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

Part I: Why Build Zero Energy

Zero Energy Ready Home:

- Definition
- The Visible Future
- Visible Future Builders
- Value Proposition
- Business Case

Part II: How to Build Zero Energy

Zero Energy Ready Home:

- **Technical Specs Overview**
  - ENERGY STAR for Homes v3 Baseline
  - Super Air-Tight Construction
  - 2012 IECC Insulation
  - Advanced Windows
  - Ducts in Conditioned Space
  - Efficient Hot Water Distribution
  - Efficient Components
  - Indoor Air Quality
  - Renewable Ready Construction
  - Performance Threshold
- **Recognition**
- **Local Solution**

Zero Energy Ready Home
Definition

A ‘Green’ Home is…

A Home with a Package of Measures
Earning a Bunch of Points
Needed to Achieve
One of Four Levels of Greenness.

‘Green’ vs. Zero Energy Ready

What’s Missing in Green Definition

Complete Systems that Ensure Bankable **Value Propositions**

What’s Included in Zero Energy Ready Definition

What Complete Systems?

Ultra-High Efficiency Systems

that optimizes cost-effectiveness

+

Assured Performance Systems

that exceeds consumer expectations

Why Efficiency + Performance

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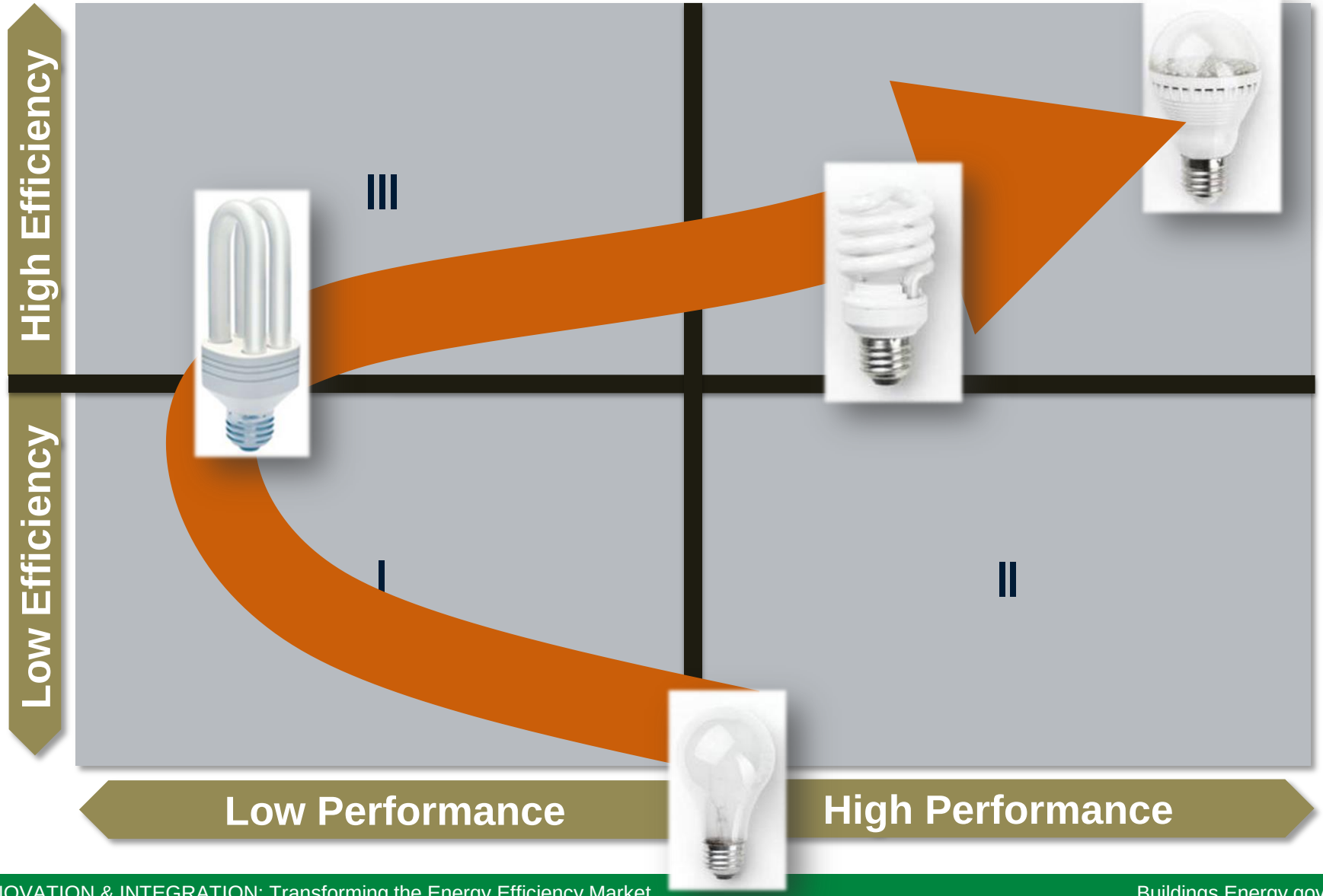
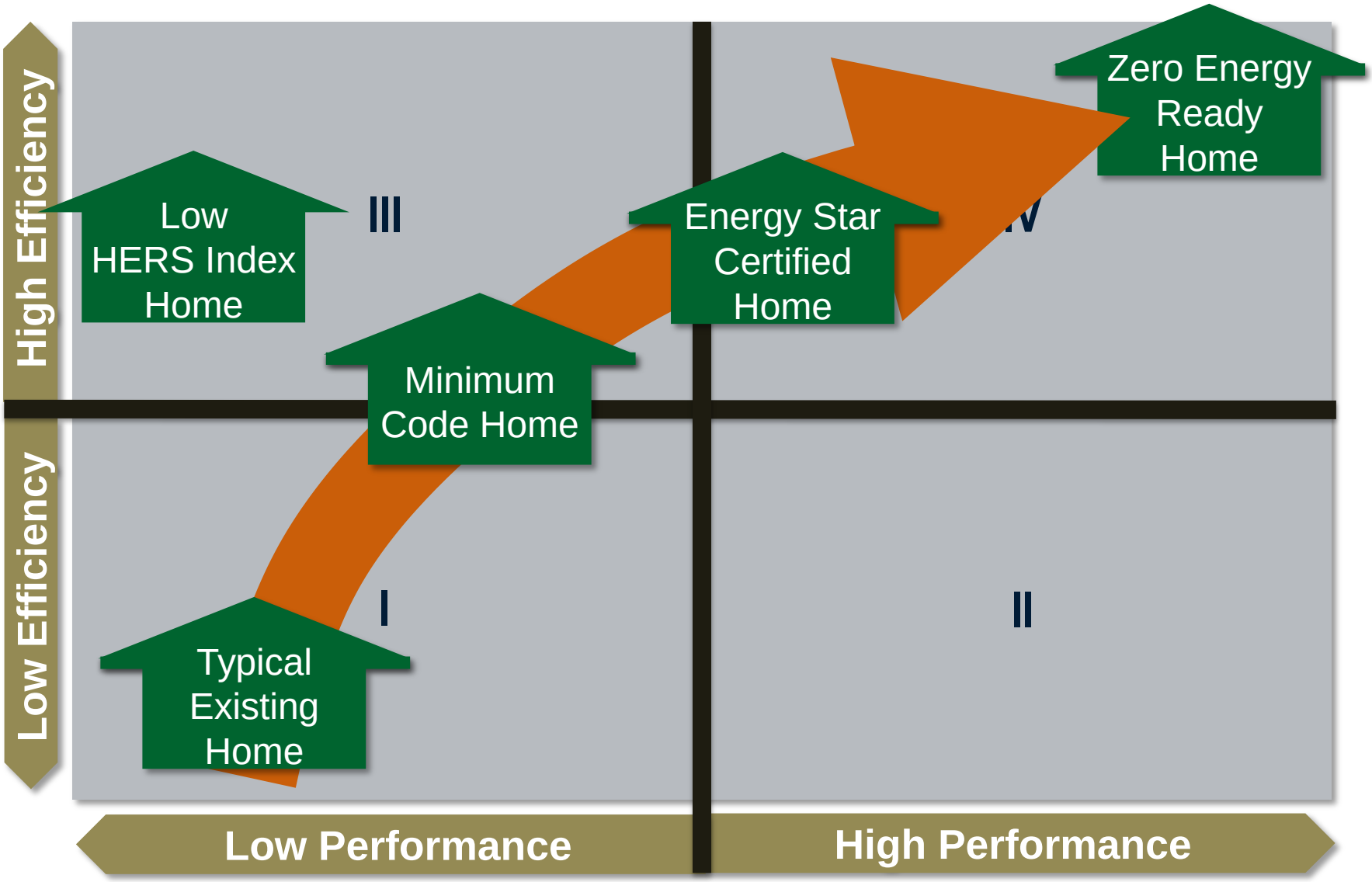


ZERH Efficiency + Performance



ZERH Definition

High-performance home so energy efficient,

all or most annual energy consumption can be offset by renewable energy.

Leverage Existing Programs That Ensure Complete Systems

[Efficiency + Performance]

Don't Reinvent the Wheel Strategy

The Visible Future

Predicting the Visible Future

"You can predict the future accurately.

All you have to do is leave out the parts you could be wrong about."

"The key… is knowing how to distinguish a ***soft trend*** *from a* ***hard trend****…*

It's knowing how to recognize certainty."

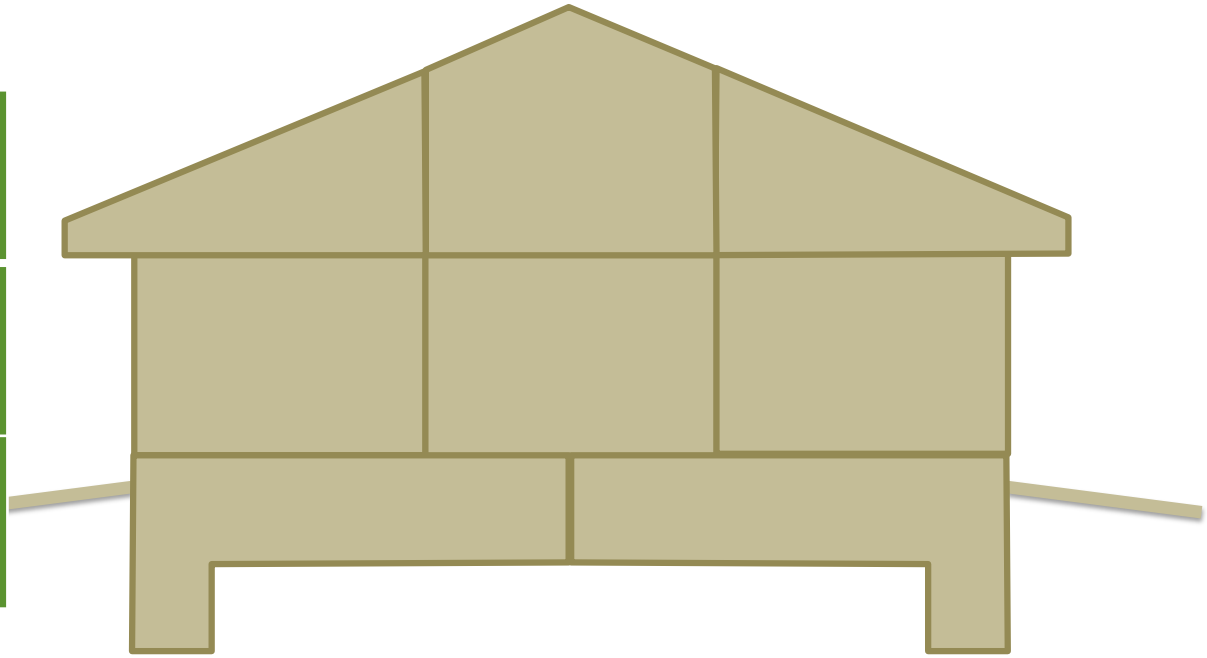
Daniel Burrus, ***"Flash Foresight"***

Predicting the Visible Future

Increasing Energy Efficiency

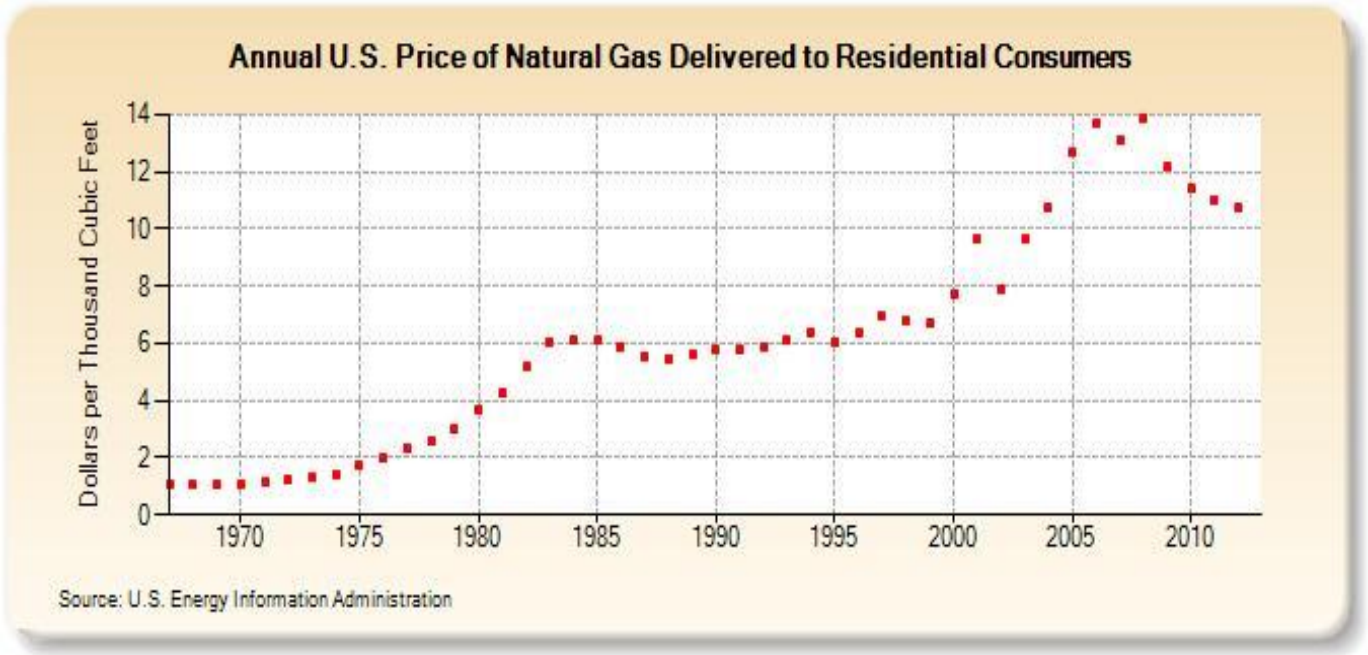
Increasing Performance

Increasing Innovation



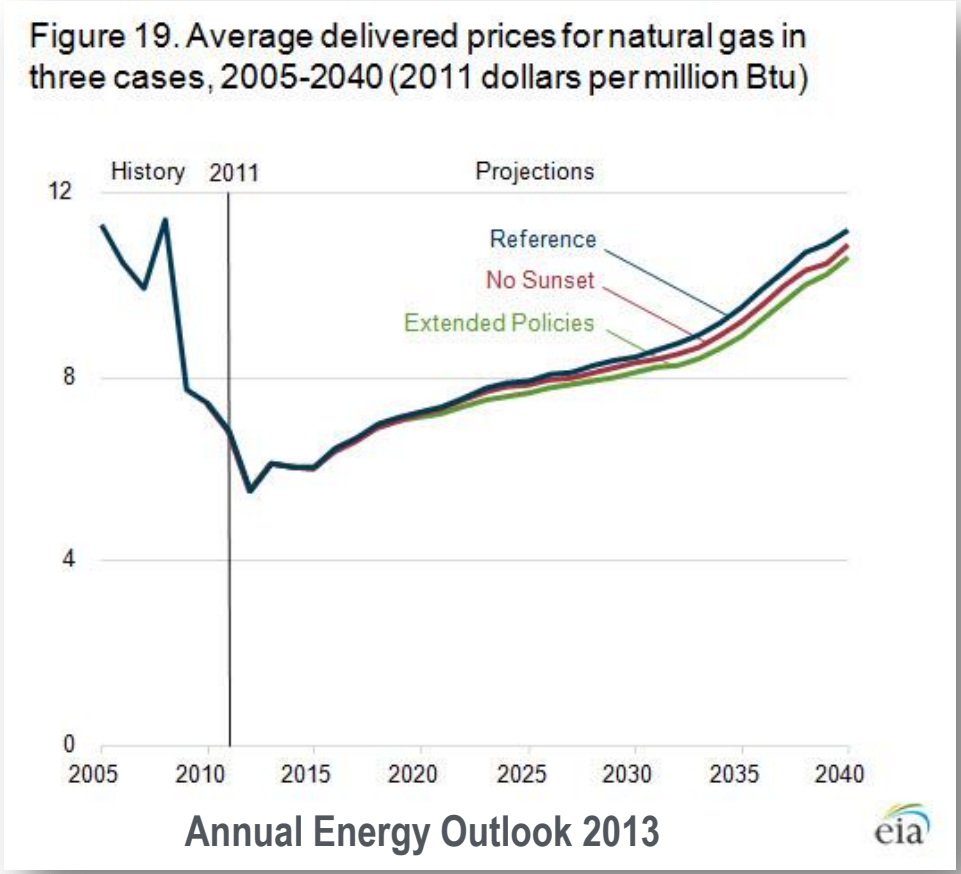
3 Hard Trends → **8 Complete Systems**

Increasing Energy Prices: Gas



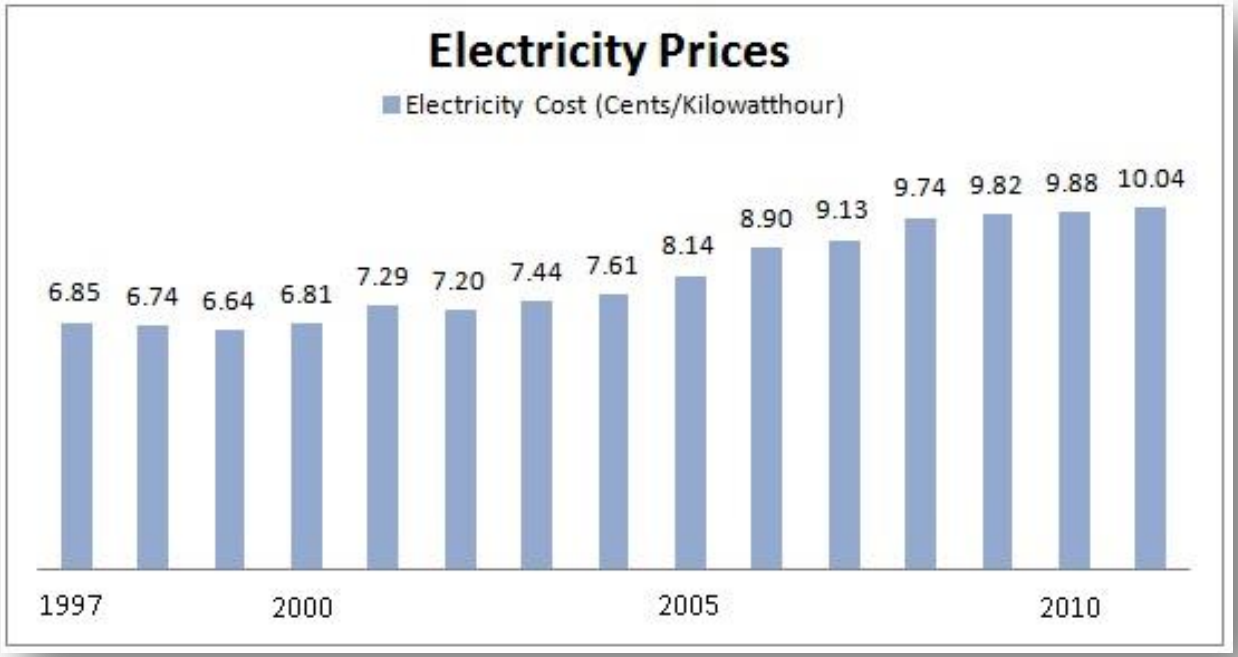
Source: U.S. Energy Information Administration

Increasing Energy Prices: Gas

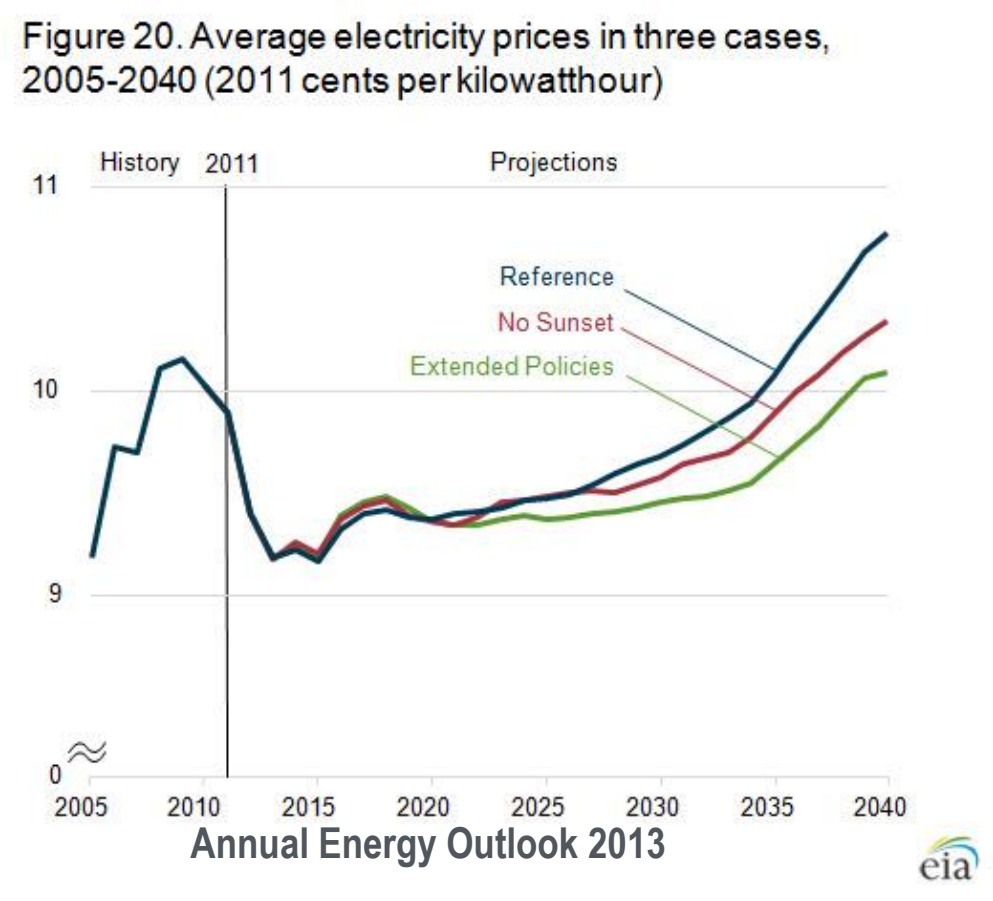


Increasing Energy Prices: Elec.

Average electricity prices have risen 37% over the last decade… However, it's where electricity prices are headed that will be exciting and profitable...

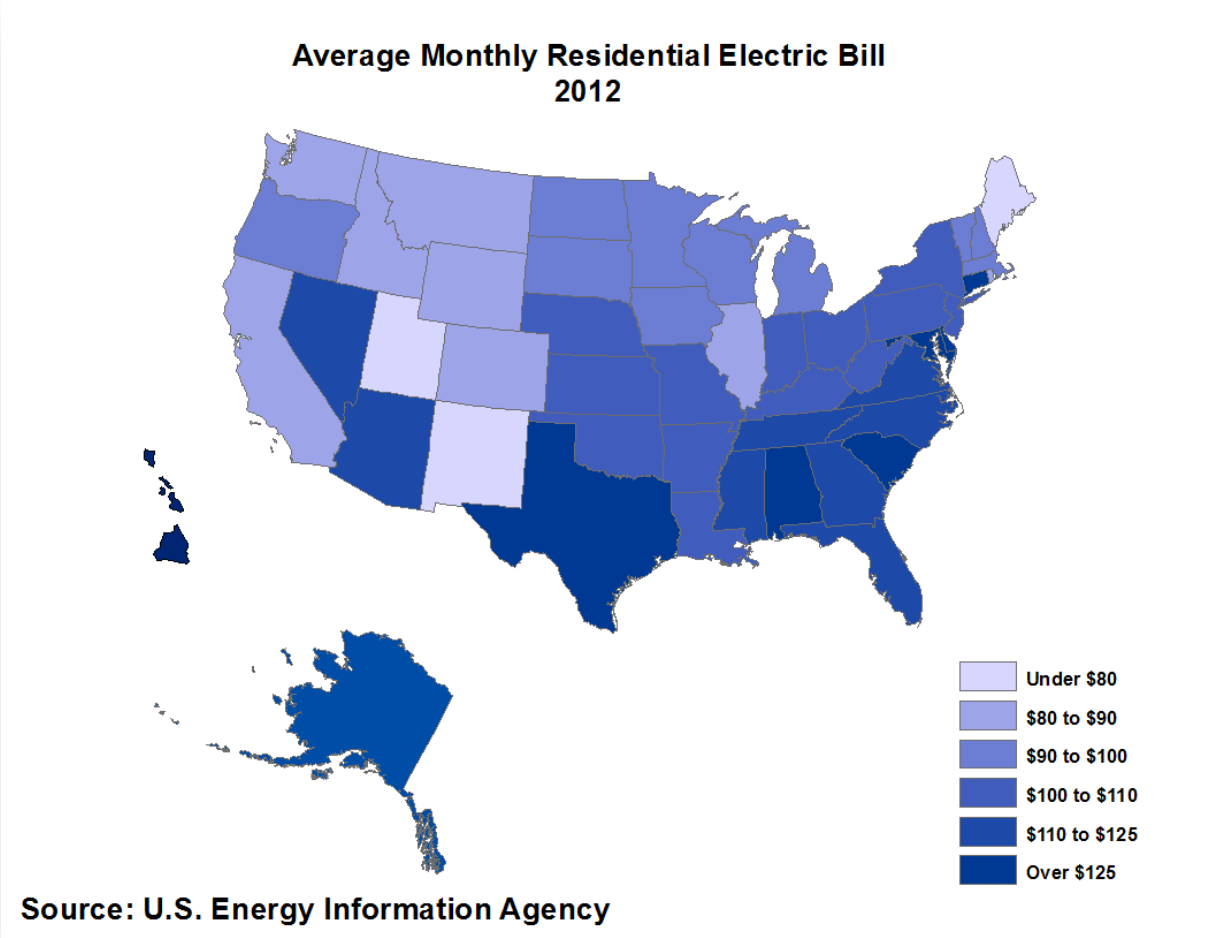


Increasing Energy Prices: Elec.



Increasing Energy Prices

National average electric bill has increased nearly 80% over the last ten years.



Hard Trend:
Increasing Rigor of Energy Codes

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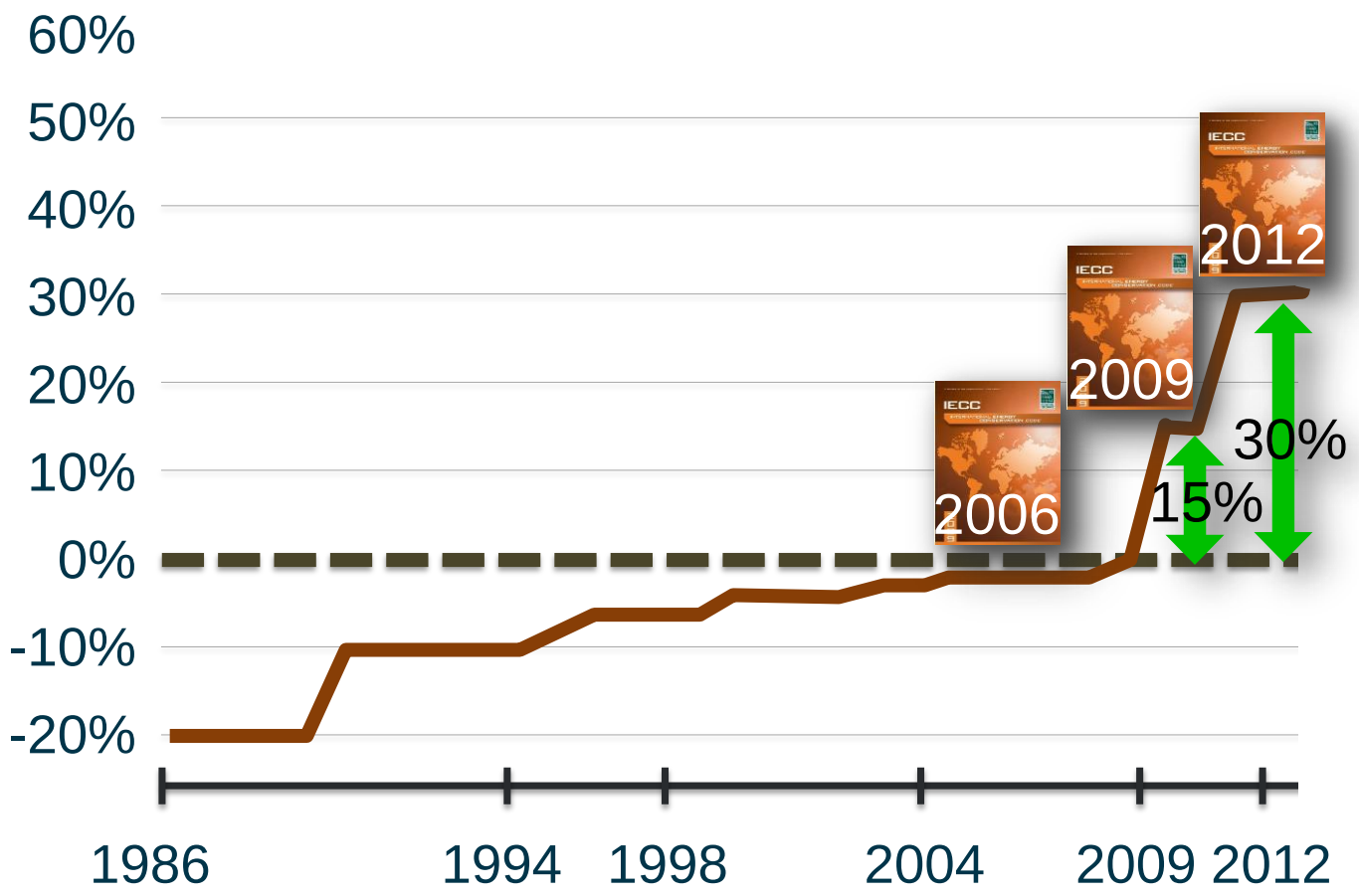
> Energy Eff. | **> Performance** | **> Innovation**



Hard Trend:
Increasing Builder Risk

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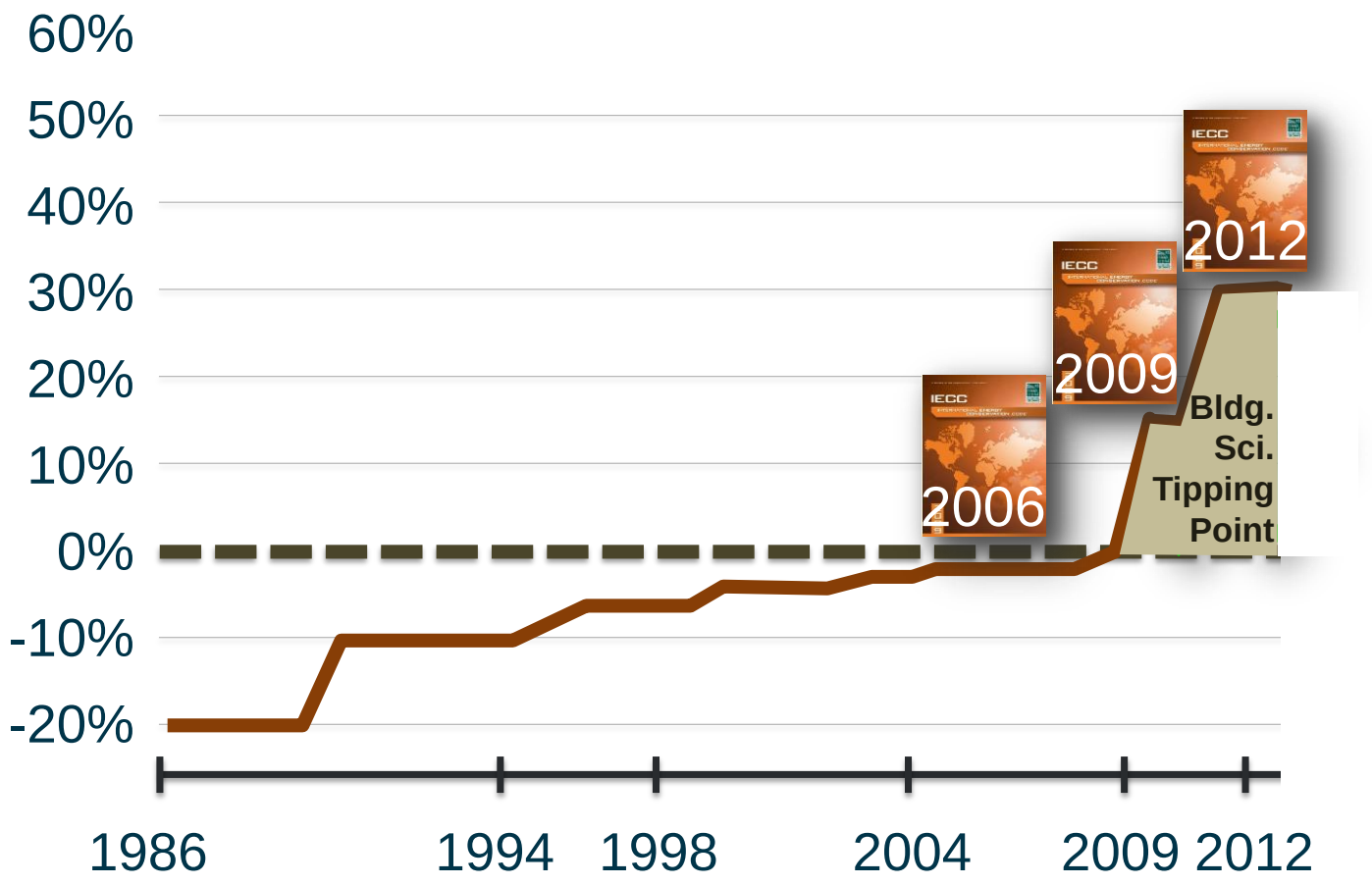
> Energy Eff. | **> Performance** | **> Innovation**



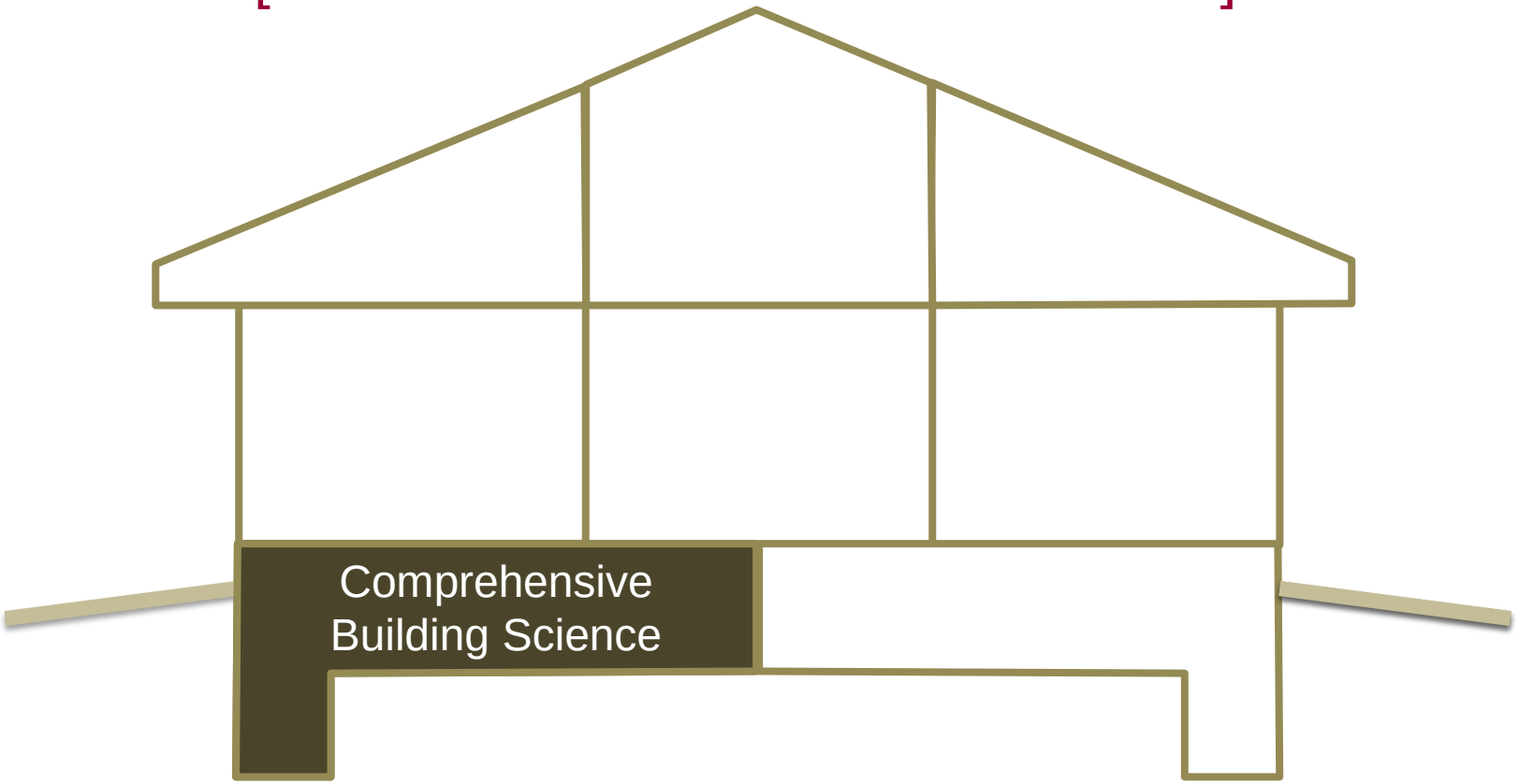
Building Science Tipping Point:

- Homes No Longer Can Dry if They Get Wet
- Homes More Likely to Get Wet with Colder Condensing Surfaces
- Homes No Longer Ensure Fresh Air
- Greater Combustion Safety Risks

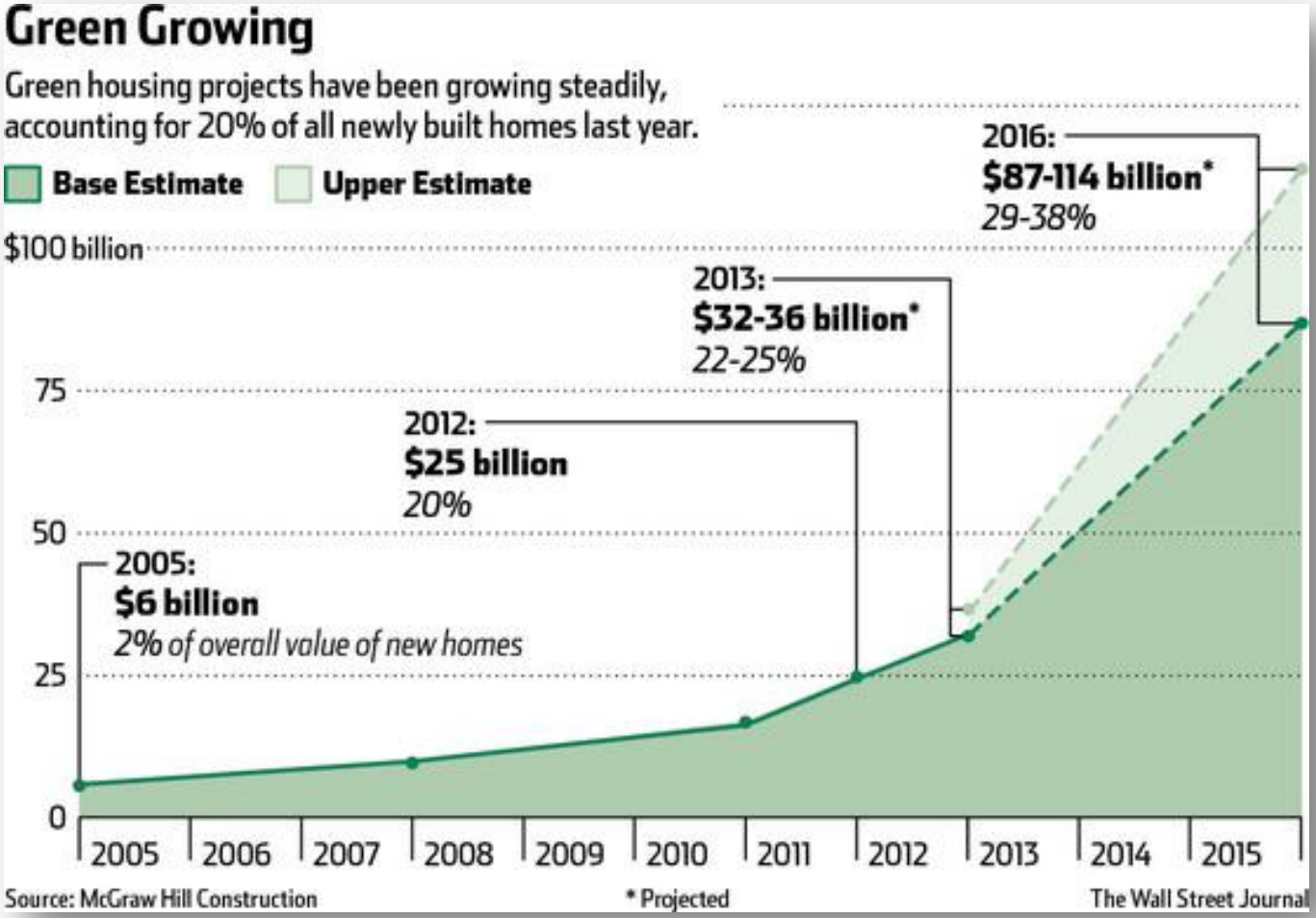
Comprehensive Building Science:

Control Air, Thermal and Moisture Flow.

[ENERGY STAR Certified Homes v3]



Increasing Energy Eff. Homes



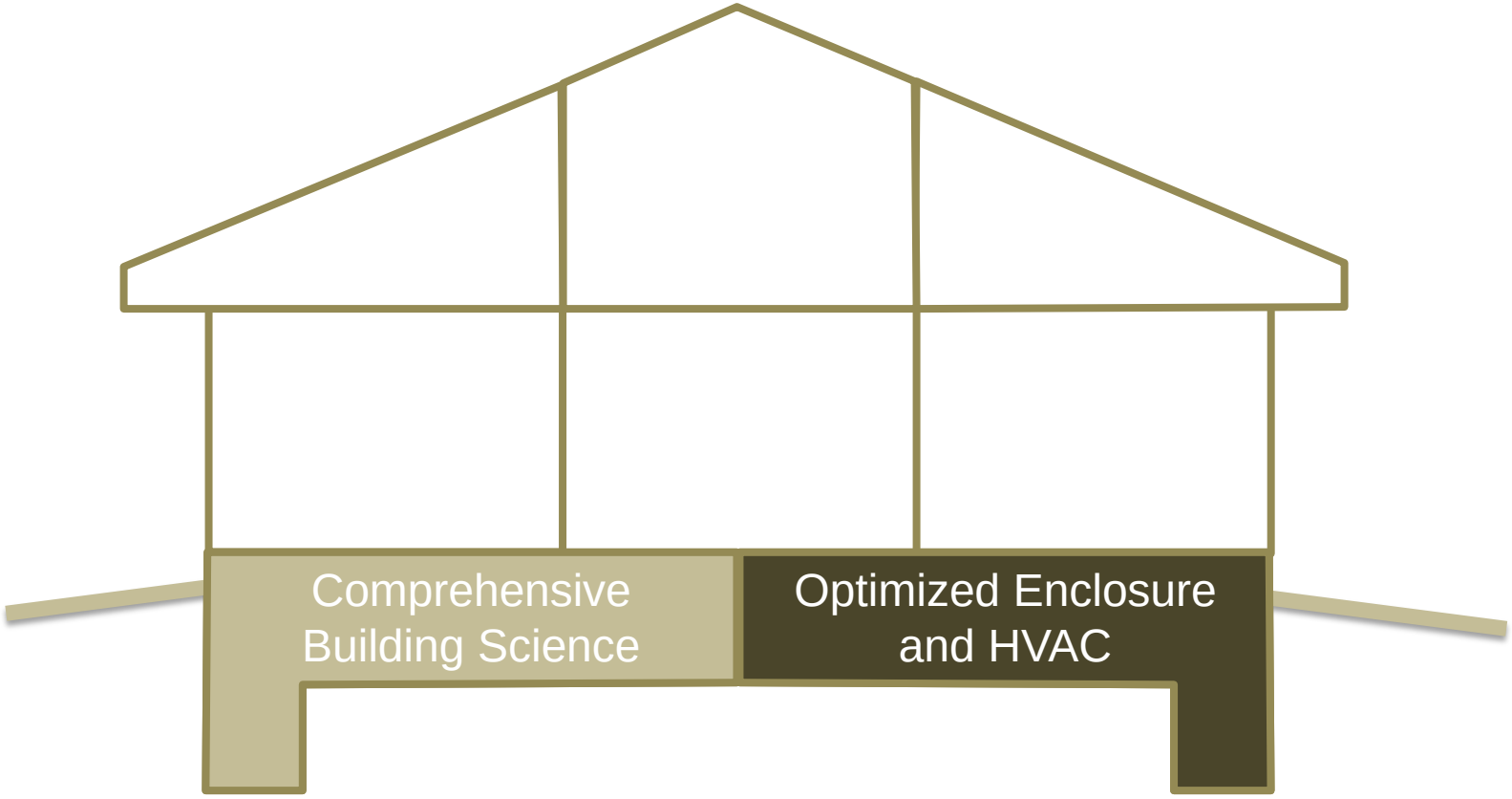
2013

- ~220,000 HERS Ratings
- Average Score 64

Optimized Enclosure and HVAC:

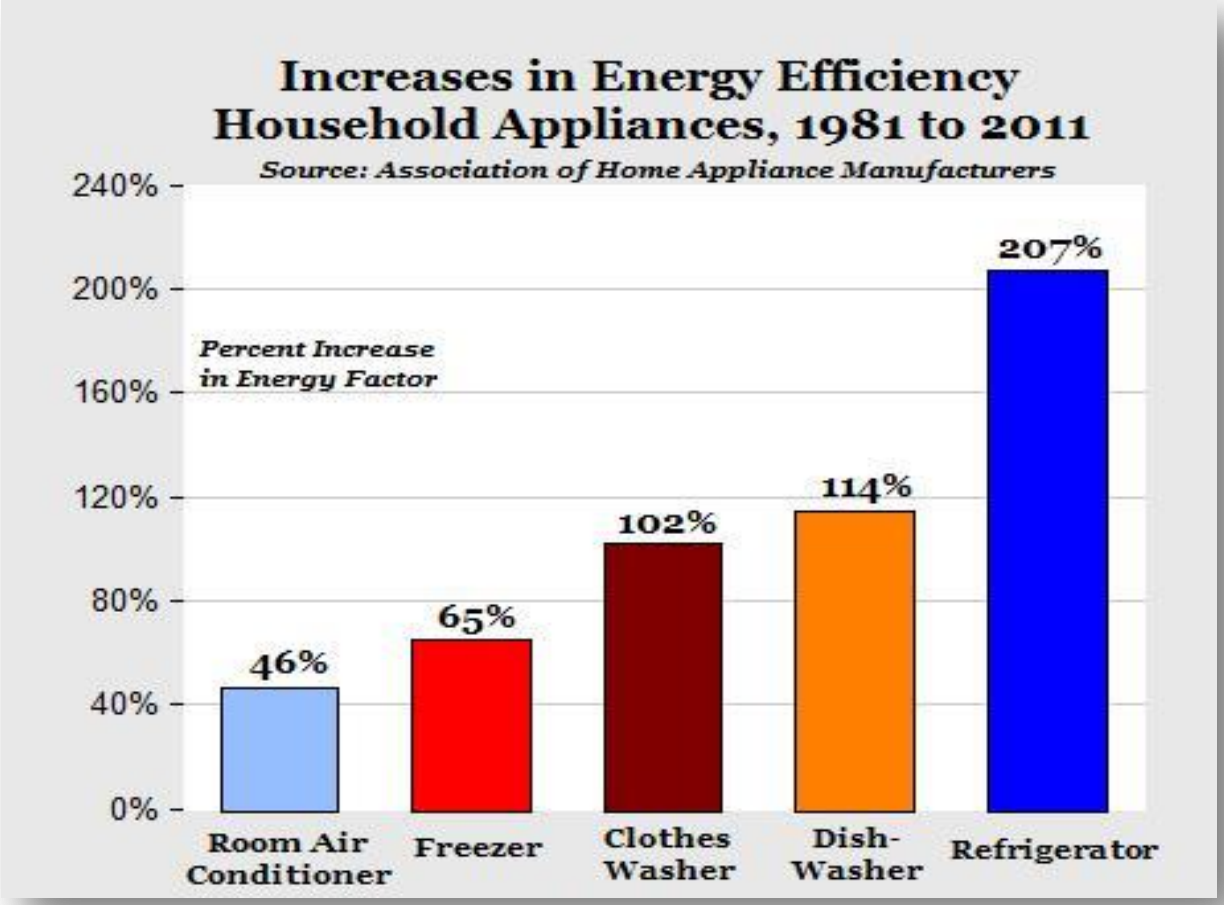
Proven Technologies and Best Practices

[DOE's Building America Program Innovations]



Increasing Energy Eff. Components

> Energy Eff. | **> Performance** | **> Innovation**



Visible Future: System #3

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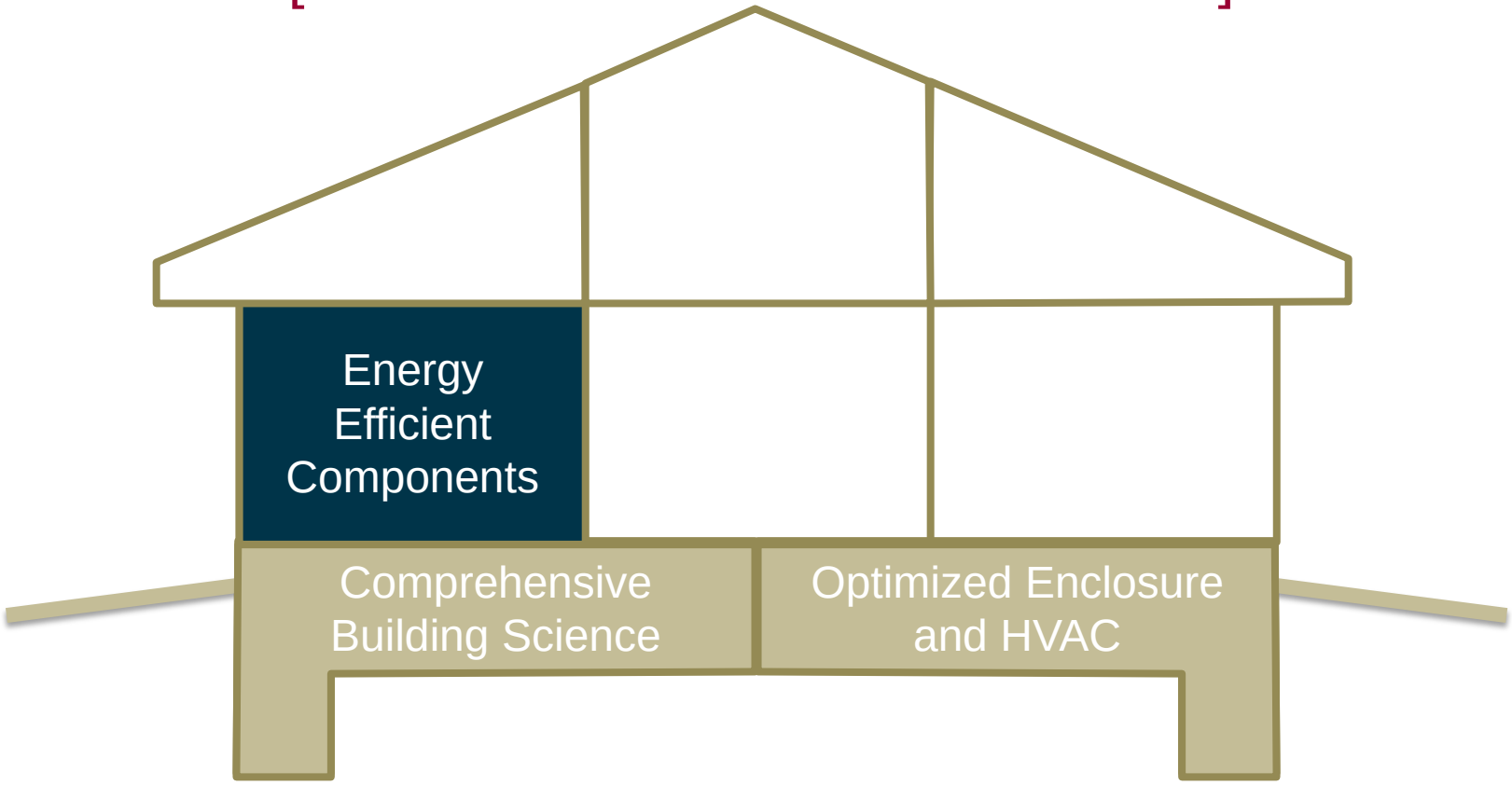
> Energy Eff. | > Performance | > Innovation

Energy Efficient Components:

High-Efficiency Appliances, Lighting, Fans

[ENERGY STAR Certified Products]



Increasing Health Concerns

$40 Billion

$20 Billion

Indoor vs. Outdoor Air Pollutants:

On average **2-5 times greater**

Up to **100 times greater**

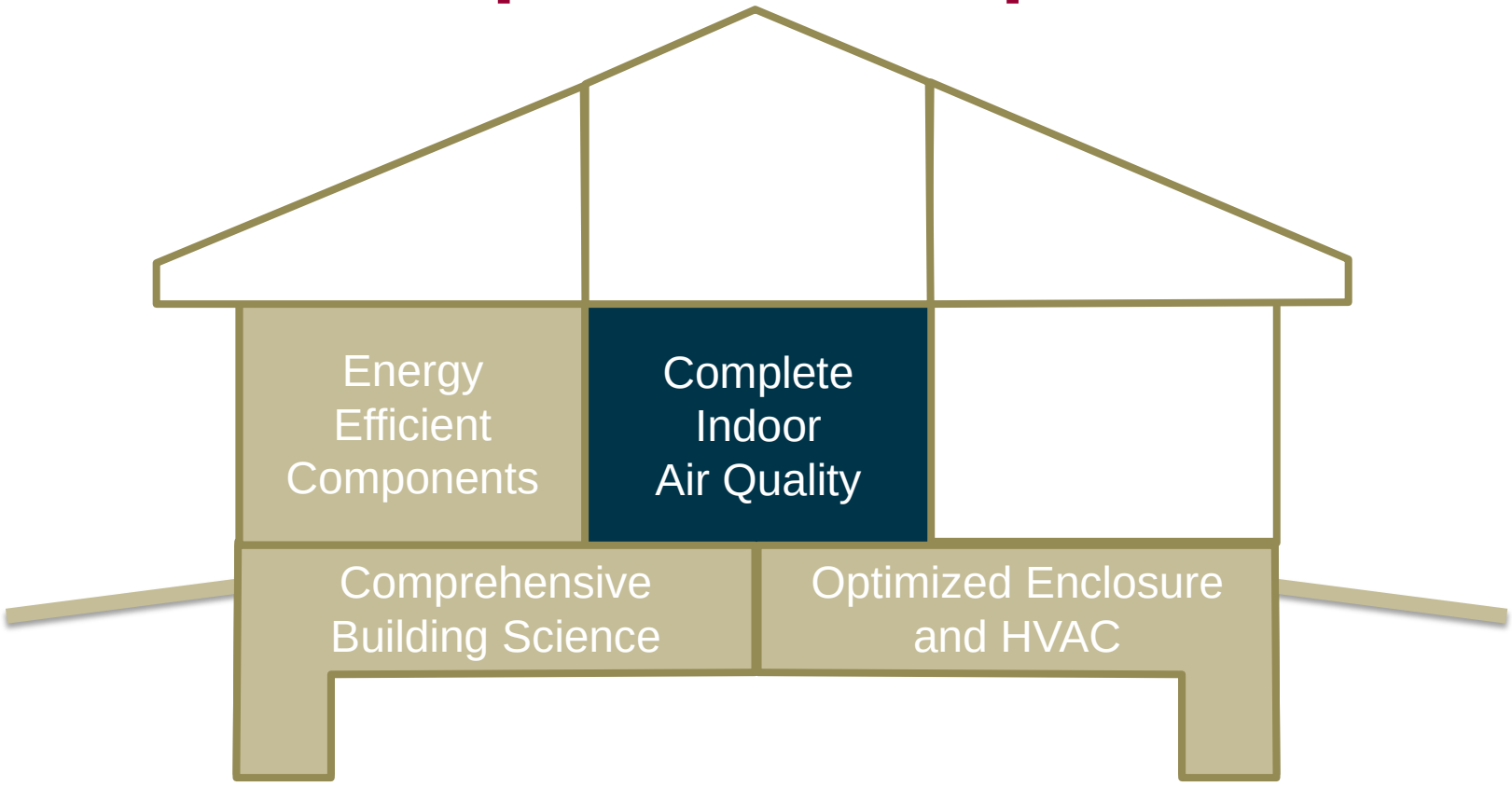
While Americans Spend

90% of time indoors

Comprehensive Indoor Air Quality:

Source Control, Dilution, and Filtration

[EPA Indoor airPlus]



Hard Trend:
Decreasing Renewable Cost

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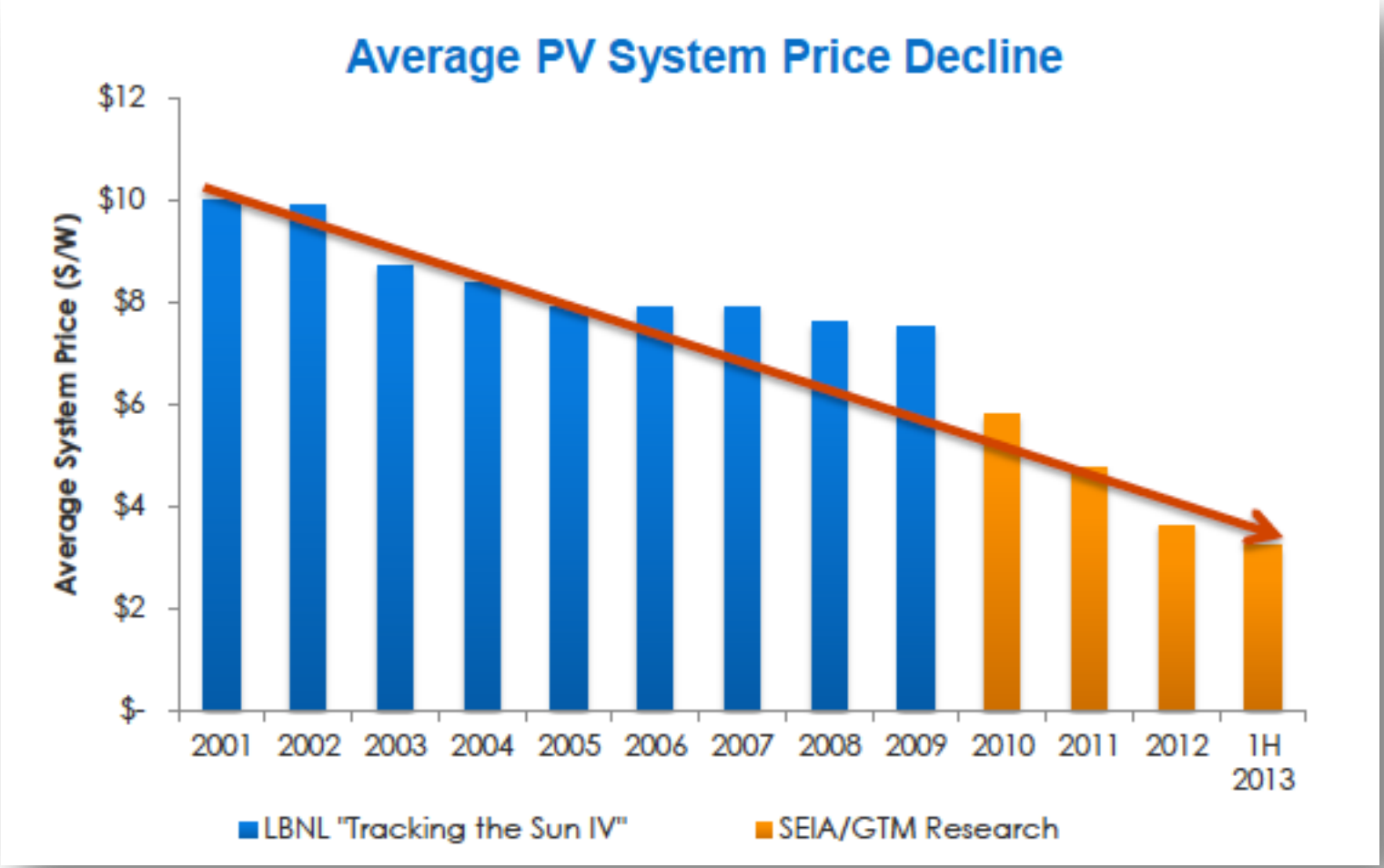
> Energy Eff. **> Performance** **> Innovation**



Visible Future: System #5

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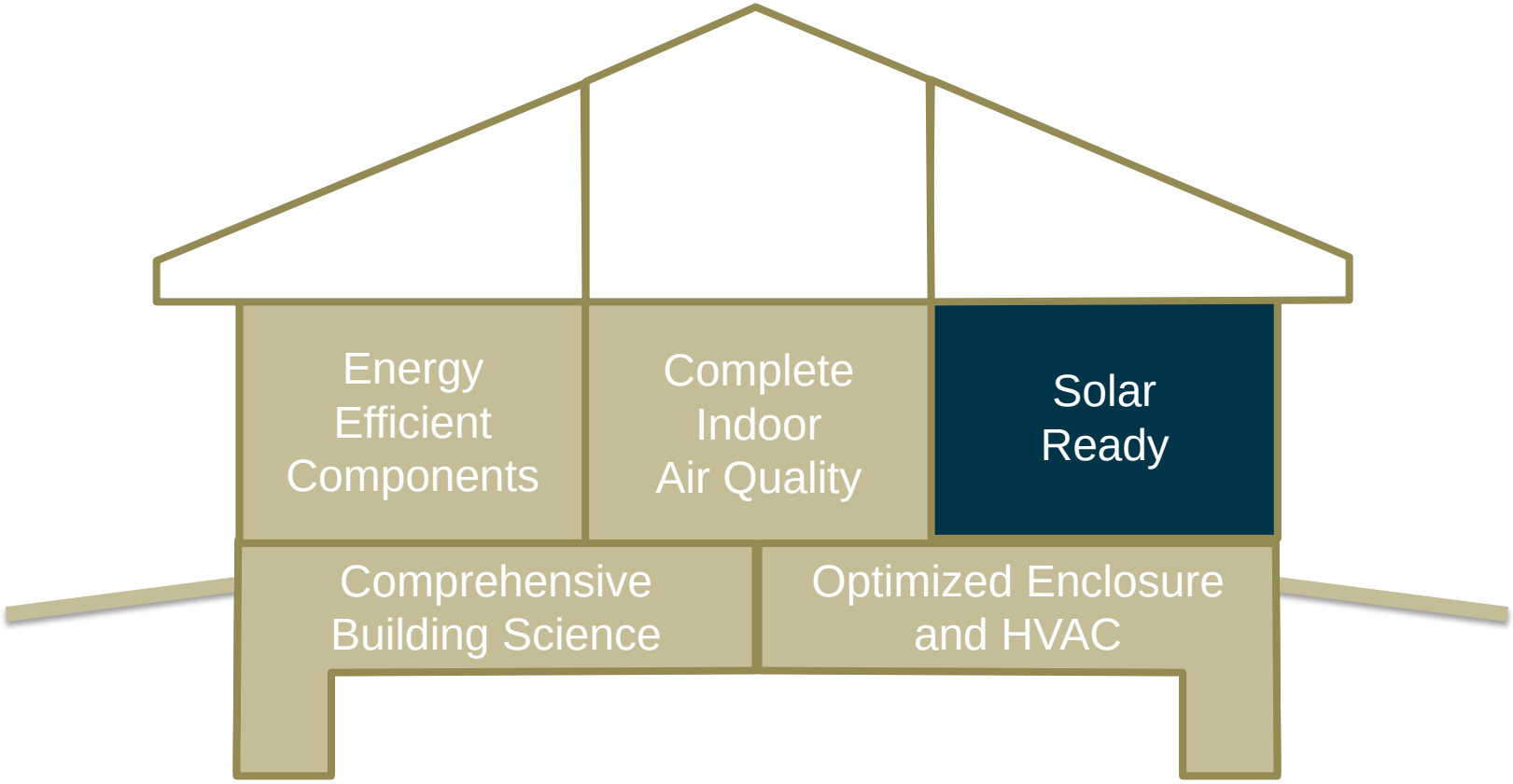
> Energy Eff. | > Performance | > Innovation

Solar Ready Package:

Low/No-Cost Details Can Save $1,000's in Future

[EPA Renewable Ready checklist]



Visible Future: System #5

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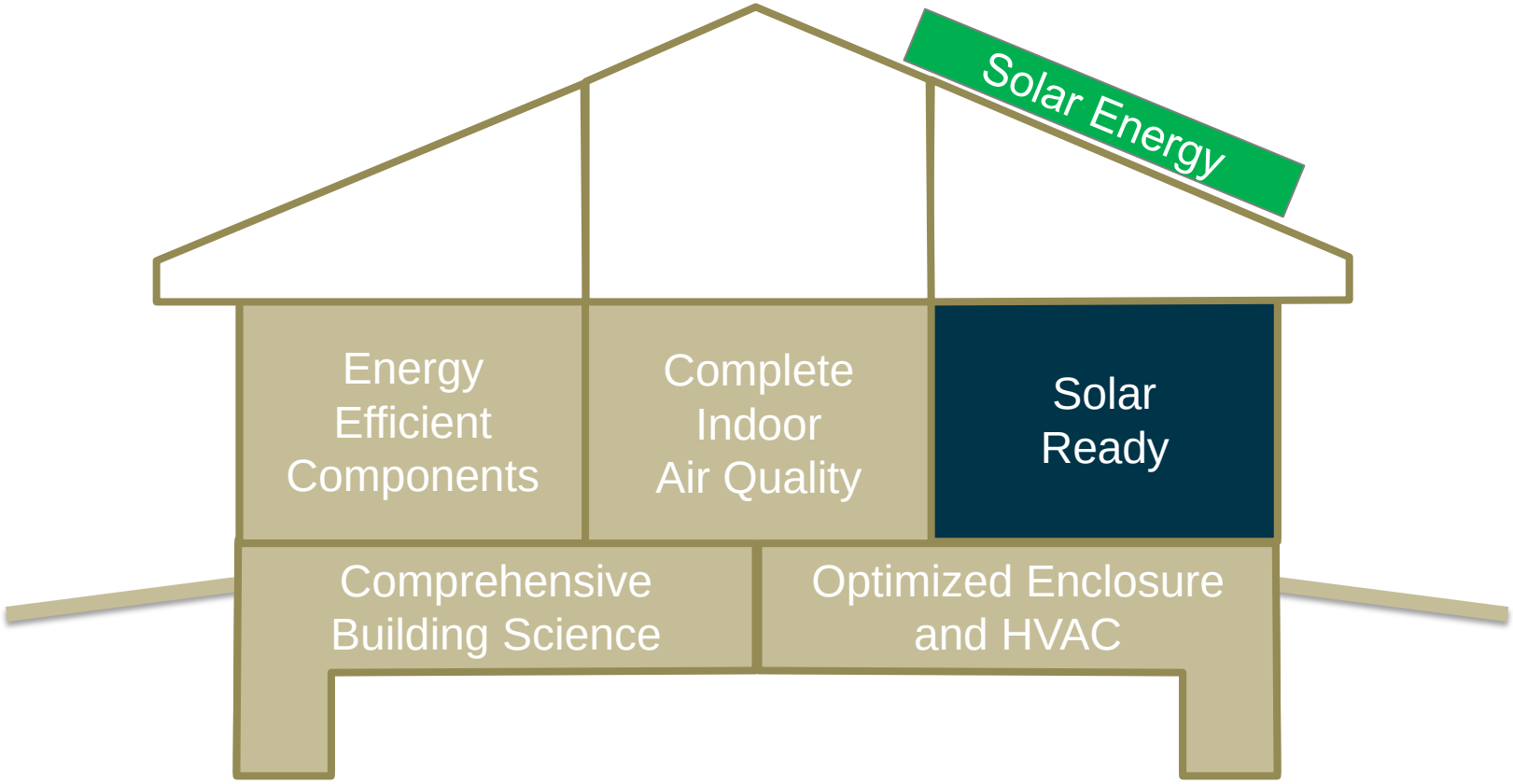
> Energy Eff. | > Performance | > Innovation

Solar Energy Last Step:

Only After 100+ Year Opportunity Cost Systems

[Offset All or Most Annual Energy Consumption]



Increasing Water Crisis

1950 – 2000:

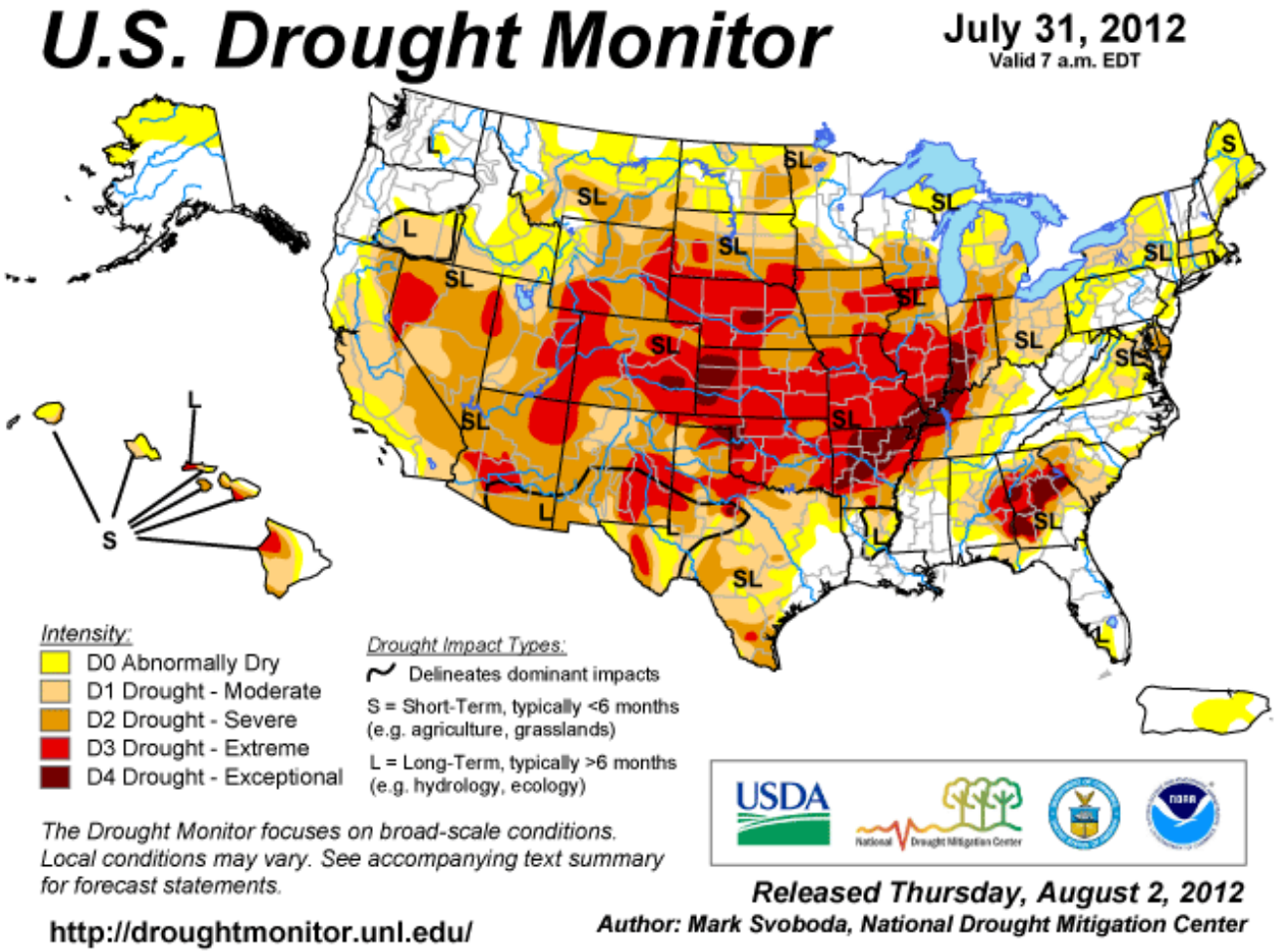
U.S. Population Doubled

Public Supply Water Demand More than Tripled

Since 2011:

> Half the U.S. Some Level of Drought.

Increasing Water Crisis



Hard Trend:
Decreasing Water Fixture Flow

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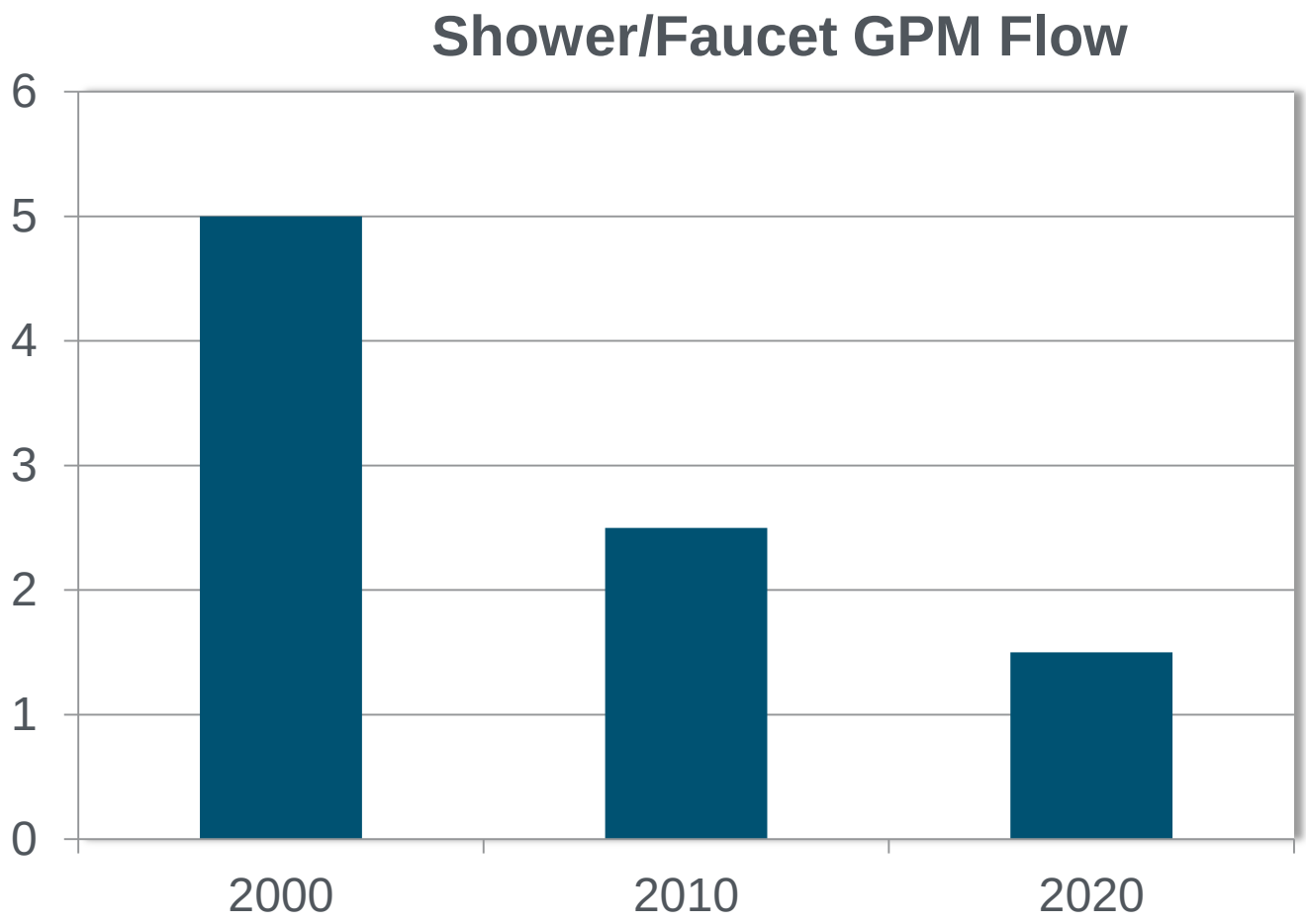
> Energy Eff. | > Performance | > Innovation



Hard Trend:
Decreasing Water Fixture Flow

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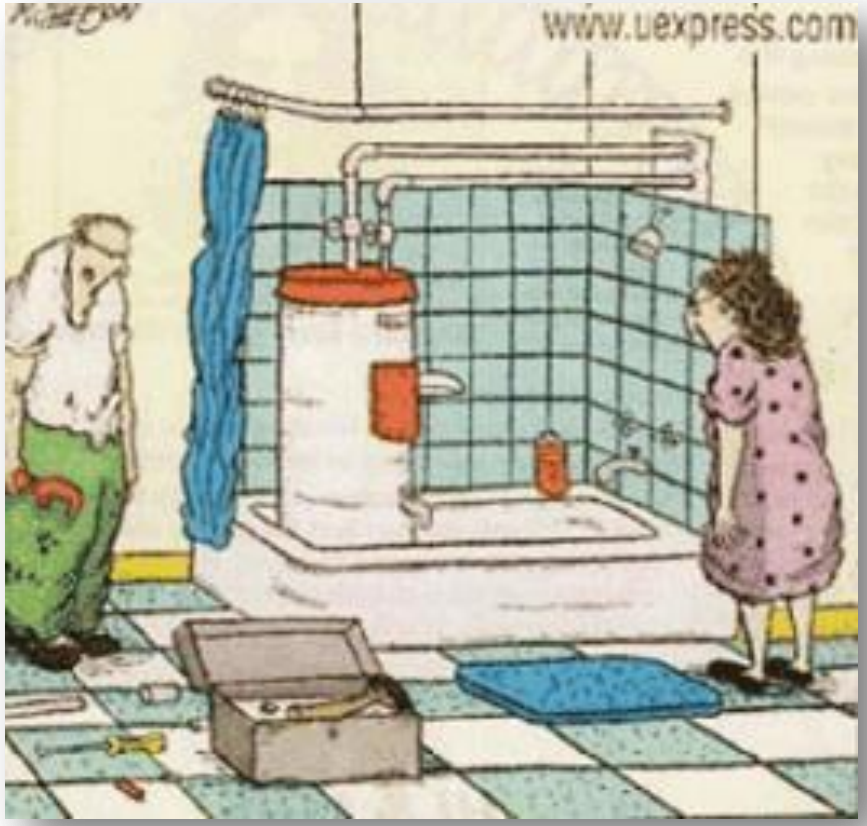
> Energy Eff. | > Performance | > Innovation



“OK, there! I don’t want to hear anyone whining about how long it takes for the water to get hot!”

Visible Future: System #6

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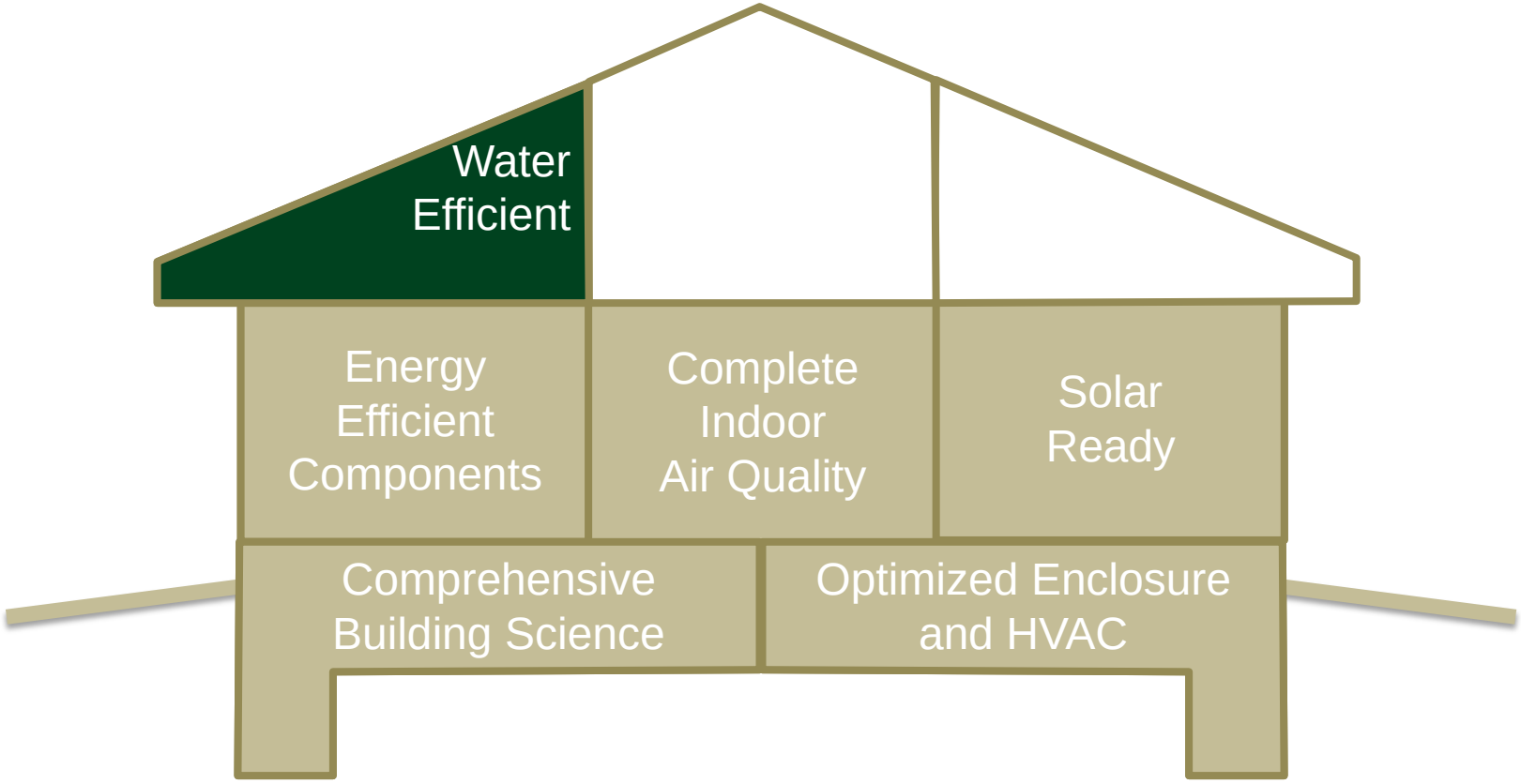
> Energy Eff. | **> Performance** | > Innovation

Water Efficiency:

Fixtures, Hot Water Distribution, & Landscaping

[EPA WaterSense specifications]



Increasing Extreme Weather

2013 Highlights

Tornadoes:

- Moore, OK:
  200 mph winds
  25 killed, 100's Injured,
  1,000+ homes destroyed
- El Reno, OK:
  widest tornado ever

2013 Highlights

Hurricane Sandy:

- 285 killed
- 115 mph winds
- Record largest spanning 1,100 miles
- $65 billion damage in the U.S.

Increasing Extreme Weather

2013 Highlights

Colorado Flooding:

- 5 killed
- Biggest civilian airlift since Katrina
- 1,200 missing or stranded
- 9+ inches rain in Boulder over 24 hrs.

Increasing Extreme Weather

2011-13 Highlights

Wild Fires:

- Largest in AZ (Wallow 2011)
- Largest and most destructive in NM (Black Forest, Waldo Canyon 2012)
- Most destructive in TX (2011)
- 3rd largest in CA (Rim 2013)

Hard Trend:
Increasing Disaster Risk

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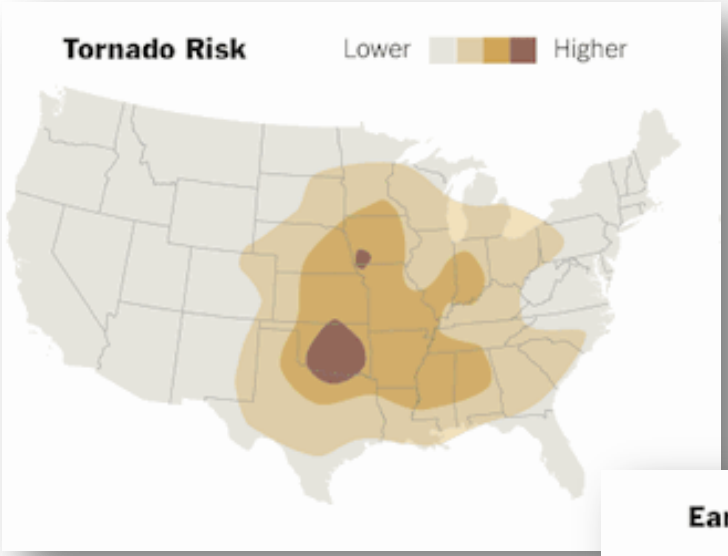
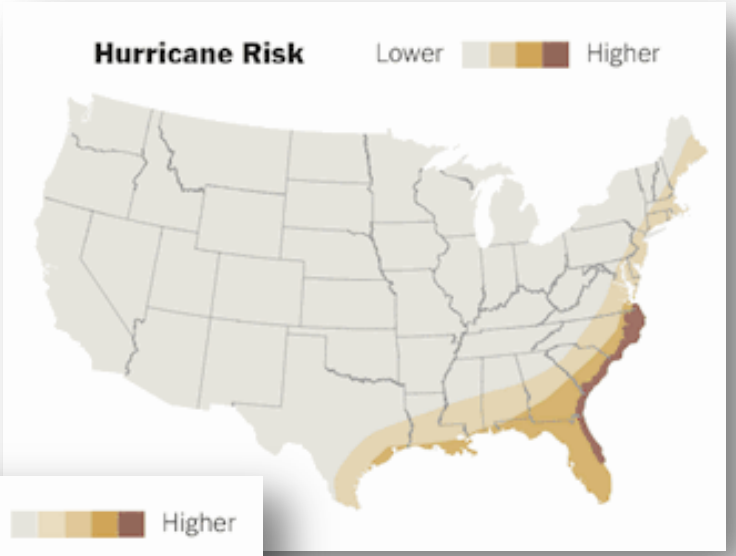
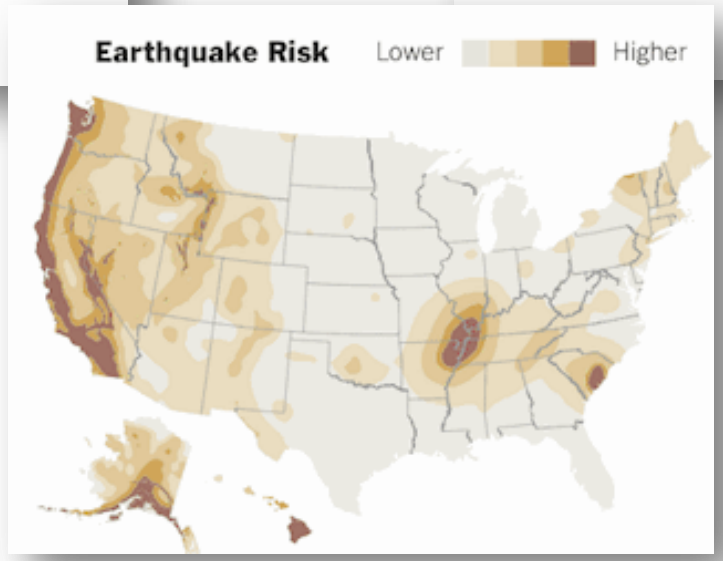
> Energy Eff. **> Performance** **> Innovation**







New York Times, April 30, 2011

Hard Trend:
Increasing Disaster Risk

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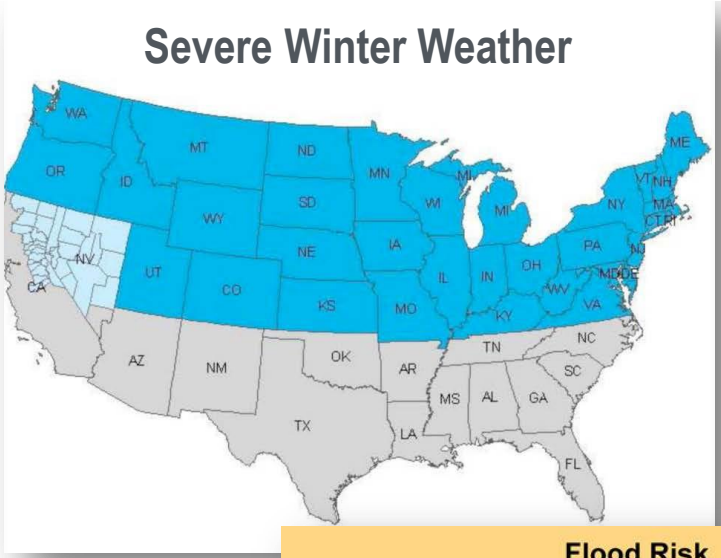
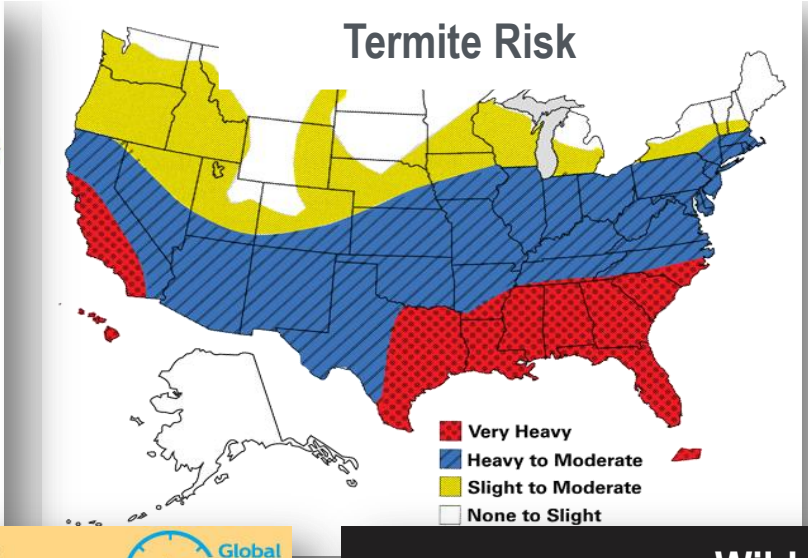
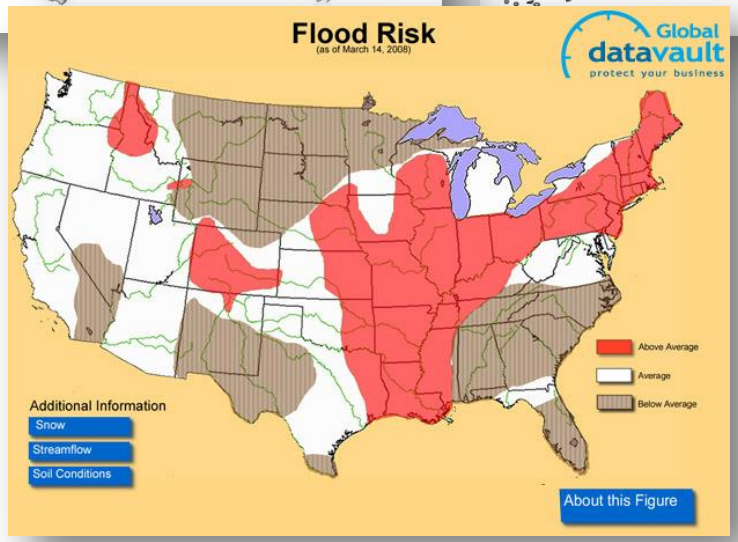
> Energy Eff. **> Performance** **> Innovation**







Visible Future: System #7

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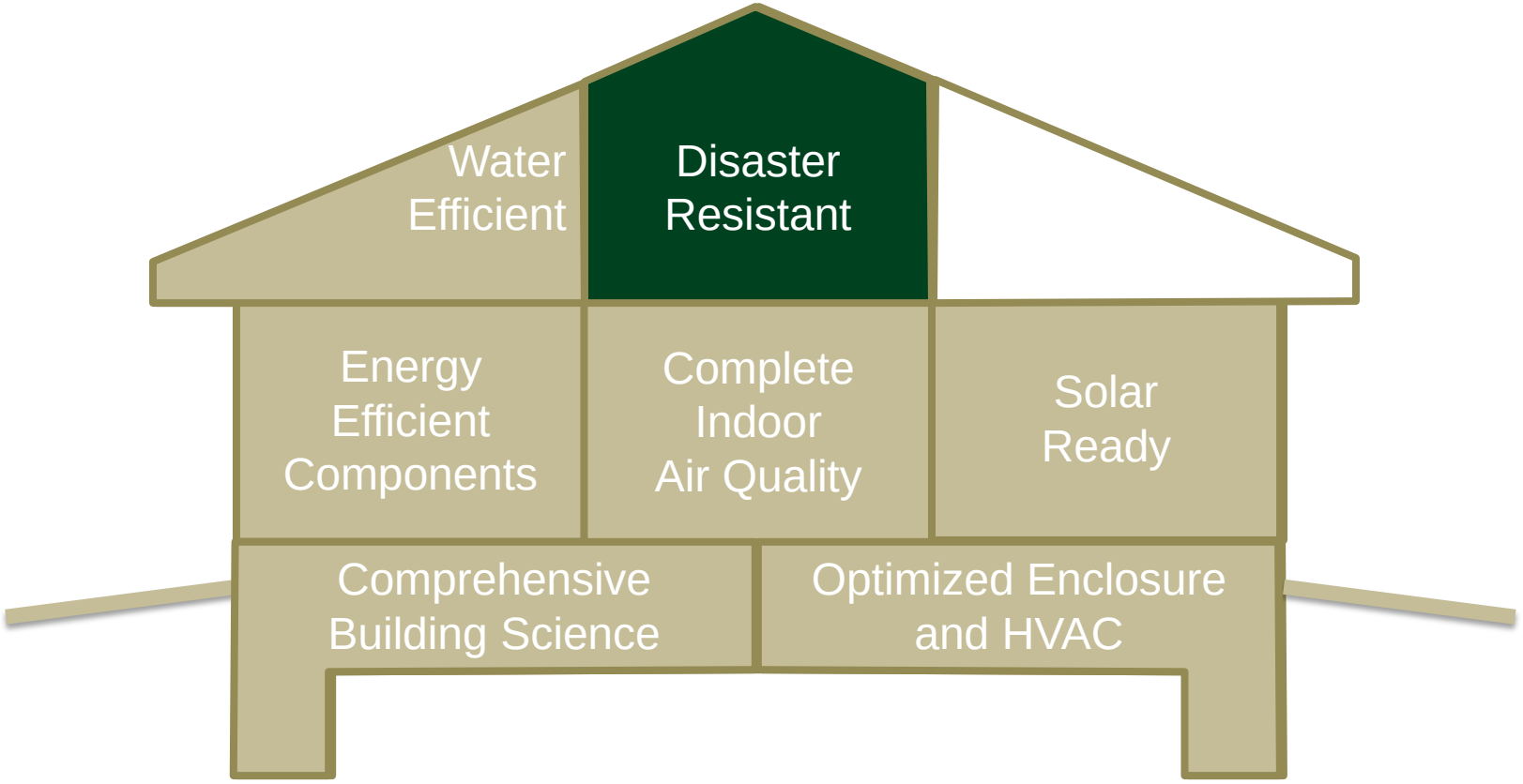
> Energy Eff. | > Performance | > Innovation

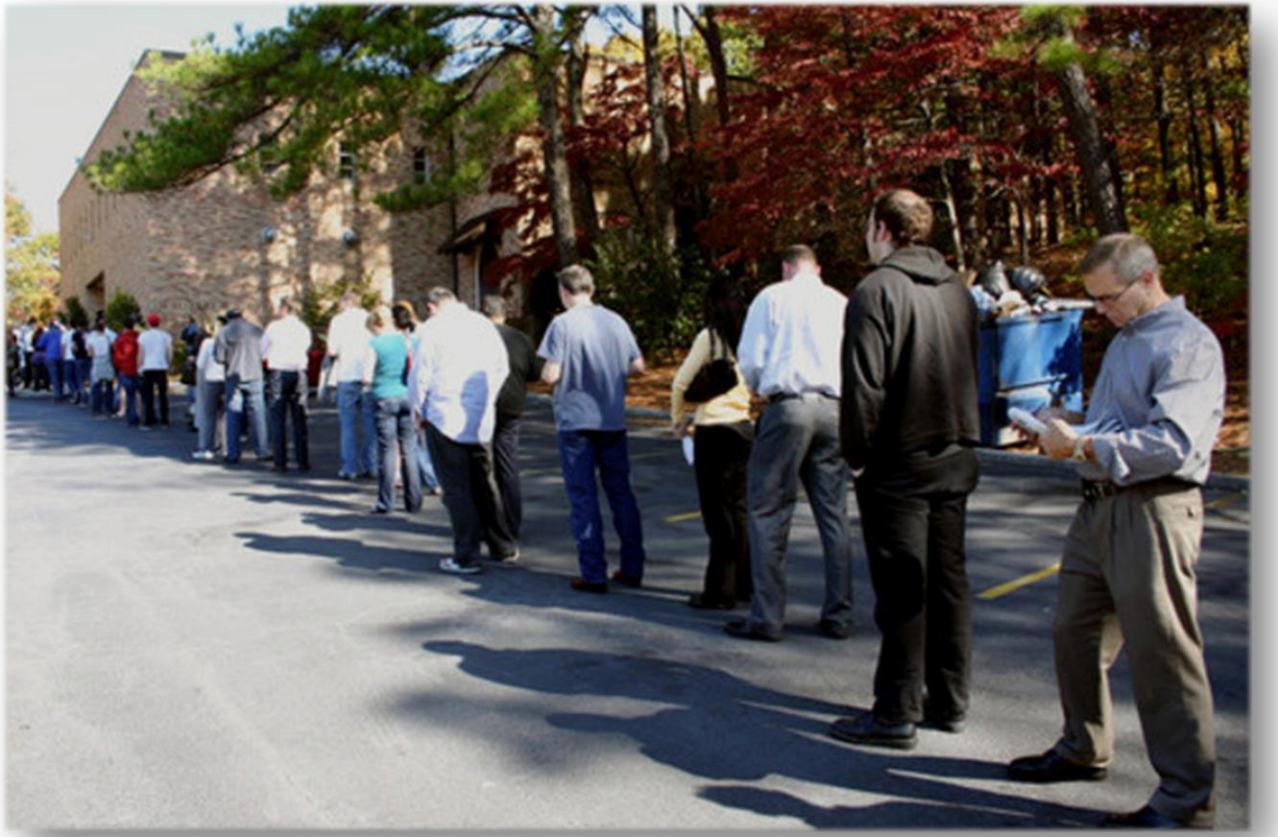
Disaster Resistance:

Weather, Natural Events, and Pests

[IBHS Fortified Homes plus Termite Protection]



> Energy Eff. | > Performance | > Innovation



78 Million Innovation Junkies

Hard Trend:
Increasing Innovation Expectation

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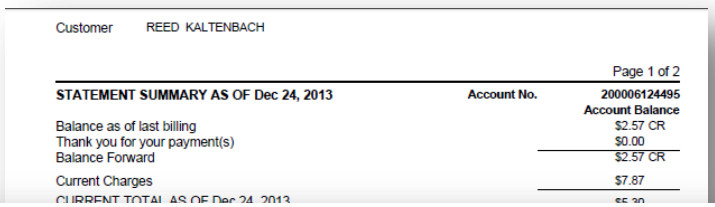
> Energy Eff. | **> Performance** | **> Innovation**



Customer REED KALTENBACH

Page 1 of 2

STATEMENT SUMMARY AS OF Dec 24, 2013 — Account No. 200006124495

	Account Balance
Balance as of last billing	$2.57 CR
Thank you for your payment(s)	$0.00
Balance Forward	$2.57 CR
Current Charges	$7.87
CURRENT TOTAL AS OF Dec 24, 2013	$5.30

Electric Detail: 6300 HINMAN DR, CLINTON

Rate/ Dates	Meter Number	Pres Read	Prev Read	Pres Date	Prev Date	Mult	KWH (Usage)	Bill Demand	KVAR Hours	Code	Amount
7E	U005169431	3888	2401	12/23	11/21	1	1487			ACTL	
RETURNED	U005169431	4506	4406	12/23	11/21	1	100			ACTL	
PROD	A012959804	5683	5417	12/23	11/21	1	266			ACTL	

11/22/13 12/23/13	Basic Charge		$7.87
11/22/13 12/23/13	Electric Energy Charge	0 kWh @ $0.091414 Per kWh	$0.00
11/22/13 12/23/13	Energy Exchange Credit	0 kWh @ $0.009279CR Per kWh	$0.00
11/22/13 12/23/13	Electric Cons. Program Charge	0 kWh @ $0.004632 Per kWh	$0.00
11/22/13 12/23/13	Power Cost Adjustment	0 kWh @ $0.000528CR Per kWh	$0.00
11/22/13 12/23/13	Merger Credit	0 kWh @ $0.000335CR Per kWh	$0.00
11/22/13 12/23/13	Federal Wind Power Credit	0 kWh @ $0.003323CR Per kWh	$0.00
11/22/13 12/23/13	Regulatory Asset Tracker	0 kWh @ $0.000000 Per kWh	$0.00
11/22/13 12/23/13	Renewable Energy Credit	0 kWh @ $0.000348CR Per kWh	$0.00
	Current Electric Charges		**$7.87**

PUGET SOUND ENERGY Account: 200006124495 — Current Bill Due Date Jan 15, 2014 — Total Amount Due $5.30

Yes, I want to give $_____to the Warm Home Fund.

Please make checks payable to Puget Sound Energy

004128

REED KALTENBACH
6300 HINMAN DR
CLINTON WA 98236

Puget Sound Energy
BOT-01H
P.O. Box 91269
Bellevue, WA 98009- 9269

008000

00637000309536 0001 01 00200006124495 000000000787 000000000530

"This accelerating rate of change is as certain as the sun rising in the east…
It will disrupt catastrophically every aspect of every industry and every aspect of human activity ***—except for those who see it coming."***

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

New Innovation Business Model:

Exceed Customer Expectations

New 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"***

Disruption with Someone Else Doing It:

- Kodak
- Polaroid
- Motorola
- Palm
- American Car Manufacturers
- TWA and other Legacy Airlines
- Converse Sneakers
- and the list goes on…

Visible Future: System #8

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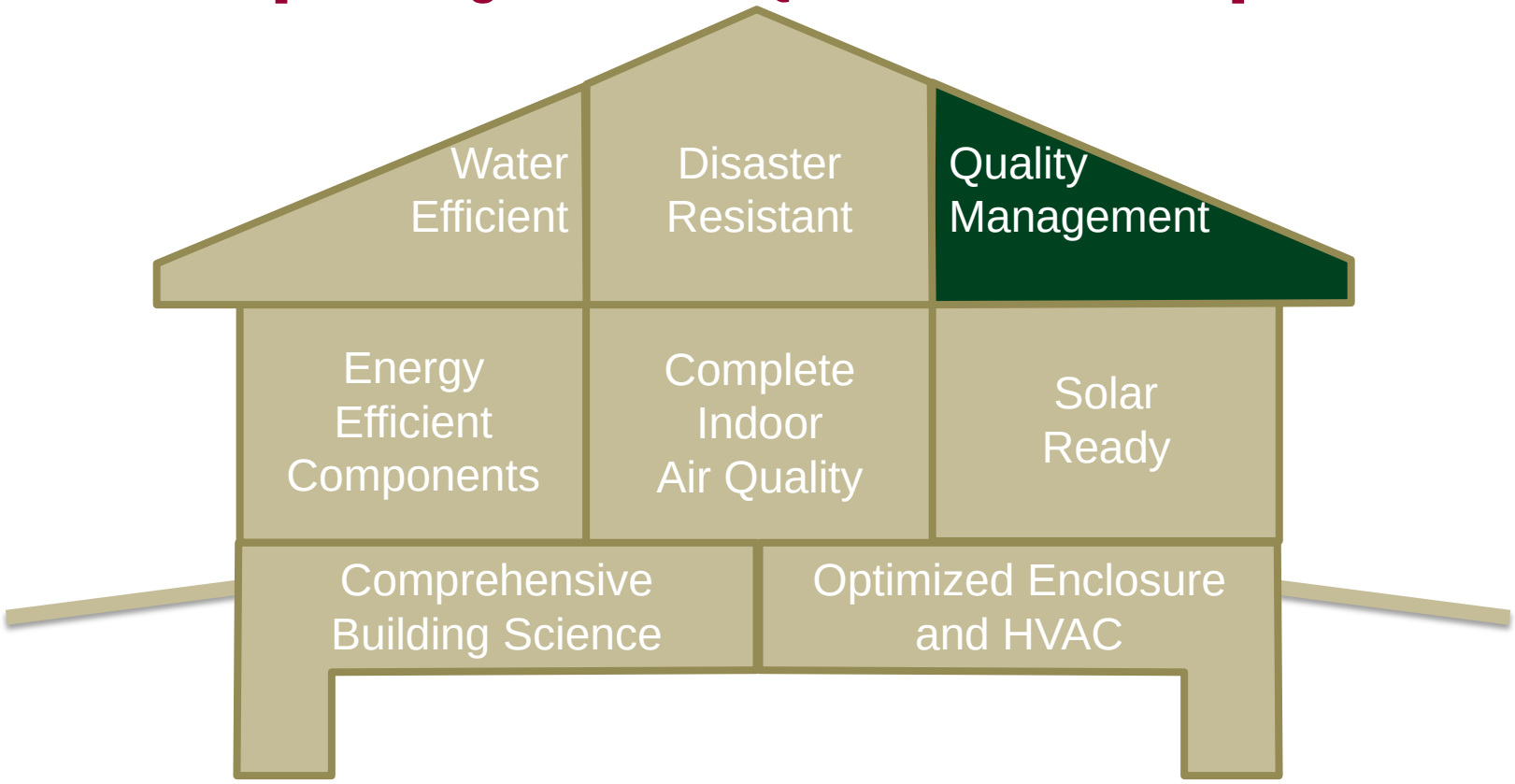
> Energy Eff. | > Performance | > Innovation

Quality Assurance:

Integrated Design, Contract Docs, and QM Plan

[Building America QA Best Practices]



Hard Trend:
More Informed Consumers

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> Energy Eff. | > Performance | > 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**

Hard Trend:
More Informed Consumers

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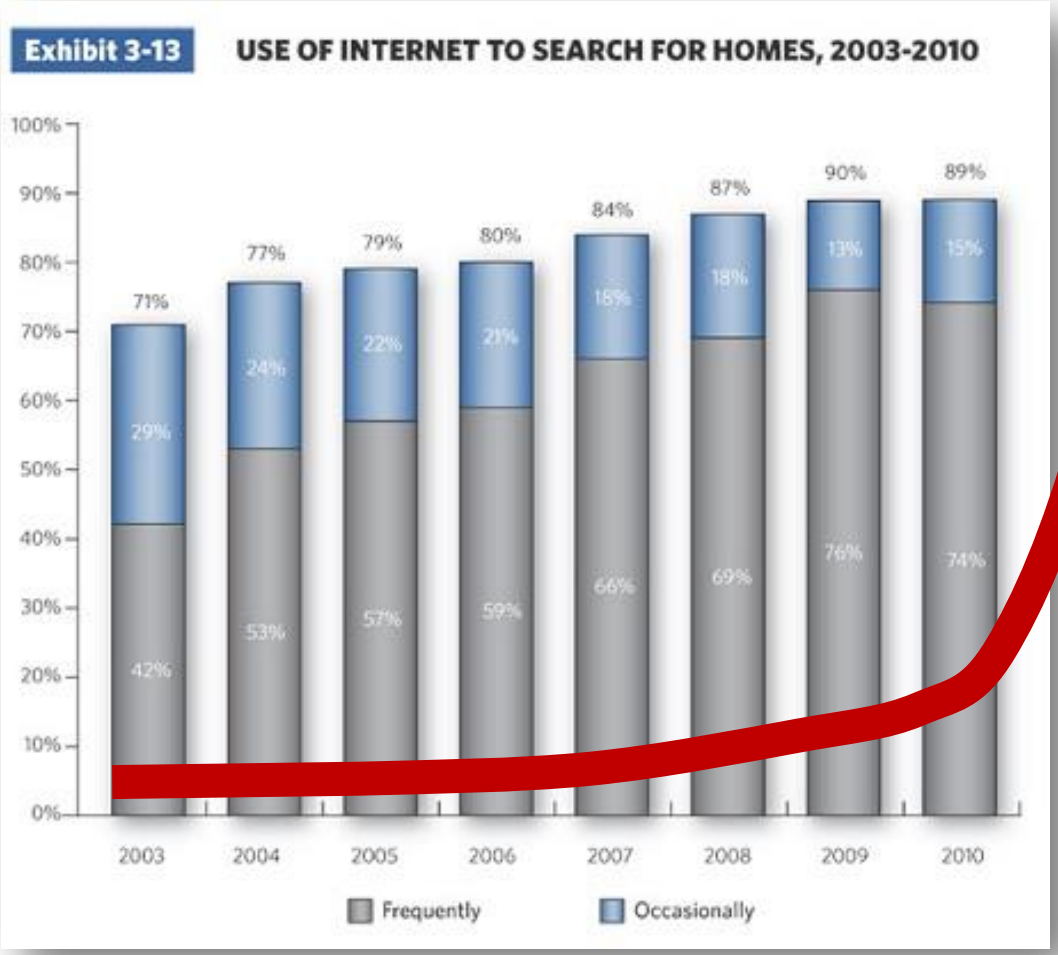

SOURCE: National Association of Realtors® - Profile of Home Buyers and sellers 2010

Hard Trend:
Aging Housing Stock

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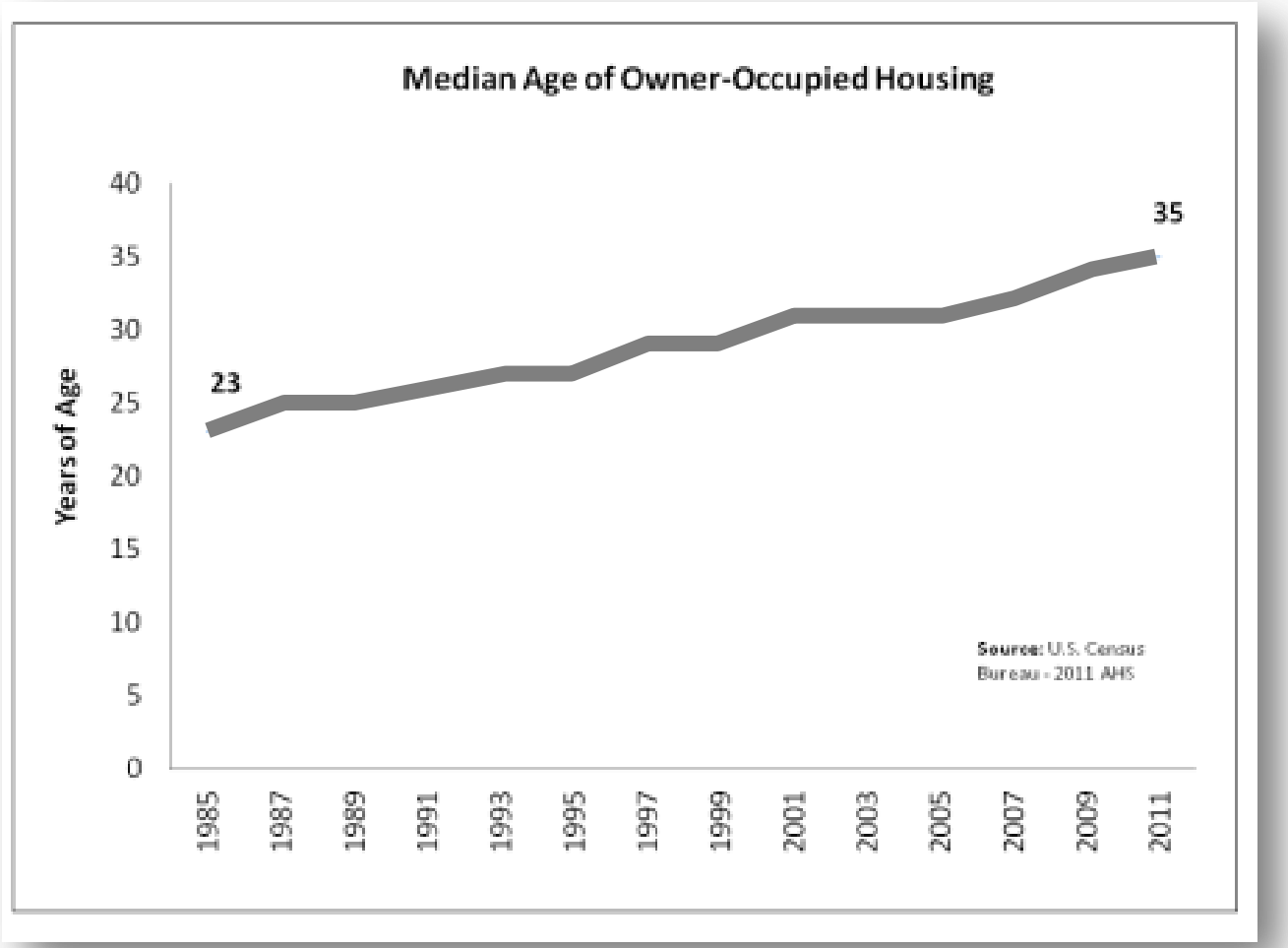
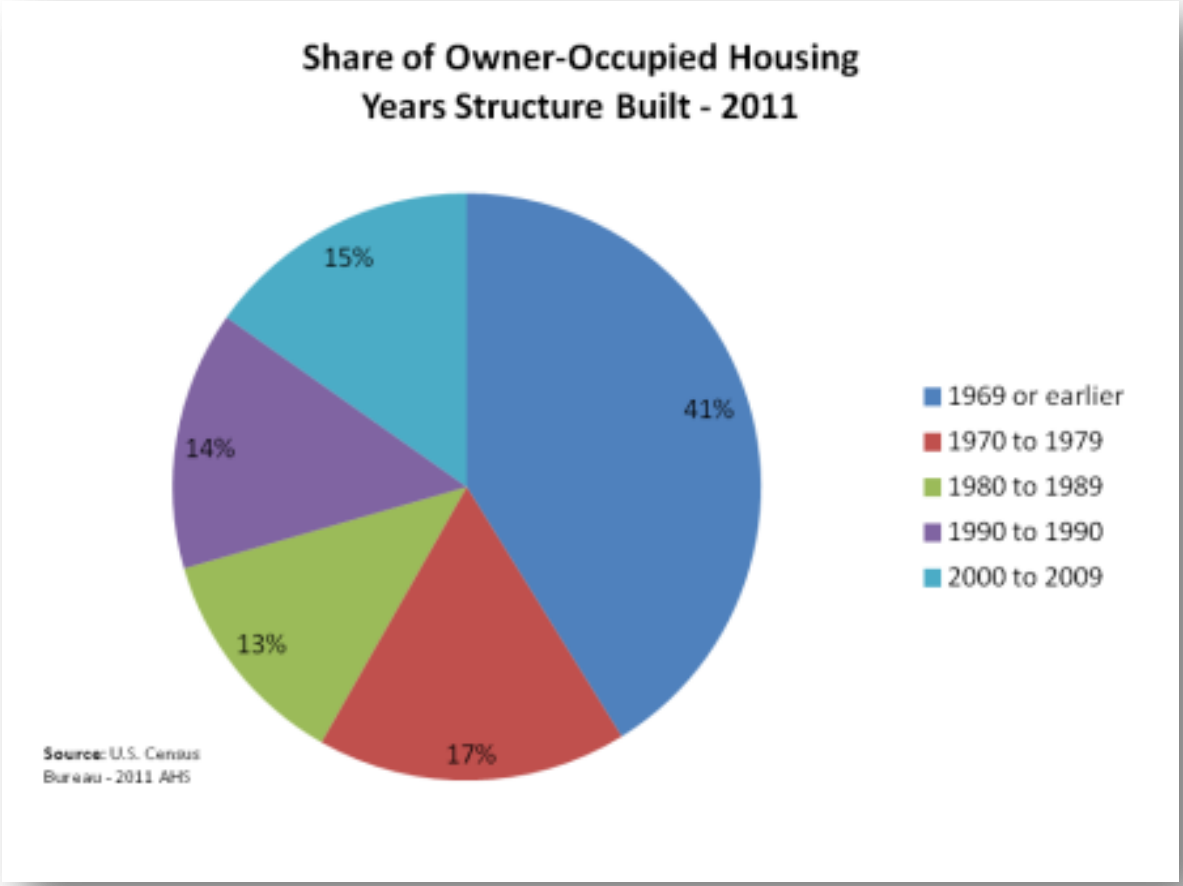
> Energy Eff. | > Performance | > Innovation




Share of Owner-Occupied Housing
Years Structure Built - 2011
15%
41%
14%
13%
17%
1969 or earlier
1970 to 1979
1980 to 1989
1990 to 1990
2000 to 2009
Source: U.S. Census Bureau - 2011 AHS

Existing Homes with:

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

Meet
85%
of Your
Competition

Visible Future: Bundled Systems

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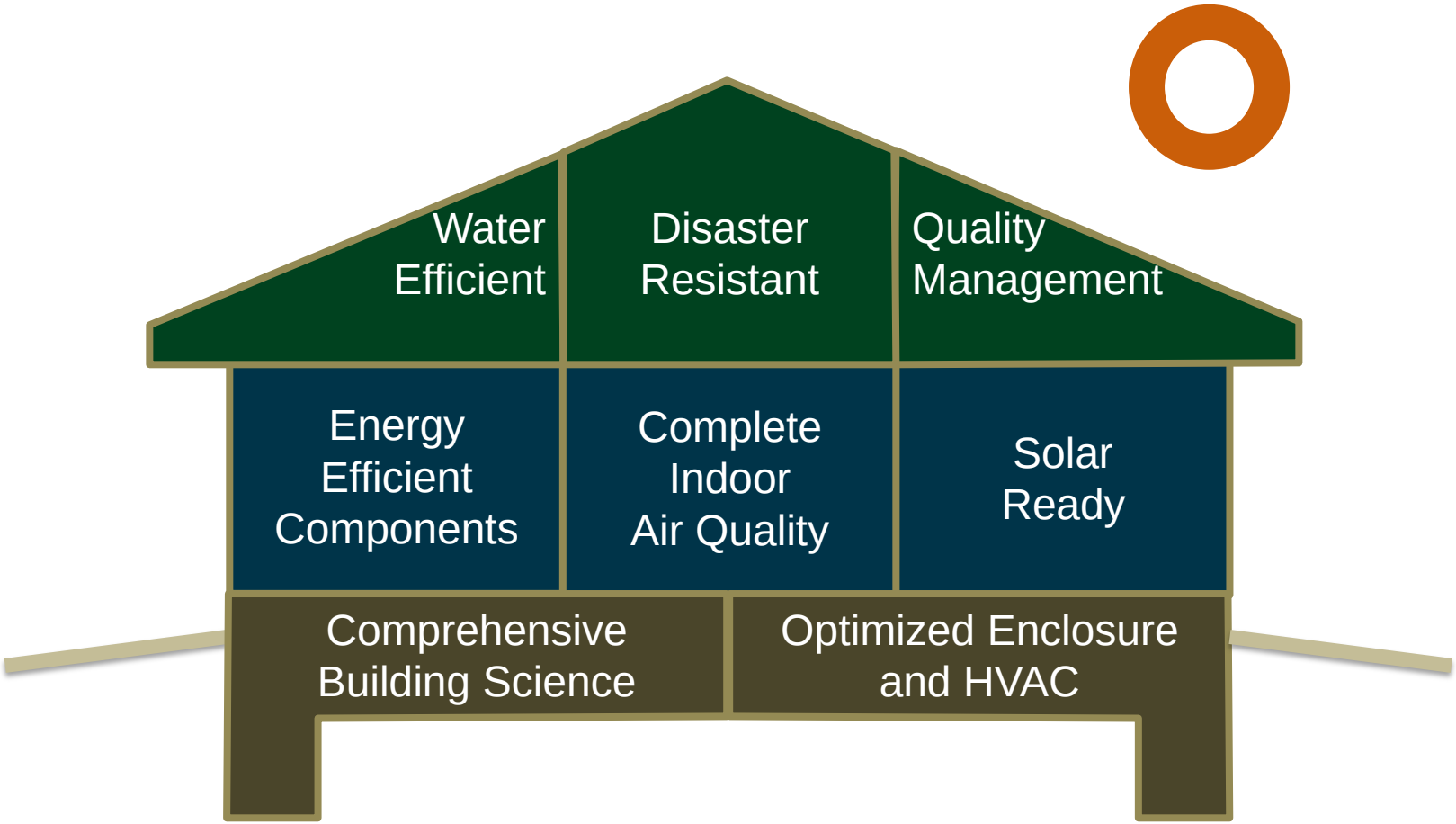
> Energy Eff. | **> Performance** | **> Innovation**



Zero Net-Energy Ready Home

Visible Future Builders

Welcome:

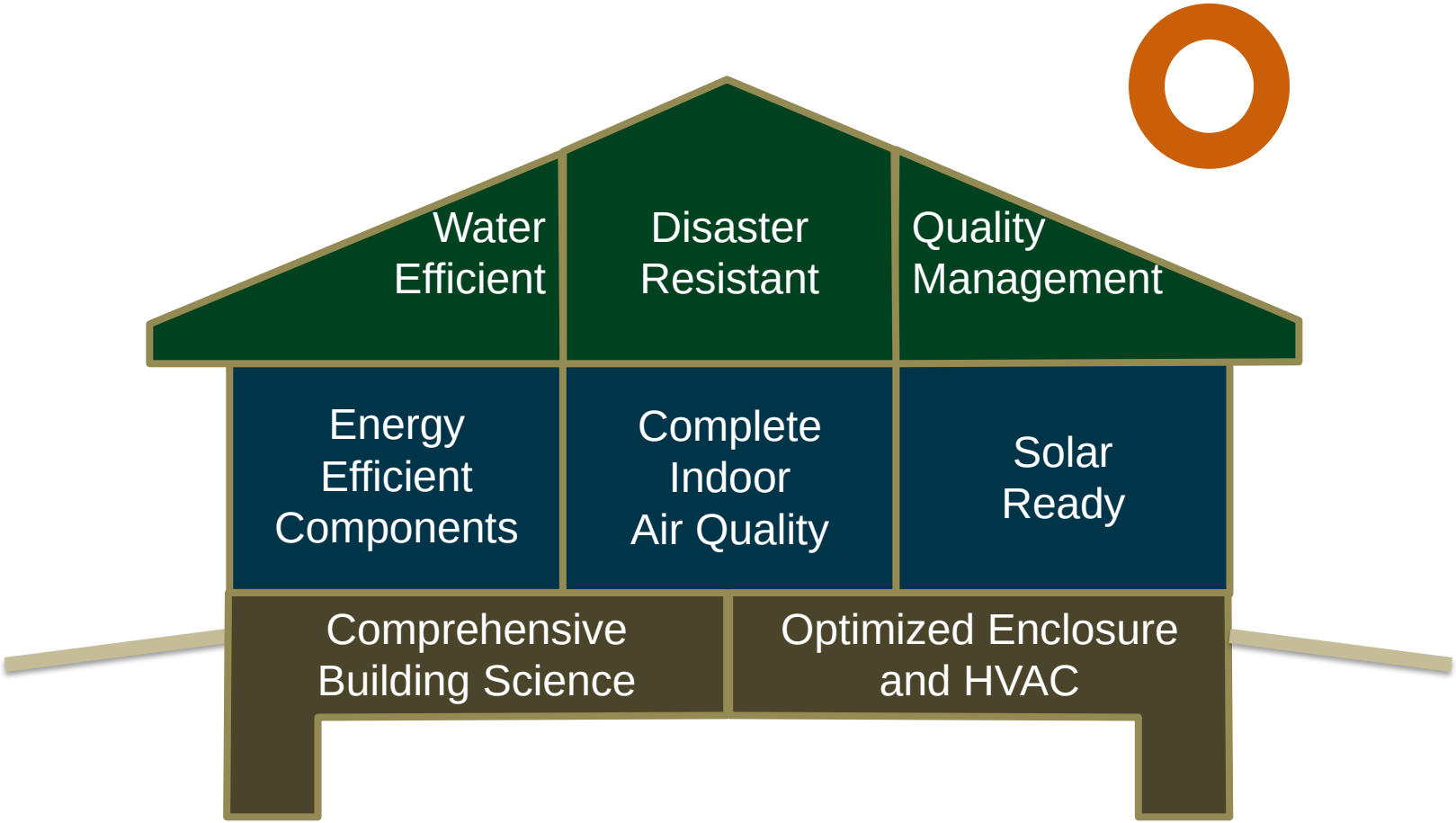
Zero Energy Ready Home

Value Propositions

Zero Energy Ready Home

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

> Energy Eff. | **> Performance** | **> Innovation**



Zero Energy Ready Home Value

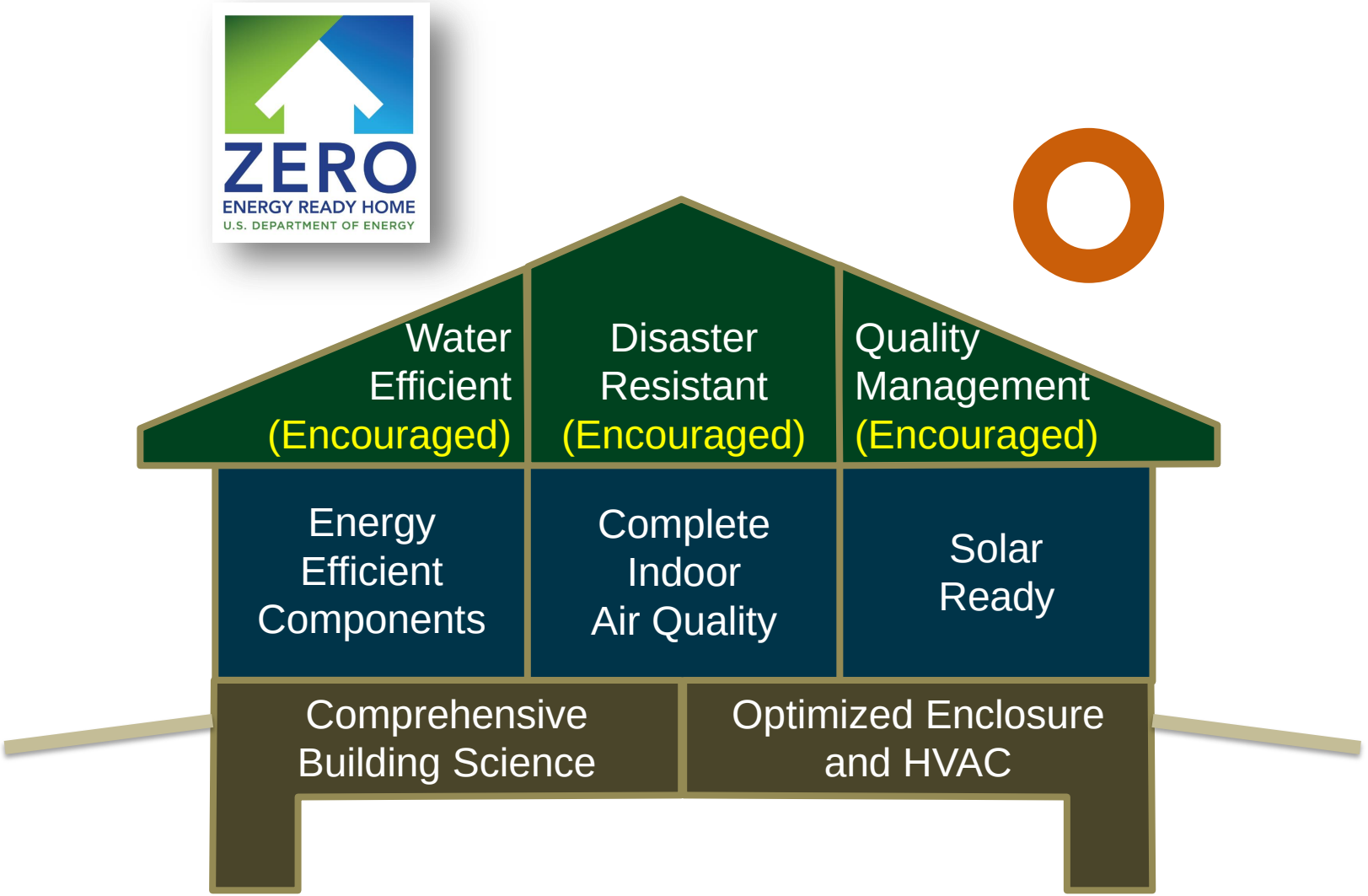
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Lives Better	Works Better	Lasts Better
Engineered Comfort	Ultra-Low Utility Bills	Quality Construction
Healthier Living	Advanced Technology	More Durability
Solar Ready	Water Efficient	Disaster Resistant
Long-Term Warranty	Black-Out Power	Lower Cost Insur./Mort.

Someone Else Doing It…

DOE Zero Energy Ready Home

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



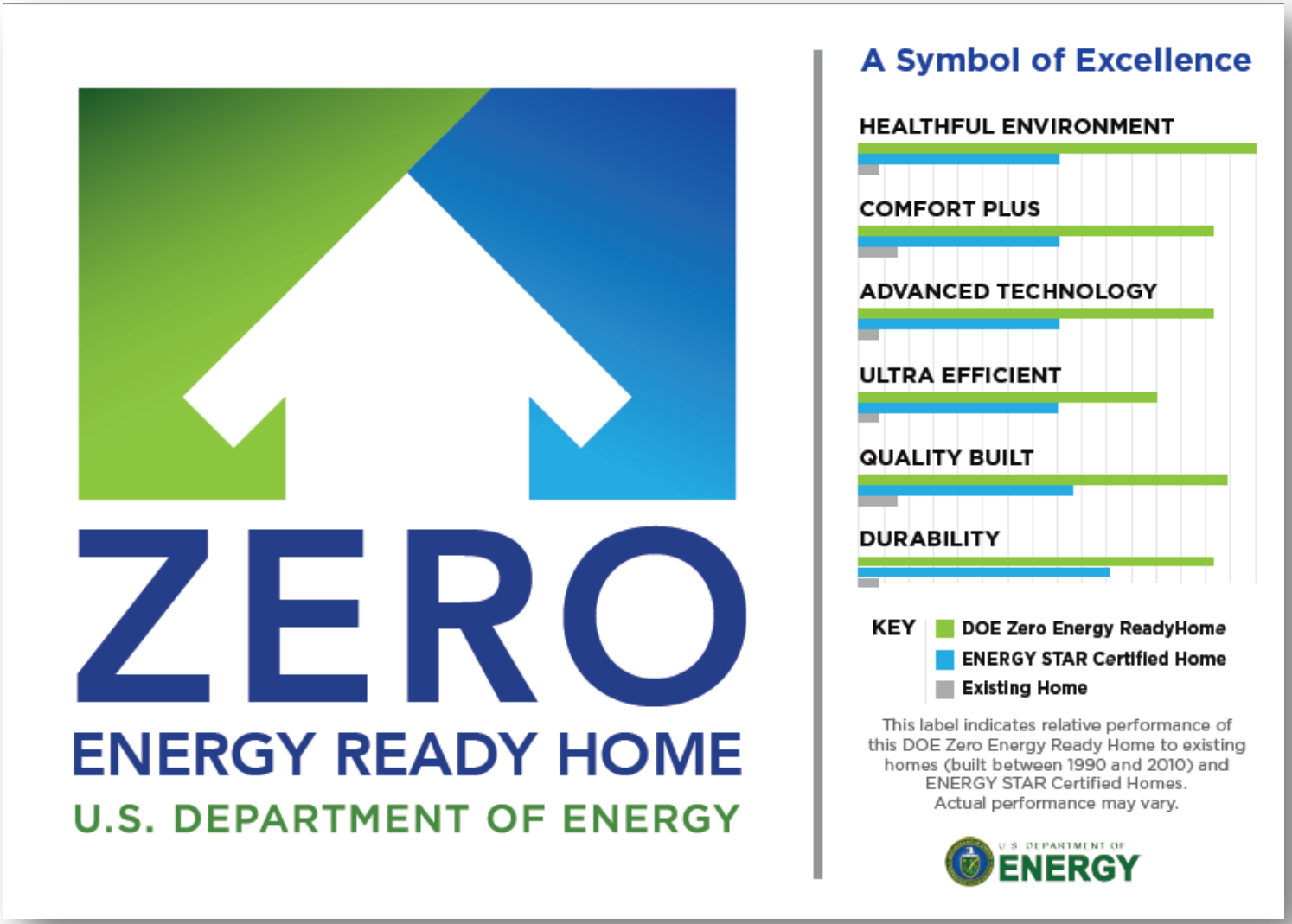
DOE ZERH Bankable Value

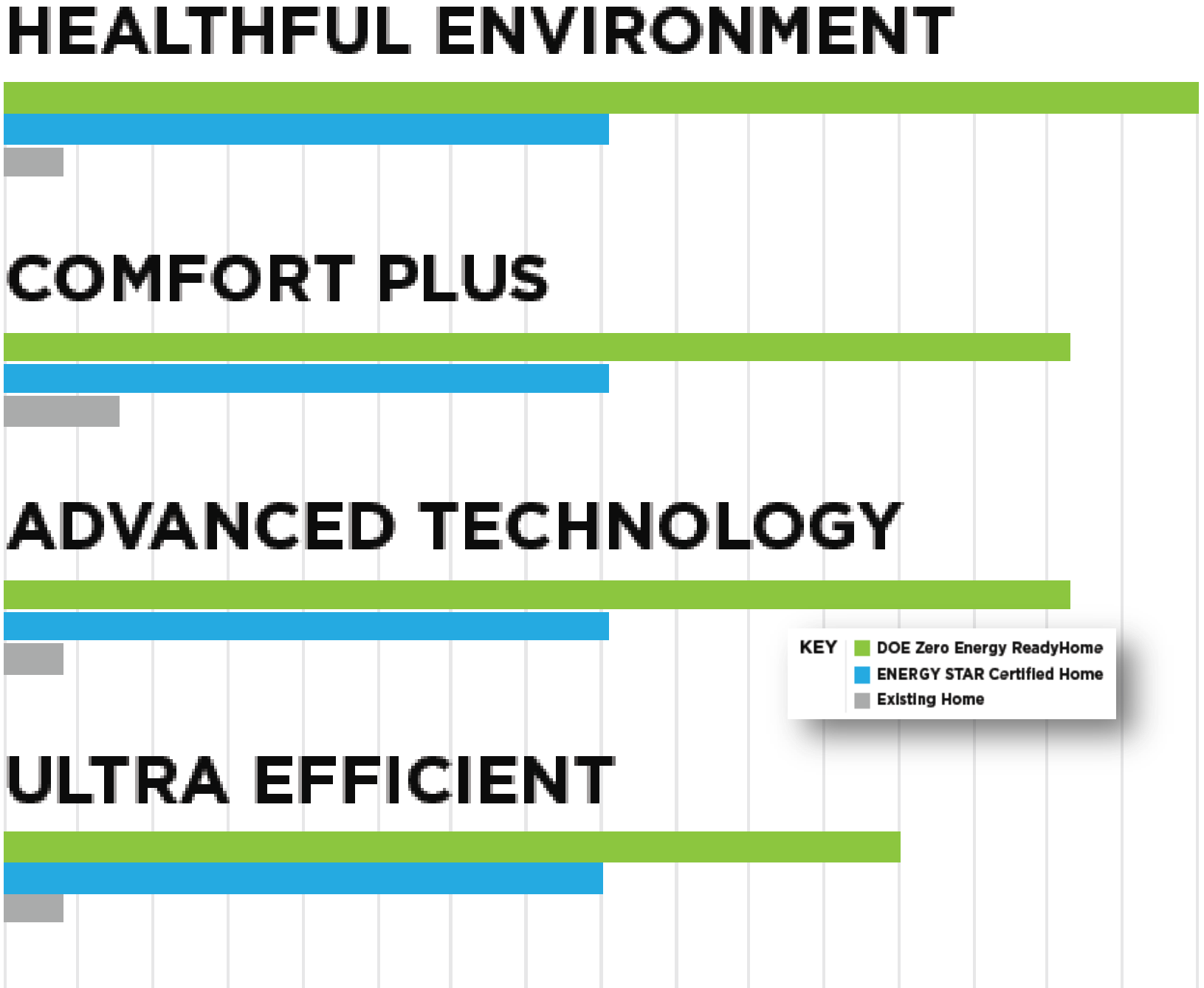
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Lives Better	Works Better	Lasts Better
Engineered Comfort	Ultra-Low Utility Bills	Quality Construction
Healthier Living	Advanced Technology	More Durability
Solar Ready	Water Efficient	Disaster Resistant
Long-Term Warranty	Black-Out Power	Lower Cost Insur./Mort.

Translating ZERH Value Proposition

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



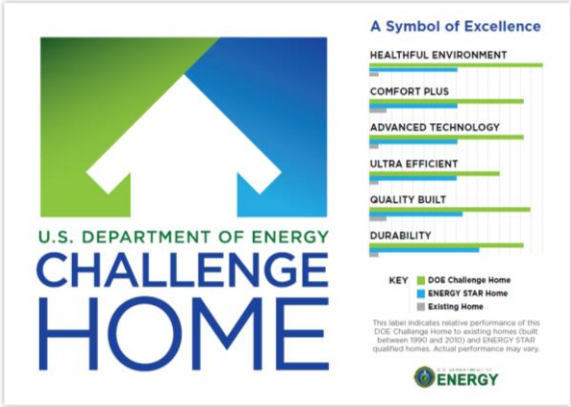

HEALTHFUL ENVIRONMENT
COMFORT PLUS
ADVANCED TECHNOLOGY
ULTRA EFFICIENT
KEY
DOE Zero Energy ReadyHome
ENERGY STAR Certified Home
Existing Home

Value Proposition Transparency

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

DOE Challenge Home Label Methodology

October 2012



DOE Challenge Home Label Methodology October 2012 1

Translating ZERH Value Proposition

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

Front Cover **Inside Spread** **Flap** **Back Cover**

Translating ZERH Value Proposition

Translating ZERH Value Proposition

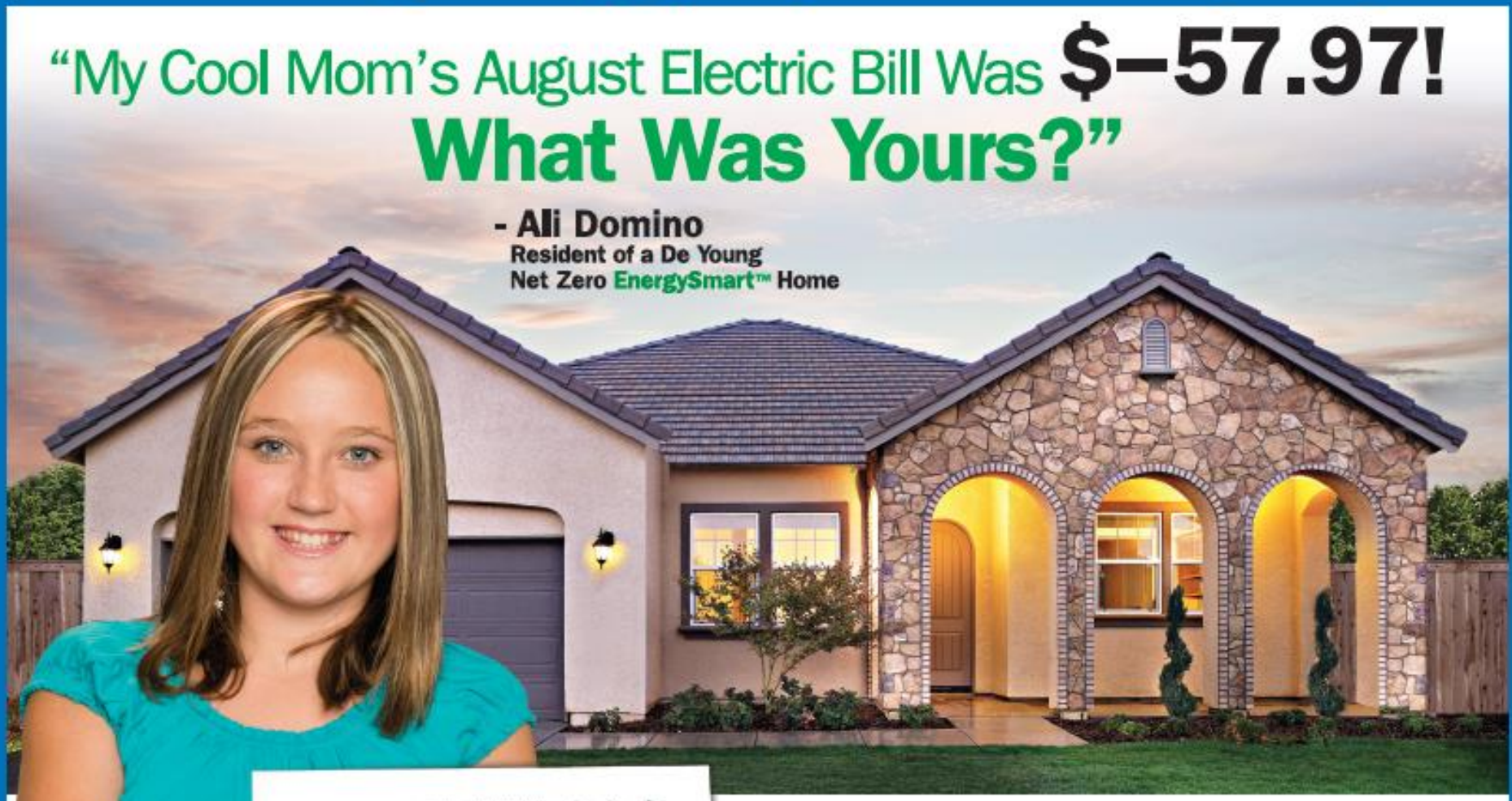
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

de young properties®

The Press Enterprise PEOPLE'S CHOICE Awards 2013

"My Cool Mom's August Electric Bill Was $–57.97! What Was Yours?"

- Ali Domino
Resident of a De Young
Net Zero EnergySmart™ Home




PACIFIC GAS AND ELECTRIC COMPANY
NET ENERGY METERING ELECTRIC STATEMENT

Ali and her mother Leah are enjoying the savings and comfort of their De Young Net Zero EnergySmart™ home. De Young homes,

Translating ZERH Value Proposition

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

Translating ZERH Value Proposition

Compare and Contrast

Backing Up Value Proposition

30-Year Warranty…

Lives Better Warranty

- Lead-Free*
- Asbestos-Free*
- Particulates Filtered to 3 Microns*
- Mold-Free*
- Combustion Safety *
- 100,000+ CF per Day Fresh/Filtered Air*
- VOC-Free*
- Formaldehyde-Free*
- Pest-Free*
- Radon-Free*

Works Better Warranty

- $40/Month Average Heating/Cooling Bill*
- Even Room-by-Room Temperatures*
- No Outdoor Drafts*
- Outside Noise Reduction*
- No Excessive Humidity*

Lasts Better Warranty

- Structural Integrity *
- No Moisture Damage*
- Dry Basements*
- No Thermal Defects*
- 90% UV Sunlight Blocked
- No Window Condensation*
- Roofing
- Siding*
- Windows
- Termite Damage *

Why * in 30-Year Warranty…

- Specified operating conditions
- Specified weather assumptions
- Specified number of occupants
- Specified limitations
- **Requirement for warranty service!**

Zero Energy Ready Home

Business Case

Minimize Cost

NAHB estimates for every **$1,000 increase** in sales price, nearly **250,000 households** fail to qualify for a mortgage on a typical new home.

[http://www.nahb.org/fileUpload_details.aspx?contentTypeID=3&contentID=40372&subContentID=112293]

Maximize Value

with proven innovations
homebuyers have to have once they try them
(e.g., make new housing compelling again).

Innovation/Value Premium Example

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

Willingness to Pay for Valued Services

Price Based on 'Value', NOT Cost

New Revenue

Innovation/Value Premium

Profit

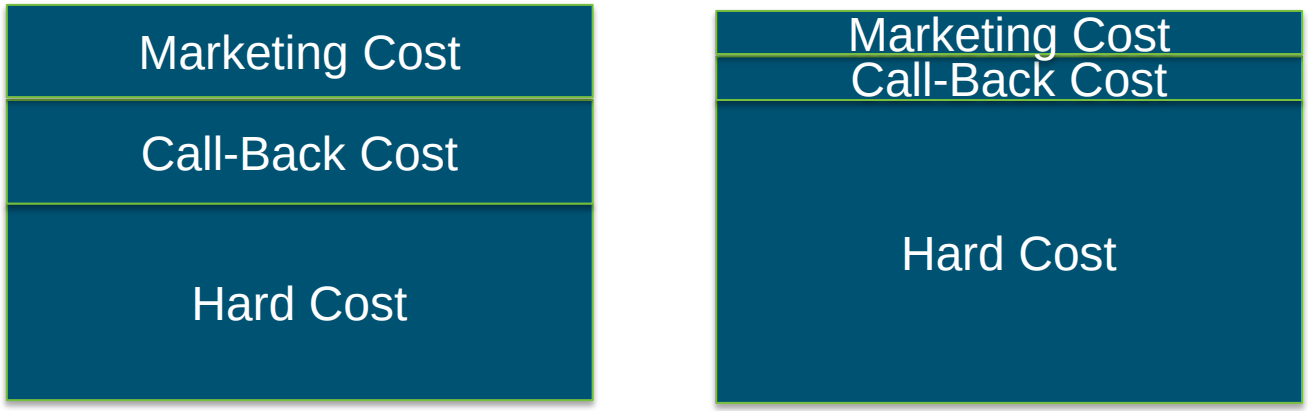
i-Phone Cost

Profit

Old Cell Phone Cost

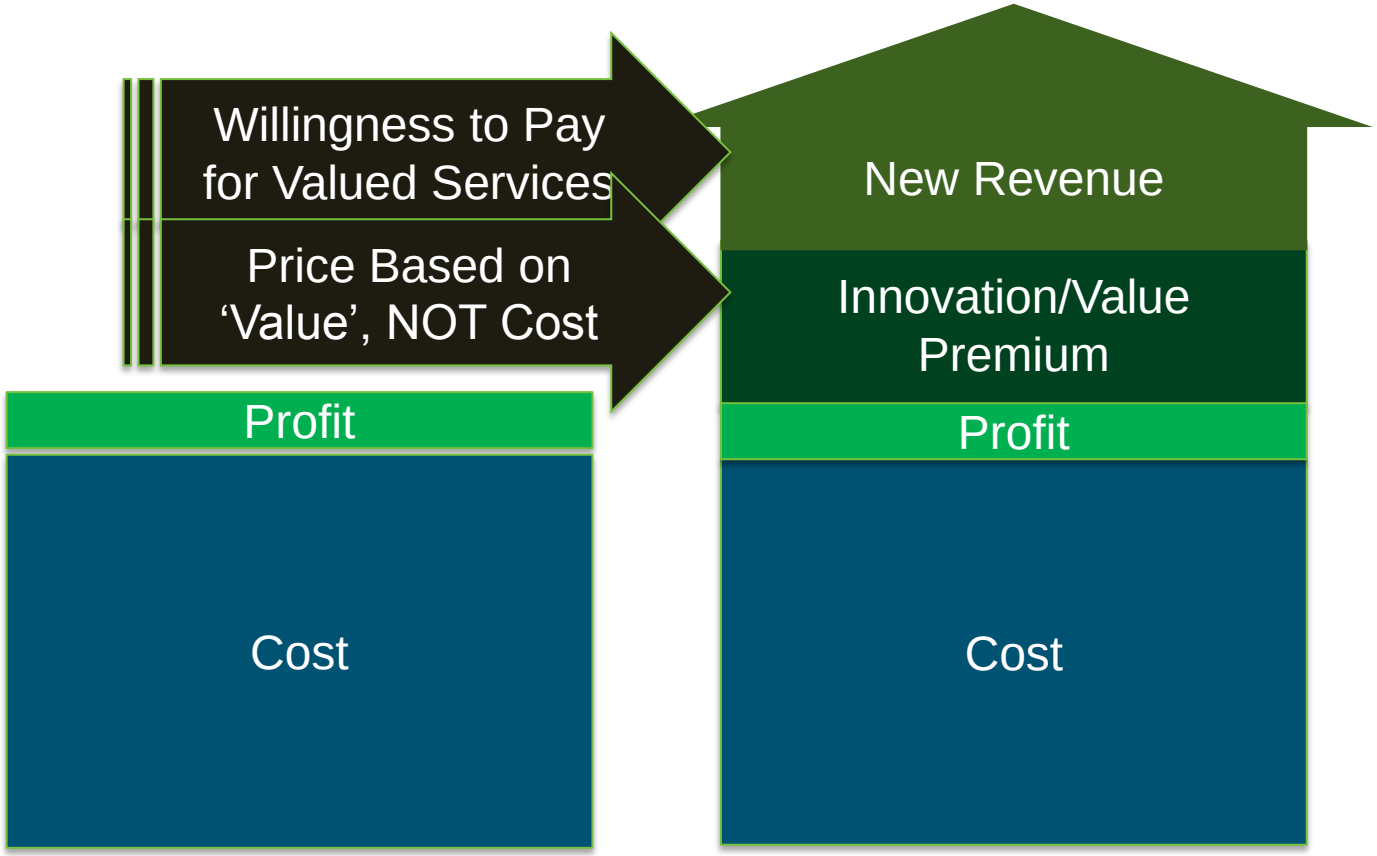
VS.

ZERH Real Cost



Standard Home **VS.** ZERH

ZERH Innovation/Value Premium



Standard Home **VS.** ZERH

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

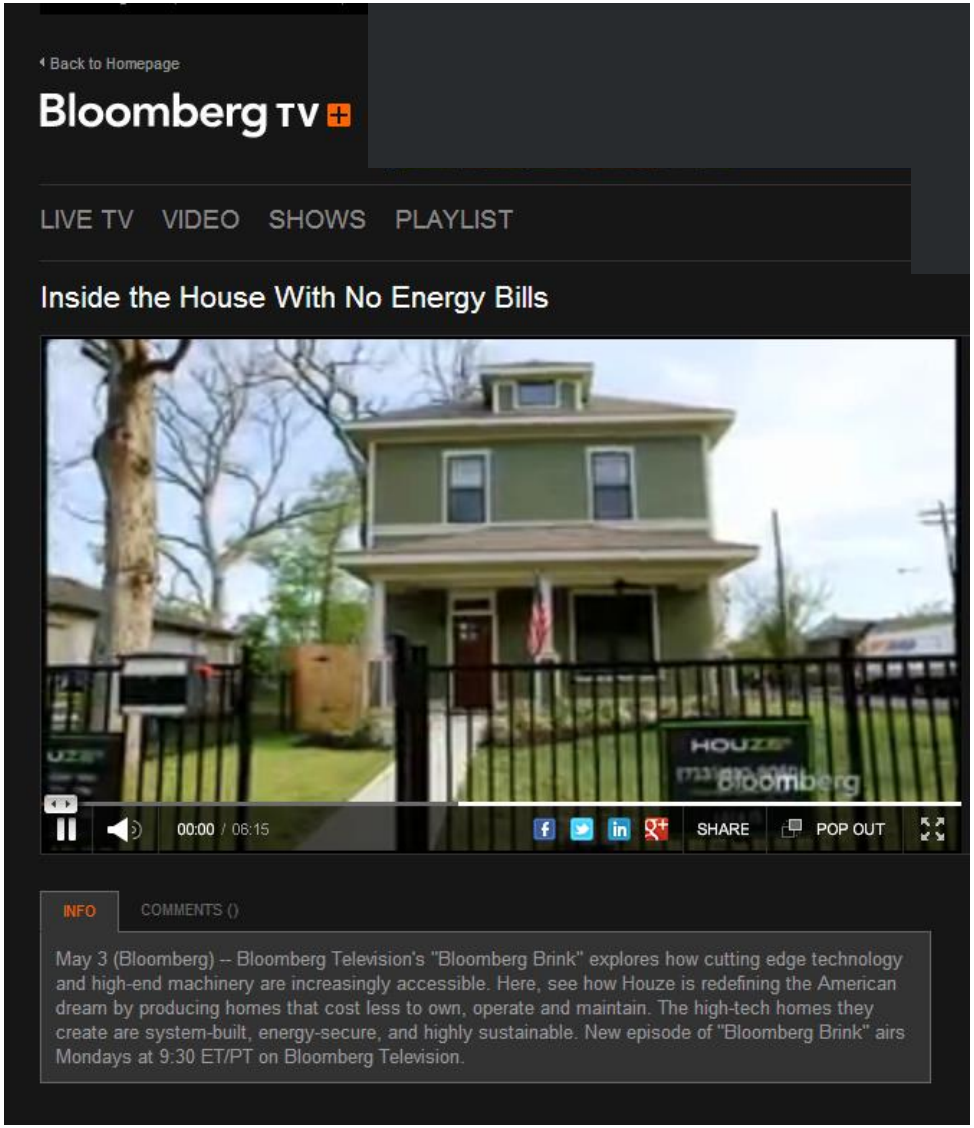
"Becoming more environmentally friendly has been the focus of the country," Moran added. "We want to give people a vision of where we think home building will be in a few years."

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.

Pent-up ZERH Demand



= 8,000 Requests for ZERH

Sensing Pent-up ZERH Demand

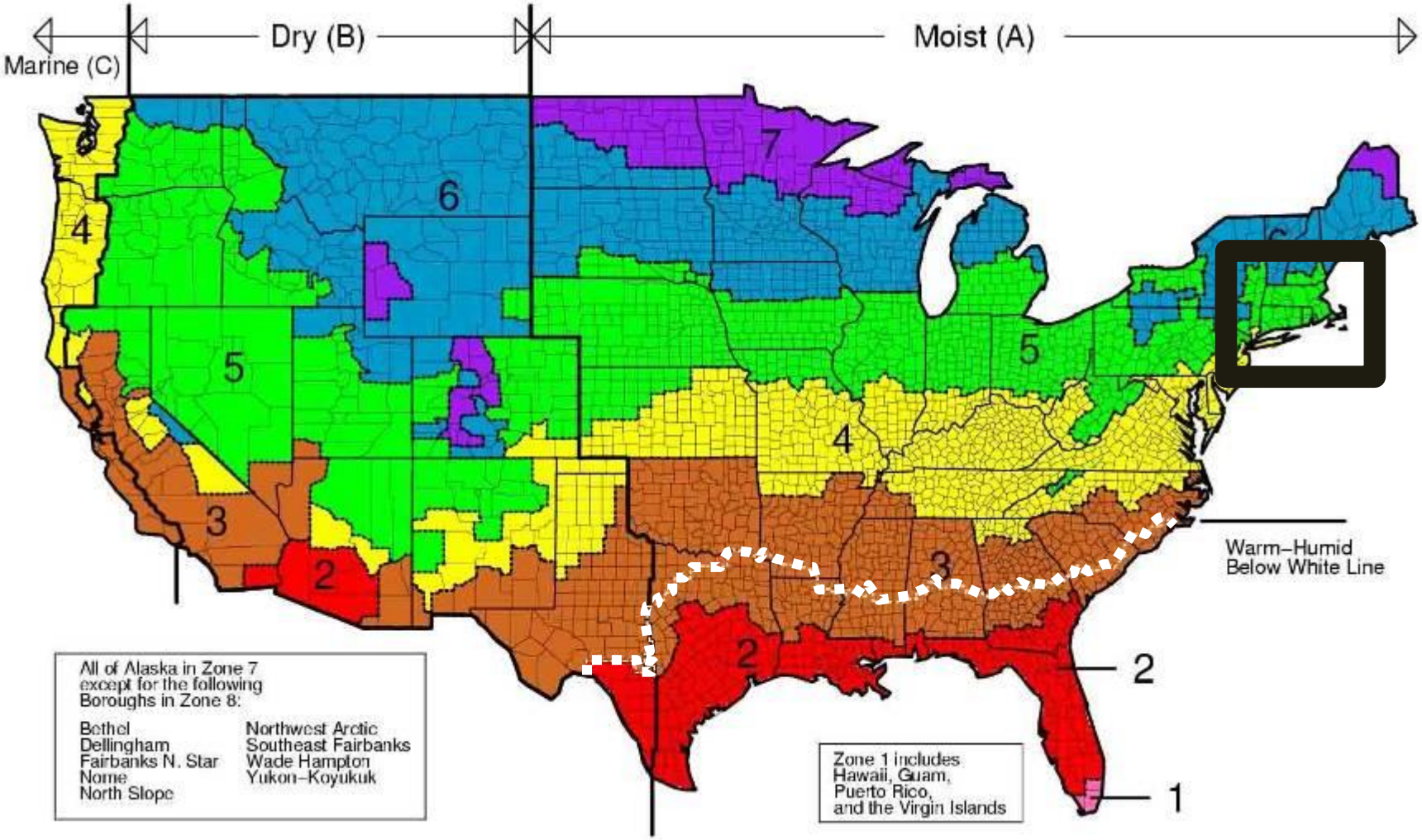
~8,000 → **~1/4**

ZERH's Committed **Staff/Budget/Time**

Zero Energy Ready Home

Technical Specifications

IECC Climate Zones



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[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]

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 Permitted Starting 4/1/2012 | 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

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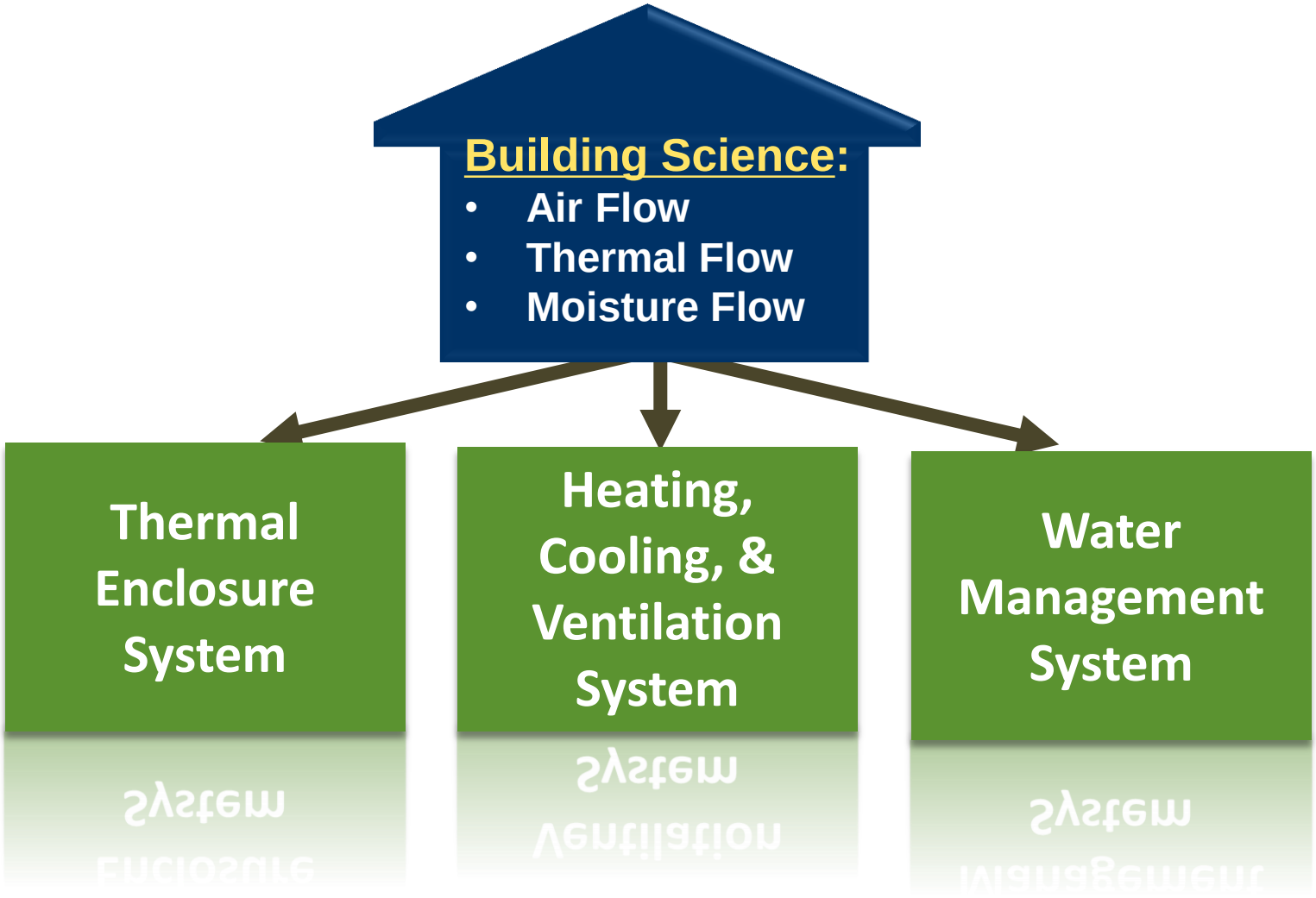
Encouraged:

- 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



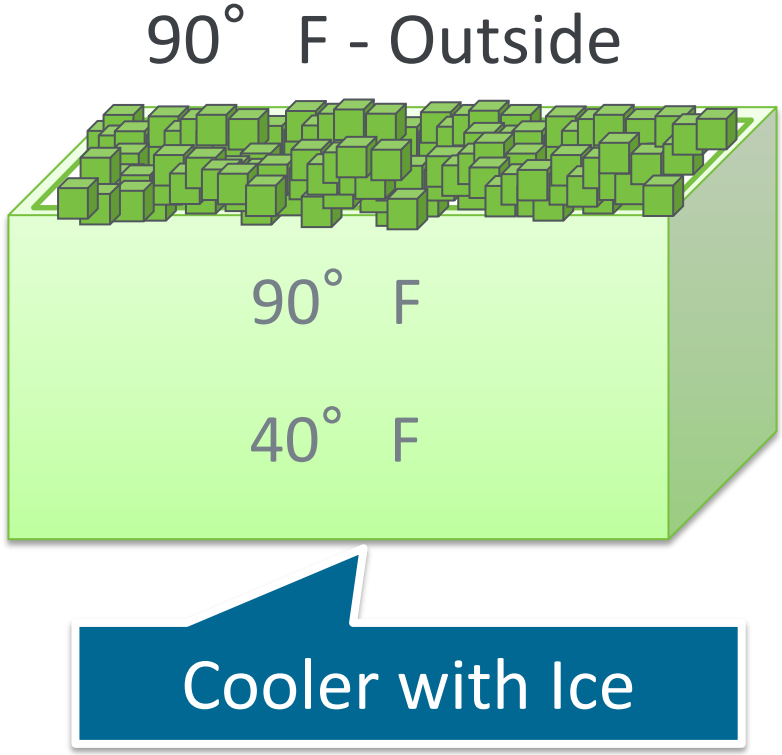
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Thermal Enclosure | Heating, Cooling & Ventilation | Water Management

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

Thermal Enclosure | Heating, Cooling & Ventilation | Water Management

1. Energy moves from more to less.



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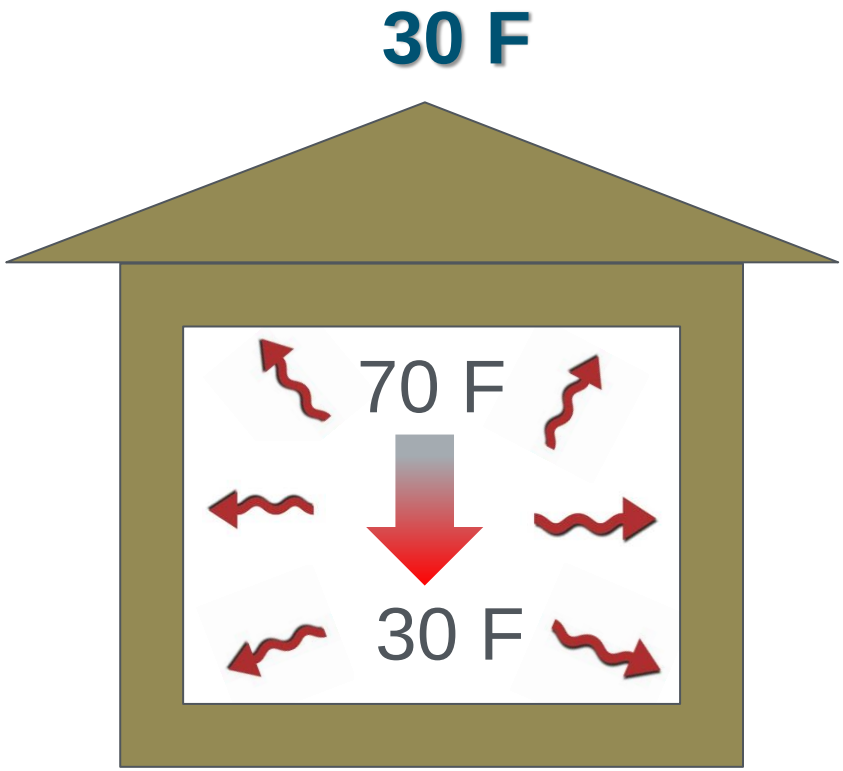


2. Heat Transfer is quantified in British Thermal Units (BTU's)

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

What We're Trying to Avoid

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

Attic air infiltration into the wall

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

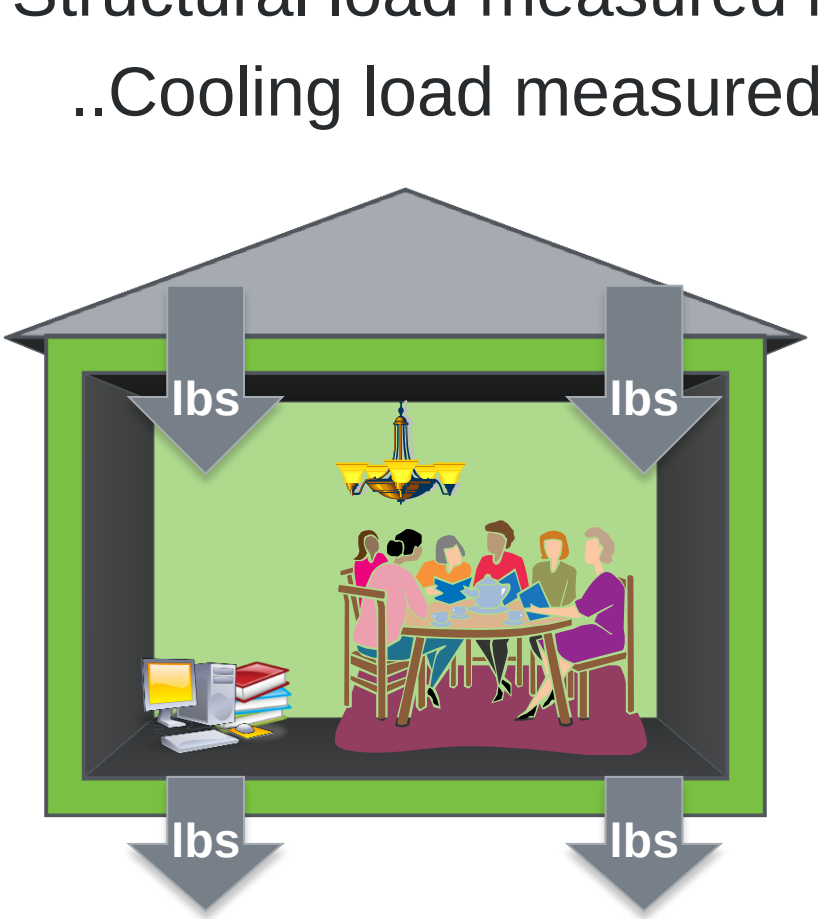
- **Heating and Cooling Equipment**:
  - High efficiency
  - Properly designed and installed
  - Combined with a duct system that's insulated, sealed, and balanced

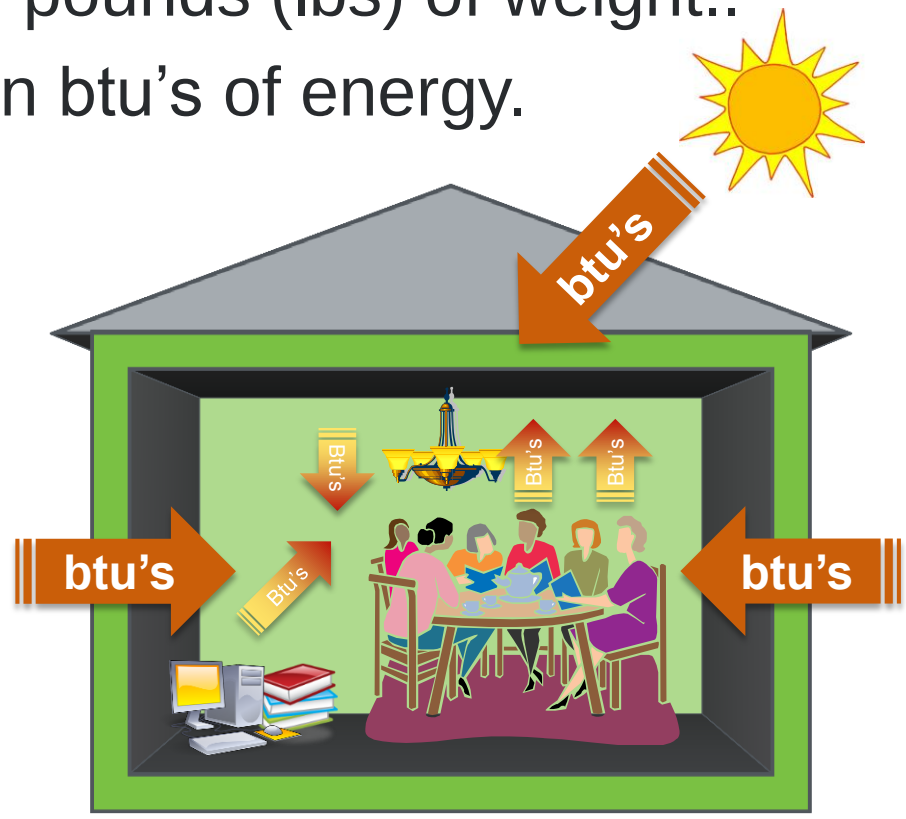
  … Maintain comfort with less energy.
- **Ventilation System:**
  - Remove low-quality air
  - Provide outdoor air
  - Filter contaminants to improve IAQ

Calculating Heating & Cooling Load

Structural load measured in pounds (lbs) of weight..

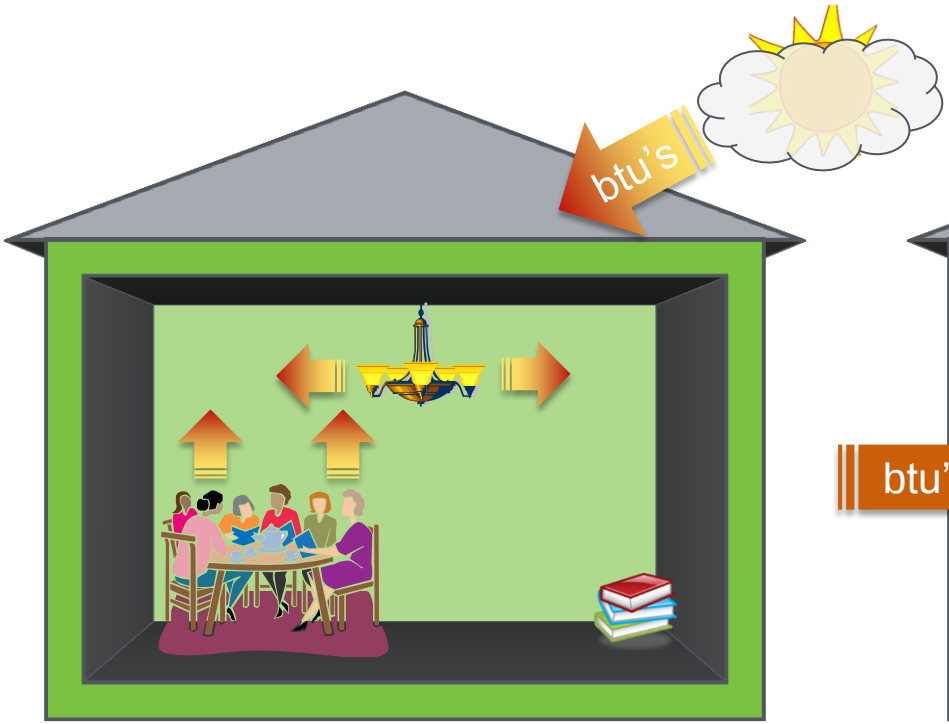
..Cooling load measured in btu's of energy.

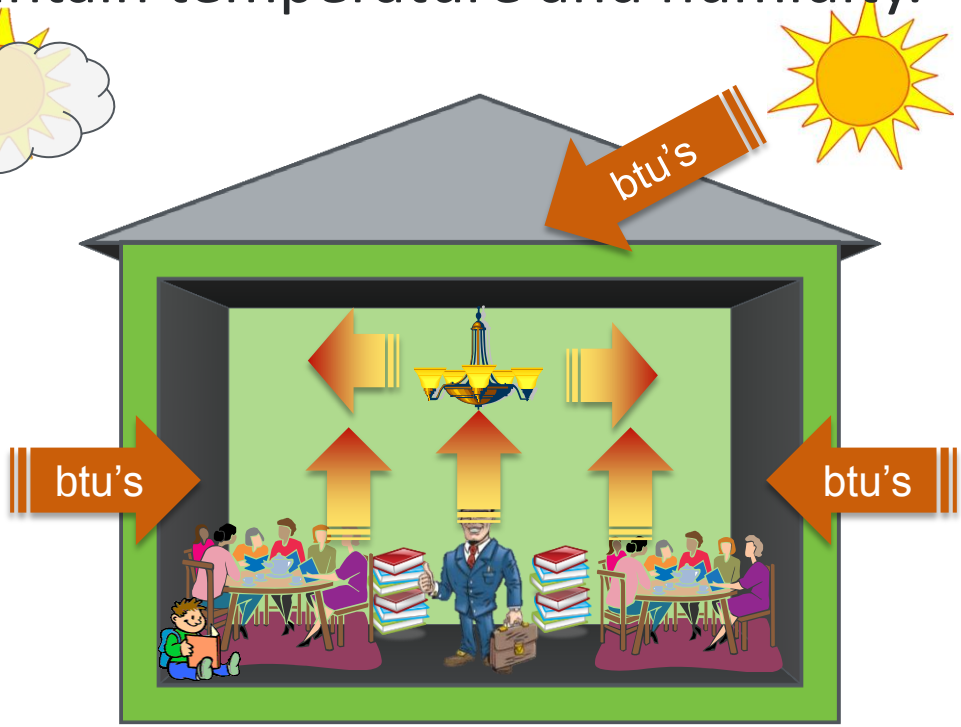




Calculating Heating & Cooling Load

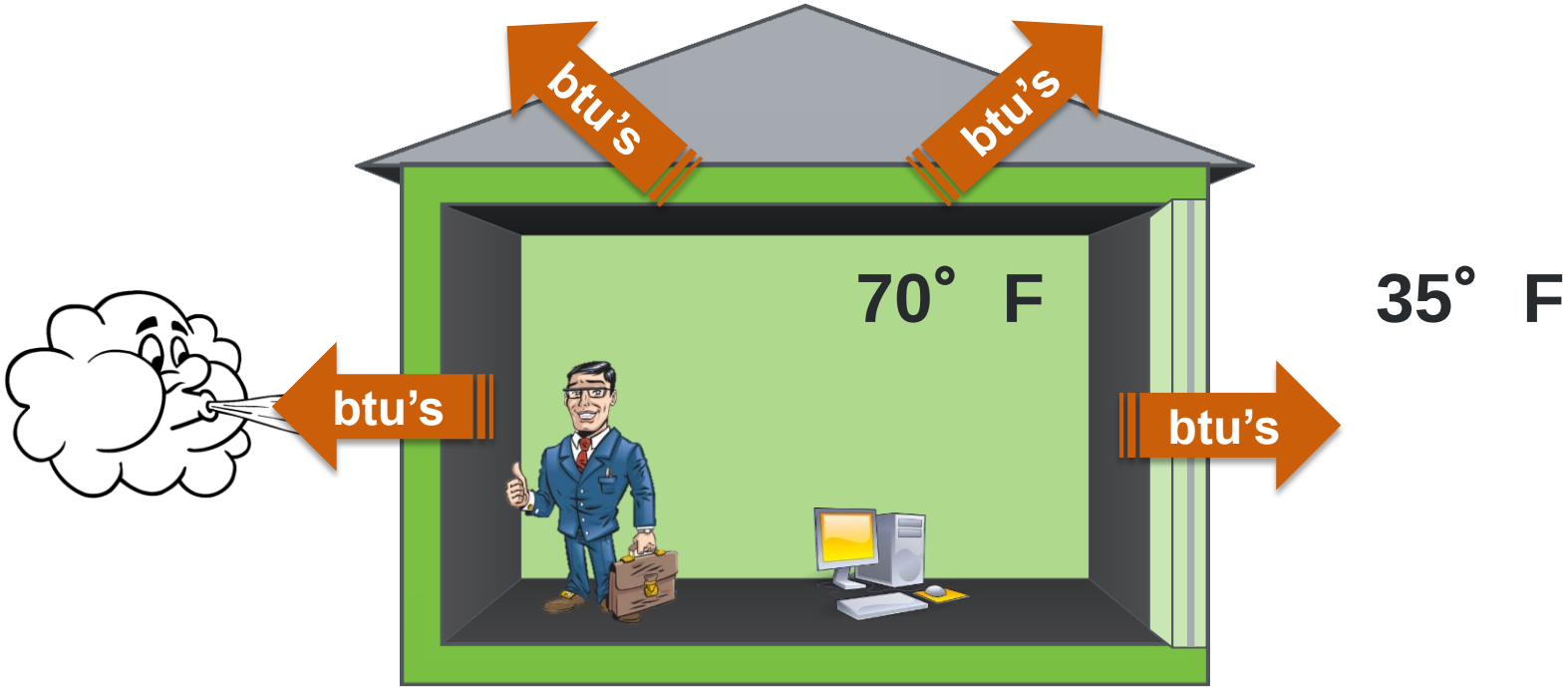
- Cooling Load varies for each hour of the year.
- Cooling Peak Load: Maximum energy added in a single hour, and must be removed to maintain temperature and humidity.





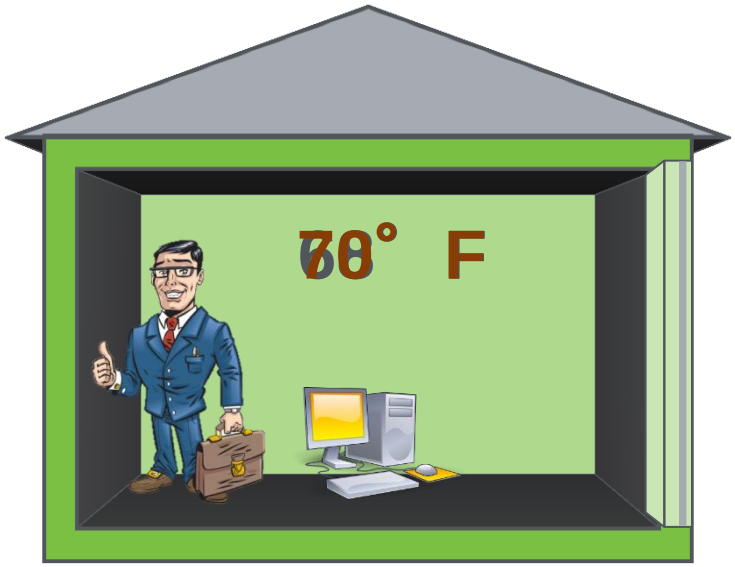
Calculating Heating & Cooling Load

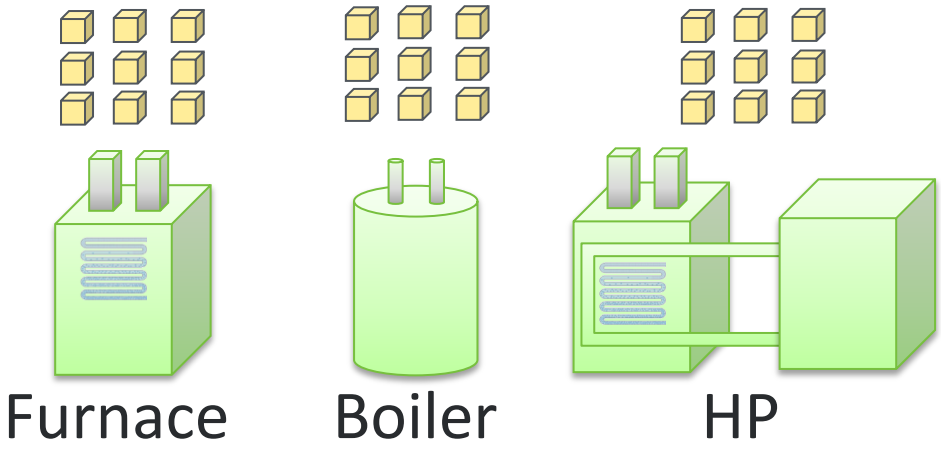
- Heating Load varies for each hour of the year.
- Heating Peak Load: Maximum energy lost in a single hour, which must be added back to maintain temperature.



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

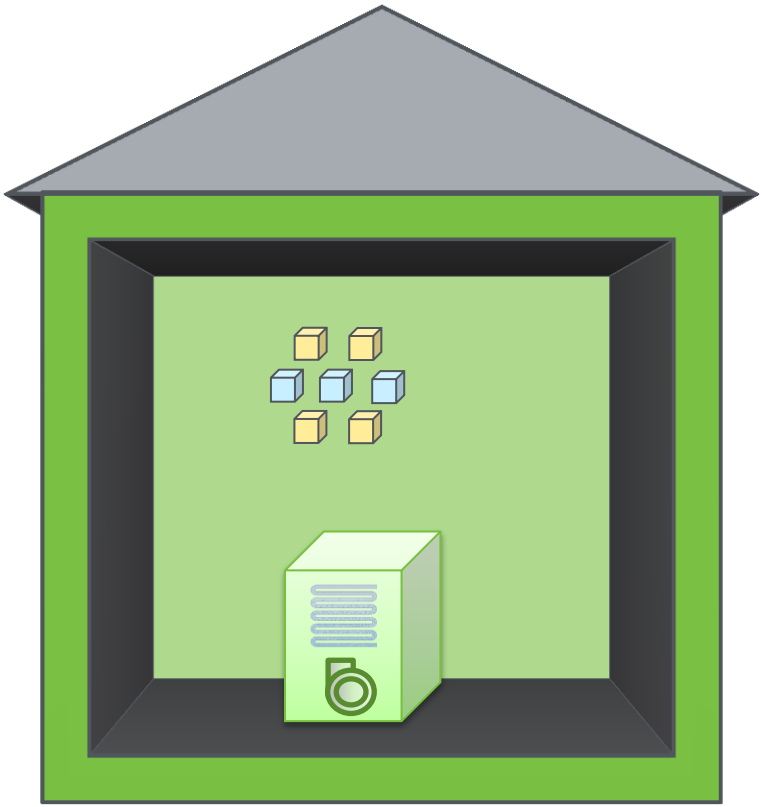
Random Acts of Sizing

HVAC-C (Sect 2); HVAC-R (Sect. 1)

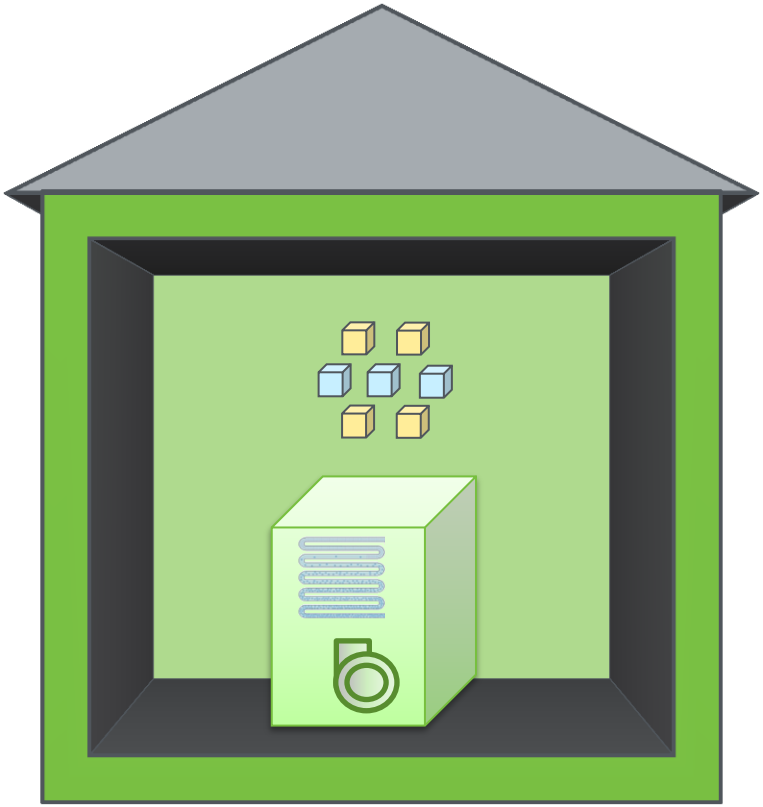
	Input Type	Low Input	Correct Input	High Input	Cooling Load kbtu Low	Cooling Load kbtu High	Cooling Load % Low	Cooling Load % High
Baseline		-	-	-	35.1		-	-
1	Outdoor Design Temperature	103 F	108 F	113 F	32.4	38.0	-8%	8%
2	Home Orientation	N	E	W	31.7	36.1	-9%	3%
3	Number of Occupants	1	4	7	34.4	36.3	-2%	4%
4	Conditioned Floor Area (Sq. Ft.)	2,160	2,400	2,640	33.9	36.3	-3%	3%
5	Window Area (Sq. Ft.)	324	360	396	33.7	36.4	-4%	4%
6	Predominant Window SHGC	0.20	0.30	0.40	32.8	36.4	-6%	4%
Combined Impact From First Six Parameters					**25.1**	**43.0**	**-29%**	**23%**

Select Equipment That Meets Loads

Heating and cooling equipment generally two modes – on & off.



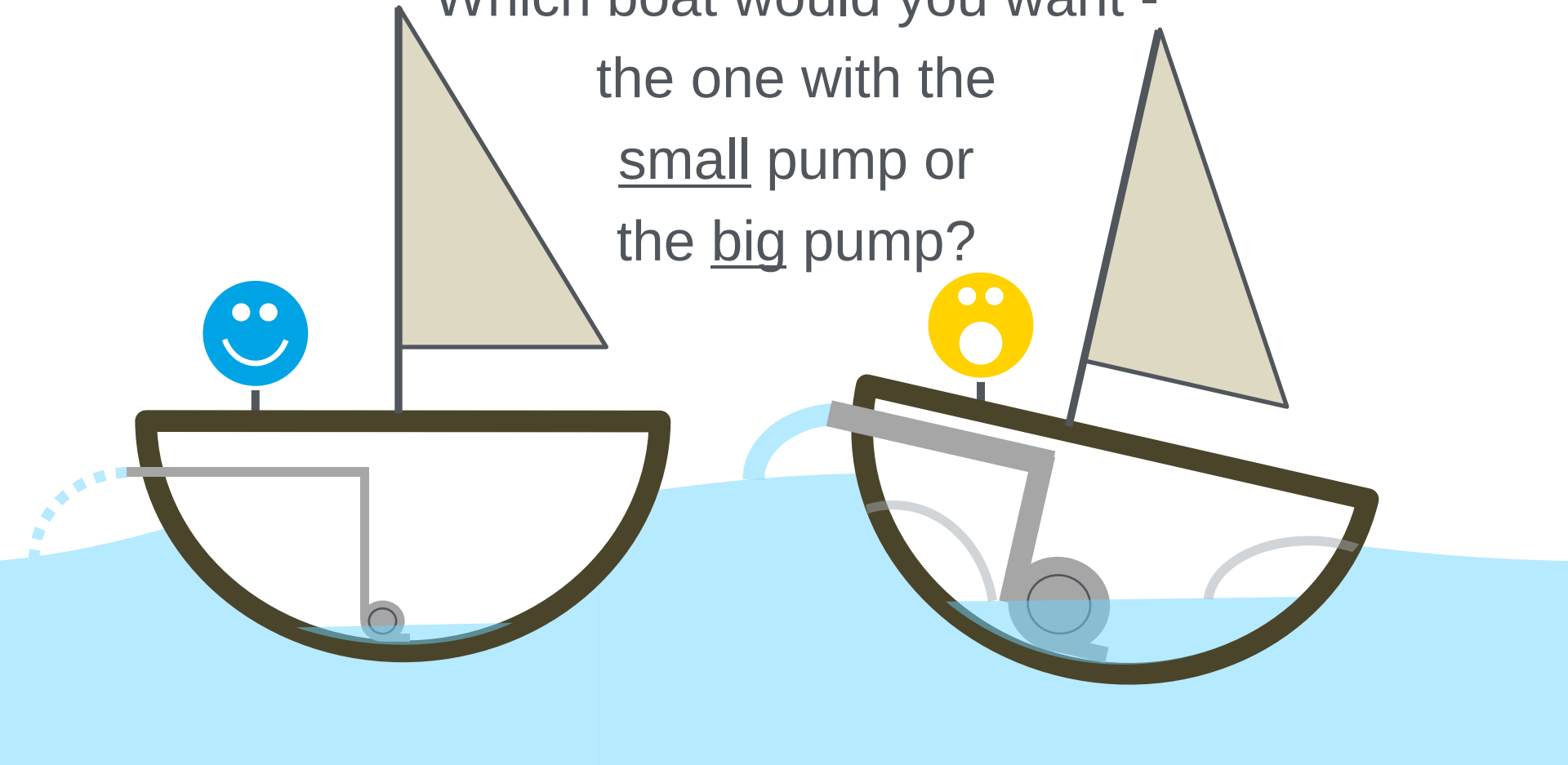
Equipment < Load



Equipment > Load

What We're Trying to Avoid

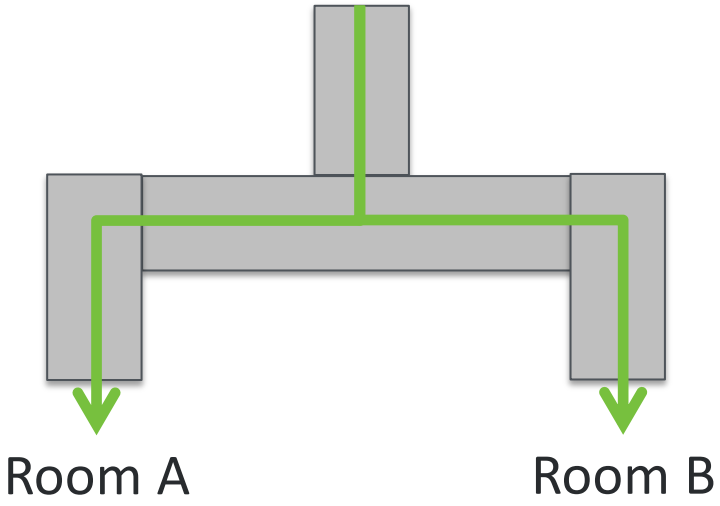
Which boat would you want - the one with the small pump or the big pump?



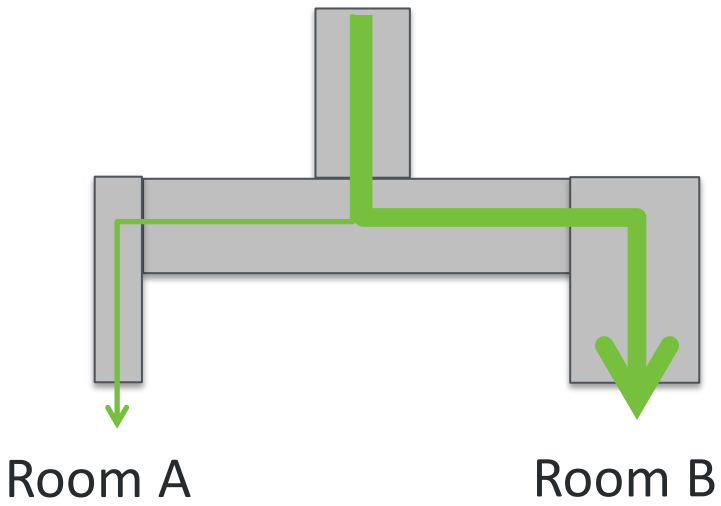
HVAC-C (3.12); HVAC-R (1.2.9)

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

1. Air follows the path of least resistance.



Equal resistance, equal flow

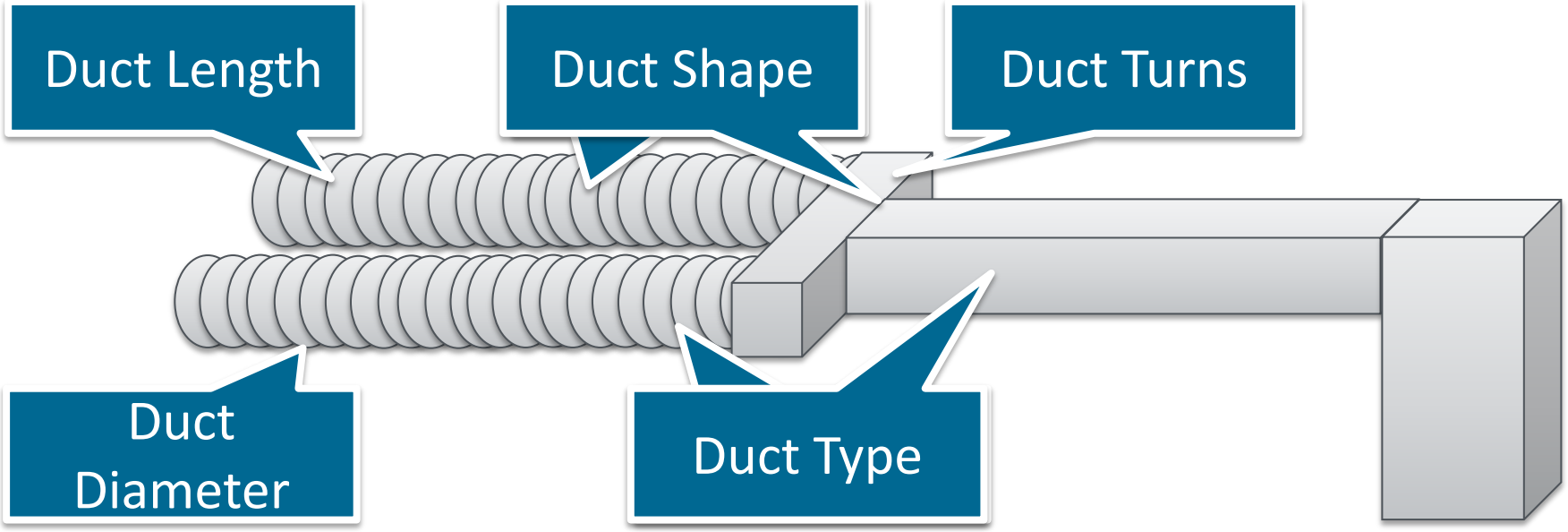


Higher resistance, less flow

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**

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

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

HVAC QI Rater Checklist

Moisture Vapor (Air Flow)

- Air Sealing
- Air Barriers
- Vapor Barriers/Retarders

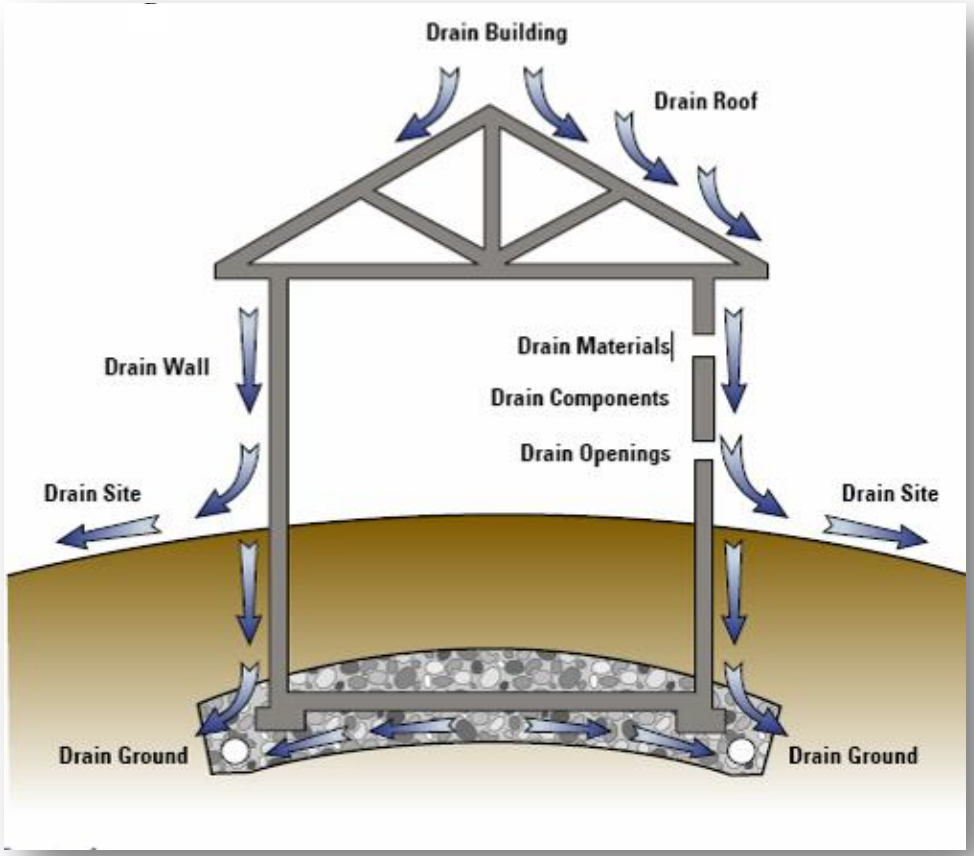
→ Thermal Enclosure Checklist

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

→ HVAC Quality Installation Checklist

Basic Concept

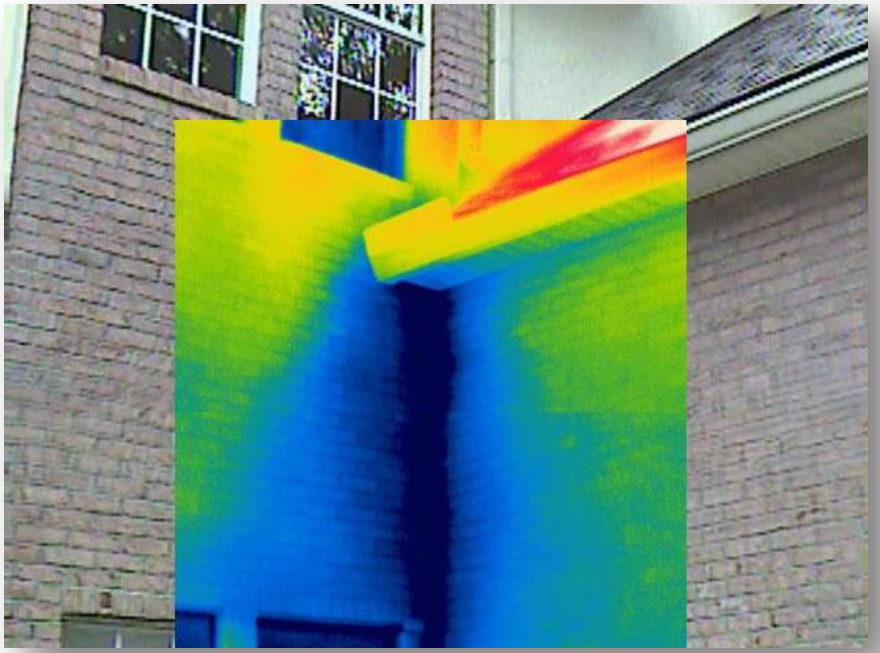
Thermal Enclosure	Heating, Cooling & Ventilation	Water Management



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

- weather resistant barriers
- flashing
- capillary breaks

Water Management Checklist

Thermal Enclosure	Heating, Cooling & Ventilation	Water Management

ENERGY STAR for Homes v3:

- ✓ Thermal Enclosure Checklist
- ✓ HVAC QI Checklist - Contractor
- ✓ HVAC QI Checklist - Rater
- ✓ Water Management Checklist

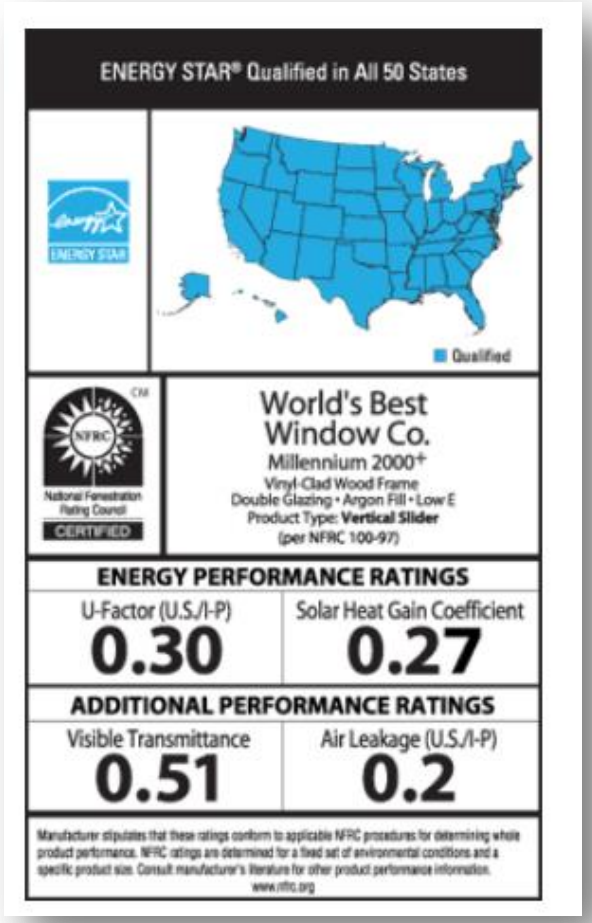
Zero Energy Ready Home

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

Zero Energy Ready Home

Technical Specifications: Best Practices Super 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	**DOE Challenge 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

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Penetrations:

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

Shafts:

- Flues
- Ducts
- Plumbing

Cracks:

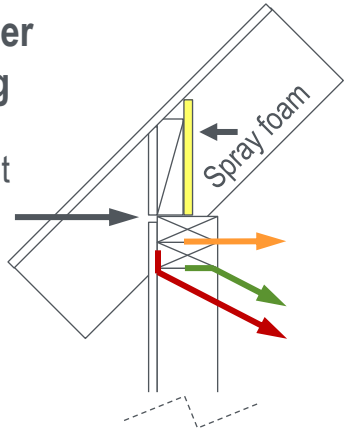
- Sill Plates
- Windows & Doors
- Drywall at Top Plate
- Access Panels
- Sheathing Joints
- Foundation/Framing

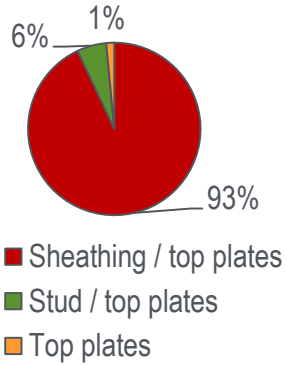
Air Leakage Distribution

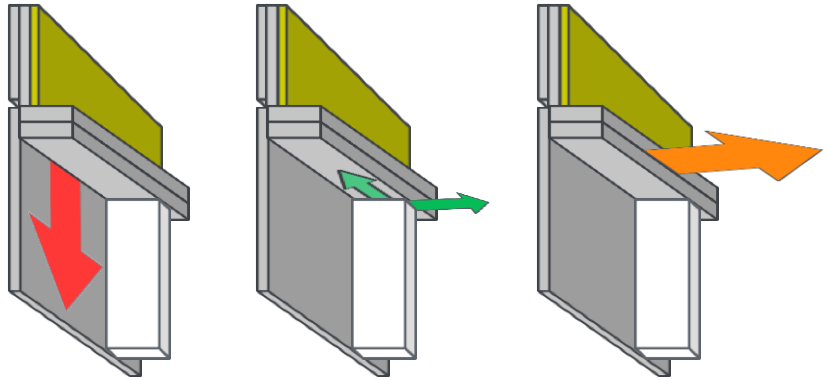
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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 Sealing with Aerosol

You've probably seen this:

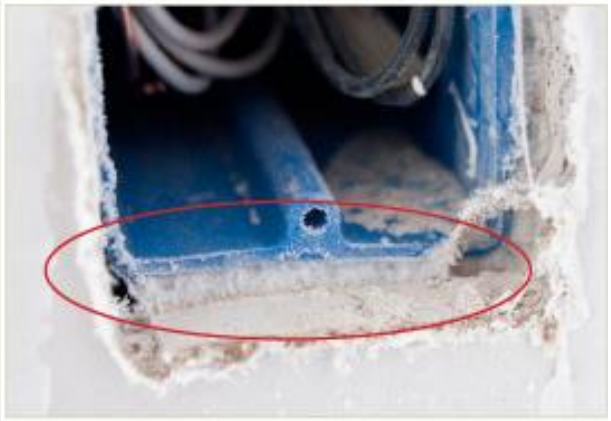
AEROSEAL
Duct Sealing From The Inside

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 monitori 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]

Climate Zone 5:

Walls: R-20 or R-13+5

Ceiling: R-49

Floor: R-30

Basement: R-15/19

Crawl Space: R-15/19

Slab: R-10 for 2 ft. depth

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

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

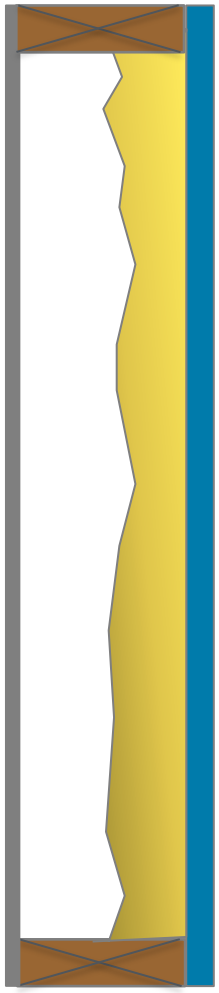
Rigid Insulation w/Sheathing

- 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 Patented 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

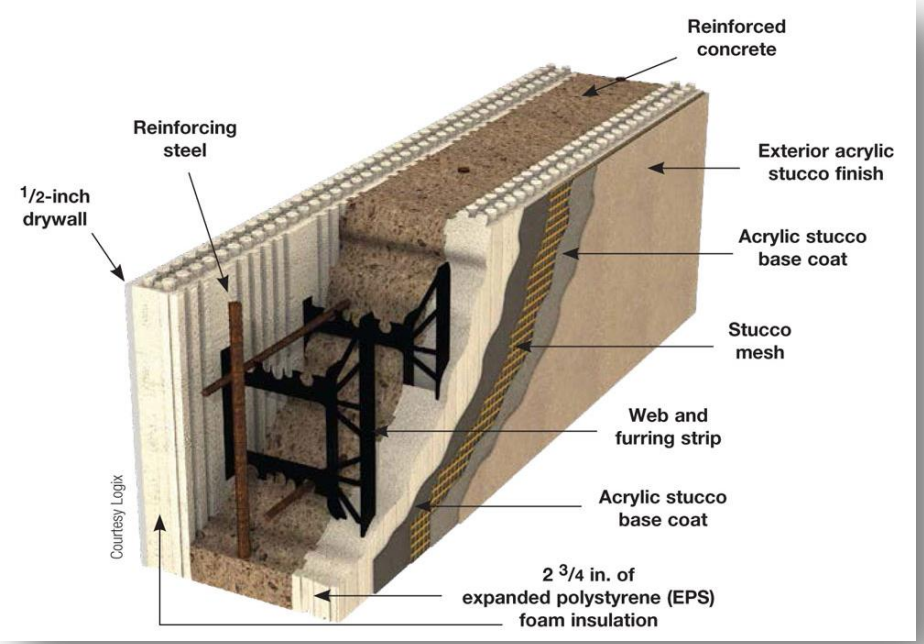
- R-18 Wall
- 2x4 Studs with 2x6 Plates
- Sheathing Attached to Plates for Near Full Racking Strength
- Complete Thermal Break Except for Top and Bottom Plates
- Condensation Surface Inside Assembly, so Must Control Air Flow
- Much Easier Installation of Cladding

Structural Insulated Panels (SIPs)

- R-20 Walls (6”)
- Substantial Thermal Break (5 – 8% Framing Factor)
- Special Construction Practices Required
- Foundation has to be Perfectly Level
- Significantly Reduced Time-of-Construction
- Reduced Dimensional Variation Corrections

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



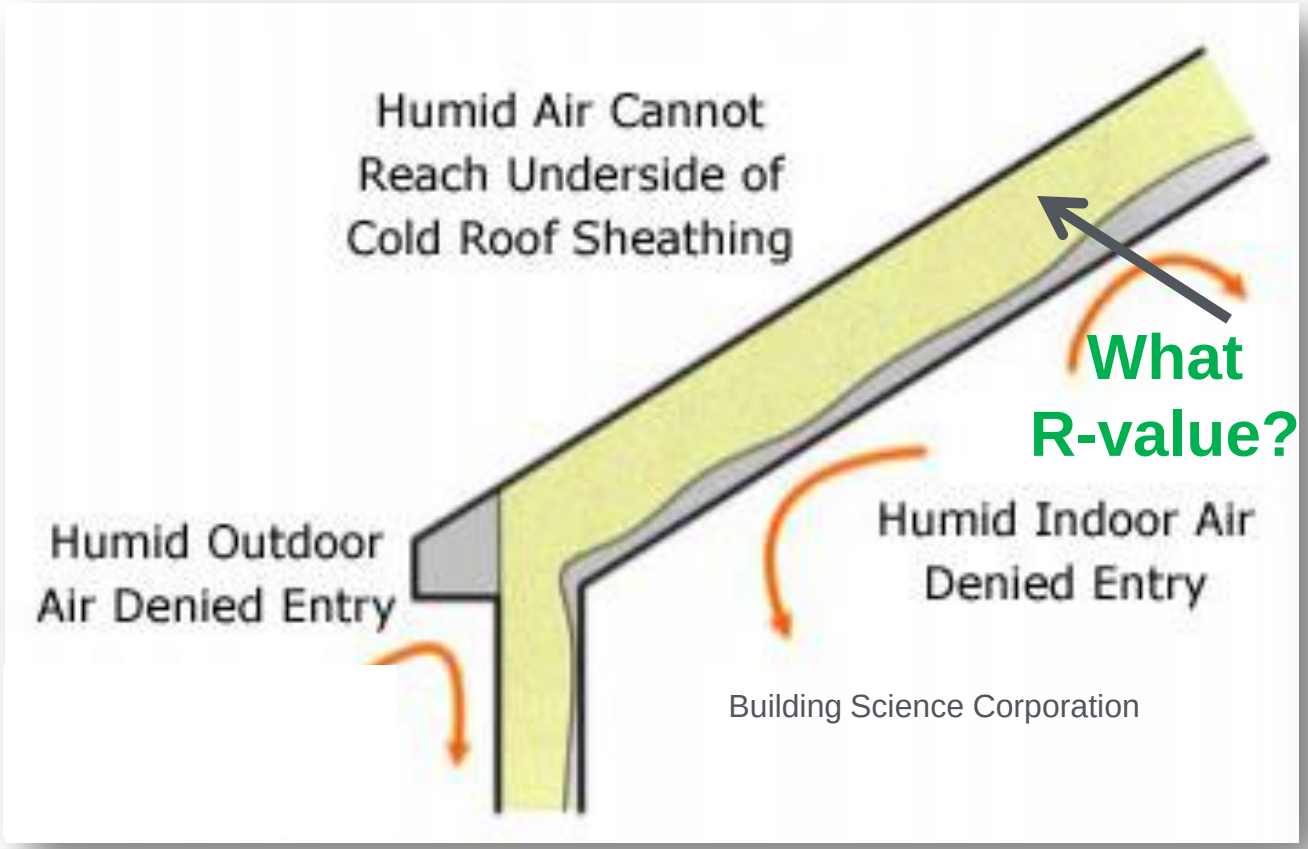
Double-Wall

- 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

Zero Energy Ready Home
High-R Roofs

Air Impermeable Insulation

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



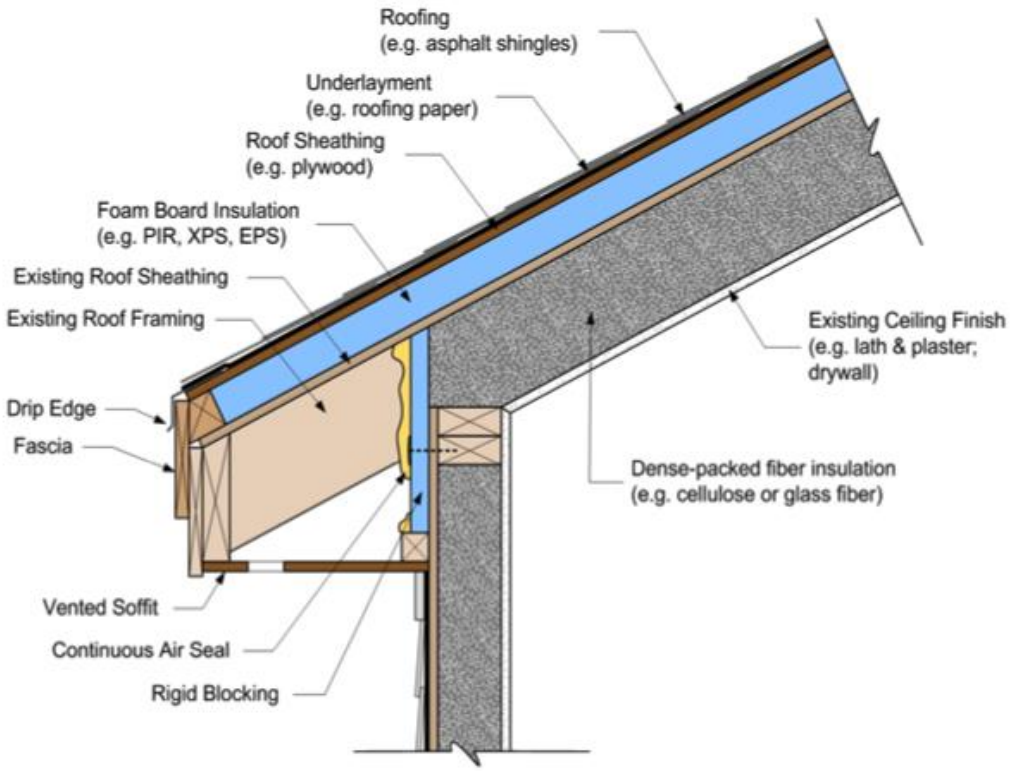
Minimum R-value of Impermeable Insulation

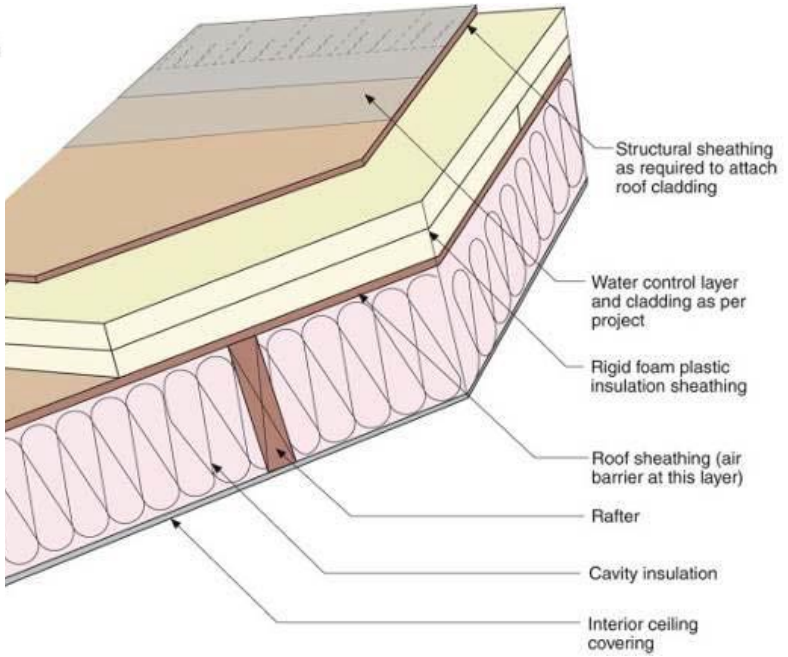
Climate Zone	Minimum Impermeable Insulation R-Value*	2012 IECC Ceiling R-Values
2B and 3B Tile Roof	None Required	30
1, 2A, 2B, 3A, 3B, 3C	R-5	38
4C	R-10	38
4A, 4B	R-15	49
5	R-20	49
6	R-25	49
7	R-30	49
8	R-35	49

*contributes but doesn't supersede 2012 IECC insulation requirements

Top Insulated Roof Deck

Building Science Corporation





Sequence of Retrofit:

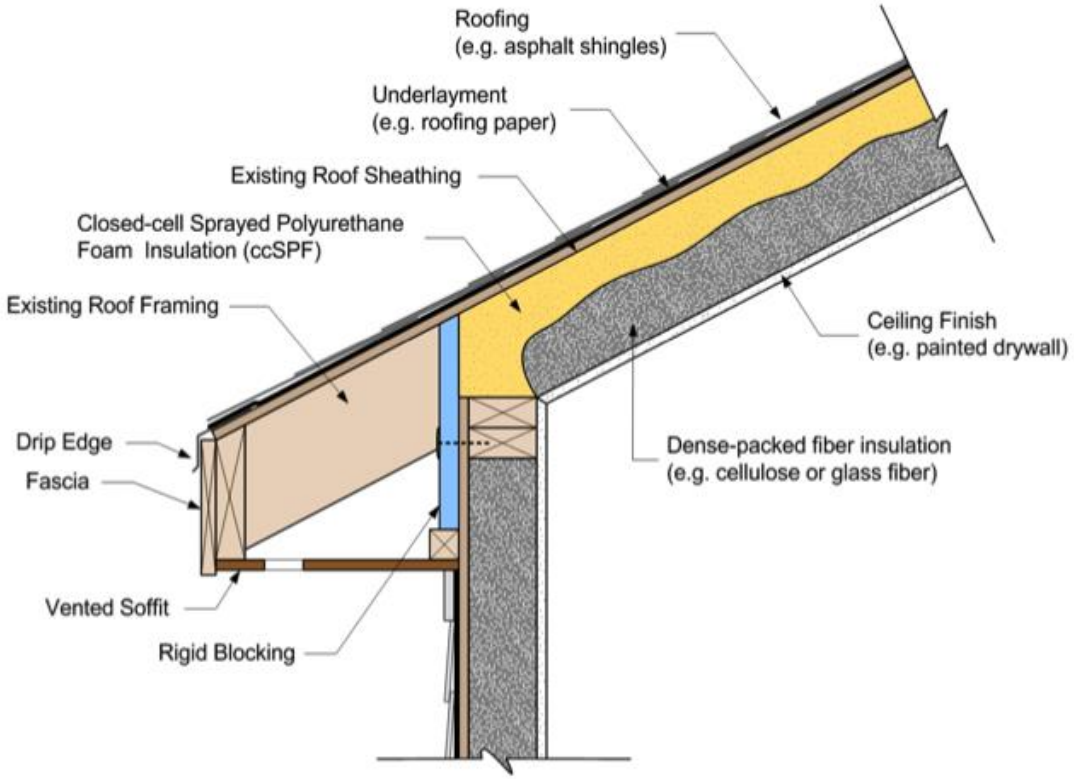
1) Remove existing roofing and underlayment; Inspect existing roof deck and framing and repair as necessary.

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



Sequence of Retrofit:

1) If keeping existing roofing, identify and repair any roof leaks prior to proceeding with retrofit; Otherwise, remove existing roofing and underlayment; Inspect existing roof deck and framing and repair as necessary.

2) Remove existing soffit and install rigid blocking to prevent loose-fill fiber insulation from blowing into soffit; Replace soffit.

3) Remove existing ceiling and insulation (if any) and install ccSPF insulation directly to underside of roof deck; Create air seal at bottom of cavity space by ensuring that foam seals to top plates, blocking, framing and roof deck.

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 Spray Foam Under Roof Decks

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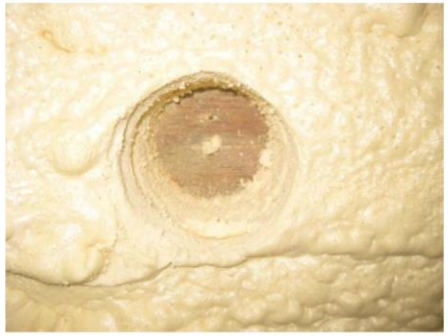


Description
- Built 2009
- Cathedralized attic
- R21 - ~3.5" ccSPF below OSB roof sheathing

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

bsc Building Science Corporation

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

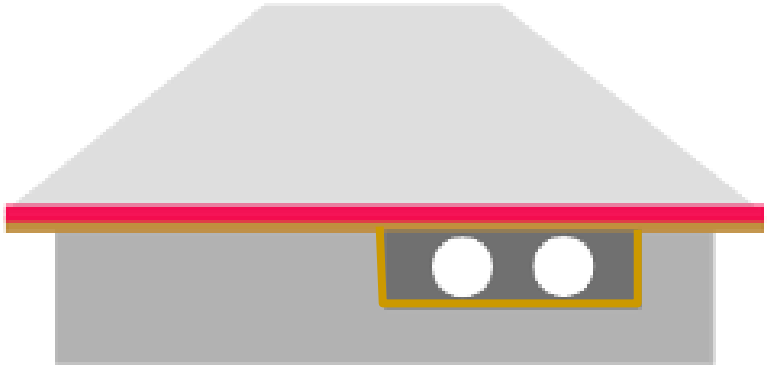
Ducts in Condit. Space Exemptions

- **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

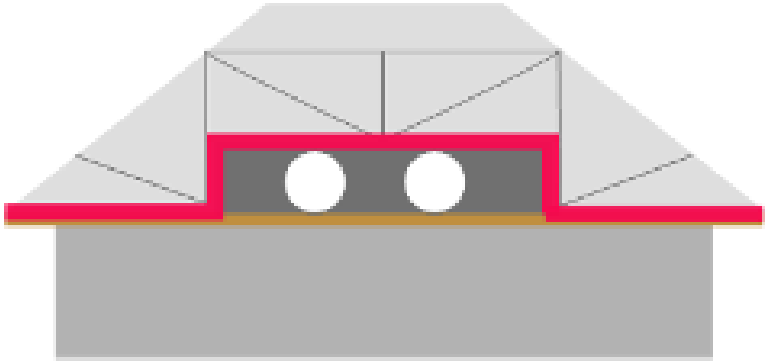


Ducts in dropped ceiling

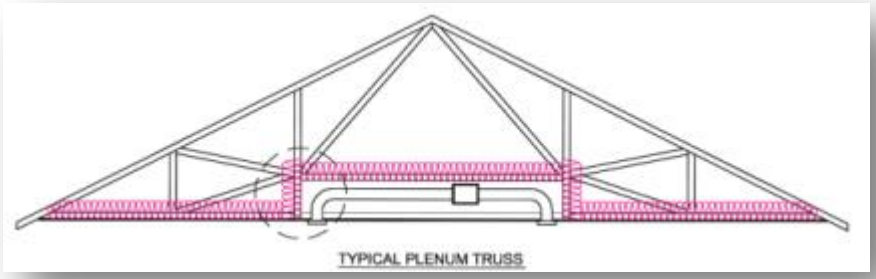
Issues:

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

Ducts in Conditioned Floor Space Option 2: Modified Attic Truss



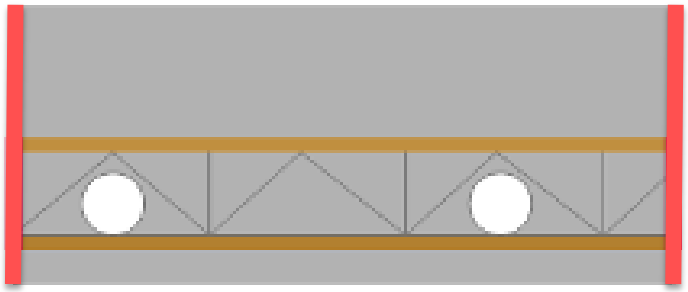
Ducts in modified truss in attic



Issues:

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

Ducts in Conditioned Floor Space Option 3: Ducts Between Floors

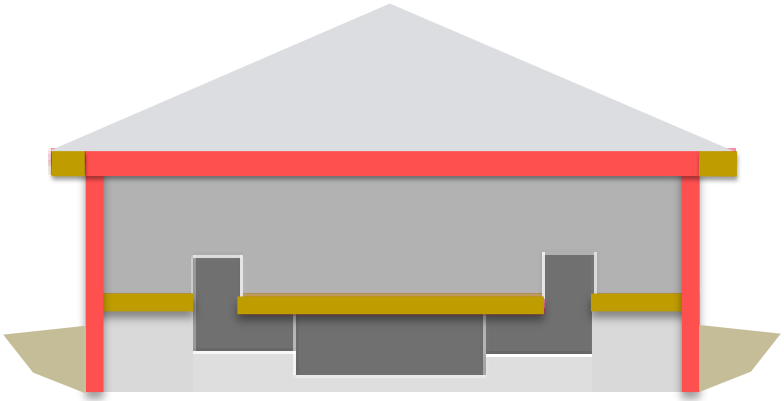


Ducts between floors

Issues:

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

Unvented Crawl Space/Basement



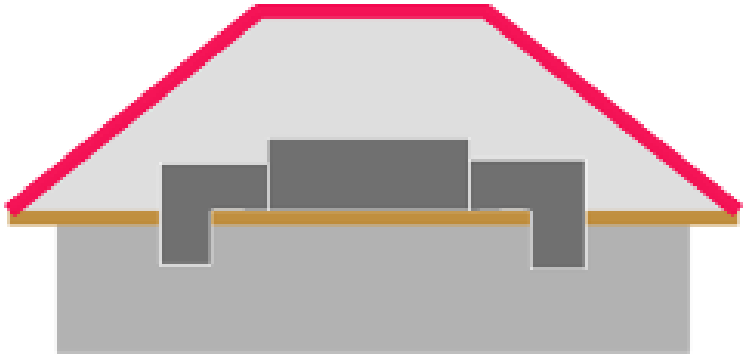
Ducts in unvented crawl space or basement

Issues:

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

Insulation at Walls

Ducts in Unvented Attic

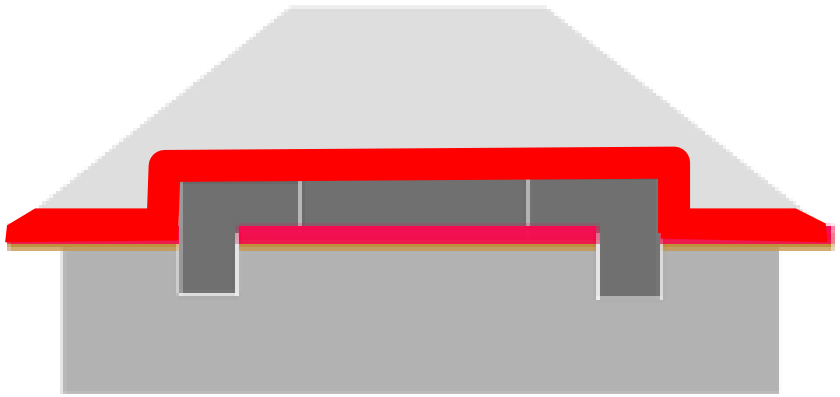


Ducts in unvented attic

Issues:

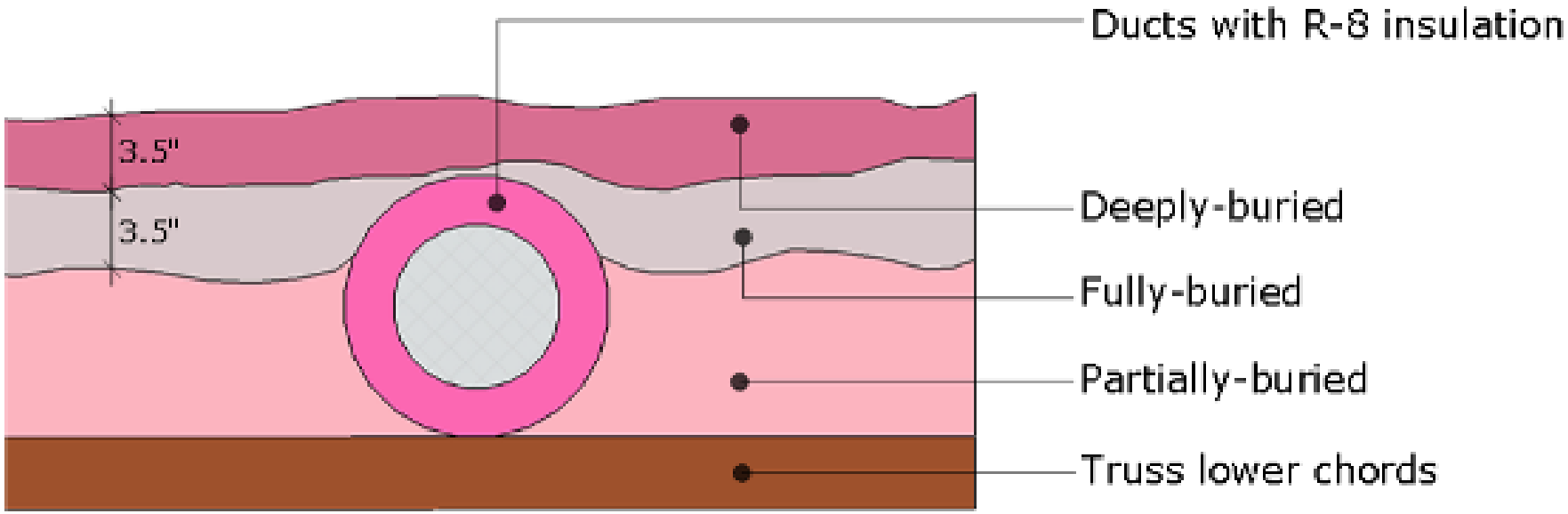
- CZ 5+, air impermeable plus a Class II VT or Class III VT in direct contact
- No Class I VR on attic floor

Ducts in Vented Attic: Dry CZs



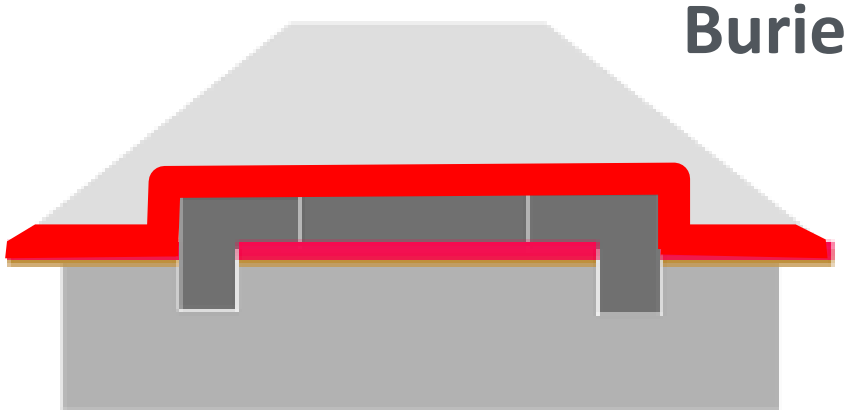
Ducts in vented attic

Buried Ducts

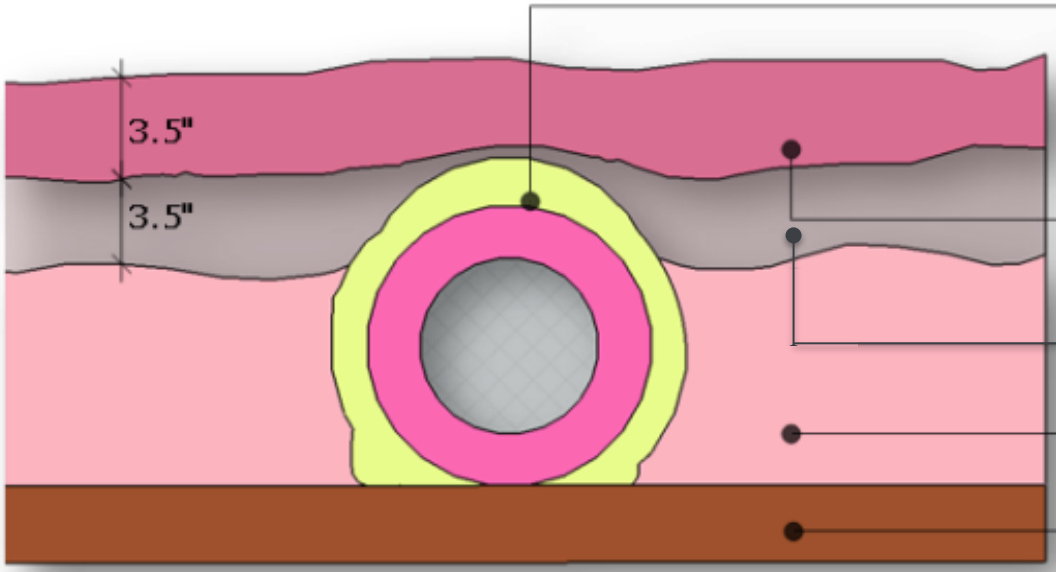


Ducts in Vented Attic: Humid CZs

Buried Encapsulated Ducts (BEDs)



Ducts in vented attic



Ducts with R-8 insulation encapsulated in 1.5 in of ccSPF

Deeply-buried = R-31

Fully-buried = R- 25

Partially-buried

Truss lower chords

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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

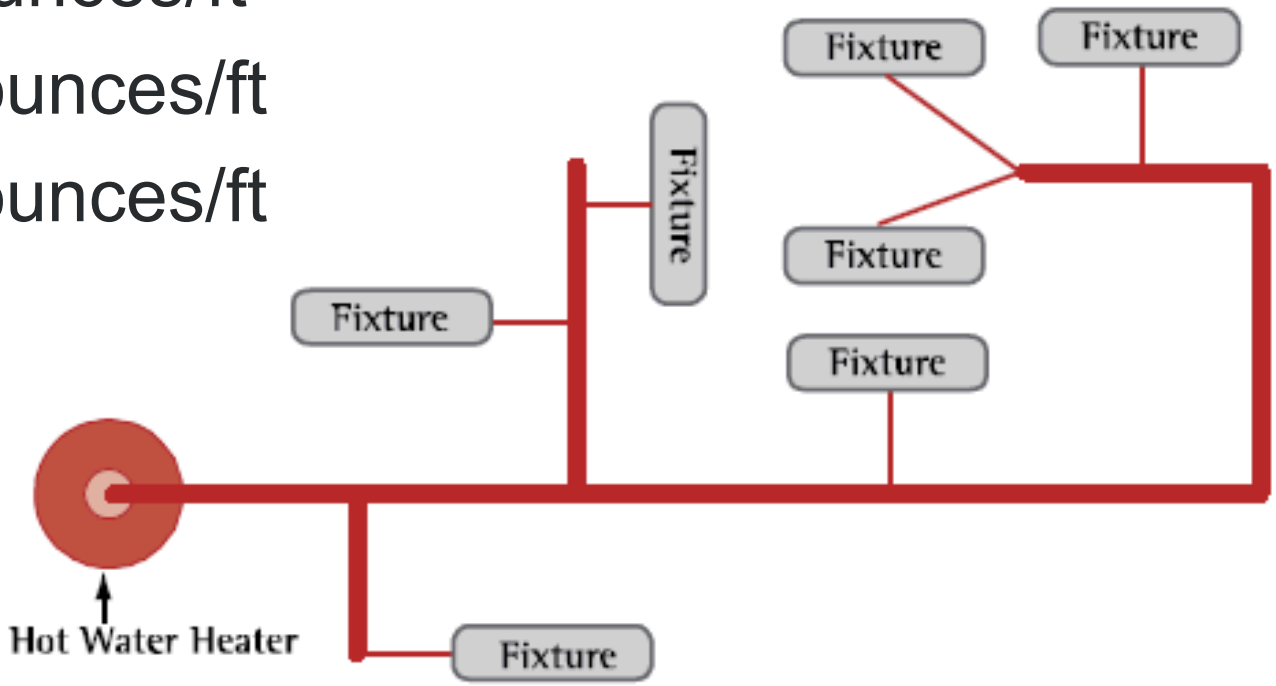
Stored Volume: 1.6 gallons

30’ tank

10’ branch

3 twig

2 GPM showerhead

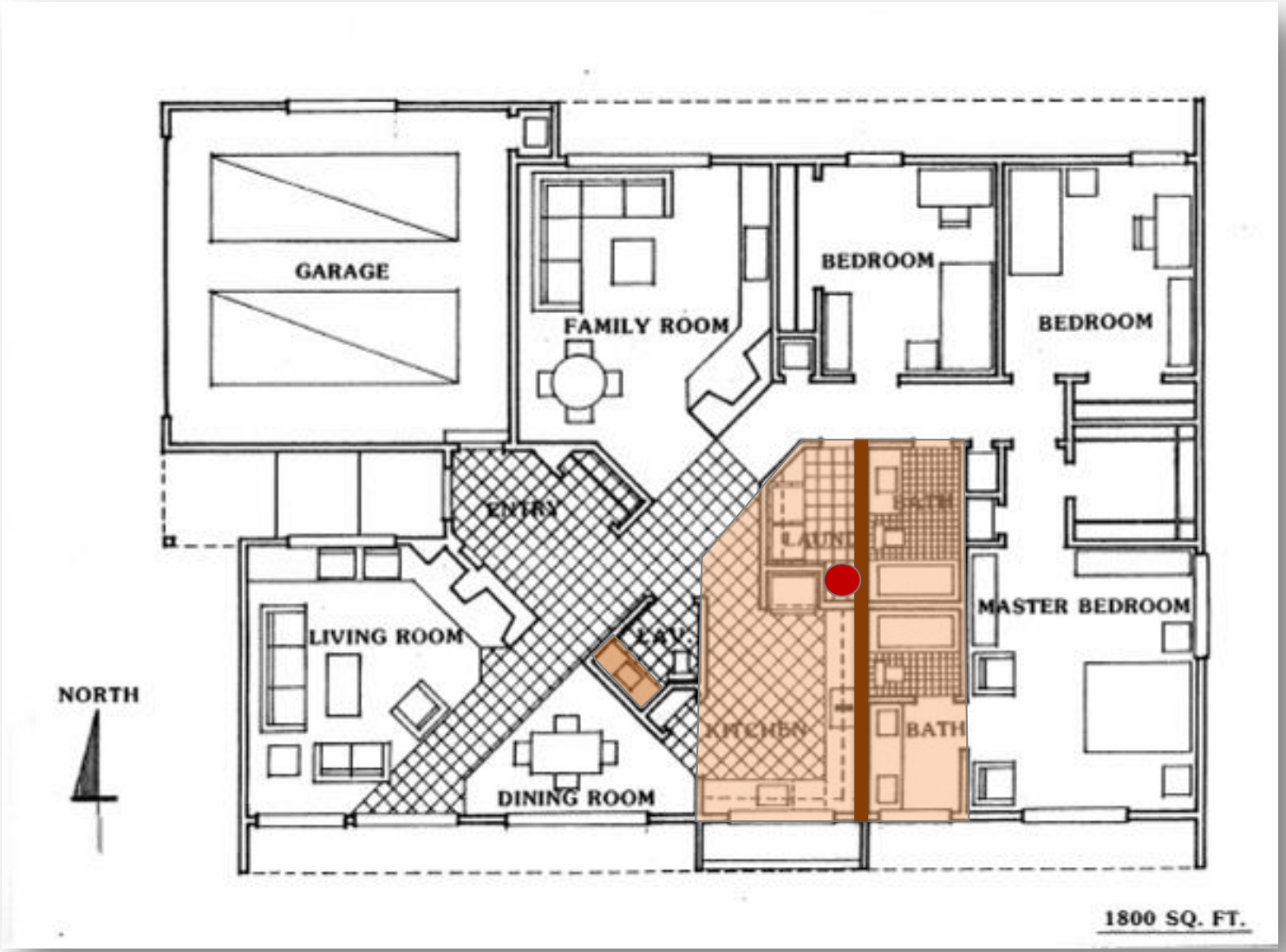


Wait Time: 1 – 1.5 minutes

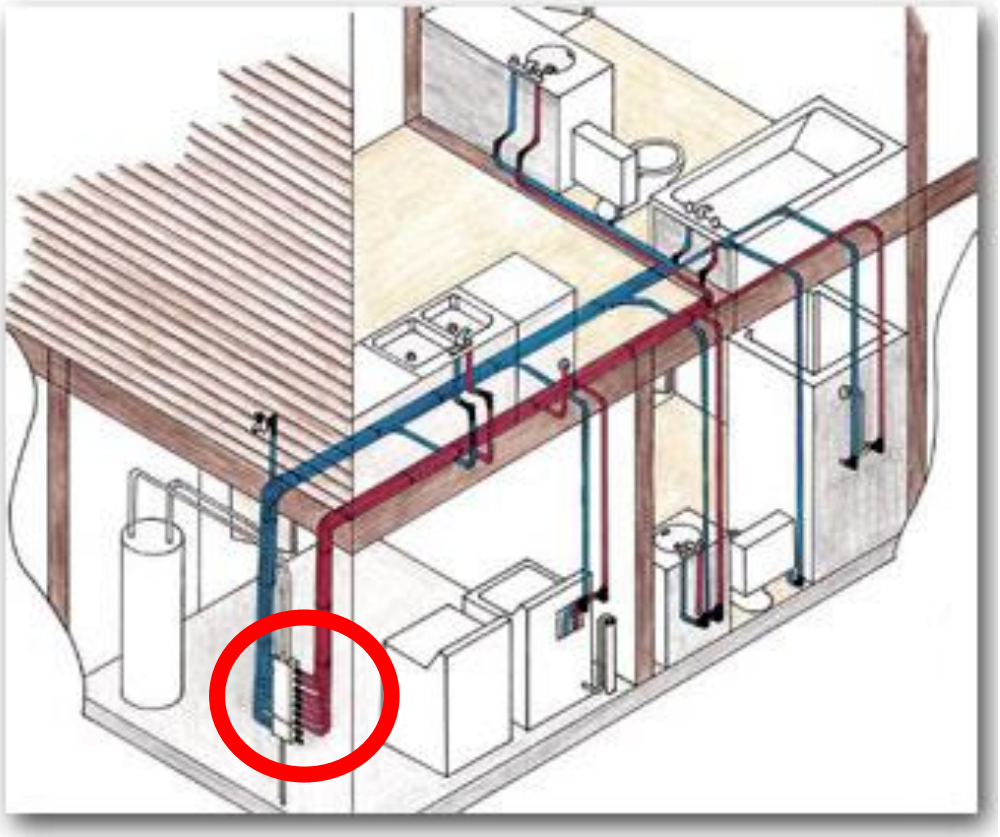
Hot Water Distribution Options

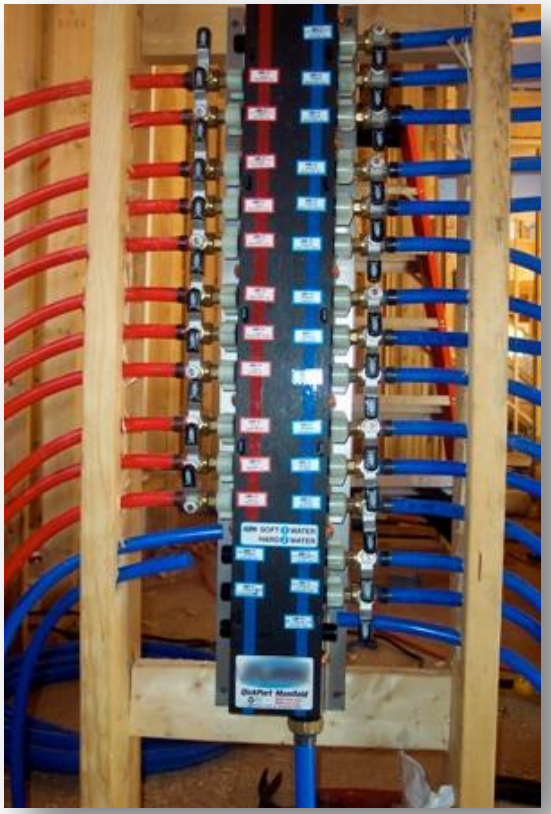
- Core Plumbing Layout (wet wall)
- Manifold System
- Demand Pumping System

Core Plumbing Layout



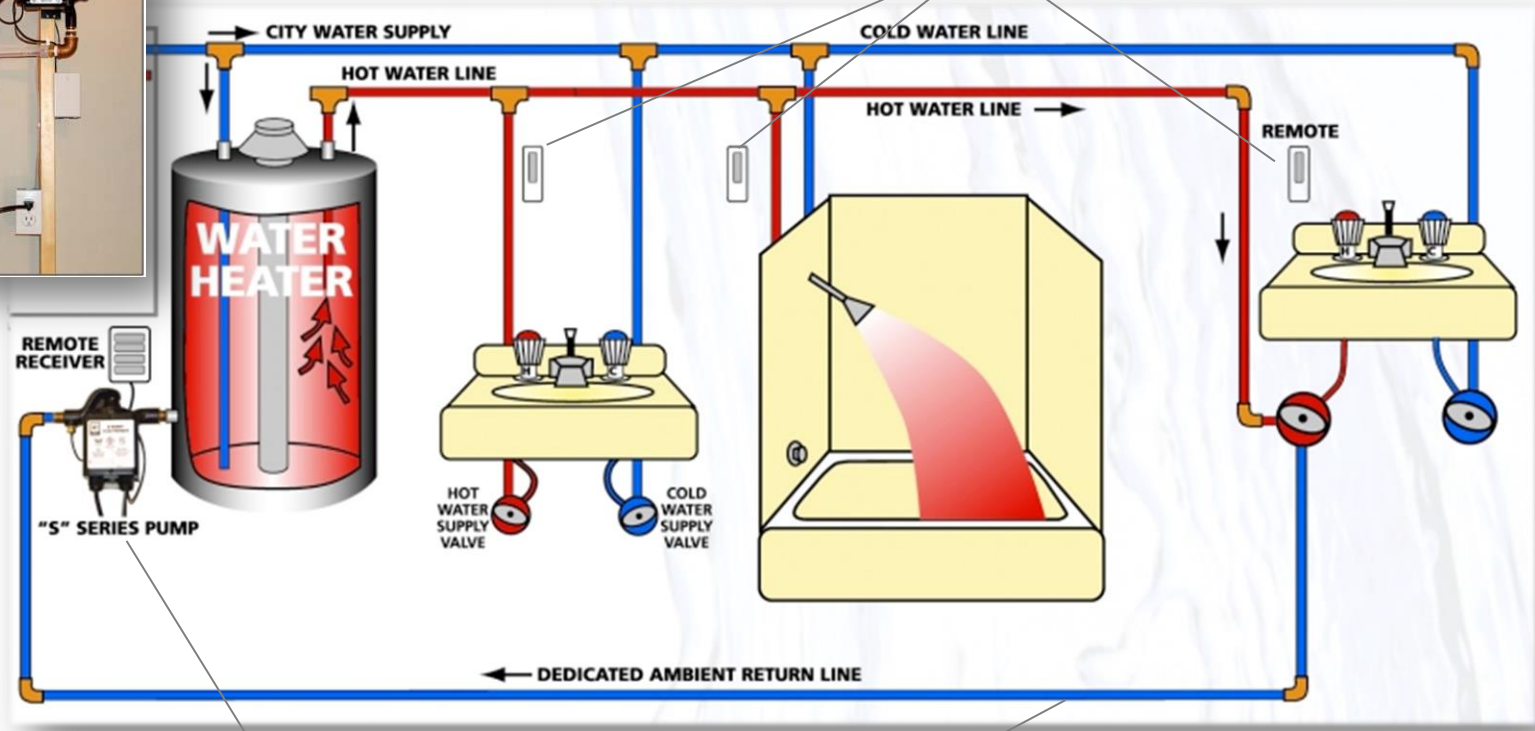
Manifold Plumbing System





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

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

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

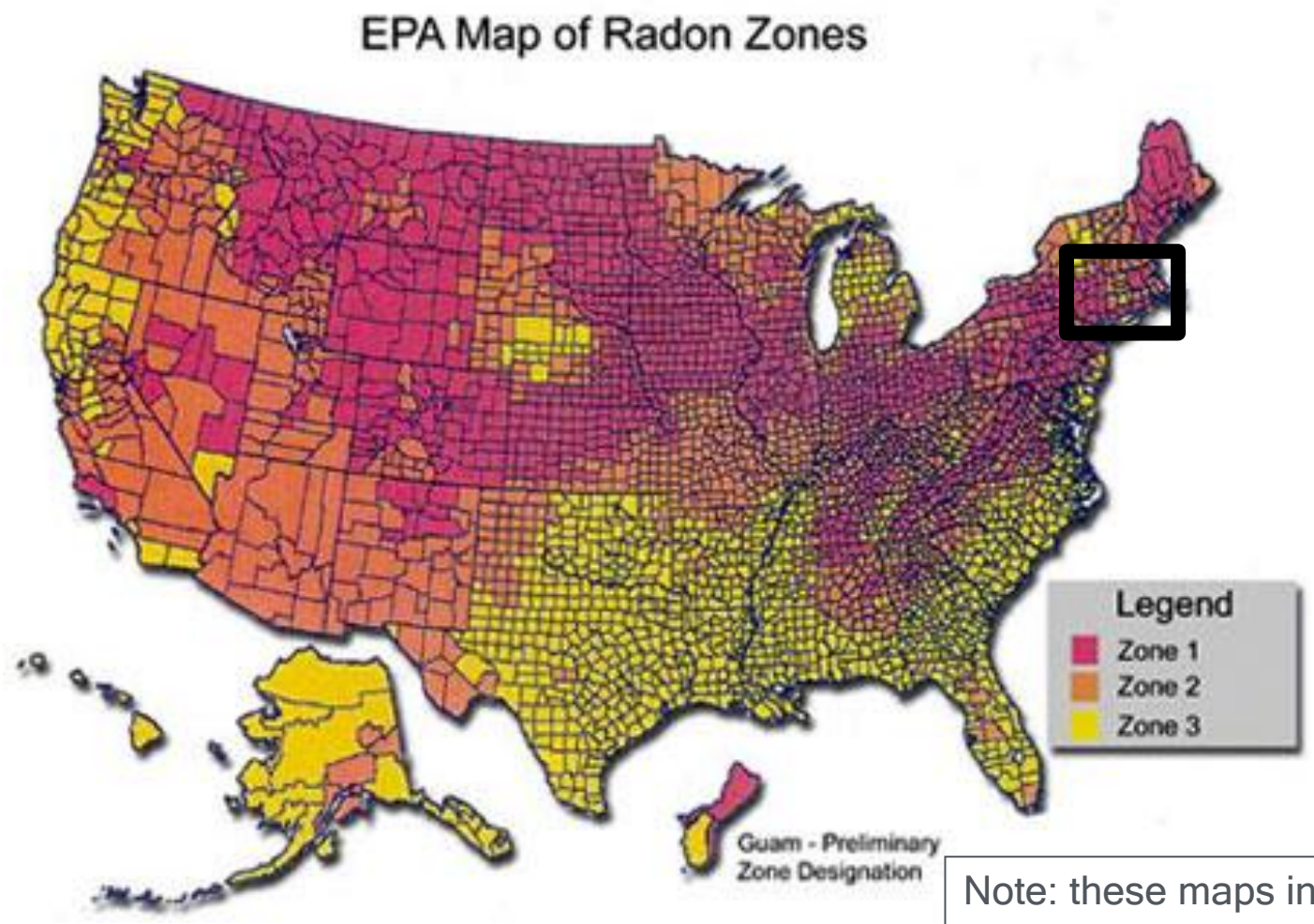
- Bulk Moisture:
  - Water-Managed Roofs
  - Water-Managed Walls/Openings
  - Water Manage Foundation/Site
  - Water Managed Materials

Water Managed Construction

- Dehumidification [Warm-Humid Climates]

HVAC System or Supplemental

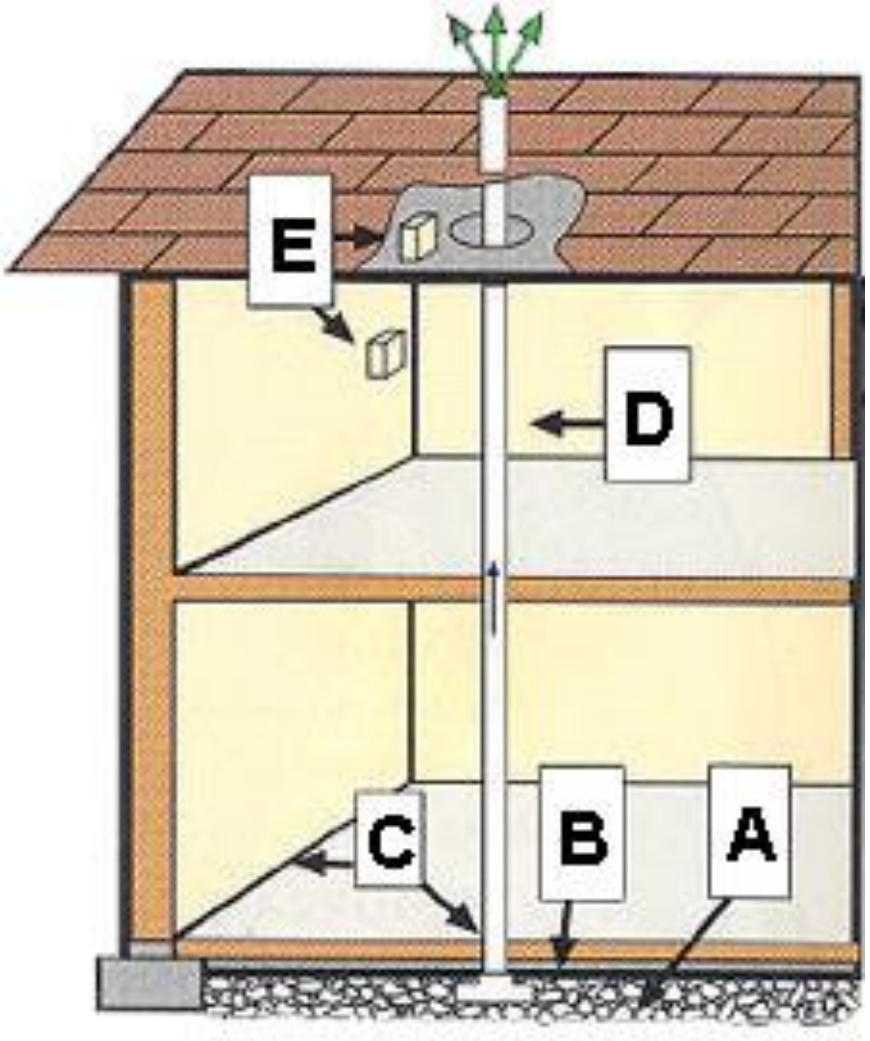
Radon Zones in U.S.



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

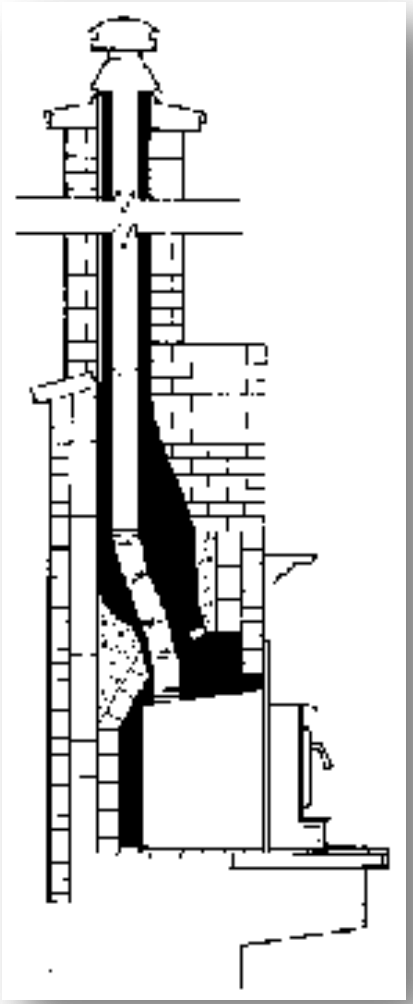
Air Sealing

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

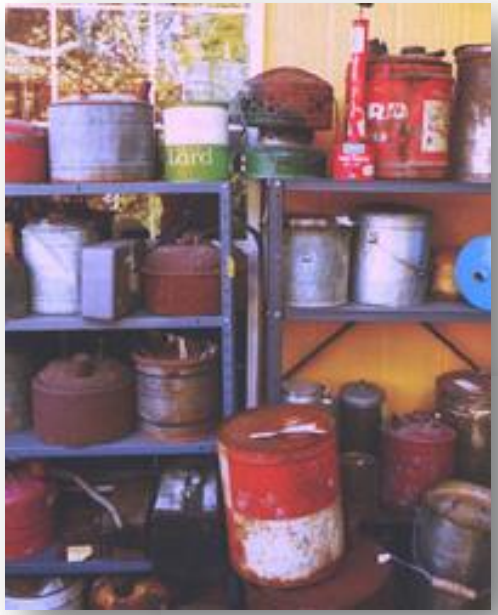
CO Alarm

Combined CO & Smoke Alarm

c UL us LISTED

Enforceable policy in Multi-family buildings

Attached Garage Isolation

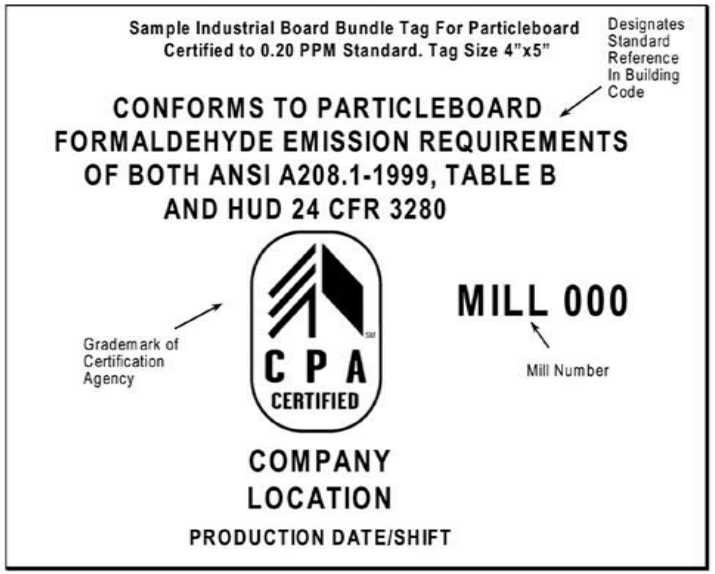


Air Sealing & Gasketed Door

Exhaust Fan Optional

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.]

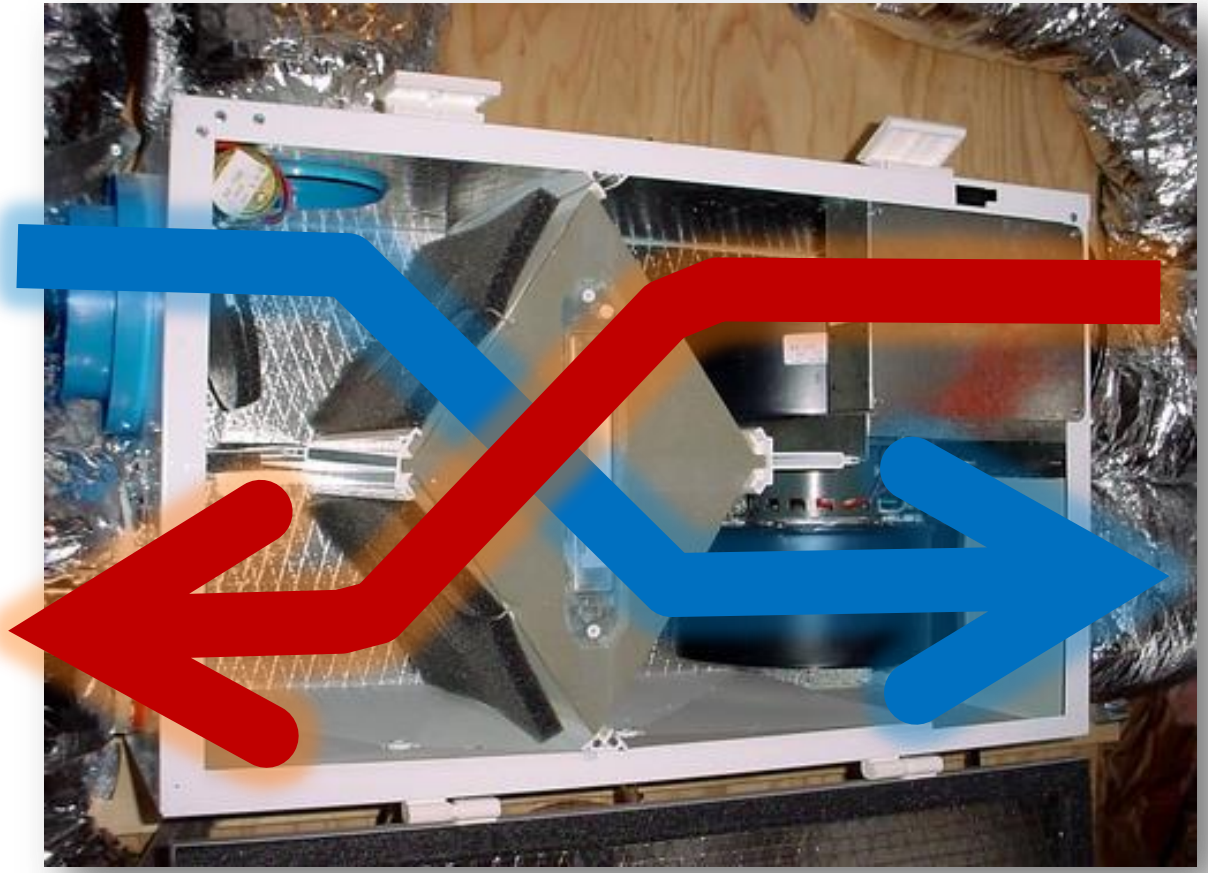
2,000 sq. ft., 3 Bedroom Home Example:

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

Exhaust-Only Ventilation

Supply-Only Ventilation

Balanced Ventilation

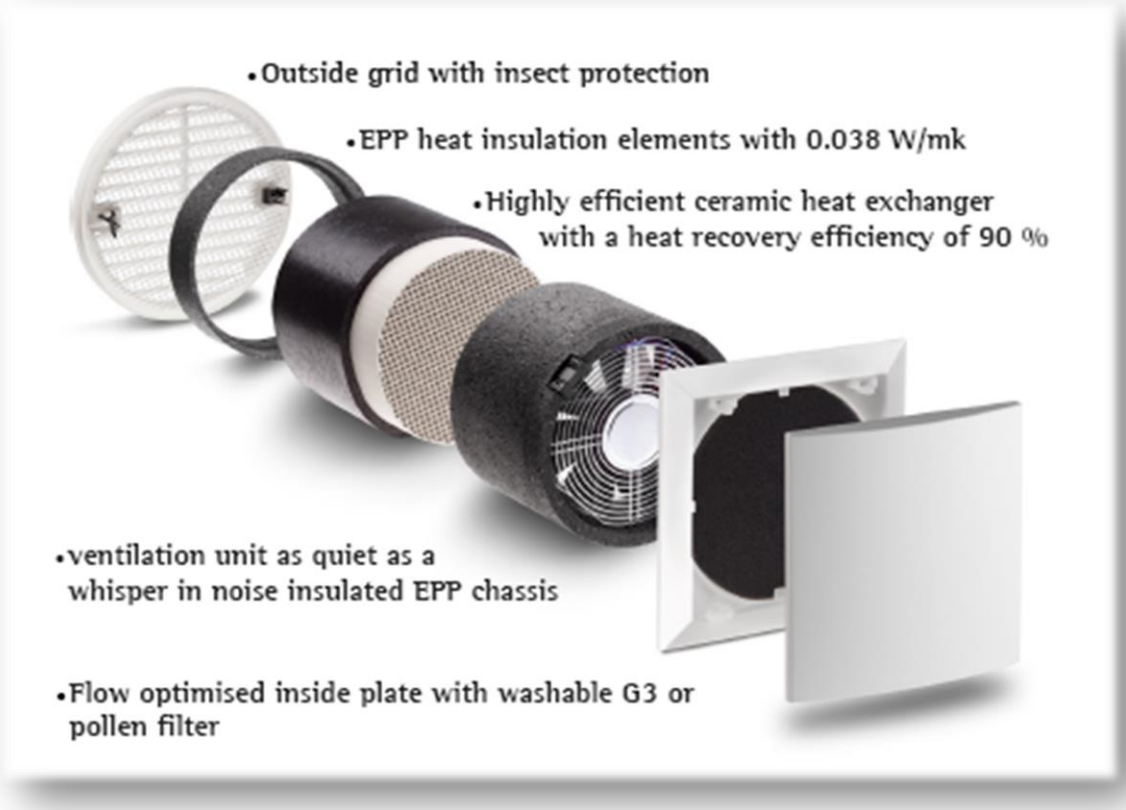


ERV or HRV

Balanced Ventilation

Simple Thru-Wall ERV

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



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

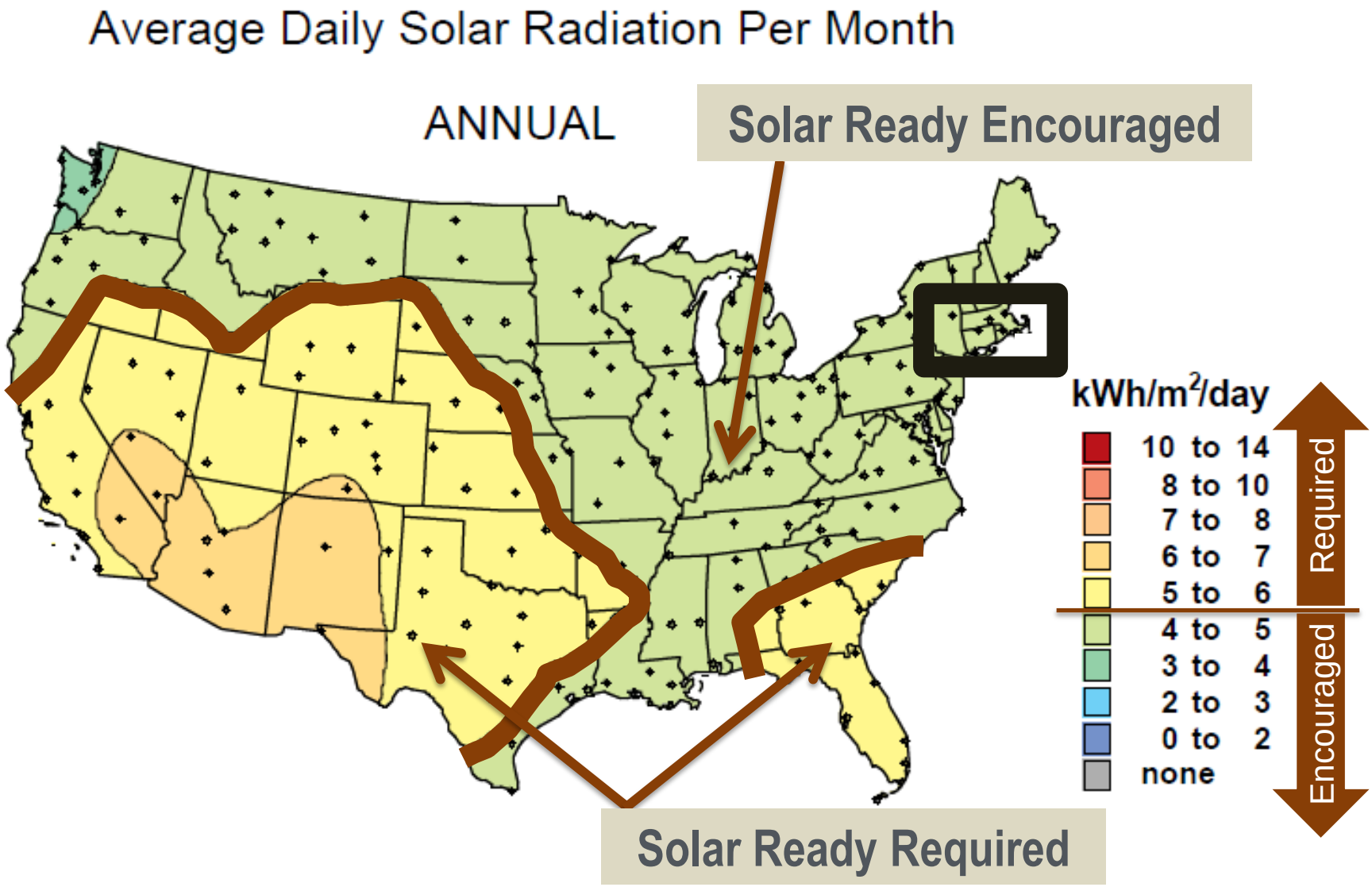
Zero Energy Ready Home

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

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

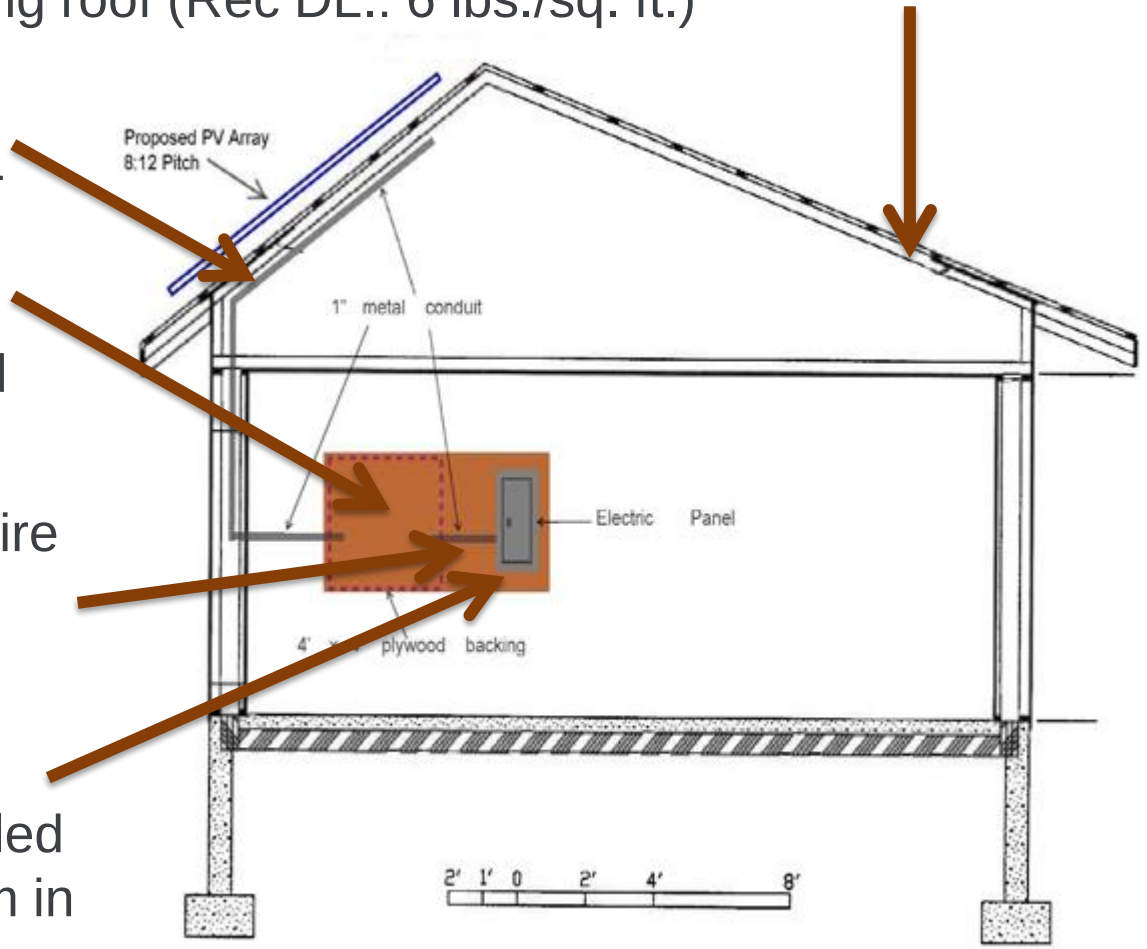
Documentation of the maximum allowable dead load and live load ratings of the existing roof (Rec DL.: 6 lbs./sq. ft.)

Conduit to run DC wire from roof to inverter

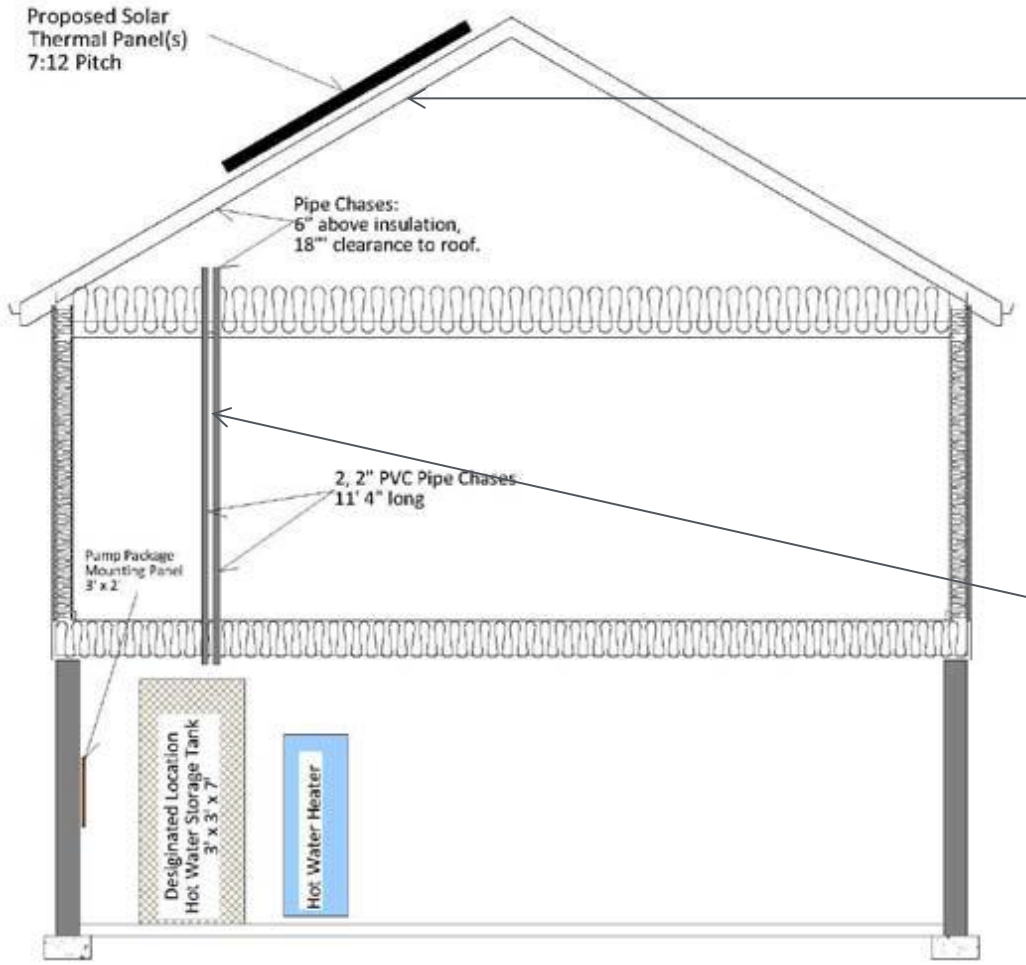
Dedicated Area for installing inverter and balance of system

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



Solar Hot Water Ready Reqts.

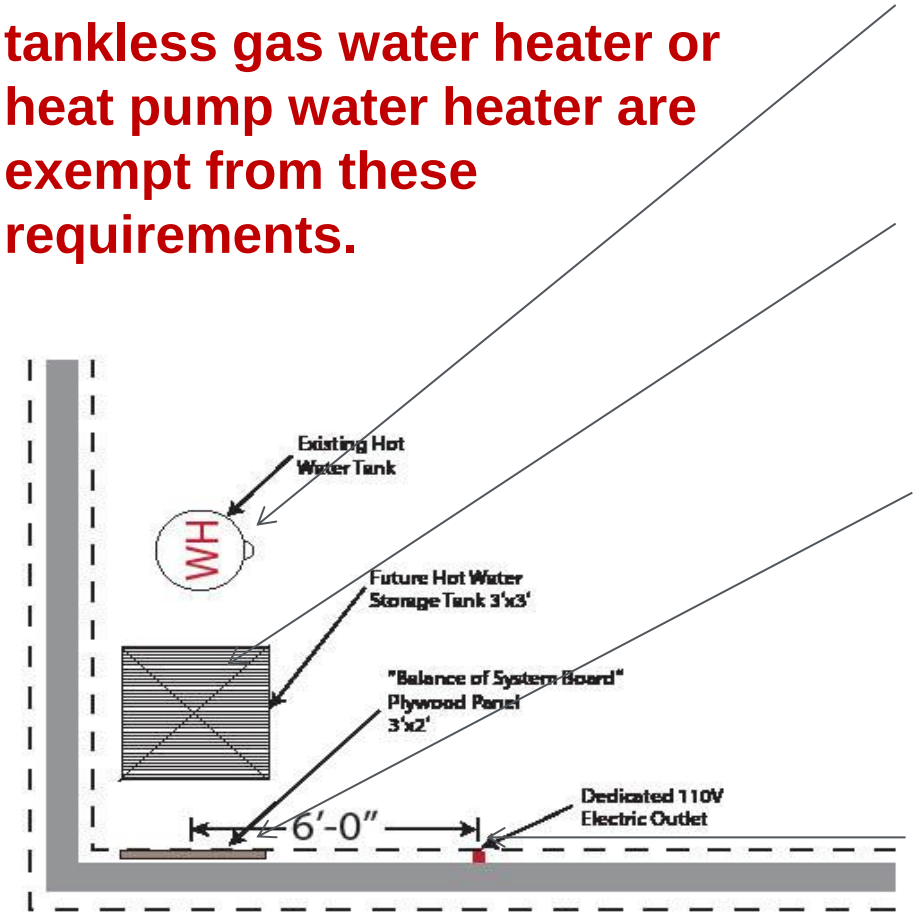


Documentation of the maximum allowable dead load and live load ratings of the existing roof (Rec DL.: 6 lbs./sq. ft.)

Chases (a single 4" or 2–2") from utility room to the attic space below designated array location. Cap and label both ends.

Solar Hot Water Ready Reqts.*

*** Homes equipped with an ENERGY STAR whole-house tankless gas water heater or heat pump water heater are exempt from these requirements.**



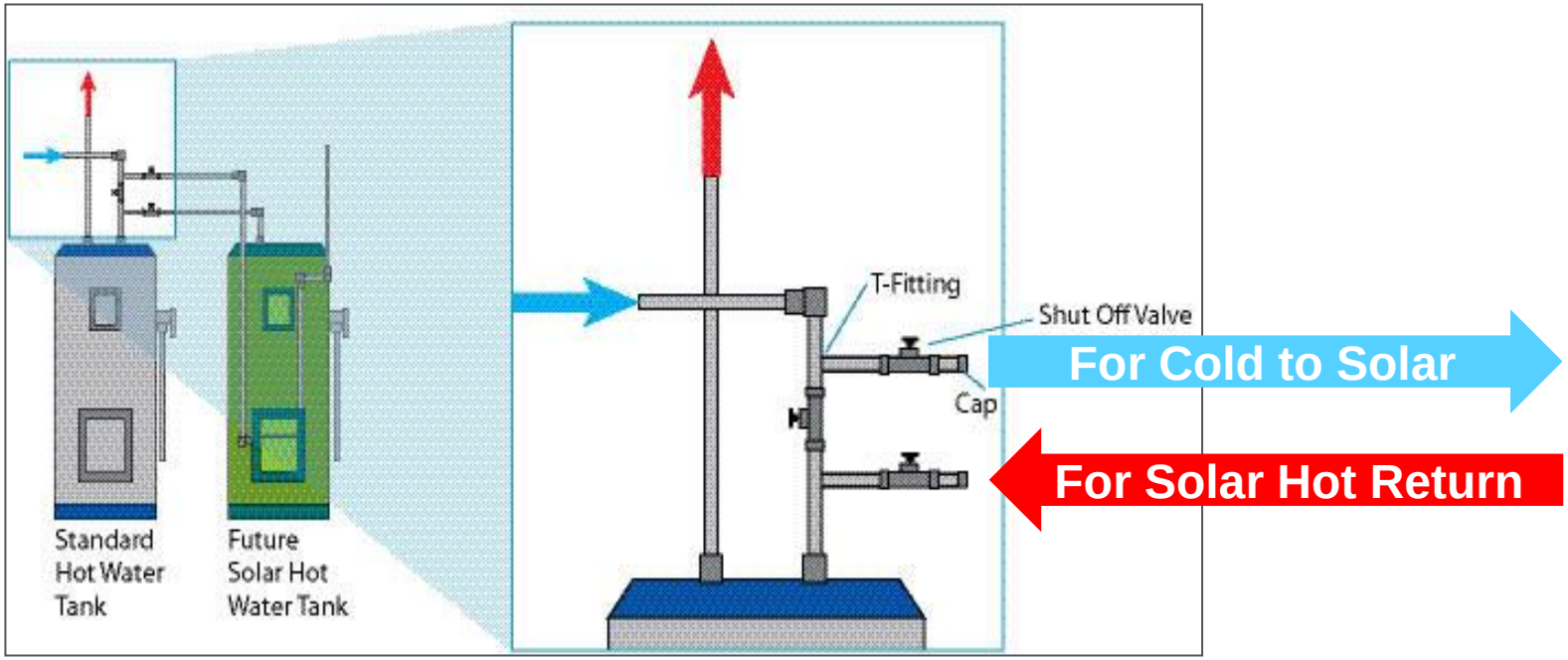
Solar Bypass Valve on the cold water feed of the water heater (cap and label both ends).

Dedicated Area (3' x 3' x 7') in the utility room adjacent to the existing water heater for a solar hot water tank.

Dedicated Area (3' x 2' plywood panel) adjacent to the solar hot water tank for the balance of system components/pumping package.

Electrical Outlet within 6' of the designated wall area.

Solar Water Heating Bypass Valve



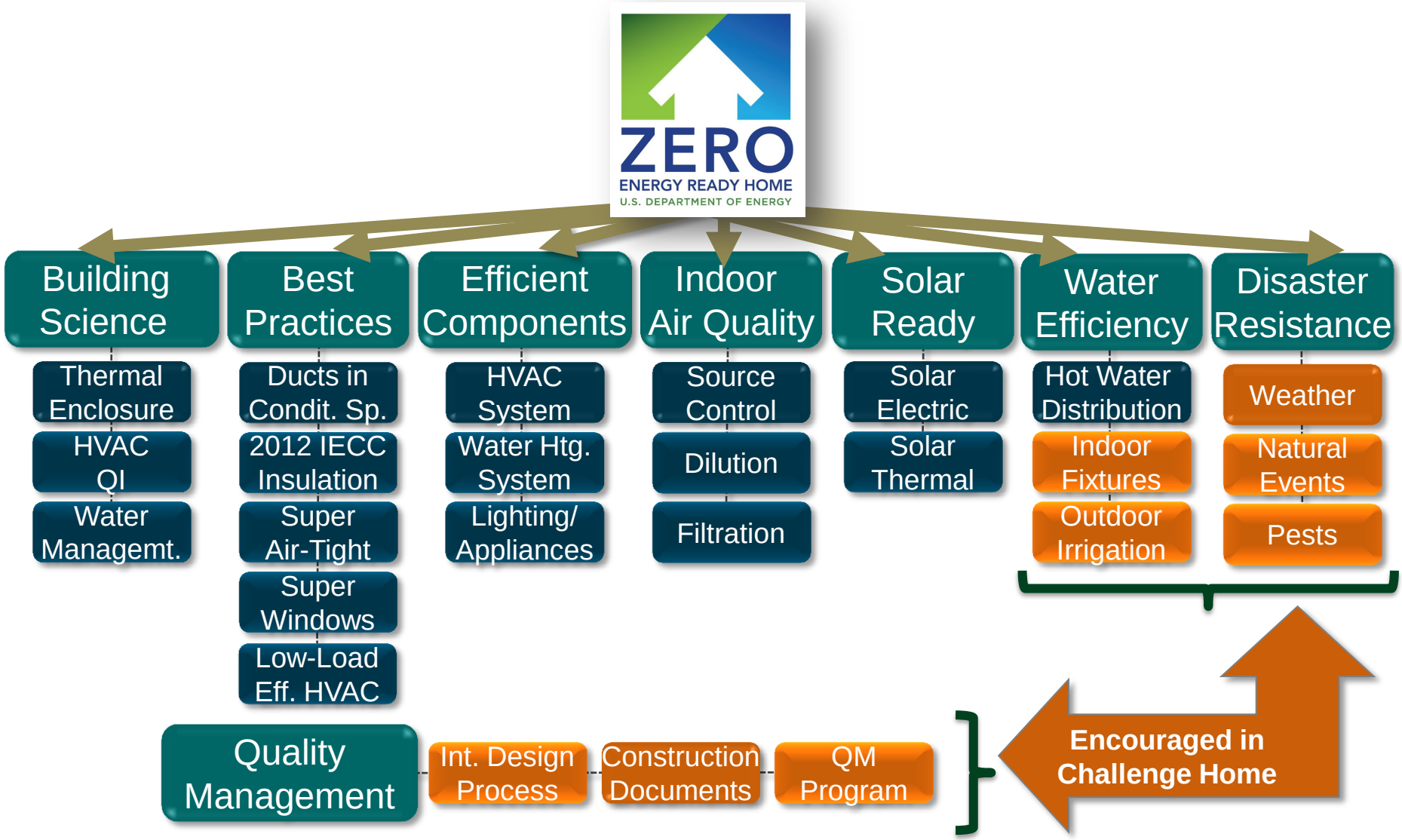
Above: The cold water feed of the existing water heater should have a code-compliant valve assembly installed to connect to the future solar storage tank. Solar bypass valve assembly includes shut-off valves on each of the stubbed and capped "T" fittings, and one shut off valve in the main pipe between the two "T" fittings.

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.

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
CZ5 Prototype - 4 BR, 2400 SF

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Specification	Target Home Spec	Design Home
AGW Insulation	R20 or R13+5	R20
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	2.0 ACH50
Ducts	Total ≤ 8 CFM25 per 100 SF of CFA; Leakage to outdoors ≤ 4 CFM25 per 100 SF of CFA	Total leakage 288 CFM25 In Conditioned Space w/ ½ ACH50 (Req.'d by ENERGY STAR) – Exempt
Furnace AFUE	94	90
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	**52**	**52 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…

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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 Challenge 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

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

- **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

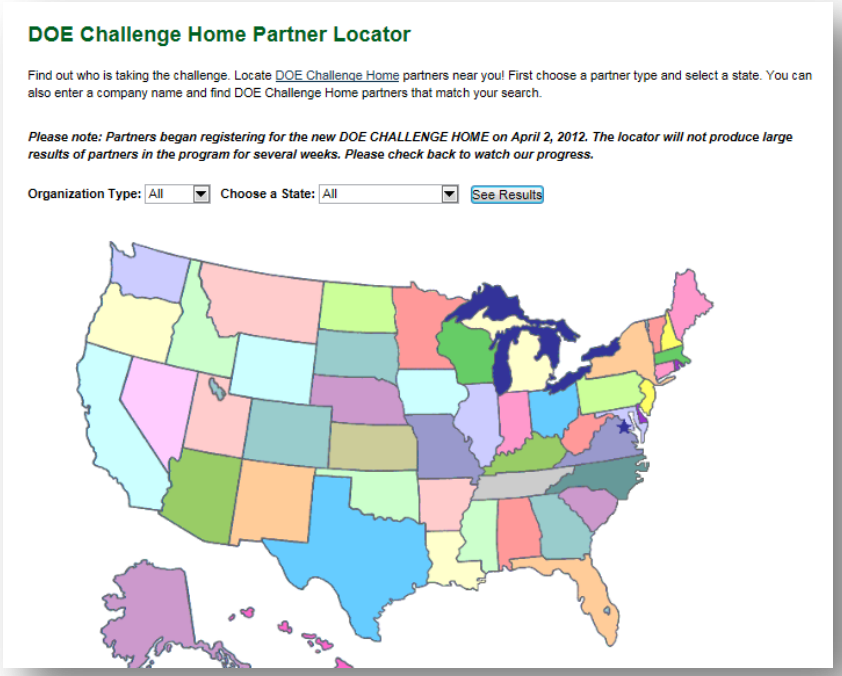
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Links Buyers to Leading Edge Builders:

- Contact Information
- Optional Commitments

- # Labeled Homes
- Website link

<u>For All Active Partners</u>



ZERH Partner Locator Tool

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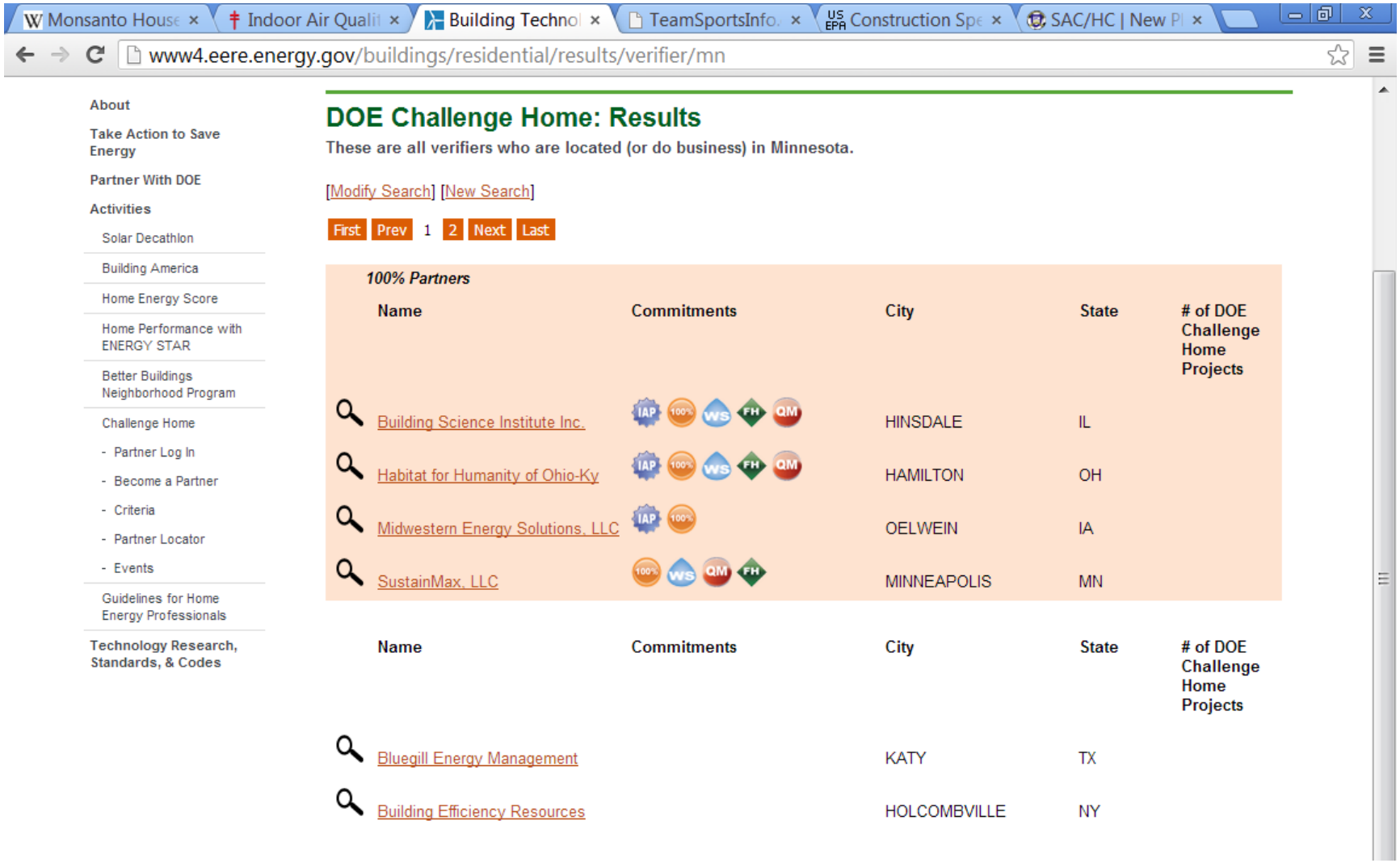

CH Housing Innovation Awards

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CH Partner Responsibilities

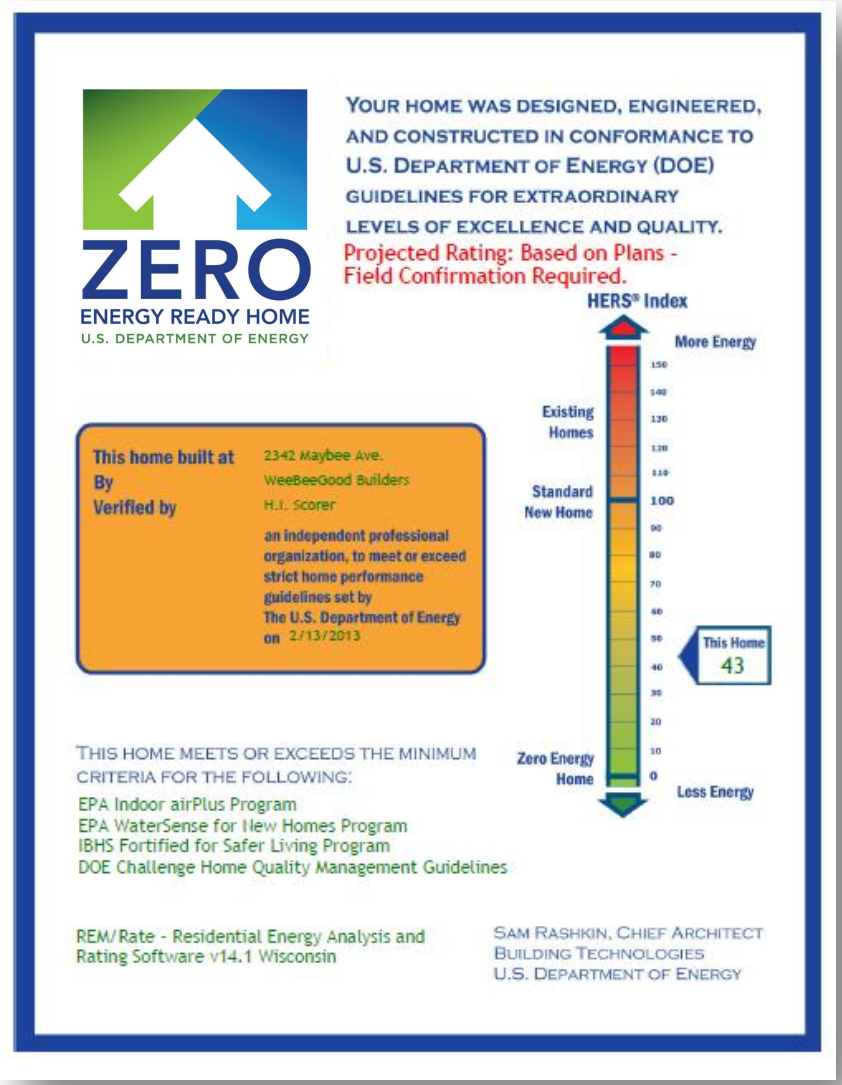
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- **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



Case Study Example

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BUILDING TECHNOLOGIES PROGRAM

DOE CHALLENGE HOME CASE STUDY

e2 Homes

Winter Park, Florida

BUILDER PROFILE

e2 Homes
President: Rob Smith
P.O. Box 3300
Winter Park, FL 32790
407-923-4229
rob@e2homes.com

FEATURED HOME/DEVELOPMENT:

- First Certified Challenge Home—October 2012, Wilson Residence, Winter Park, FL
- 4 bedrooms, 4 baths
- 4,305 conditioned space (8,000 with lanai, garage, etc.)
- Date completed: May/June 2012
- Performance Data: HERS Index without Solar PV: 57
- HERS Index with Solar PV: -7
- Modeled utility bills for a standard home of this size in this utility area: $3,378
- Projected utility costs for this home: $2,297
- Projected annual energy cost savings for this home (without solar): $1,081 PV Production = $2,420
- Projected annual energy cost savings for this home (with solar): $-123

U.S. DEPARTMENT OF ENERGY CHALLENGE HOME

The Nation's First Certified DOE Challenge Home Leaves a BIG impression with a SMALL Footprint

The first certified DOE Challenge Home—the "Wilson Residence" in Winter Park, Florida—produces more energy than it uses with construction costs one-third less than originally proposed. Completed in May 2012, this 4-bedroom, 4-bath 8,000-ft² (4,305-ft² in conditioned space) custom home scores a HERS 57, which is well below the HERS 100 for a standard home built to code. With its photovoltaic system, the home produces better than net-zero energy, with a score of HERS -7, which translates into no electric utility bills and even $123 annually in the homeowner's pocket from the utility.

The homeowner, Mr. Wilson, hired e2 Homes to build his dream home. From the start, Rob Smith (the president of e2 Homes) worked with the homeowner, his HERS rater, and his mechanical contractor to study how differing efficiency measures would impact cost, energy-efficiency, comfort, and durability. "The DOE Challenge Home is data driven and performance driven, based on all the standards…and it addresses concerns of different climates," said Smith. The team used the Challenge Home requirements (along with specifications from LEED for Homes, the Florida Green Building Coalition, the Florida Water Star Gold, and other programs) to analyze best practices in their climate zone compared to costs.

As specified in the Challenge Home requirements, the envelope was designed to meet all ENERGY STAR Version 3 requirements and 2012 IECC insulation levels. Final blower door tests show a tight envelope at 1.77 ACH 50.

The exterior walls were constructed of Aercon Autoclaved Aerated Concrete (AAC) blocks. "My client wanted AACs to avoid using drywall [in this hot humid climate]," said Smith. Like concrete block, AAC is also mold-resistant, non-combustible, and not penetrable by termites or pests, but the unique foam-like structure of the AAC also makes it insulating (R-8 for an 8-inch block), sound resistant, lightweight (one-fifth the weight of concrete), easy to saw or drill, and strong (AAC blocks and panels come structurally reinforced with rebar).

The window package they ultimately selected is ENERGY STAR, low-E 366 glass (blocks 95% of ultraviolent and infrared light), double-pane, and vinyl with a U-factor of 0.27.

The roof is light-colored Galvalume standing-seam metal assembled over engineered roof trusses that are spray foamed underneath to R-20, to create a sealed, conditioned attic that keeps summer temperatures down to 85°F instead of a typical 150°F.

DOE CHALLENGE HOME e2 HOMES

All of the 962-square-foot porch roof is comprised of solar panels with a 13.4-Kw solar array system. The 69 panels don't sit on top of the roof, they are the roof. The completely water-tight structure allows about 15% of natural light to filter through the panels, lighting the space below. The panels are dual surface meaning they can produce power from any sunlight reflected up onto their lower surface, for up to 30% greater than rated power production. All wiring is hidden within the canopy's aluminum support beams.

CHALLENGE HOME CERTIFIED:

1. **BASELINE** Certified ENERGY STAR home
2. **ENVELOPE** meets or exceeds 2012 IECC levels
3. **DUCT SYSTEM** located with the home's thermal boundary
4. **WATER EFFICIENCY** meets or exceeds the EPA WaterSense Section 3.3 specs
5. **LIGHTING AND APPLIANCES** ENERGY STAR qualified
6. **INDOOR AIR QUALITY** meets or exceeds the EPA Indoor airPLUS Verification Checklist
7. **RENEWABLE READY** meets EPA Renewable Energy-Ready Home Solar Electric and Thermal Checklists

Every DOE Challenge Home combines building science specified by ENERGY STAR for Homes and advanced technologies and practices from DOE's Building America research program.

As required by the Challenge Home, the ducts and air handler are located within conditioned space—in the unvented, insulated attic. The home is heated and cooled by three systems: on the first floor a heat pump (SEER-18, HSPF 9.5), in the master bedroom a ducted mini-split heat pump (SEER 16, HSPF 10), and on the second floor another heat pump (SEER 16.5, HSPF 9).

The team designed the ventilation system to create a slight positive pressure in the house to help control humidity. The "economy ventilation system" includes a fresh air duct to the outside of the home that is set to an electric damper regulated by the thermostat to meet ASHRAE ventilation standards.

The home is water efficient in several ways. Two tankless, propane-fired water heaters are located as close to their points of use as possible to minimize water and energy waste (i.e., one near the master bedroom and the other near the kitchen, laundry room, and other bedrooms). Also, the house is double piped so that a 7,000-gallon cistern collects and supplies rain water to all toilets, urinals, and plants in the backyard.

With the home designed for maximum energy and water conservation, the 13.5-kw Sanyo photovoltaic system completes the house. Rather than mounting the 69 solar panels on the roof, the company Superior Solar, fit them together to form a watertight structure that literally is the roof of the home's 962-ft² lanai. The Sanyo HIT Double 195 Watt solar panels are bifacial, meaning they can generate some electricity from reflected light that hits the bottom side of the panels. The panels also permit about 15% of the daylight to filter through them, lighting the porch area beneath. The hybrid inverter, a SolarEdge Power Optimizer and Inverter system, converts the panel-produced direct current power into a utility-compatible alternating current, using a unique technology that overcomes the limitations of traditional central string inverter systems but at a much lower cost than micro-inverter systems.

"At the end of the day, my message for builders considering [building to] Challenge Home is that this program is very rigorous, so it should help builders stand out from the crowd," said Smith. "If you start early in the process, there doesn't have to be a cost differential to implement high-performance building."

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

For more information on the **DOE Challenge Home**, go to www.buildingamerica.gov/challenge

PNNL-SA-XXXXX November 2012

Building America U.S. Department of Energy
www.BuildingAmerica.gov

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'

Zero Energy Ready Home

Local Solution

Meet Local HERS Raters…

Thank You

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

For More Information:

www.buildings.energy.gov/zero/

e-mail Contact:

doechallengehome@newportpartnersllc.com