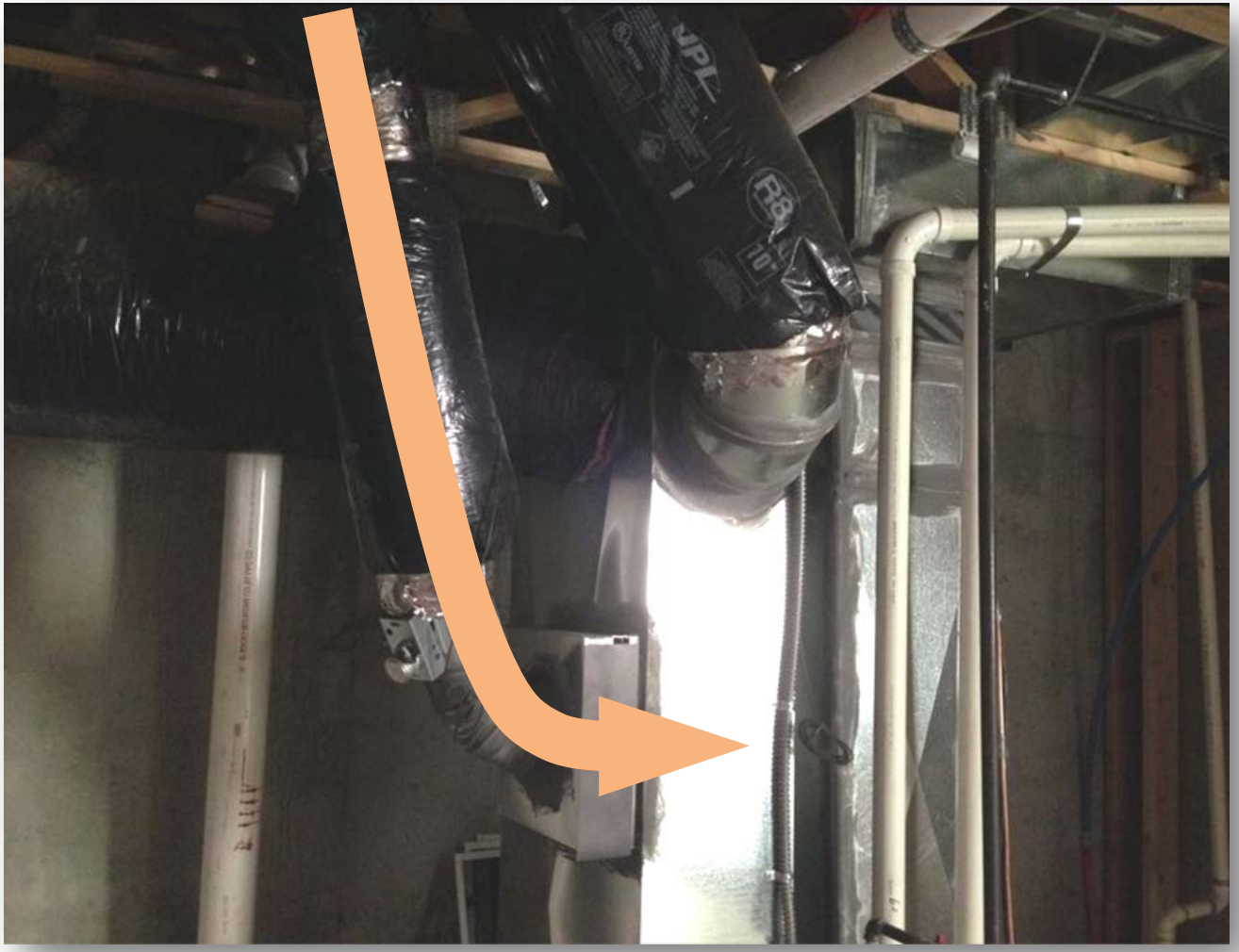
[7.5 cfm * (# bedrooms + 1)] + [.01 x Sq. Ft.]

2,000 sq. ft., 3 Bedroom Home Example:

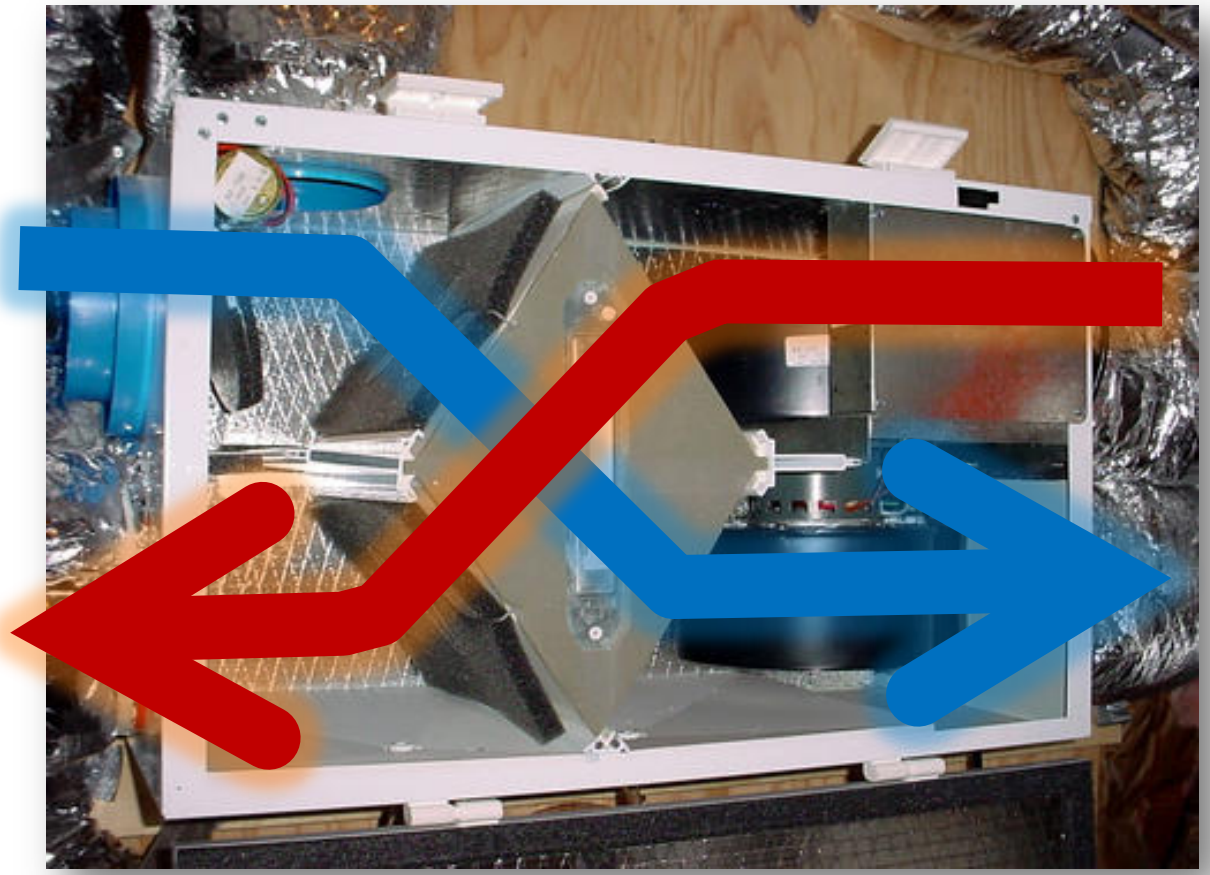
[7.5 * (3+1)] + [.01 * 2,000] = [30 + 20] = 50 cfm

Exhaust-Only Ventilation

Supply-Only Ventilation



Balanced Ventilation



ERV or HRV

Balanced Ventilation

Simple Thru-Wall ERV

- 90+% Heat Recovery
- 20-30% Humidity Recovery
- 1.4 – 2.8 W for 10/18/22 CFM

Ventilation Persistence

Spot Ventilation

- Kitchen:
  - 100 CFM Intermittent
  - 5 ACH Continuous
- Bathrooms:
  - 50 CFM Intermittent
  - 20 CFM Continuous

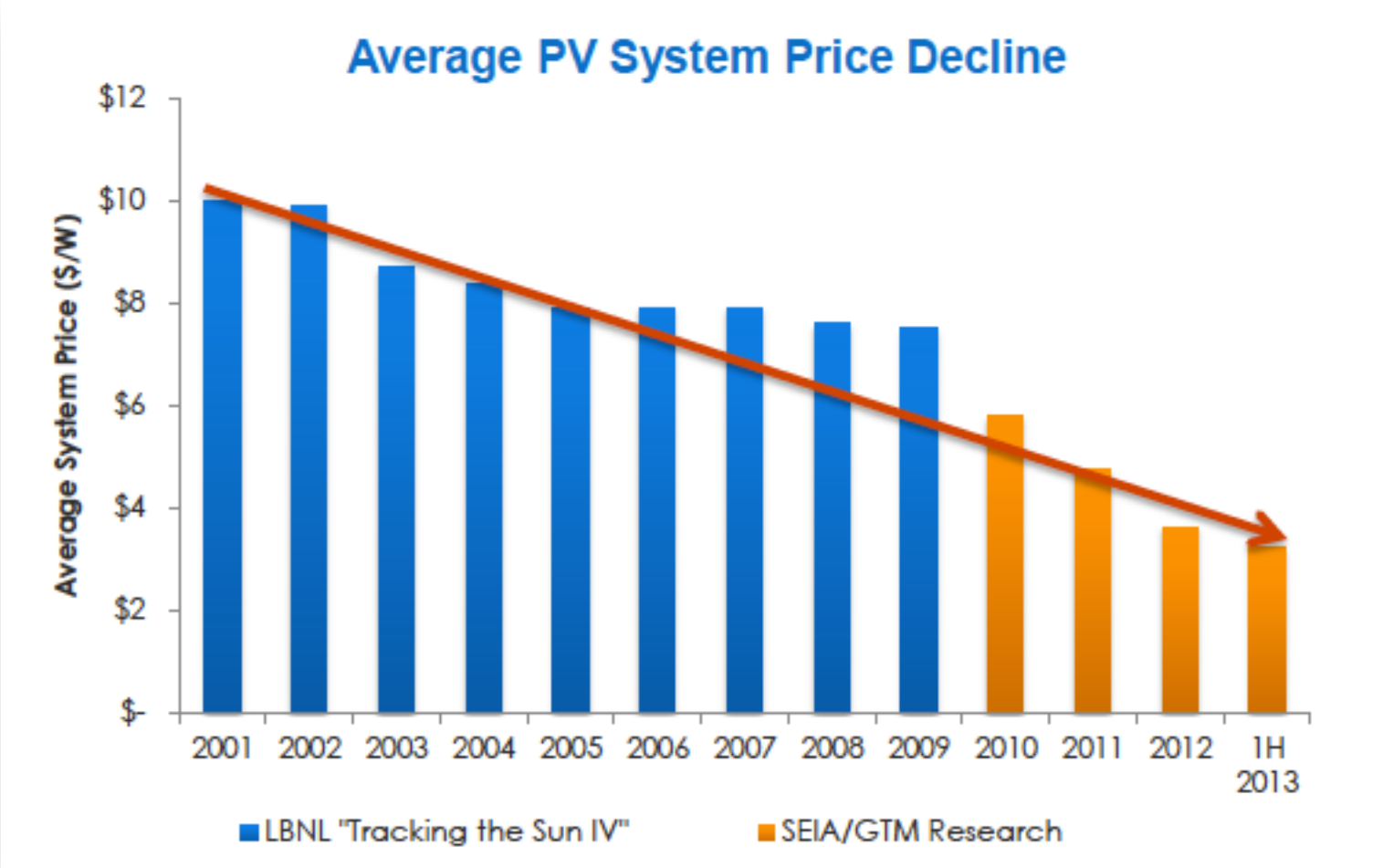
Filtration:
High-MERV HVAC Filter

8 MERV Filter Minimum

Zero Energy Ready Home

Technical Specifications Mandatory Requirements: **Renewable Ready** [Where Applicable]

Decreasing Renewable Cost

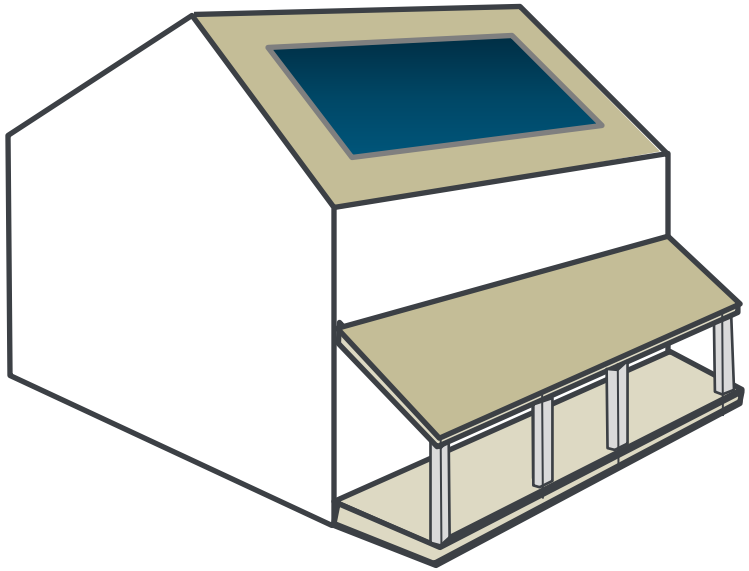


Decreasing Renewable Cost

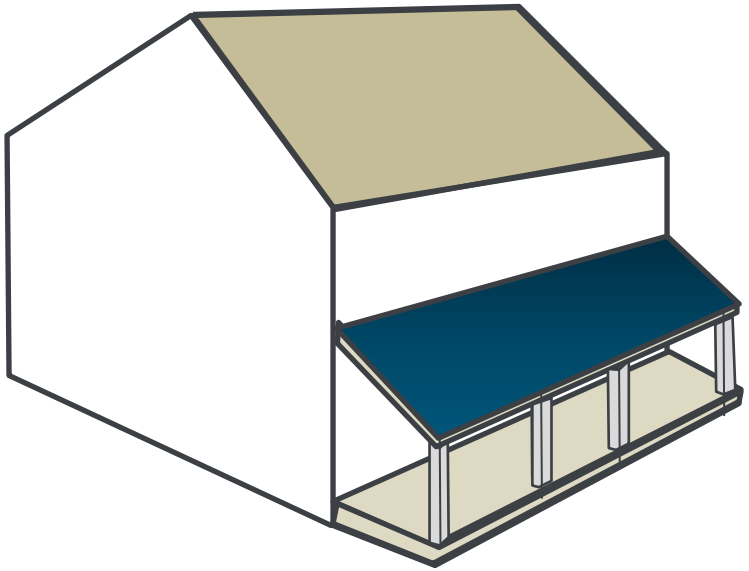
More than half of all U.S. homebuilders are expected to offer solar PV energy systems as an option in new single-family homes by 2016, up from just 12 percent in 2013.

Source:
Green Multifamily and Singe Family Homes: Growth in a Recovering Market, McGraw Hill, NAHB, 2014

Integrated Renewable Energy



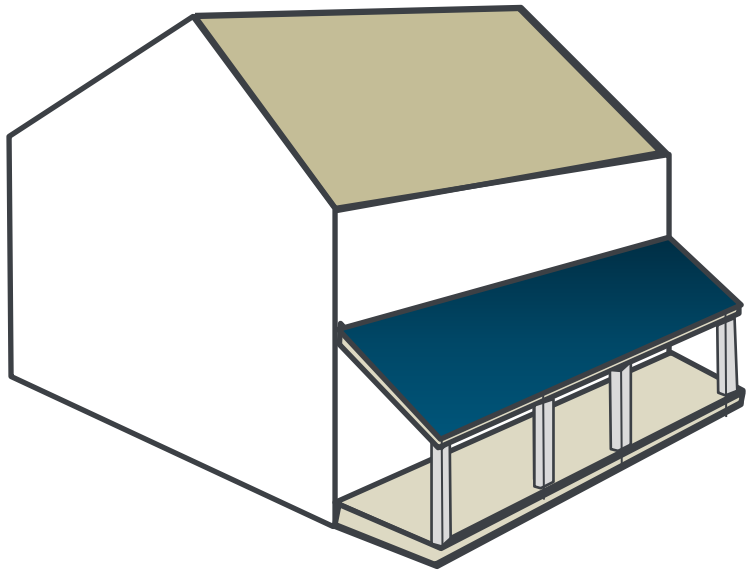
PV Mounted on Roof



PV Integrated into
Front or Rear Porch Roof
Directly on Porch Framing

Benefits:

- Cost
- Appearance
- Maintenance
- Daylighting



PV Integrated into
Front or Rear Porch Roof
Directly on Porch Framing

Integrated Renewable Energy

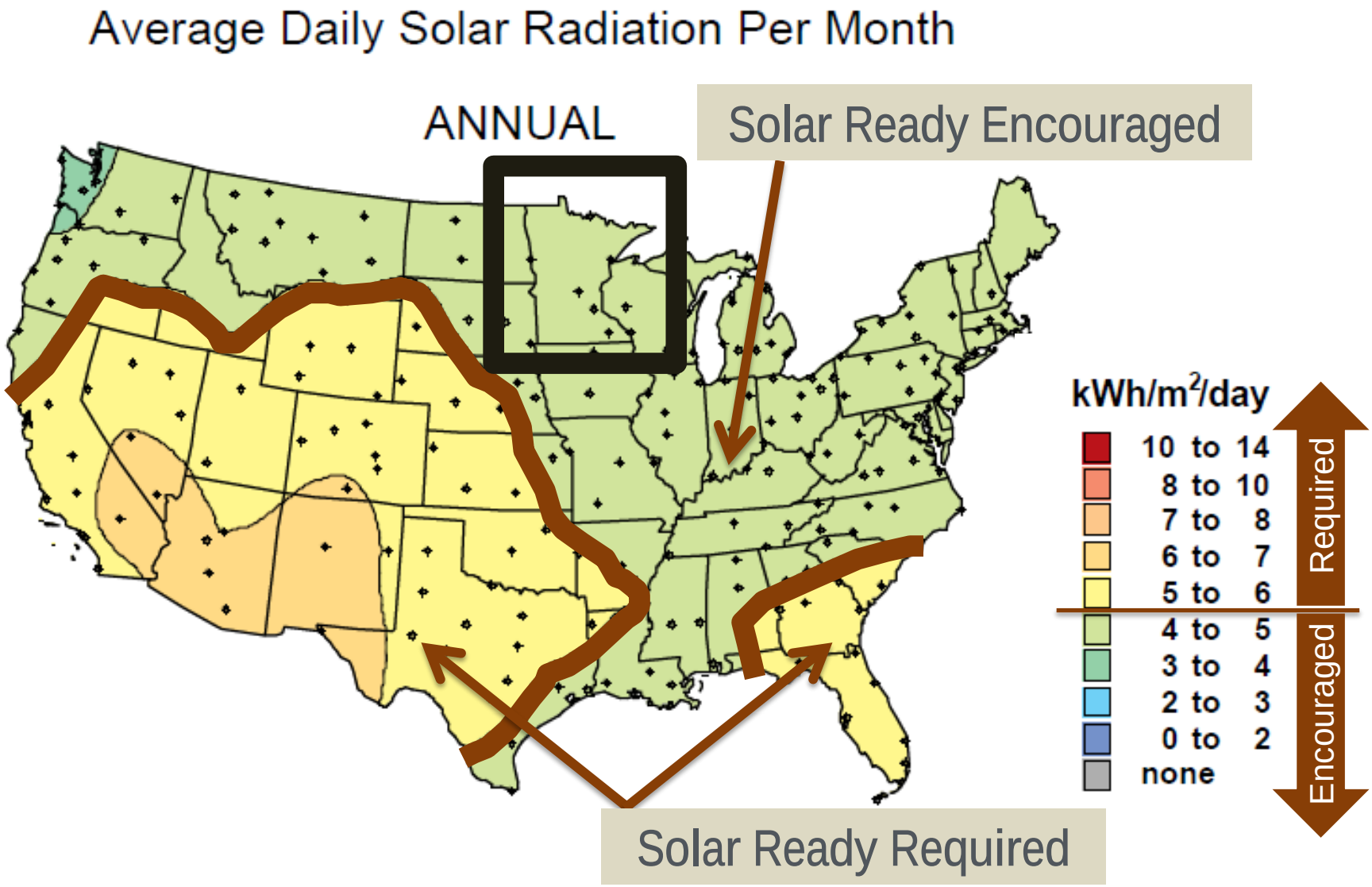
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Integrated Renewable Energy

Renewable Ready Exemptions

- Not required in areas lacking significant solar resources or shaded
- Recognition of high performance water heating systems

RERH Applicability



Screen for RERH Applicability

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

- **Renewable Energy Ready Checklists**
  - Determine applicability by zip code
  - http://gisatnrel.nrel.gov/PVWatts_Viewer/index.html
  - In this Mid-Atlantic example, solar resources = 4.8 kWh/m^2/day

Solar Electric Ready Requirements

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

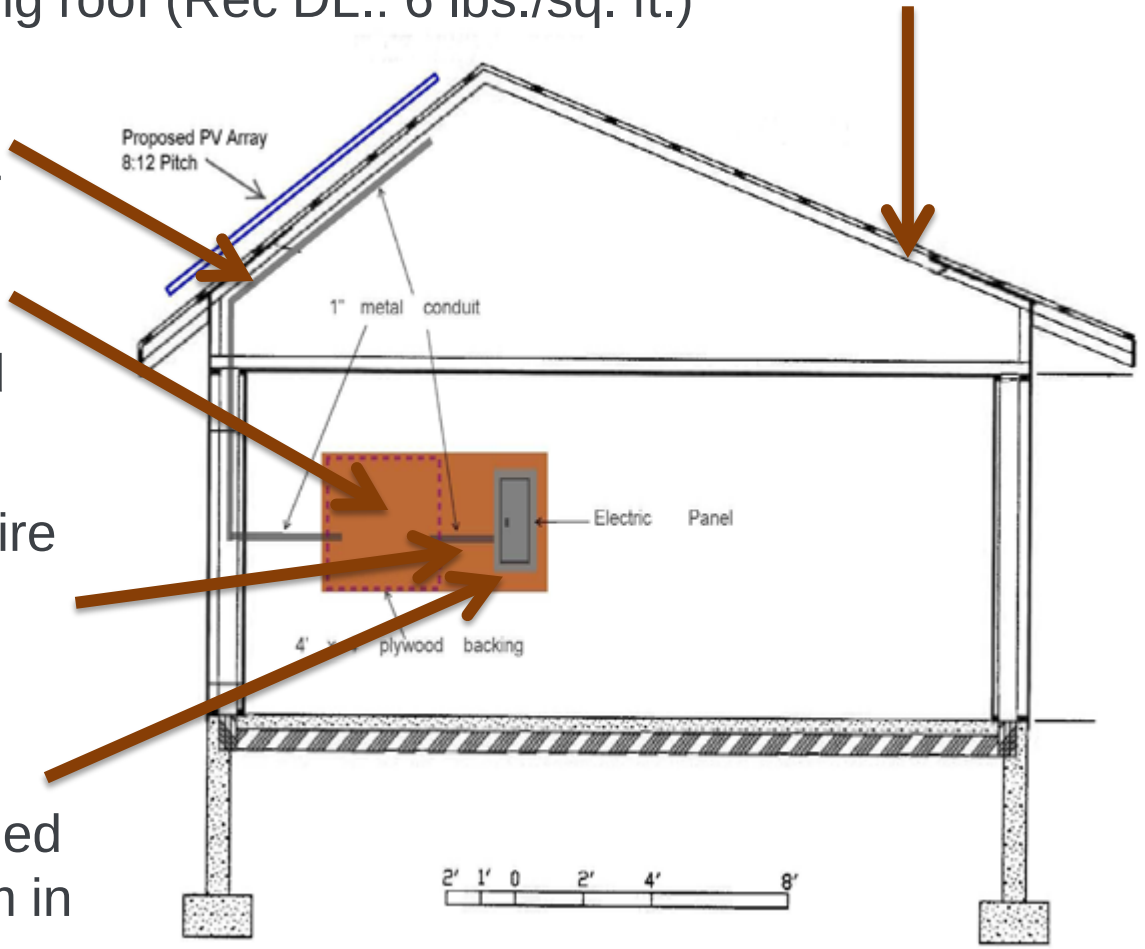
Documentation of the maximum allowable dead load and live load ratings of the existing roof (Rec DL.: 6 lbs./sq. ft.)

Conduit to run DC wire from roof to inverter

Dedicated Area for installing inverter and balance of system

Conduit to run AC wire from inverter location to electric panel

Circuit Breaker designated and/or installed for use by the PV system in the electric panel

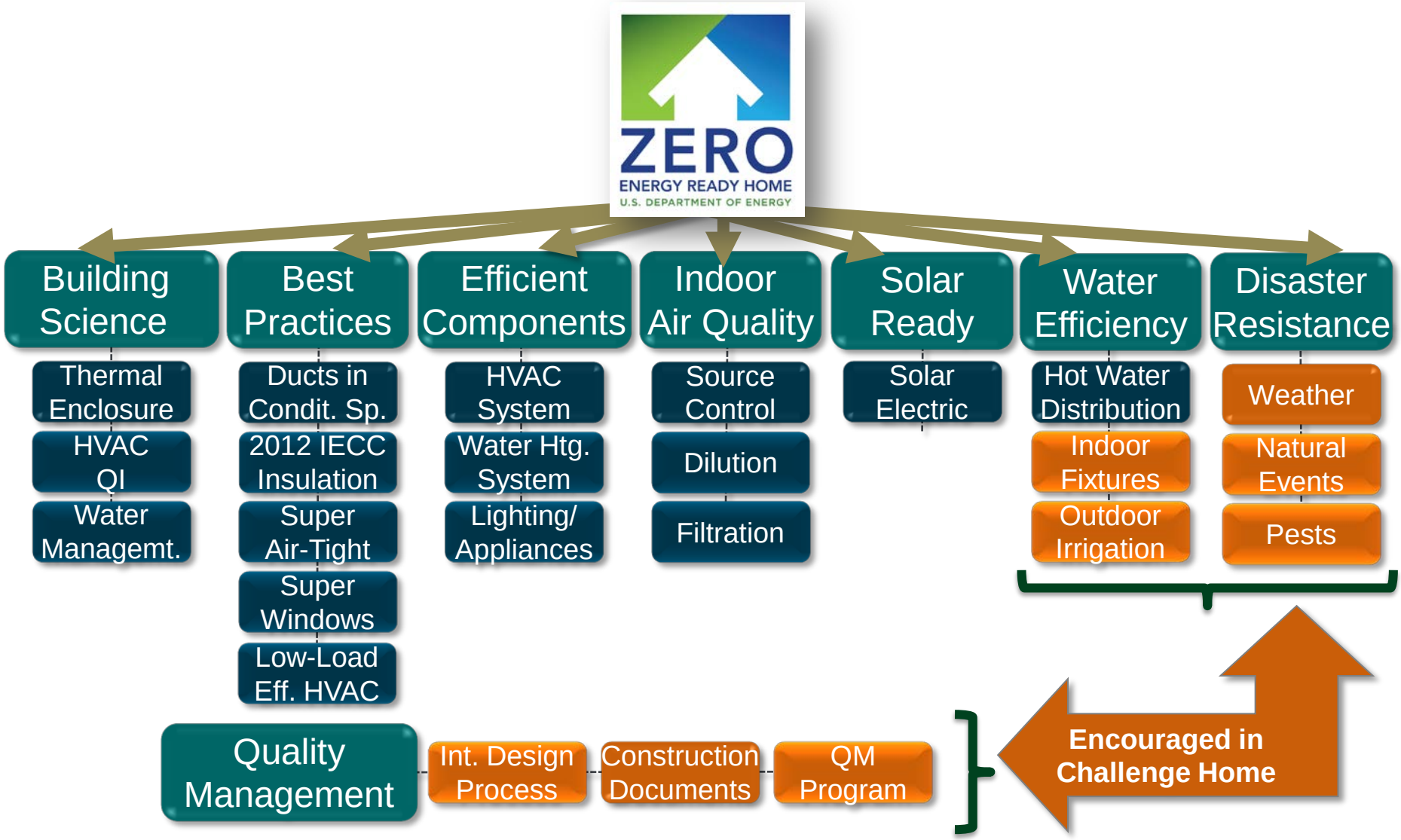


Zero Energy Ready Home

Technical Specifications: Putting It All Together

Zero Energy Ready Home Systems

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



Zero Energy Ready Home

Performance Threshold

‘Target Home’ vs. Energy Star Spec

Higher Eff. HVAC Equip.

2012 vs. 2009 IECC Insul.

More Eff. Windows

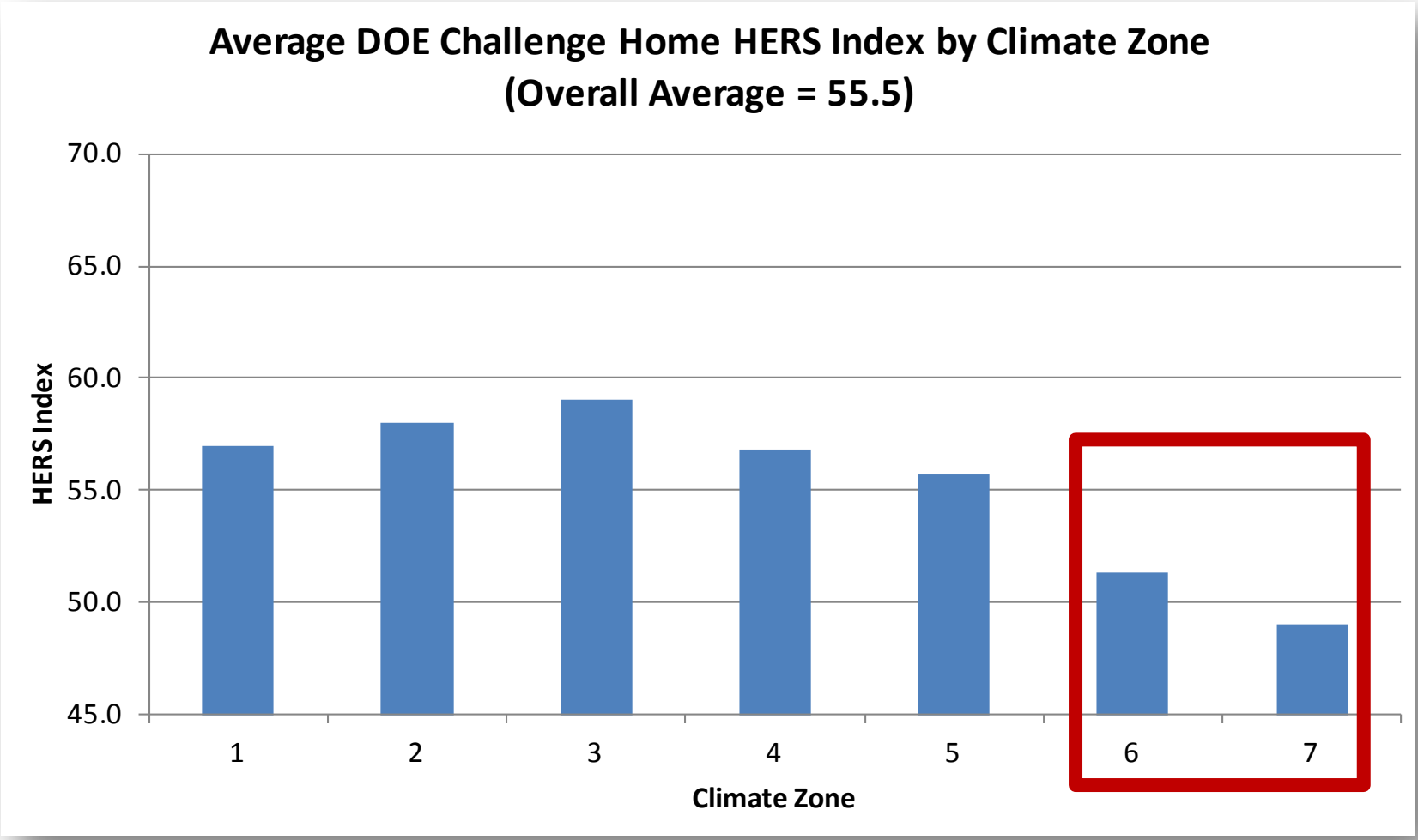
Half ACH50

ENERGY STAR Water Htg.

Exhibit 2: DOE Challenge Home Target Home [3, 17]

HVAC Equipment			
	Hot Climates (2012 IECC Zones 1,2) [18]	**Mixed Climates** (2012 IECC Zones 3,4)	**Cold Climates** (2012 IECC Zones 5,6,7,8)
AFUE	80%	90%	94%
SEER	18	15	13
HSPF	8.2	9	10 [19]
Geothermal Heat Pump	ENERGY STAR EER and COP Criteria		
ASHRAE 62.2 Whole-House MV System Performance	1.4 cfm/W; no heat exchange	1.4 cfm/W; no heat exchange	1.2 cfm/W; heat exchange with 60% SRE
Insulation and Infiltration			
• Insulation levels shall meet the 2012 IECC and achieve Grade 1 installation, per RESNET standards. • Infiltration [20] (ACH50): 3 in CZ's 1-2 | 2.5 in CZ's 3-4 | 2 in CZ's 5-7 | 1.5 in CZ 8			
Windows [21, 22, 23]			
	Hot Climates (2012 IECC Zones 1,2,)	**Mixed Climates** (2012 IECC Zones 3,4)	**Cold Clim** (2012 IECC Zones
SHGC	0.25	0.27	any
U-Value	0.4	0.3	0.27
Homes qualifying through the Prescriptive Path with a total window-to-floor area greater than 15% shall have adjusted U-values or SHGCs. [24]			
Water Heater			
ENERGY STAR minimum			
Thermostat [25] **& Ductwork**			
• Programmable thermostat (except for zones with radiant heat)			
Lighting & Appliances			
• For purposes of calculating the DOE Challenge Home Target Home HERS Index, homes shall be modeled with an ENERGY STAR dishwasher, ENERGY STAR refrigerator, ENERGY STAR ceiling fans, and ENERGY STAR lamps (bulbs) in 80% of sockets or 80% of lighting fixtures are ENERGY STAR Qualified.			

Target Home Avg. HERS Scores



Based on 1800, 2400, and 3600 ft ^{2} prototypes on climate-appropriate foundations.

Size Adjustment Factor

Homes larger than the benchmark home size must use the size adjustment factor to determine the target HERS index

Exhibit 3: Benchmark Home Size[28]

Bedrooms in Home to be Built	1	2	3	4	5	6	7	8
Conditioned Floor Area $_{\text{Benchmark Home}}$	1,000	1,600	2,200	2,800	3,400	4,000	4,600	5,200

Note: Renewable energy systems may not be used to qualify for the Challenge Home HERS Index Target Score, but may be used for the incremental HERS Index points needed for the Size Adjustment Factor.

$$\text{Size Mod. Factor} = [CFA_{\text{Benchmark Home}} / CFA_{\text{Home to Be Built}}]^{0.25}$$

[Not to Exceed 1.0]

Performance Path Example
CZ6 Prototype - 4 BR, 2400 SF

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

Specification	Target Home Spec	Design Home
AGW Insulation	R20+5 or R13+10	21+5
Attic Insulation	R49 (U=0.026)	R50
Basement Walls	R15/19	R10
Windows	U=0.27; SHGC=0.40	U=0.32; SHGC=0.30
Infiltration	2.0 ACH50	2.5 ACH50
Ducts	Total ≤ 8 CFM25 per 100 SF of CFA; Leakage to outdoors ≤ 4 CFM25 per 100 SF of CFA	In Conditioned Space Total leakage 316 CFM25 Outdoors 120 CFM25
Furnace AFUE	94	95
A/C SEER	13	13
Whole-House Mech. Vent.	77 cfm; 1.2cfm/W balanced;	77 cfm; 8.0 cfm/W exhaust-only
Water Heater	ENERGY STAR	Gas storage 0.67 EF
HERS Index	**46**	**46 COMPLIES!**

Rating & Verifying Homes

- Same: ENERGY STAR Homes framework
- New:
  - Indoor airPLUS Checklist;
  - Renewable Energy Ready Home Checklists (where applicable)
  - Hot Water Distribution test
- Submissions:
  - Send “DOE Challenge Home Verification Summary” electronically to doechallengehome@newportpartnersllc.com
  - Otherwise builders will not receive “credit” on DCH website
  - Considering RESNET National Homes Registry for future

Verifying Homes – Indoor airPLUS

- 1-page checklist
- Builder or Rater may verify
- Permissible methods:
  - Visual verification on site during construction
  - Reviewing photos taken during construction
  - Checking documentation
  - Equivalent methods as appropriate
- Sampling permitted per RESNET protocol

Verifying Hot Water Distribution

1. Initiate operation of occupant-controlled or occupancy sensor-based recirculation systems, if present,
2. Place bucket or flow measuring bag (pre-marked for 0.6 gallons) under the hot water fixture. Only fixture with greatest stored volume of hot water needs to be tested.
3. Turn on hot water; place digital thermometer into the stream of water just where it meets the water being collected; record starting temperature.
4. When water reaches 0.6 gallons record temperatures again. The temperature must increase by 10 F.

Verifying Homes – RERH

- RERH checklist for DOE ZERH Home
  - builder or rater may verify

Zero Energy Ready Home

Recognition

Lots of Recognition Choices…

ZERH ‘Brand’ Recognition

Independent Voice of Authority vs. “Trust me.”

Why Trust So Important to Builders

Nearly 1 in 3 consumers indicated they

do not trust

home building and real estate companies.

Source: The business of Trust – The Most Trusted Builders in America, Lifestory Research, January 2013

Pent-up ZERH Demand

The Washington Post

Date: Saturday, June 16, 2012
Location: WASHINGTON, DC
Circulation (DMA): 511,688 (8)
Type (Frequency): Newspaper (D)
Page: E1,E3
Keyword: KB Home

Model home shows off its green side

House in Waldorf demonstrates eco-friendly and money-saving features to buyers

BY V. DION HAYNES

"Becoming more environmentally friendly has been the focus of the country," Moran added. "We want to give people a vision of where we think home building will be in a few years."

Thus far, net-zero houses are a very tiny segment — perhaps as small as 1 percent — of the market.

Production of energy from solar panels, one of the largest components of the green-home movement, is growing. The amount of megawatts produced by home solar panels rose 104 percent in 2010, 109 percent in 2011 and is expected to increase 75 percent this year, according to Boston-based GTM Research, a consulting firm that tracks the industry for the

"They didn't have this [model] when we purchased our home" three doors down the street in October, said Nickiea Youmans, who along with her husband, Linzy, walked into the back yard to check out the house. "We would have been very interested in this," she added.

ZERH Partner Registration

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

- **Review**
  - Technical Guidelines
  - Partnership Agreement Terms
- **Register**
  - Electronically Sign Agreement
- **Choose Optional Commitments:**

100% of homes meet DOE Zero Energy Ready Home Guidelines

Homes meet EPA's WaterSense Guidelines

Homes meet IBHS's Fortified Home Guidelines

Meet DOE Challenge Home Quality Management Program

ZERH Partner Benefits

- **Resources**
  - ❑ Customizable Homebuyer Brochures
  - ❑ Branding [Logos, Home Certificates and Labels]
  - ❑ Electronic Newsletter [updates, policy changes, new innovations]
  - ❑ **Appraisal Guidance**
- **Technical Support**
  - ❑ **Building America Solution Center**
  - ❑ Building America Stakeholder Meetings
  - ❑ Building America Research Studies
- **Recognition**
  - ❑ DOE Housing Innovation Awards
  - ❑ DOE Zero Energy Ready Home Web Site Locator Tool
  - ❑ Case Studies/Virtual Parade of Home [coming]

ZERH Partner Locator Tool

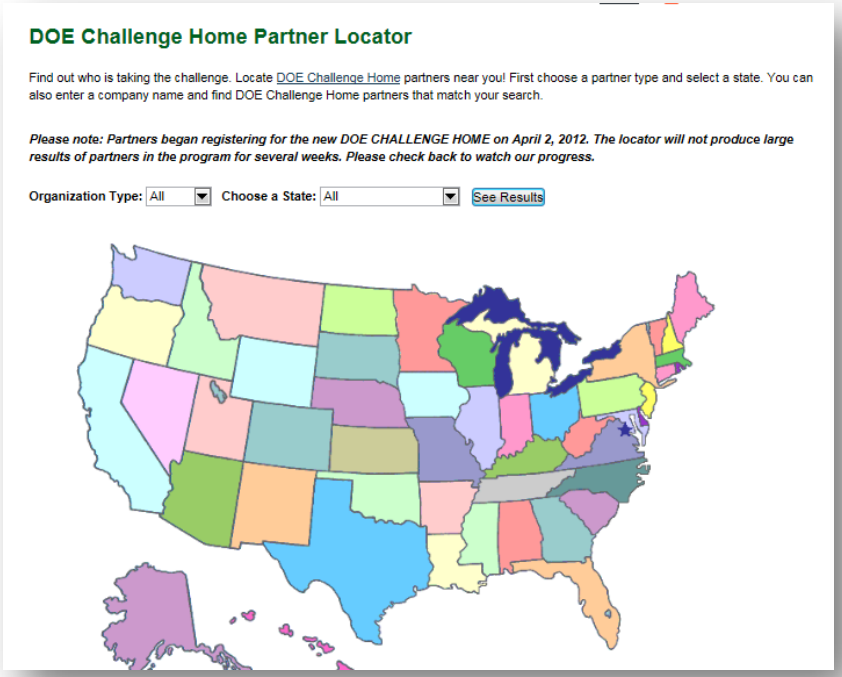
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Links Buyers to Leading Edge Builders:

- Contact Information
- Optional Commitments

- # Labeled Homes
- Website link

<u>For All Active Partners</u>



ZERH Partner Locator Tool

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

- Buildings Home
- About
- Emerging Technologies
- Residential Buildings
  - Solar Decathlon
  - Building America
  - Home Energy Score
  - Home Performance with ENERGY STAR
  - Better Buildings Neighborhood Program
  - Zero Energy Ready Home
    - Partner Log In
    - Become a Partner
    - Criteria
    - Partner Locator
    - Resources
    - Events
  - Housing Innovation Awards
  - Guidelines for Home Energy Professionals
  - Codes & Standards
- Commercial Buildings
- Appliance & Equipment Standards
- Building Energy Codes

DOE Zero Energy Ready Home: Results

Name	Type	Commitments	City	State	# of DOE Zero Energy Ready Home Projects	# of Builders Challenge Homes
100% Partners						
Boulder ZED Design Build	Builder	100%, WS, IAP	Boulder	CO	1	0
Eco Smart Building LLC	Builder	100%, WS, QM, FH, IAP	CHICAGO	IL	0	0
Edwards Design Group, Inc.	Builder	100%, WS, QM, FH, IAP	SCOTTSDALE	AZ	0	0
Elecyr Corporation	Builder	100%	Dover	NH	0	0
Energy Tech	Builder	100%, WS, IAP	CARBONDALE	CO	0	0
Energy Tech Ltd	Builder	100%, WS, QM, IAP	CARBONDALE	CO	0	0
GEOS Neighborhood Developer Llc	Builder	100%, WS, QM, IAP	BOULDER	CO	0	0
Green Team Real Estate	Builder	100%, WS, QM, FH, IAP	FORT COLLINS	CO	0	0
Harrington Construction LLC	Builder	100%, WS, IAP, PH	Fort Collins	CO	0	0
Majestic Estate Developers, Inc.	Builder	100%, WS, QM, FH, IAP, PH	Wauconda	IL	0	0
Michael Hoggard LLC	Builder	100%, WS, QM, FH, IAP, PH	Chesterfield	MO	0	0
Palo Duro Homes, Inc.	Builder	100%, IAP	ALBUQUERQUE	NM	152	235
Zero-Energy Plans LLC	Builder	100%, WS, IAP	Coupeville	WA	0	1
AquaZephyr, LLC	Builder		Ithaca	NY	11	0
Bensonwood Homes	Builder		Walpole	NH	0	0
Chandler Design-Build	Builder		MEBANE	NC	0	1

CH Housing Innovation Awards

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

ZERH Partner Responsibilities

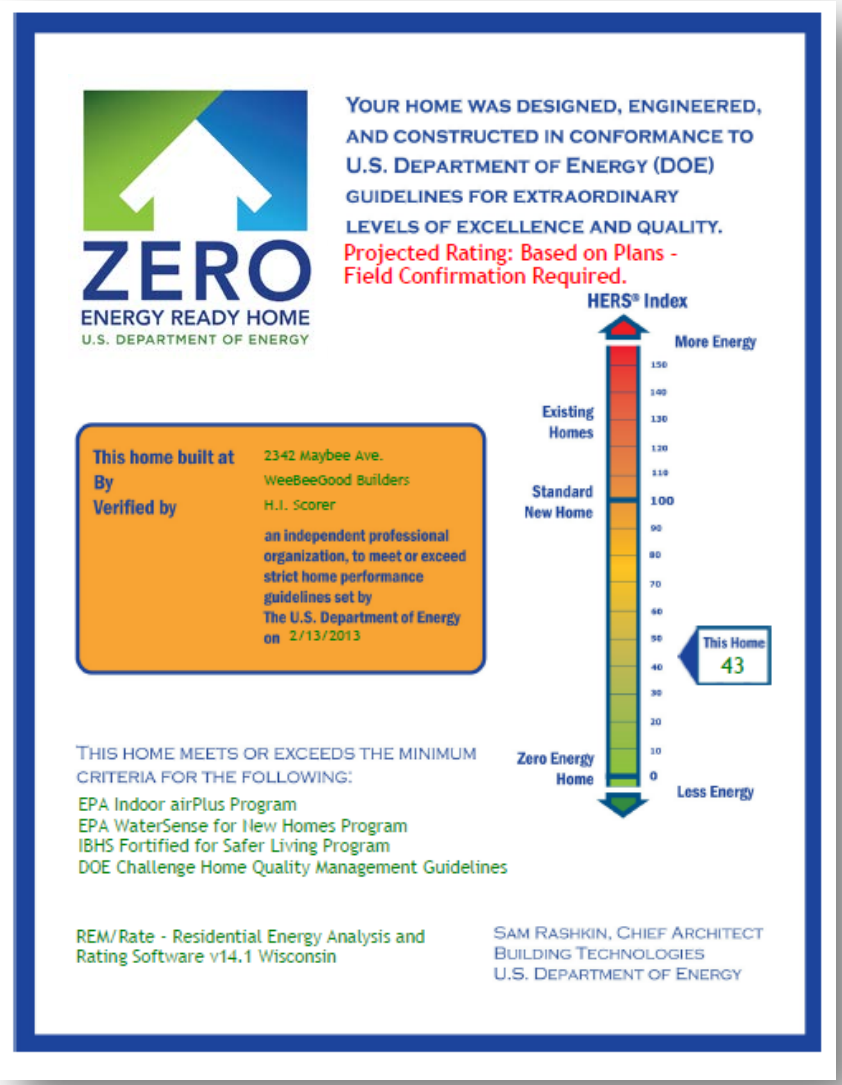
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- **Take Orientation Training**
  after registering and renew training every year
- **Provide Certificate**
  for DOE Zero Energy Ready Home to each home owner
- **Adhere to Brand Identity Guidelines**
  for proper use of the DOE Zero Energy Ready Home name and logo
- **Build/Verify at Least One Home/Year**
  to maintain active partnership

To view the full Agreement terms and disclaimers, visit:
http://www1.eere.energy.gov/buildings/zero/

ZERH Certification Process

- **Rater Prints Certificate** directly from rating software
- **Certificate Includes:**
  - Rating Details
  - Graphic HERS Index
  - Optional Programs



ZERH Builder Recommendations

- **'Test Drive' Challenge Home**
  [1- 5 homes; most not ready for wholesale change]
  Offer Zero Energy Ready Home as *'Limited Edition'*

- **Measure Profit Metrics:**
  - Cost
  - Marketing
  - Performance

- **High-Performance Looks Different!**
  - Architectural Appearance
  - 'Mark of Excellence'

Thank You

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

For More Information:

www.buildings.energy.gov/zero/

e-mail Contact:

zero@newportpartnersllc.com