DOE Zero Energy Ready Homes

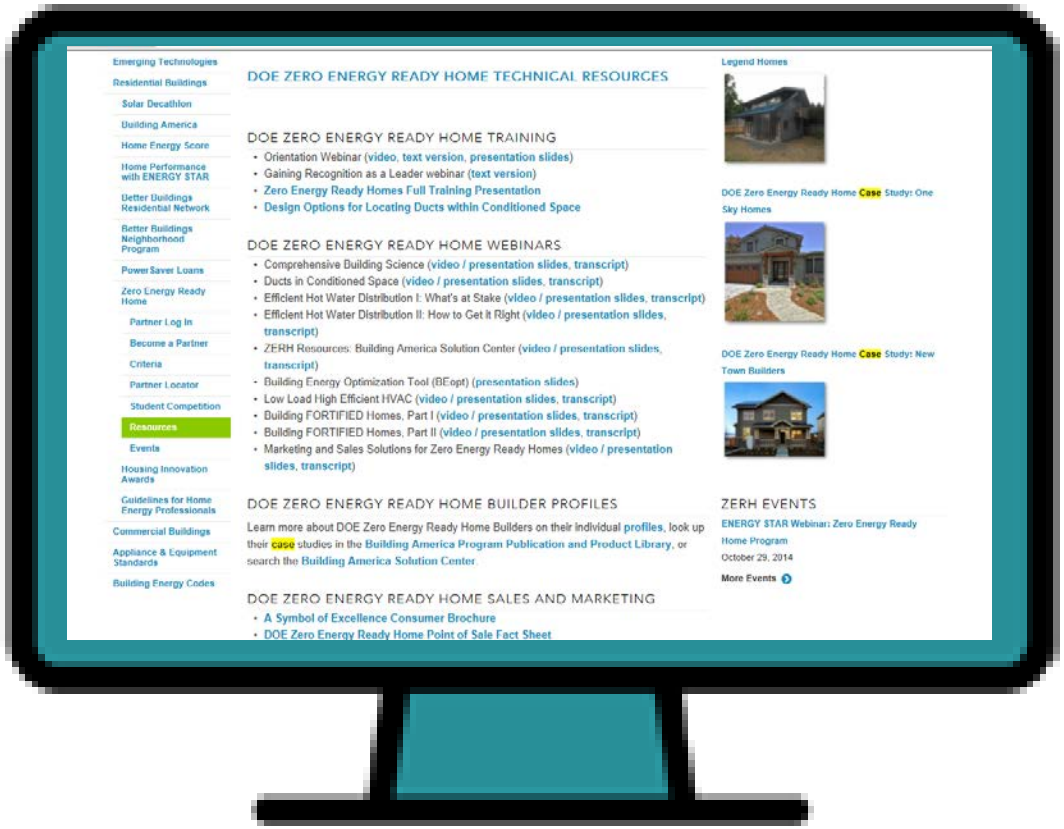
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

www.buildingamerica.gov/ZERH

Agenda

- Overview of Challenge Home Program Requirements
- Spotlight on Interior Duct Requirement
- Resources: www.buildings.energy.gov/zero
  - Training
  - Webinars
  - Case Studies



A Symbol of Excellence

Zero Energy Ready Home Goal

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

Home Innovation RESEARCH LABS

The Home of the Future….Today

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CHALLENGE HOME

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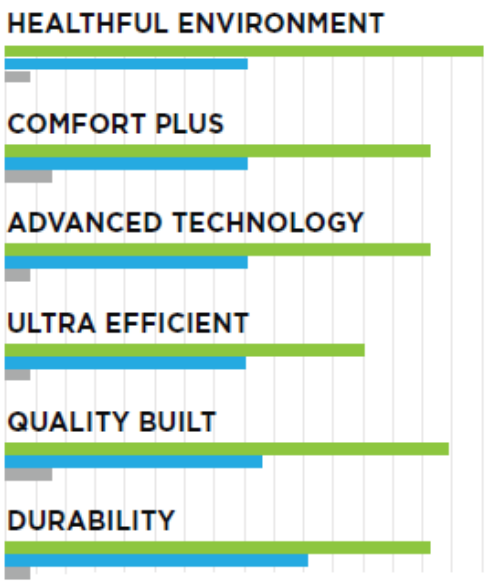

This label indicates relative performance of this DOE Challenge Home to existing homes (built between 1990 and 2010) and ENERGY STAR qualified homes. Actual performance may vary.

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Challenge Home Requirements

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Exhibit 1: DOE Zero Energy Ready Home Mandatory Requirements for All Labeled Homes

Area of Improvement	Mandatory Requirements
1. **ENERGY STAR for Homes Baseline**	☐ Certified under ENERGY STAR Qualified Homes Version 3 [9, 10]
2. **Envelope**[11]	☐ Fenestration shall meet or exceed latest ENERGY STAR requirements [12, 13] ☐ Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels[14, 15]
3. **Duct System**	☐* Ducts located within the home's thermal and air barrier boundary[16]
4. **Water Efficiency**	☐ Hot water delivery systems shall meet efficient design requirements[17]
5. **Lighting & Appliances**[18]	☐ 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**	☐ Certified under EPA Indoor airPLUS [10]
7. **Renewable Ready**[19]	☐ Consolidated Renewable Energy Ready Home (RERH) Checklist

∗ Mandatory requirements, except #3, reference standards and codes outside the program

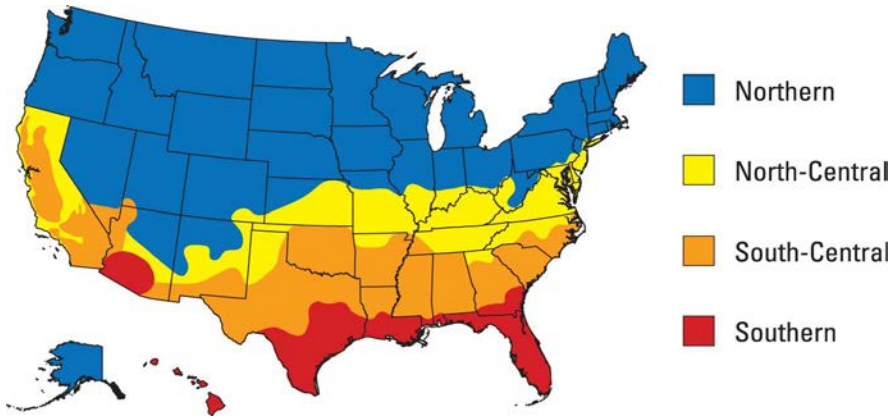
- Many exceptions! Read the 30 footnotes (5 ½ pages) for clarifications
- Direct link to National Program Requirements:

http://energy.gov/sites/prod/files/2014/04/f15/doe_zero_energy_ready_home_requirements_rev04.pdf

Challenge Home Requirements 1-7, *con't*

- #1 ENERGY STAR version 3 or 3.1 certification and meet or beat the DOE Challenge Home Target Home specifications – Target HERS Index, generally in mid-50's
- #2(a) ENERGY STAR labeled windows
  - NFRC rating req'd
  - ENERGY STAR window criteria: http://www.energystar.gov/index.cfm?c=windows_doors.pr_anat_window

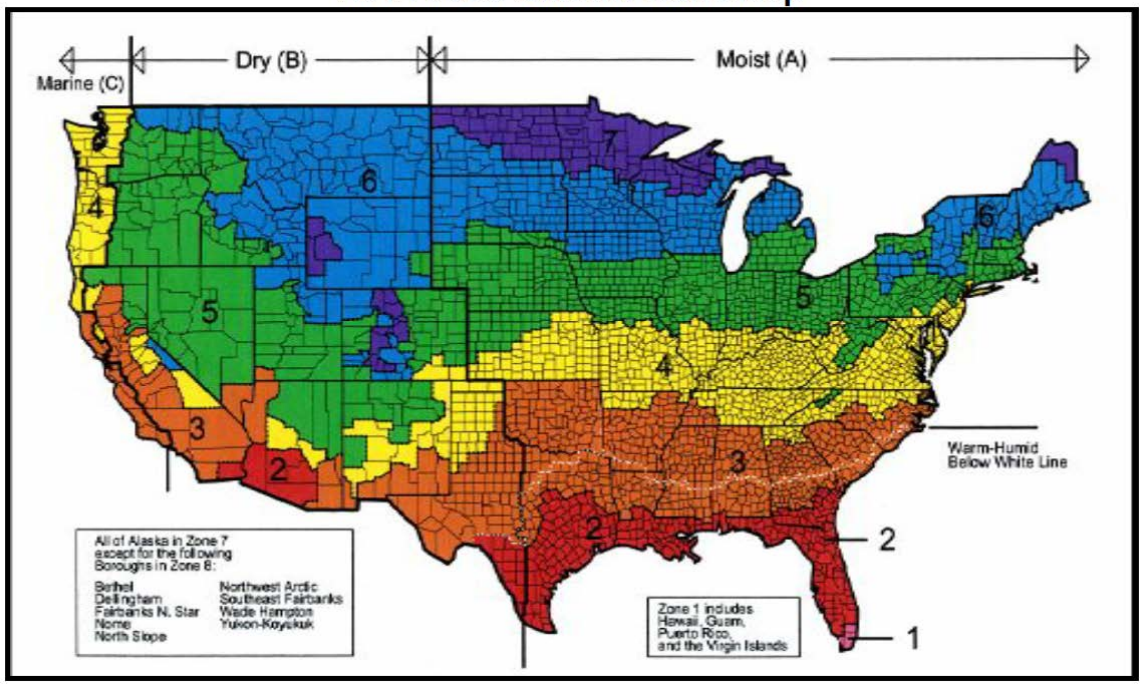
	Windows			Skylights	
	U-Factor	SHGC		U-Factor	SHGC
Northern	≤ 0.30	Any		≤ 0.55	Any
North-Central	≤ 0.32	≤ 0.40		≤ 0.55	≤ 0.40
South-Central	≤ 0.35	≤ 0.30		≤ 0.57	≤ 0.30
Southern	≤ 0.60	≤ 0.27		≤ 0.70	≤ 0.30
	Doors				
Glazing	U-Factor	SHGC			
Opaque	≤ 0.21	None			
≤ 1/2 lite	≤ 0.27	≤ 0.30			
≥ 1/2 lite	≤ 0.32	≤ 0.30			



Challenge Home Requirements 1-7, *con't*

- #2(b) Ceiling, wall, floor, and slab insulation shall meet or exceed **2012 IECC levels** or equivalent overall U-value
- 3 Paths – First, what's your IECC climate zone number?

2012 IECC Climate Zone Map



Challenge Home Requirements 1-7, *con't*

- #2(b) Path 1 focuses on the insulation itself
  - IECC 2012, Chapter 4, Table 402.1.1 provides prescriptive ***Insulation*** R-values

2012 IECC Prescribed R-values (Table 402.1.1)

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	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	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.40	49	20 or 13+5[h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20+5 or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.32	0.55	NR	49	20+5 or 13+10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

Challenge Home Requirements 1-7, *con't*

- #2(b) Path 2 – Focuses on *assemblies* (e.g. walls and floors) – Table 402.1.3 provides max U-values for combined materials in an assembly (batts + blue board)
- #2(b) Path 3 – Focuses on a WHOLE HOUSE AVERAGE
  - Area weighted average of U-values that allows trade-offs between walls, floors, ceilings, roofs, & windows

2012 IECC Equivalent U-values (Table 402.1.3)

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
1	0.50	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.082	0.165	0.064	0.360	0.477
3	0.35	0.55	0.030	0.057	0.098	0.047	0.091[c]	0.136
4 except Marine	0.35	0.55	0.026	0.057	0.098	0.047	0.059	0.065
5 and Marine 4	0.32	0.55	0.026	0.057	0.082	0.033	0.050	0.055
6	0.32	0.55	0.026	0.048	0.060	0.033	0.050	0.055
7 and 8	0.32	0.55	0.026	0.048	0.057	0.028	0.050	0.055

Challenge Home Requirements 1-7, *con't*

- #3 - All ducts and air handlers located within the thermal and air barriers – "*ducts in conditioned space"* more later
- #4 Hot water distribution system
  - Goal: Minimize "stand-by" loses while waiting for hot water
  - Design goal: ≤ 0.5 gallons stored between water heater and farthest outlet
  - Test procedure: ≤ 0.6 gallons stand by loss at farthest outlet
  - On-demand recirculating systems are allowed. Timer- and temperature-based recirculating systems are not.
- #5 - All installed refrigerators, dishwashers, clothes washers, exhaust fans, ceiling fans and 80% of lighting (fixtures and/or bulbs) are ENERGY STAR qualified.
  - Find ENERGY STAR products:
  - http://www.energystar.gov/index.cfm?c=products.pr_find_es_products

Challenge Home Requirements 1-7, *con't*

- #6 - EPA Indoor airPLUS
  - Recently Revised 2013 to align with ENERGY STAR for New Homes (prerequisite)
  - Version 1 (Rev. 01) – for homes permitted after July 1, 2013 http://epa.gov/iaplus01/pdfs/construction_specifications.pdf
  - Program components – many criteria covered by ENERGY STAR checklists
    - Moisture Control
    - Radon Control
    - Pest Barriers
    - HVAC Systems .
    - Combustion Pollutant Control
    - Low Emission Materials
    - Home Commissioning
  - Main web page: http://epa.gov/iaplus01/index.html

Challenge Home Requirements 1-7, *con't*

- #7 EPA Renewable Ready Compliant
  - Material for Solar Electric (Photovoltaic (PV)) and Solar Thermal are similar with exact entries for some criteria
  - Program components:
    - Design and preparation for future installation
    - Homeowner awareness
    - Provision for necessary electric circuits, wiring, plumbing, etc.
  - Not require in some situations – see next slides
  - EPA Renewable Energy Ready Home Guides
    - PV Guide: https://www.energystar.gov/ia/partners/bldrs_lenders_raters/rerh/docs/Renewable_Energy_PV.pdf
    - Water Heating Guide: https://www.energystar.gov/ia/partners/bldrs_lenders_raters/rerh/docs/Renewable_Energy_SWH.pdf

Challenge Home Requirements 1-7, *con't*

- #7 EPA Renewable Ready Requirements Only Apply if:
  - ≥5 kWh/m2/day average daily solar radiation
  - Use your zip code to check your location here: http://gisatnrel.nrel.gov/PVWatts_Viewer/index.html

Challenge Home Requirements 1-7, *con't*

- #7 EPA Renewable Ready Requirements Only Apply if:
  - PV or solar HW is not already installed
  - Location does not have significant natural shading (e.g., trees, tall buildings) on the south-facing roof
  - Home as designed has adequate free roof area within +/- 45° of true south as noted in the table below.

Conditioned Floor Area of House (ft^2)	Minimum Roof Area for Solar Electric RERH Checklist (ft^2)	Minimum Roof Area for Solar Thermal RERH Checklist (ft^2)
≤ 2000	110	40
≤ 4000	220	60
≤ 6000	330	80
>6000	440	100

Interior Duct Strategies

- Traditionally, ducts have been located in vented attics and crawlspaces, basements.
- Performance Objective of Interior Ducts (Req'm #3)
  - Reduce heat transfer to/from ducts
  - Eliminate duct leakage to outside of conditioned space and limit the attendant moisture and air flow dynamics
- Practical Objectives for Interior Ducts – on the job site
  - Locate ducts and air handler to the inside of a continuous thermal barrier (wall/floor/ceiling insulation) AND to the inside of a continuous whole house air barrier
- Building America interior ducts overview:
  - http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/measure_guide_ducts_new_con.pdf

Interior Duct Strategies

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- Unvented adjacent spaces
  - Unvented Attic - Manatee County HFH (FL)
  - Unvented Crawl Space - Huntington Area HFH (WV)
  - Conditioned Basement - HFH of Greater Cincinnati (OH)
  - Basements and floor cavities housing ducts need air barrier and insulation at band joist similar to unvented crawl spaces
- Interior duct chases
  - Modified Truss Design - SE Volusia County HFH (FL) and Putnam County HFH (OH)
  - Fur Down Soffit Duct Chase - HFH Broward County (FL) (not Challenge Home)
- Eliminate ducts
  - Mini-split Systems - Cave Run HFH (KY)
  - Hydronic heating
- Super-insulate ducts
  - Buried ducts - emerging strategy, recent study:
  - http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/encaps_ducts_hothumid.pdf

Sealed and Unvented Attic

- Spray foam at the roof deck forms air barrier and thermal barrier
- More expensive and greater surface area
- Debate w/in building science community about closed vs open cell
- Thickness limited by material
- Closed cell foam has higher R-value per inch than other insulations
- Install dead wood and backer to separate from porches attics
- Ensure continuous insulation has no holes and fill in over top plates
- Hire an installer with experienced field crew, proven track record
- Airtightness metric in scope of work
- Caution: foam creates an air tight space, use caution with temporary heating, no propane heaters
- HFH Challenge Home Affiliate: Manatee County HFH

Photos: Manatee County Habitat for Humanity. Photo credit: Florida Solar Energy Center, David Beal

Unvented, Sealed Crawl Spaces

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- ***Ins and air barrier at stem walls instead of floor cav***
- Primary air barrier: house wrap
- Secondary air barrier: Poly ground cover + **series of sealing points**
- Check air tightness during blower door test
- Rim Joist sealing similar to rim joist between up/down stairs and basements
- Comprehensive guidance at:
- http://www.crawlspaces.org/
- HFH Challenge Home Affiliates
  - Unvented Crawl: Huntington Area HFH (WV)
  - Conditioned Basement: HFH of Greater Cincinnati (OH)

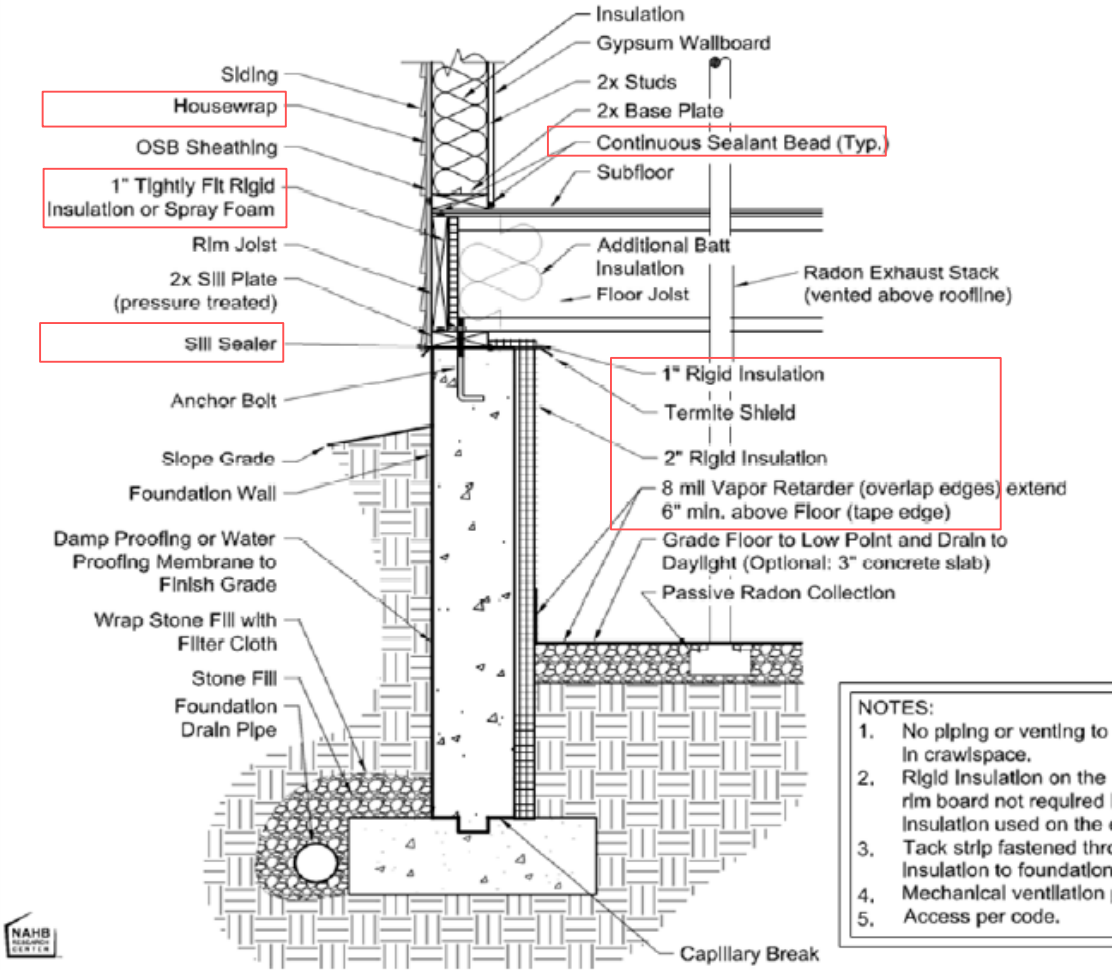

Image credit: National Home Builders Association Research Laboratory. Included in Building America publication: http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/crawlspace_found_retrofit.pdf

Unvented, Sealed Crawl Space

- Sample procedure (develop QA checklists for tasks occuring at different times in the construction process)
- Before floor joists:
  - Insulate stem walls with rigid insulation, seal edges and seams
  - Grade crawl space, cover with 6-8 mil poly sealed at the edges and seams, lap up and seal to stem walls and piers
  - Seal around sump pump covers and framing for access panels
  - Provide termite inspection shield
- After floor and exterior wall framing, before house wrap:
  - Seal bottom plate to sub-floor to rim joist to mud sill to termite strip to stem wall
- Seal and insulate rim joist from inside crawlspace
- Extended house wrap to and seal to mud sill (above termite inspection strip
- Seal around rough framing of access panels; insulate and weather strip access panel opening

Modified Truss (Fur Up) Chase

- Modified Truss “Fur Up” Duct Chase
  - Truss designed for chase
  - “Ladder” frame creates bottom of chase
  - **Must be separated from attic by air and thermal barriers (e.g. tape and mud + insulation**
  - **Supply** registers mounted in ceiling
  - Difficult to do w/fully ducted return
- HFH Challenge Home Affiliates
  - SE Volusia County HFH (FL)
  - Putnam County HFH (OH)

Modified Truss (Fur Up) Chase

- All duct chases are vulnerable to invasion – looks like great place to run wiring for security, phone, hall lighting fixtures, etc

- Blown-in insulation won't stick to sides of chases which are essentially knee walls.
- Difficult to get full insulation at top corners of chase
- Knee wall insulation difficult to secure
- *Important: Likely can not reach IECC 2012 req'm for ceiling R-value OR U-value at the knee wall (considered a ceiling). Use path 3, whole house, area weighted average*

Fur Down Soffit Duct Chase

- Critical details for traditional “fur-down chase” - soffit construction approach
  - Top and sides of soffit formed by continuous air barrier
  - “Ladder” framing installed to inside surface of chase sides
  - Carefully mark bottom of chase above finish door height

Florida affiliates Broward County Habitat (left and center), Lakeland Habitat (right)

Sources: http://www.ba-pirc.org/pubs/pdf/M1_12_1-4.pdf and http://www.ba-pirc.org/pubs/pdf/interior_ducts.pdf

Fur Down Soffit Duct Chase

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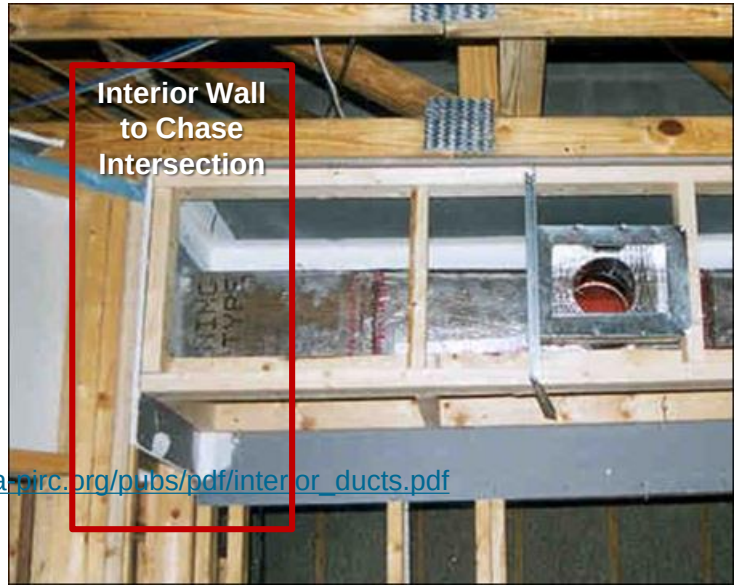
- Pros and cons
  - Ceiling height is lowered – widen hall to reduce “cave” syndrome
  - Sides of chase don’t have to be insulated
  - Difficult to do with fully ducted return – central return w/passive return air transfers from bedrooms
  - Use chase to create architectural interest
  - Complexity of creating and sealing chase at interior walls is a major challenge – easy ***going down the hall, but going through a wall, the cavity must also be separated from the attic at the top plate***



M1 ba-pirc.org/pubs/pdf/interior_ducts.pdf

Fur Down Soffit Duct Chase – Alternate Approach

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- Eliminates complexity at interior walls by putting air barrier *above* the top plates
- Critical details for alternative soffit construction
  - Top of soffit is formed by continuous, taped and mudded drywall ***(air barrier)*** above the top plates
  - Layout the duct chase ON THE PLAN during design
  - Step 1: Layout duct chase on the floor w/chalk or spray paint
  - Step 2: Slide drywall over top plates to mirror duct path, tape and mud, provide blocking as needed to level and support drywall
  - Step 3: Mechanical rough in, strap ducts in place

Tommy Williams Homes, Gainesville, FL

Photo credit: Ken Fonorow, Florida H.E.R.O.and http://www.fsec.ucf.edu/en/publications/pdf/FSEC-RR-385-11.pdf

Fur Down Soffit Duct Chase

  - Step 4: build “ladder” framing (on the ground) and hang to create sides and bottom of chase
  - Step 5: finish ceiling as usual
- Difficult to do with fully ducted return
- Central return w/properly sized passive return air transfers from bedrooms

Tommy Williams Homes, Gainesville, FL

Photo credit: Ken Fonorow, Florida H.E.R.O.and http://www.fsec.ucf.edu/en/publications/pdf/FSEC-RR-385-11.pdf

Interior Duct Strategies Recap

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3. Eliminate ducts
   - Mini-split Systems - Cave Run HFH (KY)
   - Hydronic heating
4. Super-insulate ducts
   - Buried ducts - emerging strategy

Learn More and Next Steps

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Website: www.buildings.energy.gov/challenge/

- Submit Partnership Agreement (see handout)
- Attend Upcoming ZNERH Trainings and Technical Training webinars ***(see "Events")***
- Review Specifications and Identify Areas of Need
- Partner Locator – HVAC & rater/verifier need to be partners
- Build a Challenge Home
- Write a press release!
- Work with Building America to do a Case Study
- Submit an Application for an Award!

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Q&A