DOE Challenge Home



Energy Efficiency & Renewable Energy



Zero Net-Energy Ready Home Training

SAM RASHKIN Chief Architect Building Technologies Program

Outline



Zero
Net-Energy
Ready
Homes:



Why Now

- Home of the Future
- Builders in Action
- Made Simple
- Business Case
- Value Proposition
- Technical Specifications
- Recognition w/Challenge Home
- Local Solution





Zero Net-Energy Ready Homes Why Now





Composite U.S. Housing Price Indices



Less Price Competitiveness





High-Performance Urgency



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Building Science Tipping Point:

- Homes No Longer Can Dry if They Get Wet
- Homes No Longer Ensure Fresh Air
- Greater Combustion Safety Risks

Poor Comfort [temperature, noise]

High-Performance Opportunity

Room-to Room, Floor-to-Floor, Basements

Health Risks

High Utility Bills

Dust, Combustion By-Products, Radon, Chemicals, Lead/Asbestos

- Moisture Problem Risks
 Mold, Dank Rooms/Basements
- Excessive Bugs/Pests
- Durability Issues
 Roofs, Siding, Foundation, Equipment, Furnishings

Meet 95+% of Your **Competition:** Existing Homes with...

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Urban Center Preference



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Innovation Preference



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78 Million Innovation Junkies





Zero Net-Energy Ready Home of the Future



"We build products people never knew they wanted, but have to have once they try them."

Tim Cook, Apple CEO

Home People Never Knew They Wanted, But Have to Have...



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Zero Net-Energy Ready Homes Builders in Action



Welcome: Guest ZNERH Builders





Zero Net-Energy Ready Homes Made Simple

ZNERH Strategy



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Ultra-High Efficiency

- Enclosure
- Low-Load HVAC
- Components

High-Performance

- Affordable
- Comfort
- Health

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- Durability
- Renewable Readiness
- Water Conservation
- Disaster Resistance

Efficiency + Performance Example

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DOE Challenge Home Path

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Ensure Comprehensive Building Science

with complete systems to control air, thermal and moisture flow. [comply with ENERGY STAR Certified Homes v3]





Add proven technologies and best practices

to optimize the thermal enclosure and HVAC system. [apply innovations from DOE's Building America program]





Include energy efficient components

to complement the high-performance enclosure. [specify ENERGY STAR appliances, lighting, and fans]





Provide comprehensive pollutant control

because IAQ is critical in homes this tight and well-insulated. [substantially comply with EPA Indoor air Plus]





Ensure low/no-cost details that can save \$1,000's downstream to install solar

since homes are ready for zero net-energy performance. [implement elements of EPA Renewable Ready checklist]





Start addressing related water efficiency issues

to complete environmentally responsive strategy. [encourage EPA WaterSense specifications]







Don't ignore disaster resistance

to help ensure homes built this well last 100's of years. [encourage IBHS Fortified Homes specifications]





Integrate QA/QC practices

to help ensure the success of builder partners. [encourage Building America QA best practices]





All the steps add up to DOE Challenge Home...





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







Zero Net-Energy Ready Homes 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



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Home Innovation Real Cost



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Home Innovation/Value Premium



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Less Buyers Less Urgency to Buy Less Price Competitiveness High-Performance Urgency **High-Performance Opportunity** Urban Center Preference Innovation Preference



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ZNERH 'Brand' Recognition

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Independent Voice of Authority vs. "Trust me."

Pent-up Consumer Demand



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"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.

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The closer link to leadership, the higher the innovation/value premium.

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Innovation Leadership Example



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Name a <u>safe</u>car?



You're looking at a perfect Volus. A Volus that performul exactly an our safety engineers designed it to Its items and rear unde, for example, collapsed on impact. As a result, stash of the crash-energy was also their interest of being pussed on to the pussengers.

The corb middle section, however, didn' collapse. That's because the entire prosetyper compartment is surrounded by Wolvels images "solivly cap." Made of six loss section used pillars, this protectible housing is strong enough to support the weight of six Velues. But the possengers of this car were also protected in ways you can't see. Because inside are such standard features as a detwert side Supplemental Restraint System, a cellapshite steering column and, of course, 3-point sort belts, force and rear.

Every Value is designed to help protect in presengers and these ways. And, so a next, will solk remarkably sendle to this one after being in the same type of acodent. If you're concerned about safers, was east find a soore beautiful car.

Innovation Leadership Example









Innovation option shouldn't look the same as the standard option. [owners want 'badge of honor']

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Innovation Looks Different



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2012 Toyota Highlander

2012 Lexus RX400

Different, NOT Eclectic



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Existing Home: Low Performance

Retrofitted Home: High-Performance



Innovation investment is wasted if you don't evaluate business metrics.

Sample Business Metrics



Cost:

- True Credit/Debit Construction Costs
- Time of Sale
- Profit Margins
- Call-Back Expenses

Marketing:

- Homebuyer Visits
- Media Exposure
- Referrals

Performance:

- Customer Satisfaction
- Actual Billing Data





Zero Net-Energy Ready Homes Value Proposition

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ENERGY Energy Efficiency & Renewable Energy



Only the top builders in the country meet extraordinary levels of excellence specified by U.S. Department of Energy (DOE) guidelines. **Feel great knowing you selected a 'best-in-class' home.**



U.S.

Department of Energy



Advanced Technology

Starting with a solid foundation of building science specified by ENERGY STAR for Homes, every DOE Challenge Home adds advanced technology features from DOE's world-class research program, Building America. **Look for the proven innovations**



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Visionary

Every DOE Challenge Home embraces a unique opportunity during design and construction to meet and exceed forthcoming codes. Additional details can save \$1,000s installing a solar system down the road. **Rest assured your largest investment** will meet future expectations.



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ACME Homes



Ultra-Efficient

Every DOE Challenge Home is so energy efficient, a small solar system can often offset most, or all, of your utility bills. We call this <u>Zero Net-Energy Ready</u>.

Never worry about rapidly increasing utility costs.



Energy Efficiency & Renewable Energy

ACME Homes



Comfort Plus

Extraordinary attention to detail and better equipment included in every DOE Challenge Home surround you with even temperatures, low humidity, and quiet in every room on every floor.

Take home satisfaction to a new level.

ENERGY Energy Renew

Energy Efficiency & Renewable Energy



Healthful

The same way we want nutritious food on our plates, we want healthy air in our homes.

Every DOE Challenge Home has a comprehensive package of measures that minimize dangerous pollutants, provide continuous fresh air, and effectively filter the air you

Provide a healthier home for your family.

ENERGY Energy Efficiency & Renewable Energy



Advanced construction practices and technologies are specified for every DOE Challenge Home, but that is not enough. Independent verifiers rigorously inspect and test each home with detailed checklists diagnostics.

Hold your home to a higher standard.



Energy Efficiency & Renewable Energy

ACME Homes



Enduring

The advanced levels of energy savings, comfort, health, durability, quality, and future performance in every DOE Challenge Home deliver exceptional value. Value that will stand the test of time. Live life in a home built to last.

Optional Value Proposition



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Smart

It costs less to own our DOE Challenge Homes because the monthly energy savings can easily exceed the increased monthly mortgage cost for all the added value **Spend less for a better home.**

Translating Value Proposition





Value Proposition Transparency





Translating Value Proposition





Translating Value Proposition



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Compare and Contrast

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30-Year Warranty...

Healthy Air Warranty

- Lead-Free*
- Asbestos-Free*
- Particulates Filtered to 3 Microns*
- Mold-Free*
- Combustion Safety *
- 150,000 CF per Day Fresh/Filtered Air*
- > VOC-Free*
- Formaldehyde-Free*
- Pest-Free*
- Radon-Free*

Affordable Comfort Warranty

- \$60/Month Average Heating/Cooling Bill*
- Even Room-by-Room Temperatures*
- No Outdoor Drafts*
- Outside Noise Reduction*
- No Excessive Humidity*

Durability 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 Net-Energy Ready Homes Technical Specifications

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- Comprehensive Building-Science
- Complete Systems vs. Points (Checklists)

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- Variable vs. Fixed HERS Index Score
- House Size Adjustment to HERS Score



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DOE Challenge Home Framework

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Mandatory **Reqts.**

	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, a} Celling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels ⁹		-	
1	3. Duct System	 Ducts located within the home's thermal and air barrier boundary¹⁰ 			Must
	. Water Efficiency	Hot water delivery systems shall meet efficient design requirements ¹¹	7		wust
	5. Lighting & Appliances ¹²	All Installed refrigerators, dishwashers, and ciothes 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			Comply
	6. Indoor Air Quality	 EPA Indoor airPLUS Verification Checklist and Construction Specifications¹⁵ 			
	7. Renewable Ready ¹⁴	EPA Renewable Energy Ready Home Solar Electric Checklist and Specifications ¹⁶ EPA Renewable Energy Ready Home Solar Thermal Checklist and Specifications ¹⁶]		

Exhibit 2: DOE Challenge Home Target Home ^{1, 17}

		2.000	onancing	ge 11011	ic range		·							
	HVAC Equipment ¹⁰													
		Hot Climat (2012 IECC Zone	98 26 1,2) ¹⁹	(2	Mixed C 2012 IECC 4 except	limates 2 Zones 3 Marine)		Cole (2012 4 Ma	d Climate IECC Zor rine 5,6,7,	18 nes ,8)				
	AFUE	80%			90	%			94%		- 1			
	SEER	18			15	5			13					
'Target	HSPF	8.2			9	1			10 ²⁰					
laiget	Geothermal Heat Pump		E	NERGY	STAR EEI	R and CO	P Criteria	3				Tuesd	- 04	
Home'	ASHRAE 62.2 Whole-House Mechanical Ventilation System	1.4 cfm/W no heat exch	l; ange		1.4 cft no heat e	m/W; xchange		1. heat excha	2 cfm/W; nge with 6	0% SRE		Irad	e-Ot	Т
	Insulation and Inflitration											Flexi	hilit	V
Specs	 Insulation levels shall meet th Infiltration²¹ (ACH50): 	e 2012 IECC and ach 3 In CZ's 1-2	leve Grade 2.5 in CZ's	1 installa 3-4 3	ation, per l 2 in CZ's §	RESNET 5-7 1.	standards .5 In CZ 8	5. }					MIIIL	y
	Windows ^{22, 23, 24}													
		Hot Climat	tes Mixed Climates				Cold Climates		8	- 1				
		(2012 IECC Zon	ones 1,2,) (2012 IECC Zones 3, 4 except Marine)			(2012 IECC Zones 4 Marine 5,6,7,8)		nes ,8)						
	SHGC	0.25		0.27				any			- 1			
	U-Value	0.4			0.3	3			0.27		- 1			
	Homes qualifying through the Prescriptive Path with a total window-to-floor area greater than 15% shall have adjusted U-values or SHGCs. ²⁸													
	Water Heater													
	ENERGY STAR minimum; for he	ating oil water heater	rs use EF -	0.60										
	Effective for Homes Permitted Starting 4/1/2012	F	evised 07/0	01/2012					Page 2	ofS				
		Exhibit 3	3: Benchi	mark H	ome Siz	ze ²⁶					\square			
Size Adjust.	Redrooms in Home to be Bu	ilt	1	2	3	4	5	6	7	8 /		aenti	cal	O
Factor	Conditioned Floor Area Bench	mark Home	1,000	1,600	2,200	2,800	3,400	4,000	4,600	5,200	E	Inerg	v St	ar
												J		





Zero Net-Energy Ready Technical Specifications Mandatory Requirements:

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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 [€]	 Fenestration shall meet or exceed latest ENERGY STAR requirements ^{7 8} Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels⁹
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 Specifications¹⁵ EPA Renewable Energy Ready Home Solar Thermal Checklist and Specifications¹⁶

Encouraged:

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





Zero Net-Energy Ready **Technical Specifications Mandatory Requirements: ENERGY STAR for Homes Version 3 Baseline**

What is Building Science





Air Sealing Air Barriers

- Thermal Bypass
- Wind Intrusion

Insulation

- Adequate Quantity
- Proper Installation
- Minimum Thermal Bridging

Adv. Windows

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Thermal

Enclosure

System

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Thermal

Enclosure

System

HVAC

Quality Installation

System

Moisture Vapor (Air Flow)

- air sealing
- air barriers
- vapor barriers/retarders
- whole-house ventilation
- spot ventilation
- HVAC quality installation

Bulk Moisture

- weather resistant barriers
- flashing
- capillary breaks

Water Managed Construction System


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ENERGY STAR for Homes v3:

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



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Zero Net-Energy Ready **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



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	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 Net-Energy Ready **Technical Specifications: Best Practices Super Air-Tight Construction**

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



- Climate Zones 1-2: 3.0 ACH50
- Climate Zones 3-4: 2.5 ACH50
- Climate Zones 5-7: 2.0 ACH50
- Climate Zone 8: 1.5 ACH50

Air Seal All The 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 Joints

Air Leakage Distribution

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2-Story house (Floor area = 2,000 ft²) Sheathing / roof joint unsealed $\cong 0.5 \text{ ACH}_{50}$

	DOE Challe	enge Home	IECC 2012		
Zone s	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

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Contribution

to

requirement

(%)

10

17

17

17

1.5" | 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 \geq 50% of leakage

4" o 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 \geq 50% of leakage

Fasteners





Air leaked at nailed fasteners

Repeat test with screwed fasteners

Air Leakage Contribution Estimates

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- 1. Sheathing/Foundation Joint Unsealed
- 2. Sheathing/Roof Join Unsealed
- 3. (4) Electrical Outlets
- 4. (5) Ceiling Lights
- 5. <u>Return Duct</u>

= 0.51

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- = 0.51
- = 0.17
- = 0.29
- = 0.22
 - 1.7 ACH₅₀



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Zero Net-Energy Ready **Technical Specifications Mandatory Requirements: Envelope:** 2012 IECC Insulation



- Assures enclosure 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]

IECC Climate Zones

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2012 IECC Prescriptive Reqts.

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Climate Zone	Fenestration	Skylight U-Factor	Glazed Fenestration SHGC	Ceiling R-Value	Wood Frame Wall R-Value
1	NR	0.75	0.25	30	13
2	0.40	0.65	0.25	38	13
3	0.35	0.55	0.25	38	20 or 13+5 ^h
4 except Marine	0.35	0.55	0.40	49	20 or 13+5 ^h
5 & Marine 4	0.32	0.55	NR	49	20 or 13+5 ^h
6	0.32	0.55	NR	49	20+5 or 13+10 ^h
7 & 8	0.32	0.55	NR	49	20+5 or 13+10 ^h

Climate Zone	Mass Wall R-Value ⁱ	Floor R- Value	Basement ^c Wall R-Value	Slab ^d R- Value, Depth	Crawl Space ^c Wall R- Value
1	3/4	13	0	0	0
2	4/6	13	0	0	0
3	8/13	19	5/13 ^f	0	5/13
4 except Marine	8/13	19	10 /13	10, 2 ft	10/13
5 & Marine 4	13/17	30 g	15/19	10, 2 ft	15/19
6	15/20	30 ^g	15/19	10, 4 ft	15/19
7 & 8	19/21	38 ^g	15/19	10, 4 ft	15/19

2012 IECC Equivalent U-Factors^a

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Climate Zone	Fenestration	Skylight U- Factor	Ceiling U- Factor	Frame Wall U-Factor
1	0.50	0.75	0.035	0.082
2	0.40	0.65	0.030	0.082
3	0.35	0.55	0.030	0.057
4 except Marine	0.35	0.55	0.026	0.057
5 & Marine 4	0.32	0.55	0.026	0.057
6	0.32	0.55	0.026	0.048
7 & 8	0.32	0.55	0.026	0.048

^a Non-fenestration U-factors shall be obtained from measurement, calculation, or an approved source.

Equivalent U-Factors (cont.)



Climate Zone	Mass Wall U-Factor ^b	Floor U- Factor	Basement Wall U-Factor	Crawl Space Wall U-Factor
1	0.197	0.064	0.360	0.477
2	0.165	0.064	0.360	0.477
3	0.098	0.047	0.091 ^c	0.136
4 except Marine	0.098	0.047	0.059	0.065
5 & Marine 4	0.082	0.033	0.050	0.055
6	0.060	0.033	0.050	0.055
7 & 8	0.057	0.028	0.050	0.055

^b When more than half of insulation is on interior, following maximum Ufactors apply: CZ1-0.17, CZ2 – 0.14, CZ3 – 0.12, CZ4 (except Marine) – 0.087, CZ5 CZ4 Marine – 0.065, CZ6 -8 – 0.057.



Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels [Table R402.1.1].

The following [4] exceptions apply:

- a) Equivalencies for steel framing
- b) For attics, R-30 satisfies R-38 reqt.;
 R-38 satisfies R-49 reqt. where full height of uncompressed insulation at the lower R-value extends over the wall top plate at the eaves (except if alt. calculations in d) used).





Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels [Table R402.1.1.] The following [4] exceptions apply:

c. For ceilings w/o attic spaces, R-30 okay if above R-30 required, but there is insufficient clearance.

Limited to 500 sq. ft. or 20% of total insulated ceiling area, whichever is less. This exemption shall not apply if the alternate calculations in d) are used;

Implication: Designs with extensive cathedral ceilings may need to incorporate SPF or rigid insulation; unvented attic designs may also be incorporated



Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels [Table R402.1.1].

The following [4] exceptions apply:

- d) An alternate equivalent U-factor or total UA calculation:
 - **U-factor** equal or less than Table 402.1.3.
 - Total building thermal envelope UA
 to the total UA from U-factors in Table 402.1.3.
 - Fenestration products (i.e., windows, skylights, doors) are included in this calculation.
 - Attic eave, slab edge, and attic platform insulation reqts. (4.1 through 4.3 of the ES for Homes V3 TES) shall be met.
 - The UA calculation method consistent with ASHRAE HOF and include thermal bridging effects: ASHRAE zone method or equivalent, and not a series-parallel path calculation method.



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Zero Net-Energy Ready **Technical Specifications Mandatory Requirements: Ducts in Conditioned Spaces**

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- Significant Thermal Losses:
 - Thermal losses triple for ducts in unconditioned vs. conditioned space

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- Total thermal losses can range from 10-45%
- Extensive unconditioned space penetrations
- Significant Performance Impacts:
 - -IAQ
 - Comfort
 - Durability

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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

which do not directly deliver conditioned air from the HVAC unit may be located in attics if all joints, including boot-to-drywall, are fully air sealed with mastic

Ductless HVAC system

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- 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



Issues:

Architectural Integration

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





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Ducts in Conditioned Floor Space



Ducts in modified truss in attic



Issues:

- Design Integration
- Good Fit w/Narrow Plans

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• Sealed Air Barrier Critical



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Ducts in Conditioned Floor Space



Issues:

Simple Installation

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- Design Flexibility
- Cost-Effective
- Floor Registers Likely





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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







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
Rigid + Air Permeable Insulation

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5.2 Rigid Insulation Board above structural roof sheathing + air-permeable insulation in direct contact with the underside of the sheathing



Is there a minimum R value of this rigid foam board above the sheathing?

Rigid foam (Impermeable) ABOVE THE ROOF SHEATHING

Roof Sheathing

Rafter

Cavity Insulation (Can be Air-Permeable)

Building Science Corporation

Air-Impermeable + Air-Permeable Insulation

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5.3 AIR-IMPERMEABLE and AIR-PERMEABLE insulation. If air-impermeable insulation



Building Science Corporation

Ducts in Vented Attic



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Buried Encapsulated Duct (BED)



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Step 1: Install low-profile compact ducts on top of ceiling framing.



Before ceiling drywall



After ceiling drywall



Step 2: Mastic seal ducts and perform leakage test.



Test total duct leakage to assure performance levels are met (total leakage < 3 cfm25 per 100 ft2 conditioned space)



Step 3: Apply 1.5" minimum ccSPF Option 1- prior to ceiling gypsum board





Step 3: Apply 1.5" minimum ccSPF Option 2- after ceiling gypsum board





Step 4: Install loose-fill insulation.



- Insulation must be ASTM classified as "mineral-fiber", and cover the ccSPF by 2" min. (cellulose doesn't qualify)*
- Some foams are exempt from this requirement

*Ignition barrier protection requirement

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2009 IRC requires that spray foam insulation applied to the exterior of ductwork (Section M1601.3) in attics (Section R316.5.3) meet several requirements:

- Flame spread index less than 25
- Smoke-developed index less than 450
- No attic storage or occupancy
- Spray foam protected by ignition barrier (1.5" mineral fiber)
 - Or meets R316.6 (no ignition barrier required)



- Code-related considerations:
 - IRC Sections R807.1, M1601.3, R316.5.3, R316.6
 - DOE Challenge Home
 - Title 24 of California Code of Regulations
- Technical References:
 - Multiple research reports since 2000
 - Upcoming BA Technical Report
 - Upcoming BA Measure Guideline

www.buildingamerica.gov

Building America Resources



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Zero Net-Energy Ready **Technical Specifications: Best Practices Efficient Low-Load HVAC**

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Efficient Low-Load HVAC



Challenge Home Target Home Specifications:

	Hot Climates IECC CZ 1-2	Mixed Climates IECC CZ 3-4 except Marine	Cold Climates IECC CZ 5-8 and 4 Marine
AFUE	80%	90%	94%
SEER	18	15	13
HSPF	8.2	9	10
Geo HP	ENERGY STAR EER and COP Criteria		
ASHRAE 62.2 Whole-House Ventilation	1.4 cfm/W: no heat exch.	1.4 cfm/W: no heat exch.	1.2 cfm/W: w/heat exch. 60% SRE



- Challenge Home Technology Options
 - Variable-Speed or multi-stage
 - Ductless Mini-Split Heat Pump Systems
 - Optimized distribution
 - GSHPs
 - Combi-Systems [e.g., heat, water heating, vent.]





Zero Net-Energy Ready Technical Specifications Mandatory Requirements: Efficient Hot Water Distribution

Water Efficiency as a System



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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)



- "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.

Built for when water was free and energy was cheap!

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Copper L piping:



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Built for when water was free and energy was cheap!

Copper L piping:



- $\frac{3}{4}$ = 3.22 ounces/ft
- $\frac{1}{2}$ " = 1.55 ounces/ft





Demand Pumping System









Zero Net-Energy Ready Technical Specifications Mandatory Requirements: Efficient Lighting, Appliances, and Fans



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



ENERGY STAR Gas Water Heating

- Storage with $EF \ge 0.67$
- "Extra Credit":
 - Whole-Home Tankless with $EF \ge 0.82$
 - Condensing with $EF \ge 0.8$
- ENERGY STAR Electric Water Heating
 - Heat Pump Water Heater with $EF \ge 2.0$
- ENERGY STAR Solar Water Heating
 - Solar with SF \geq 0.5
- Oil Water Heating
 - Any oil-fired water heater with $EF \ge 0.6$



- Heat Pump Clothes Dryer
- Induction Cooktop

Typical Clothes Dryer Inefficiency

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Heat 70^o F air to 125^o F, circulate to remove moisture, and then exhaust All the air in a 1,500 sf home is exhausted out over a 60 minute cycle

Typical Clothes Dryer Hot Wall

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After 40 Minute

Advanced Heat Pump Clothes Dryer

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4.5 vs. 12,000 CF Air Plus No Exhaust Vent

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Advanced Induction Cooktop



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Zero Net-Energy Ready 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)
- Dust Mites –asthma
- ~40% households with significant respiratory issue
- Radon Control

- 5 Pa depressurization

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Comprehensive Approach to IAQ:

- Water-managed assemblies*
- Radon
- Pests
- HVAC
- Combustion safety
- Materials
- * **Exception:** ENERGY STAR for Homes V3 Water Management Checklist can be used instead of IAP "Moisture Control" provisions



Source Control

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

Dilution

• Filtration

HVAC Quality Installation System

Source Control: Moisture Moisture Control System

- Air Sealing
- Air Barriers
- Water-Managed Roofs
- Water-Managed Walls/Openings
- Water Manage Foundation/Site
- Water Managed Materials
- Dehumidification in Warm-Humid Climates

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Thermal Enclosure System

Water Managed Construction









Source Control: Moisture

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Source Control: Radon Radon Zones in U.S.



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Source Control: Radon Radon Resistant Construction



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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

Source Control: Biological Contaminants **Pests**



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Source Control: Biological Contaminants Screened Openings



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Corrosion-proof rodent/bird screens for openings (e.g., copper or stainless steel mesh) <u>Exception</u>: clothes dryer vent

Source Control: Biological Contaminants Foundation Sealing



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Sealed Sump Pump

Air Sealing

Source Control: Combustion By-Products Power/Direct Vent Equipment



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Power Vented Water Heater

Direct-Vent Furnace

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Source Control: Combustion By-Products Certified Fireplaces & Stoves



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

Source Control: Combustion By-Products Certified CO Alarms



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CO Alarm in each bedroom area



CO Alarm



Combined CO & Smoke Alarm



Enforceable policy in Multi-family buildings



Source Control: Combustion By-Products Attached Garage Isolation

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Source Control: Chemicals Low Formaldehyde Pressed Wood



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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



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.

Source Control: Chemicals Low VOC Paints



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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.



carpet-rug.org





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Zero Net-Energy Ready **Technical Specifications Mandatory Requirements: Renewable Ready** [Where Applicable]

RERH Applicability



Average Daily Solar Radiation Per Month



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- Basic, minimal/no cost steps accommodate a future renewable energy system such as:
 - Document max. allowable roof dead/live load ratings \checkmark
 - Provide conduit between attic and equipment \checkmark
 - ✓ Reserve & label space in electrical service panel for future PV breaker
- Allowances:
 - Not required in areas lacking significant solar resources
 - Recognition of high perf. water heating systems



Screen for DCH Mandatory Items



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Renewable Energy Ready Checklists

- Determine applicability by zip code
- <u>http://gisatnrel.nrel.gov/PVWatts_Viewer/index.html</u>
- In this Mid-Atlantic example, solar resources = 4.8 kWh/m²/day



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Provide code-compliant documentation of the maximum allowable dead load and live load ratings of the existing roof (Rec DL.: 6 lbs./sq. ft.)

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Install permanent roof anchor fall safety system on roof pitches greater than 3:12.



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A roof anchor should be installed on a roof subsurface or vertical wall.

Dedicated Solar PV Plywood Panel

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To make the house RE ready, the builders should dedicate and label an area for mounting an inverter and balance of system components. With balance of PV system components installed on plywood panel.

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Builders should reserve or install a dual pole circuit breaker in the electrical service panel for use by the PV system, in accordance with the National Electric Code.





Typical Construction

RERH Compliant

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Solar Hot Water Ready Requirements



Provide code-compliant documentation of the maximum allowable dead load and live load ratings of the existing roof (Rec DL.: 6 lbs./sq. ft.)

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

Solar Hot Water Ready Requirements*

Homes equipped with an

ENERGY STAR whole-house

tankless gas water heater or

heat pump water heater are

exempt from these

requirements.

*

Install a solar bypass valve on the cold water feed. of the water heater (cap and label both ends).

Dedicate and label a 3' x 3' x 7'area in the utility room adjacent to the existing water heater for a solar hot water tank.

Dedicate and label a 3' x 2' plywood panel area adjacent to the solar hot water tank for the balance of system components/pumping package.

Install an electrical outlet within 6' of the designated wall area.





Solar Water Heating Only: Solar hot water storage tanks typically hold 80 to 120 gallons of water and weigh 800 lbs to 1,200 lbs when filled.

The builder should provide the homeowner with code-compliant documentation of the maximum dead weight load rating for all non-concrete floor assemblies in the designated location of the solar hot water storage tank.

Solar Water Heating Bypass Valve



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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.

Solar Water Heating Balance of System Components



Above: SWH infrastructure installed

Pictured is the final installation of the pump package into an area designated for the balance of system components.

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Builders should dedicate and label a wall space of 3' x 2' adjacent to the solar hot water tank for this purpose.

A power source or wall outlet should also be installed within 6 feet of this area

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Zero Net-Energy Ready **Technical Specifications Encouraged:** Water Conservation

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Buildings.Energy.gov



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• **1950 – 2000**:

U.S. Population Doubled Public Supply Water Demand More than Tripled

• Since 2011: > Half the U.S. with

Some Level of Drought.



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Released Thursday, August 2, 2012 Author: Mark Svoboda, National Drought Mitigation Center

http://droughtmonitor.unl.edu/

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Water Use at Home



- More than 1.2 million homes were constructed in 2010 and 2011 in U.S.
- Average water use is 70% indoors, 30% outdoors.
- Outdoor use is higher in Southwest and other dry regions.
- 20% savings readily achievable

Residential Indoor Water Use



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)

WaterSense Labeled Products

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Tank-Type

Toilets

1,100 labeled

models



Lavatory Faucets 3,400 labeled models

Showerheads 600 labeled models



Irrigation Controllers 30 labeled models

Flushing Urinals 140 labeled models

Labeled products are listed at: www.epa.gov/watersense/products

Built for when water was free and energy was cheap!

Copper L piping:

- 1" = 5.53 ounces/ft
- ³/₄" = 3.22 ounces/ft
- 1/2" = 1.55 ounces/ft





- The system shall store no more than 0.5 gallons 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 fixture before hot water is delivered (accounts for water that must be removed from the system before hot water can be delivered).
- Recirculation systems must be demand initiated (push button or motion sensor).
 - Timer and temperature activated recirculation systems do not meet this requirement.



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All toilets shall be WaterSense labeled tank-type.





All bathroom sink faucets or faucet accessories (e.g., aerators) shall be WaterSense labeled.

Bathroom sink flow test





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All kitchen sink faucets must have a maximum flow rate of 2.2 gpm.



Valve and connection hoses

Kitchen sink flow test



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Shower compartment requirements:

- The total allowable flow rate of water flowing at any given time from all showerheads must be limited to 2.0 gpm per 2,160 square inch (in²) increment or less of shower compartment floor area.
- Additional showerheads are allowed for each additional 2,160 in² floor area increment, provided the total flow rate from all flowing devices in each compartment is less than or equal to 2.0 gpm and the additional showerheads are operated by separate controls.

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Showerhead requirements:

- All showerheads shall be WaterSense labeled.
- In cases where more than one showerhead or hand-held shower is provided in combination with others in a single device intended to be connected to a single shower outlet, the entire device must meet the maximum flow requirement in all possible operating modes.







Showerhead flow test





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- If a dishwasher is installed, it shall be ENERGY STAR[®] qualified.
- If clothes washer are installed, including those in common-use laundry rooms, they shall be ENERGY STAR qualified with a water factor (WF) ≤ 6.0 gallons per water cycle per cubic foot capacity.



If an evaporative cooling system is installed, it must meet the following criteria:

- Shall use a maximum of 3.5 gallons of water per ton hour of cooling when adjusted to maximum water use.
- Blowdown shall be based on the time of operation, not to exceed 3 times in 24 hours.
- Once-through or single-pass cooling systems, systems with continuous blowdown/bleedoff, and systems with timer-only mediated blow-down management do not meet the requirements.

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If a water softener is installed, it shall be certified to meet NSF/ANSI 44 including Section 7 voluntary requirements for efficiency rated systems, including:

- Use demand-initiated regeneration controlled by a flow meter or water hardness sensor.
- Have a rated salt efficiency ≥ 3,350 grains of total hardness exchanged per pound of salt (NaCl equivalency).
- Must not include devices that use a clock timer to set regeneration on a fixed time schedule.
- Must not regenerate using more than 5.0 gallons of water per 1,000 grains or hardness removed during the service cycle.





Drinking Water Treatment



- If a drinking water treatment system is installed, it must be certified to meet applicable NSF/ANSI standards:
 - NSF/ANSI 42 Drinking Water Treatment Units Aesthetic Effects
 - NSF/ANSI 53 Drinking Water Treatment Units Health Effects
 - NSF/ANSI 55 Ultraviolet Microbiological Water Treatment Systems
 - NSF/ANSI 58 Reverse Osmosis Drinking Water Treatment Systems
 - NSF/ANSI 62 Drinking Water Distillation Systems
- Such systems shall yield at least 85 gallons of treated water for each 100 gallons of water processed (i.e., it shall have an efficiency rating equal to or greater than 85%).



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In multi-family buildings, each unit must be individually metered, submetered, or equipped with an alternate technology capable of tracking water use and making the information available to the residents of the individual unit.

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WaterSense Water Budget applied to:

- Front Yard only for single-family homes
- All areas improved upon by the builder for single-family and multi-family buildings
- Temporary landscapes (e.g., straw over bare soil) may be installed if permanent landscapes cannot be installed due to climate conditions.

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If an Irrigation System is installed, it must:

- Be designed or installed AND audited by a professional certified by WaterSense program
- Use fixed spray irrigation on turfgrass only and achieve at least a 65 percent distribution uniformity
- Use drip or micro irrigation on all plants other than turfgrass
- Include WaterSense labeled irrigation controllers
 or soil moisture sensors



Zero Net-Energy Ready **Technical Specifications Encouraged: Disaster Resistance**

Disaster Resistance as a System

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Weather

- Wind
- Hurricanes
- Tornado/Hail
- Severe Winter Storms

Natural Events

- Floods
- Wildfires
- Earthquakes

Pests

- Termites
- General Pests

U.S. Disaster Map



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Disaster Risk in the U.S.

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Disaster Risk in the U.S.

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Weather: Tornado Risk Map



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Weather: Hurricane Risk Map







Table 3-2: Adding 20 MPH to ASCE 7 basic wind speeds for FORTIFIED Design Wind Speed requirements (MPH)

ASCE 7 Wind Speed	Building Code Design Wind Speed (or interpolate between values)	FORTIFIED Design Wind Speed
< 90	90	110
90 - 100	100	120
100 – 110	110	130
110 – 120	120	140
120 – 130	130	150
130 – 140	140	160
140 – 150	150	170
> 150	150	170



One Requirement:

Install an impact resistant roofing [UL 2218 Class 4 or FM 4473 Class 4 which is appropriate for flexible roofing products like asphalt shingles and metal panels or shingles]

A continuous load path in wood frame construction:

- 1. metal connectors between the rafters/trusses and the double top plate,
- 2. various systems involving connectors, sheathing, rods, hold-downs, etc to transfer loads from the top plate through the wall and into the foundation
- 3. properly designed and detailed foundations

A continuous load path in masonry construction:

- 1. metal connectors between the rafters/trusses and the bond/tie beam,
- 2. horizontal re-bar installed in the bond/tie beam,
- vertical re-bar in fully grouted cells (number and location depends on design conditions) connecting to
- horizontal steel in the footing/foundation (Figure 3-10)

Weather: Wind Continuous Load Path



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Typical wall connections with stud spacing the same as truss/rafter spacing. Figure 305G-1, IBHS Guide





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Installation of secondary water resistance using self-adhering strips.



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Metal straps, clips, and connectors installed on the outside of the wall.





Metal straps, clips, and connectors installed on the inside of the wall.



Weather: Severe Winter Weather Risk Map



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- Addit. moisture barrier at roof eaves (ice flashing)
- Heating strips at drains on flat roofs
- No heat source installed in unconditioned attic
- No uninsulated recessed lights
- All attic access doors treated as exterior doors (insulated, sealed, and weather stripped/gasketed)
- All hidden attic penetrations (stack vents, partition walls, electric chases, etc.) properly sealed
- Sufficient insulation on piping in exterior assemblies or prohibit pipes in external assemblies or unheated spaces

Natural Events: Flood Risk Map



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Minimum Requirements of the National Flood Insurance Program (NFIP) except:

- The building must be at least 3' higher than the BFE (Base Flood Elevation)
- The foundations in Coastal A zones must adhere to same requirements as those in V zones. That is, only open elevated foundations are allowed.





Typical shoreline elevation showing flood zones V, Coastal A and X (Coastal Construction Manual, 3rd edition, FEMA 55).

Natural Events: Wildfire Risk Map



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- Non-combustible street number at least 4' high
- Firewood Storage and LP Containers at least 50' away from home structure and at least 15' defensible space
- Non-combustible screening covering attic/sub-floor vents
- Gutters and downspouts of noncombustible materials
- Min. 12' wide driveways with min. 13.5' vertical clearance
- Gates must open inward and at least 2' wider than driveway
- Individual fire extinguishers
- Spark arrestors in all chimneys
- Defensible space that varies by hazard area classification
- Additional requirements base on hazard area classification (extreme, high, or moderate)

Defensible Space Varies:

- Extreme Hazard Area -100'
- High Hazard Area 50'
- Moderate Hazard Area 30'



Defensible Space Characteristics:

- Grass mowed below 6"
- Regular Irrigation
- For trees >18', prune lower branches within 6' of ground

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- Trees at least 10' apart
- No tree limbs within 10' of home
- All plants or plant groups >20' apart
- No vegetation under decks
- Remove all dead/dying vegetation



Combustible and Non-combustible Soffit Materials Combustible

- Vinyl
- PVC
- Wood boards or panels less than or equal to ½" thick (including plywood and OSB)

Noncombustible

- Aluminum
- Wood boards or panels greater than ¹/₂" in thickness (including plywood and OSB)
- Cementitous soffit board

Wildfire Protection Criteria that Varies by Wildfire Hazard Level
Natural Events: Wildfire Spark Arrestors

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Spark Arrestor for chimney

Natural Events: Earthquake Risk Map





Natural Events: Earthquake Risk Map



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Pests: Termite Infestation Chart





Note: Lines defining areas are approximate only. Local conditions may be more or less severe than indicated by the region classification.

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- Termite Resistant Construction
 - Treated Wood Framing (e.g., Borate)
 - Steel Framing (but need to address thermal bridging)
 - Masonry Construction

Pest Control

- Air-Tight Construction
- Screened Openings
- Integrated Pest Management (IPM)



Zero Net-Energy Ready **Technical Specifications Encouraged: Quality Management**

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1. Complete Construction Documents

- Qualify as Designed to Earn ENERGY STAR
- Document all Challenge Home specifications

2. Integrated Design Process

- Meet with all trades/rater early in the design process
- Document all meeting outcomes
- LEED for Homes Integrated Process Prerequisite complies

3. Formal Quality Management Program

- Written procedures and field checklists
- In-house inspections and field-test protocols
- Training requirements for staff and contractors





Zero Net-Energy Ready Technical Specifications: Putting It All Together

Zero Net-Energy Ready System



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Zero Net-Energy Ready Homes Performance Threshold





	HVAC Equipment				
Higher Fff.		Hot Climates	Mixed Climates	Cold Climates	
		(2012 IECC Zones 1,2) ¹⁸	(2012 IECC Zones 3,4)	(2012 IEGC Zones 5,6,7,6)	
HVAC	AFUE	80%	90%	94%	
Fauin	SEER	18	15	13	
Equip.	HSPF	8.2	9	10 ¹⁹	
	Geothermal Heat Pump	EN	ERGY STAR EER and COP Crit	teria	
2042 10	ASHRAE 62.2 Whole-House	1.4 cfm/W;	1.4 cfm/W;	1.2 cfm/W;	
2012 VS.	MV System Performance	no heat exchange	no heat exchange	heat exchange with 60% SRF 1	
2009 IFCC	Insulation and Infiltration				
	 Insulation levels shall meet the Insulation²⁰ (ACHE0); 	1e 2012 IECC and achieve Grade	1 installation, perRESNET stand	ards.	
Insul.	Windows ^{21, 22, 23}	31110231-2 2.51110233	-4 2110235-7 1.51110	Half /	ACH50
		Hot Climates	Mixed Climates	Cold Clim.	
		(2012 IECC Zones 1,2,)	(2012 IECC Zones 3,4)	(2012 IECC Zones	
Mara Eff	SHGC	0.25	0.27	any	
	U-Value	0.4	0.3	0.27	
Windows	Homes qualifying through the U-values or SHGCs. ²⁴	Prescriptive Path with a total v	vindow-to-floor area greater th	han 15% shall have ar instead	
	Water Heater			ENE	RGY
	ENERGY STAR minimum			STAR	Water
	Thermostat25 & Ductwork				
	 Programmable thermostat (ex 	xcept for zones with radiant heat)		i	tg.
	Lighting & Appliances				
	 For purposes of calculating th STAR dishwasher, ENERGY sockets or 80% of lighting fix 	ne DOE Challenge Home Target H STAR refrigerator, ENERGY STA tures are ENERGY STAR Qualifie	lome HERS Index, homes shall b R ceiling fans, and ENERGY ST/ d.	e modeled with an ENERGY AR lamps (bulbs) in 80% of	

Exhibit 2: DOE Challenge Home Target Home 3.17

Target Home Avg. HERS Scores



Energy Efficiency & Renewable Energy



Based on 1800, 2400, and 3600 ft² prototypes on climate-appropriate foundations.

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

Exhibit 3: Benchmark Home Size²⁸

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

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.

Size Mod. Factor = [CFA _{Benchmark Home} /CFA _{Home to Be Built}] ^{0.25} [Not to Exceed 1.0]

Performance Path Example CZ4 Prototype - 4 BR, 2400 SF



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Specification	Target Home Spec	Design Home
AGW Insulation	R20 or R13+5	R21
Attic Insulation	R49 (U=0.026)	R50
Basement Walls	R10/13	R10
Windows	U=0.30; SHGC=0.27	U=0.30; SHGC=0.27
Infiltration	2.5 ACH50	3.0 ACH50
Ducts	Total ≤ 8 CFM25 per 100 SF of CFA; Leakage to outdoors ≤ 4 CFM25 per 100 SF of CFA	Total leakage 288 CFM25 Leakage to outdoors 140 CFM25
Furnace AFUE	90	90
A/C SEER	15	15
Whole-House Mech. Vent.	77 cfm; 1.4cfm/W no heat exchange;	77 cfm; 8.0 cfm/W exhaust-only
Water Heater	ENERGY STAR	Gas storage 0.67 EF
HERS Index	52	52 COMPLIES!

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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 <u>doechallengehome@newportpartnersllc.com</u>
 - Otherwise builders will not receive "credit" on DCH website
 - Considering RESNET National Homes Registry for future

REM/Rate V14.2 & DOE CH Compliance Reporting

- Automatically programs the Target Home and compares to Design Home
- Mandatory Requirements
- Optional Home Builder Commitments

REM/Rate v 14.2 - D	CH Trade Off Design - CZ6 2 story	bsmnt.blg	-
File Building View I	Extras Libraries Reports Tools I	Help	
🗈 🚅 🖬 🍫 📑 📰 🛛	≷ 🖬 🖬 🗿 🚯 🗠 🕒 🤋		
Marking any given chec referenced by that chec	kbox certifies that the home complies v kbox.	with all mandatory requirements	
DOE Challenge Home	ə		
Home Builder ID#:	12345		
- Mandatory Require	ements		
I ← enestration		Indoor Air Quality	
I Insulation	j∕ Lighting	Pan Efficiency	
Panawable En	ergy Ready Solar Electric	J♥ Duct Location	
	ergy neady solar hot water		
Optional Home Bu	ilder Commitments for Recognition		
Yes 💌	Certified under the EPA Indoor airPlu	us Program*	
Yes 🔻	Certified under the EPA WaterSense	e for New Homes Program	
No	Certified under the IBHS fortified for S	Safer Living Program	
No	Followed the DOE Challenge Home	Quality Management Guidelines	
No	The buyer of this home signed a waiv access to utility bill data for one year.	iver giving DOE Challenge Home r.	
*Certification compliance v achieve full c	under the DOE Challenge Home permi vith Indoor airPLUS. Builders seeking t ompliance with the Indoor airPLUS Ver	nits limited exceptions to full the Indoor airPLUS label must rification Checklist.	
-	X 13	<u>I</u>	
Errors/Warnings			
No errors or warnings exist			

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REM/Rate V14.2 & DOE CH Compliance Reporting



- DOE Challenge Home Compliance on "Compliance" tab
- Also note "Tax Credit" which passes in Most/All cases

差 🖩 🖦 🖱 📕 👌 🗗 🔐 🕼 곍 係 刁 ┣ ?	Analysis
	Updated: 10:42:47 AM
-Whole House Infiltration	
Measurement Type: Blower door test	Programs
Heating Season Infiltration Value: 2.00	V2.0 ENERGY STAR Passes
ACH @ 50 Pascals	V2.5 ENERGY STAR Passes
Cooling Season Intiltration Value: 2.00	V3.0 ENERGY STAR Passes
Shelter Class	Tax Credit Passes
2009 IECC Verification:	DOE Challenge Passes
	HERS Index 50
Mechanical Ventilation System for IAQ	NY HERS Score N/A
Type: Balanced	- Code
	IECC 2012 Energy Code Passes
Sensible Recovery Efficiency (%): 60.0	IECC 2009 Energy Code Passes
	IECC 2006 Energy Code Passes
I otal Recovery Efficiency (%):	IECC 2004 Energy Code Passes
Rate (cfm): 77	IECC 2003 Energy Code Passes
	IECC 2000 Energy Code Passes
Hours/Day: 24.0	IECC 1998 Energy Code Passes
For wetter	ECCONVS-2010 Passes
Tan watts.	ECC of Southern Nevada Passes
Multi-Carller Carlor	MEC 1995 Energy Code Passes
Ventilation Strategy for Cooling	MEC 1993 Energy Code Passes
Cooling Season Ventilation: Natural Ventilation	MEC 1992 Energy Code Passes
	ASHRAE 90.2 Code Passes
	Energy Area Compliance

Software Note: Eval./Diagnosing UA Compliance

- REM/Rate V14.2 models this UA Calc. automatically
- Non-compliance messages show if envelope doesn't meet 2012 IECC UA
- Use "2012 IECC Building UA Compliance" for diagnosing issues
 - Doesn't include fenestration





REM/Rate V14.2 & DOE CH Compliance Reporting



- Plan Review Feedback [required submission]
- Common Issues
 - Design HERS > Target Home HERS
 - Failure to Check Mandatory Boxes
 - 2012 IECC UA Not Low Enough
 - Unvented attics can be tricky
 - Duct not in conditioned space

DOE Challenge Home Verification

Projected Rating: Based on Plans - Field Confirmation Required

The building DOES NOT meet DOE CHALLENGE for the following reasons:

The Design Home HERS Index is larger than the DOE Challenge HERS Index Target.

- HERS Index w/o PV is 56
- HERS Index with PV is 56
 DOE Challenge HERS Index T:
- DOE Challenge HERS Index Target w/o SAF is 53 DOE Challenge HERS Index Target w/SAF is 53

The HERS Index w/o PV must be lower than the DOE Challenge HERS Index Target w/o SAF AND the HERS Index with PV must be lower than the DOE Challenge HERS Index Target with SAF.

Energy Performance	
House Type	DOE Challenge Home Builder Partner ID#
Single-family detached	12345
Year built	Square footage of Conditioned Space including Basement
2013	3968.0
Number of Bedrooms	Square footage of Conditioned Space without Basement
4	2368.0
Site address (if not available, list the site Lot #)	Registered Builder
555 Main Street	
Rockville	Certified Rater
MD, 20853	
HERS Index without On-site Generation	Date of Rating
56	
HERS Index with On-site Generation	Rating Software
56	REM/Rate - v14.1
HERS Index of the Target Home using size adjustment factor	Estimated annual energy costs(\$)
53	1428
Estimated annual energy use	Estimated annual energy savings
Electric: 14986 kWh \ Natural Gas: 220 Therms	Electric: 10648 kWh \ Natural gas: -9 Therms
Energy cost rates	Estimated annual emissions reductions
Electric: 0.08 \$/kWh \ Natural Gas: 0.50 \$/Therms	CO2: 7.0 tons / SO2: 116.5 lbs / NOx: 26.1 lbs

DOE Challenge Home Certification

As the certified Rater for this house, I certify this house meets/complies with all mandatory requirments of the DOE Challenge home guidelines, including the following:

Compliance with all ENERGY STAR Qualified Homes Version 3 requirements and checklists

X Compliance with Mandatory Fenestration Requirements

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

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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.



- Follow checklists in RERH documents, but apply DOE Challenge Home exceptions
- Revised checklist under development





Zero Net-Energy Ready **Recognition with DOE Challenge Home**

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Lots of Recognition Choices...

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What Challenge Homes Means...

Energy Efficiency & **Renewable Energy**





CH Partner Registration Process



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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

CH Partner Benefits

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Resources

- Customizable Homebuyer Brochures
- □ Case Studies
- Branding [Logos, Home Certificates and Labels]
- Electronic Newsletter [updates, policy changes, new innovations]

Technical Support

- Building America Solution Center
- Building America Stakeholder Meetings
- Building America Research Studies

Recognition

- DOE Housing Innovation Awards
- DOE Challenge Home Web Site Locator Tool



Links Buyers to Leading Edge Builders:

- Contact Information
- Optional Commitments



- # Labeled Homes
- Website link

For All Active Partners

DOE Challenge Home Partner Locator

Find out who is taking the challenge. Locate <u>DOE Challenge Home</u> partners near you! First choose a partner type and select a state. You can also enter a company name and find DOE Challenge Home partners that match your search.

Please note: Partners began registering for the new DOE CHALLENGE HOME on April 2, 2012. The locator will not produce large results of partners in the program for several weeks. Please check back to watch our progress.



CH Partner Locator Tool

ENERGY Energy Efficiency & Renewable Energy

	-				
About Take Action to Save Energy	DOE Challenge He These are all verifiers who a	ome: Results are located (or do business) in Minne	sota.		
Partner With DOE Activities Solar Decathlon	[<u>Modify Search</u>] [<u>New Search</u>] First Prev 1 2 Next Las	terresters landen nå efternøker og utbernes var som postsynden og			
Building America	100% Partners				
Home Energy Score	Name	Commitments	City	State	# of DOF
Home Performance with ENERGY STAR	hund	communents	city	State	Challenge Home
Better Buildings Neighborhood Program	<u>^</u>				Projects
Challenge Home	Building Science Institu	<u>te Inc.</u> 👾 🥯 🥸 👾 🔐	HINSDALE	IL	
 Partner Log In Become a Partner 	A Habitat for Humanity of	Ohio-Ky 🔅 😳 🐟 🕸	HAMILTON	ОН	
- Criteria		tions LLC 🍈 🚳		10	
- Partner Locator	· Midwestein Energy our		OLLWLIN		
- Events	SustainMax, LLC	🥯 🚭 🥶 🕸	MINNEAPOLIS	MN	
Guidelines for Home Energy Professionals					
Fechnology Research, Standards, & Codes	Name	Commitments	City	State	# of DOE Challenge Home Projects
	Q Bluegill Energy Manage	ment	KATY	TX	



- Take Orientation Training
 after registering and renew training every year
- Provide Certificate
 for DOE Challenge Home to each home owner
- Adhere to Brand Identity Guidelines
 for proper use of the DOE Challenge 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/challenge/

CH Partner Account Maintenance

- Update Company Information;
- Add, Delete, and Edit Contacts;
- Add/Update Your Logo;
- Add Commitments; and
- Access Key Tools and Resources

[http://www4.eere.energy.gov/buildings/challenge/my_account]

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CH Certification Process



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Rater Prints Certificate

directly from rating software

Certificate Includes:

- Rating details
- Graphic HERS
 Index
- List of optional programs





Case Study:

Builder can opt to provide project information focused on marketing, business case, and technical innovations

• Utility Bill Data:

Home buyer can opt to provide billing data over one-year period.



'Test Drive' Challenge Home

[1- 5 homes; most not ready for wholesale change] Offer Challenge Home upgrade as *'Limited Edition'*

Measure Profit Metrics:

- Cost
- Marketing
- Performance

High-Performance Looks Different!

- Architectural Appearance
- 'Mark of Excellence'

World-Class Expert Guidance...



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Sution Center

...At Your Fingertips

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QA/QC

DESIGN



Garage Rim/Band Joist

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Insulation

Checklist Manager **Building Science** Explorer Browser

CAD Files

Guides

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- Case Studies
- Image Gallery
- References

Attic Knee Walls

Please Register or Login to Provide Feedback.

SC	ope		10			-	
			-	TV	LUP		Y-IL
Ful	ly Aligned Air	Barrier			a wa	Allelan	
Α.	Install a top ar at the top and cavities	nd bottom plate or blo bottom of all knee wa	cking all		A Bikc		
Β.	Back attic kne barrier or other prevent insulat a continuous t	ee walls with a rigid ai r supporting material ion from sagging and hermal barrier*	ir to create		•		
C	Seal all seams	s, gaps, and holes of	the air	F	F		
0.	barrier with cal	UN OF IDATE					

An air barrier is defined as any durable solid material that blocks air flow between conditioned space and unconditioned space, including necessary sealing to block excessive air flow at edges and seams

Scope: Clearly defines and bounds the topic in a way builders and remodelers can contractually obligate their subcontractors.

diameter unless otherwise indicated by the manufacturer. Hexible air barriers shall not be made of kraft

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Image Gallery

References

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•	Description	Ensuring Success	Climate	Training	CAD	Compliance	More Info.
De	scription						
Kne of s flow this attic ceili attic	e walls, the wa ignificant air lea ing under the k air flow: either c floor, includin ing deck below c roofline to the	alls that separate con- akage if a continuous mee wall and under th a continuous air barri g the spaces betweer to or a continuous air b top plate of the home	ditioned from air barrier i ne floor boa ier can be p n the attic fl parrier can l e's exterior	m unconditi s not provid rds of the at provided fron loor joists fr be installed wall With 6	oned sp ed to pr ttic roon n the top om the l from the either m	ace in an attic, event unconditi n. There are tw p of the knee w bottom of the knee e top of the kne ethod the air ba	, can be a source ioned air from o ways to block of vall down to the ance wall to the ee wall along the arrier should be
inst defii unc ade mat insu dryv worl	alled before ins ned as any dur onditioned spa quate support t erial can includ lation that is c vallers. This ta kflow at the spa	stalling attic floor insul able, solid material th ce, including necessa to resist positive and i de thin sheet goods so overed with spray foar sk should be included ecific job site.	lation to the nat blocks a negative pre uch as rigio m. These n I in the con	e unconditio air flow betw to block exc essures with I insulation, naterials ma tract for the	ned port een con cessive nout disp dry wal ny be ins appropr	tion of the attic iditioned space air flow at edge placement or d I, OSB, plywoo stalled by insul riate trade depe	An air barrier is and amage. Air barrier od, or rolled batt ators, framers, or ending on the



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Description: Provides an explanation of the building topic and in some cases specific "how-to" implementation steps.



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Image Gallery

References

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E	nsuring Success
BI	ower door testing, conducted as part of whole-house energy performance testing, may help indicat
wł	tether air leakage at knee walls has been successfully sealed. An infrared camera may also be us
to	determine air leakage at the knee wall, if a sufficient temperature difference exists between the att
an	d the conditioned space of the house to see the leakage. An experienced technician can also che
foi	air leaks beneath the knee walls with a smoke pencil or by feeling for leaks with the back of the
ha	nd.



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Ensuring Success: Related health, safety, durability, performance issues, test-in/test-out requirements, and scheduling and sequencing considerations.

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Clir	nate						
ENE	RGY STAR Ve	ersion 3, (Rev. 6)					
Ther	mal Enclosure	Checklist, Fully-Alig	ned Air Bar	riers. A con	nplete a	ir barrier shall	be provided the
surfa	ice of walls for	Climate Zones 4-8.	or surface (n wans in ai	r ciimat	e zones, anu a	iiso at interior
DOE	Challange H						
Exhi	bit 2: DOE Ch	<u>ome</u> allenge Home Target	Home. Infil	tration (ACH	150): Zo	nes 1-2: 3; Zor	nes 3-4: 2.5; J
5-7:	2; Zone 8: 1.5.	Envelope leakage s	hall be det	ermined by	an appr	oved verifier us	ing a RESNE
appr	oved testing pr	otocol.					
	1		- 13	7.4			-
	A	2 6	1	- St	3	(In 1	3
			- A	30	3	The state	
	4	15 A			5	1 Aler	e
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	A.C.			4	<u> </u>	59	
	E.	R S		4	Z		



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Climate: Climate-specific codes, standards, ENERGY STAR, and Challenge Home guidance.

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Training: resources such as Right and Wrong/Sequencing installation images. COMING: Videos and presentations

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Component Explorer	Please <u>Register</u> or <u>Login</u> to Provide Feedback.	
Checklist Manager		
Building Science Explorer	Scope Description Ensuring Success Climate Training CAD Compliance More In	ifo.
Browser	CAD Images	
Guides		
CAD Files		MOBILE FIELD KIT
Case Studies		The Building America
Image Gallery		save items to your profil
References	formation from the second seco	for review or use on-site
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		or
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CAD: Architectural CAD files of the building topic in DWG and PDF forms.

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Scope	Description	Ensuring Success	Climate	Training	CAD	Compliance	More Info.
						-	
Cor	npliance						

Thermal Enclosure Checklist, Fully-Aligned Air Barriers. A complete air barrier shall be provided that is fully aligned with the insulation at exterior surface of walls in all climate zones; and also at interior surface of walls for Climate Zones 4-8. All insulated vertical surfaces are considered walls (e.g., above and below grade exterior walls, knee walls) and must meet the air barrier requirements for walls, with the exception of adiabatic walls in multifamily dwellings.

DOE Challenge Home

Exhibit 2: DOE Challenge Home Target Home. Certified under ENERGY STAR Qualified Homes Version 3. Infiltration (ACH50): Zones 1-2: 3; Zones 3-4: 2.5; Zones 5-7: 2; Zone 8: 1.5. Envelope leakage shall be determined by an approved verifier using a RESNET-approved testing protocol. Building envelope assemblies, including exterior walls and unvented attic assemblies (where used), shall comply with the relevant vapor retarder provisions of the 2012 International Residential Code.

ASTM E1677-11

Standard Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls. This specification covers minimum performances and specification criteria for an air barrier material or system for framed, opaque walls of low-rise buildings. The provisions are intended to allow the user to design the wall performance criteria and increase air barrier specifications for a particular climate location, function, or design.



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Compliance: Specific compliance references/links from applicable codes and standards.



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1. 2009 IECC—International Energy Conservation Code

More Info:

- References Full citations with links for content.
- Case Studies Summaries of whole-house best practices.
- Resources Relevant information not previously cited as references

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Zero Net-Energy Ready Local Solution



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Meet Local HERS Raters...





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Thank You



For More Information:

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