Agenda

- Overview of Challenge Home Program Requirements
- Spotlight on Interior Duct Requirement
- Resources: [www.buildings.energy.gov/zero](http://www.buildings.energy.gov/zero)
  - Training
  - Webinars
  - Case Studies
A Symbol of Excellence

U.S. DEPARTMENT OF ENERGY

CHALLENGE HOME

ZERO ENERGY READY HOME

U.S. DEPARTMENT OF ENERGY
Zero Energy Ready Home Goal

High-performance home so energy efficient, all or most annual energy consumption can be offset by renewable energy.
The Home of the Future….Today
Challenge Home Requirements

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

<table>
<thead>
<tr>
<th>Area of Improvement</th>
<th>Mandatory Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ENERGY STAR for Homes Baseline</td>
<td>Certified under ENERGY STAR Qualified Homes Version 3[^9][^10]</td>
</tr>
<tr>
<td></td>
<td>Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels[^14][^15]</td>
</tr>
<tr>
<td>3. Duct System</td>
<td>Ducts located within the home's thermal and air barrier boundary[^16]</td>
</tr>
<tr>
<td>4. Water Efficiency</td>
<td>Hot water delivery systems shall meet efficient design requirements[^17]</td>
</tr>
<tr>
<td>5. Lighting &amp; Appliances[^18]</td>
<td>All installed refrigerators, dishwashers, and clothes washers are ENERGY STAR qualified.</td>
</tr>
<tr>
<td></td>
<td>80% of lighting fixtures are ENERGY STAR qualified or ENERGY STAR lamps (bulbs) in minimum 80% of sockets</td>
</tr>
<tr>
<td></td>
<td>All installed bathroom ventilation and ceiling fans are ENERGY STAR qualified</td>
</tr>
<tr>
<td>6. Indoor Air Quality</td>
<td>Certified under EPA Indoor airPLUS[^10]</td>
</tr>
</tbody>
</table>

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

- Many exceptions! Read the 30 footnotes (5 ½ pages) for clarifications
Key Technical Specification

Challenge Home Requirements 1-7, cont’d

• #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

<table>
<thead>
<tr>
<th>Windows</th>
<th>Skylights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U-Factor</td>
</tr>
<tr>
<td>Northern</td>
<td>≤ 0.30</td>
</tr>
<tr>
<td>North-Central</td>
<td>≤ 0.32</td>
</tr>
<tr>
<td>South-Central</td>
<td>≤ 0.35</td>
</tr>
<tr>
<td>Southern</td>
<td>≤ 0.60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Glazing</th>
<th>U-Factor</th>
<th>SHGC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opaque</td>
<td>≤ 0.21</td>
<td>None</td>
</tr>
<tr>
<td>≤ 1/2 lite</td>
<td>≤ 0.27</td>
<td>≤ 0.30</td>
</tr>
<tr>
<td>≥ 1/2 lite</td>
<td>≤ 0.32</td>
<td>≤ 0.30</td>
</tr>
</tbody>
</table>
Key Technical Specification

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](image-url)
### 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)

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR&lt;sup&gt;b&lt;/sup&gt;</th>
<th>SKYLIGHT&lt;sup&gt;b&lt;/sup&gt; U-FACTOR</th>
<th>GLAZED FENESTRATION SHGC&lt;sup&gt;b, e&lt;/sup&gt;</th>
<th>CEILING &lt;i&gt;R&lt;/i&gt;-VALUE</th>
<th>WOOD FRAME WALL &lt;i&gt;R&lt;/i&gt;-VALUE</th>
<th>MASS WALL &lt;i&gt;R&lt;/i&gt;-VALUE&lt;sup&gt;i&lt;/sup&gt;</th>
<th>FLOOR &lt;i&gt;R&lt;/i&gt;-VALUE</th>
<th>BASEMENT WALL &lt;i&gt;R&lt;/i&gt;-VALUE&lt;sup&gt;c&lt;/sup&gt;</th>
<th>SLAB&lt;sup&gt;d&lt;/sup&gt; &lt;i&gt;R&lt;/i&gt;-VALUE &amp; DEPTH</th>
<th>CRAWL SPACE&lt;sup&gt;c&lt;/sup&gt; WALL &lt;i&gt;R&lt;/i&gt;-VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NR</td>
<td>0.75</td>
<td>0.25</td>
<td>30</td>
<td>13</td>
<td>3/4</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0.40</td>
<td>0.65</td>
<td>0.25</td>
<td>38</td>
<td>13</td>
<td>4/6</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0.35</td>
<td>0.55</td>
<td>0.25</td>
<td>38</td>
<td>20 or 13+5&lt;sup&gt;h&lt;/sup&gt;</td>
<td>8/13</td>
<td>19</td>
<td>5/13&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0</td>
<td>5/13</td>
</tr>
<tr>
<td>4 except Marine</td>
<td>0.35</td>
<td>0.55</td>
<td>0.40</td>
<td>49</td>
<td>20 or 13+5&lt;sup&gt;h&lt;/sup&gt;</td>
<td>8/13</td>
<td>19</td>
<td>10/13</td>
<td>10, 2 ft</td>
<td>10/13</td>
</tr>
<tr>
<td>5 and Marine 4</td>
<td>0.32</td>
<td>0.55</td>
<td>NR</td>
<td>49</td>
<td>20 or 13+5&lt;sup&gt;h&lt;/sup&gt;</td>
<td>13/17</td>
<td>30&lt;sup&gt;g&lt;/sup&gt;</td>
<td>15/19</td>
<td>10, 2 ft</td>
<td>15/19</td>
</tr>
<tr>
<td>6</td>
<td>0.32</td>
<td>0.55</td>
<td>NR</td>
<td>49</td>
<td>20+5 or 13+10&lt;sup&gt;h&lt;/sup&gt;</td>
<td>15/20</td>
<td>30&lt;sup&gt;g&lt;/sup&gt;</td>
<td>15/19</td>
<td>10, 4 ft</td>
<td>15/19</td>
</tr>
<tr>
<td>7 and 8</td>
<td>0.32</td>
<td>0.55</td>
<td>NR</td>
<td>49</td>
<td>20+5 or 13+10&lt;sup&gt;h&lt;/sup&gt;</td>
<td>19/21</td>
<td>38&lt;sup&gt;g&lt;/sup&gt;</td>
<td>15/19</td>
<td>10, 4 ft</td>
<td>15/19</td>
</tr>
</tbody>
</table>
**Key Technical Specification**

**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)

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR</th>
<th>SKYLIGHT U-FACTOR</th>
<th>CEILING U-FACTOR</th>
<th>FRAME WALL U-FACTOR</th>
<th>MASS WALL U-FACTOR</th>
<th>FLOOR U-FACTOR</th>
<th>BASEMENT WALL U-FACTOR</th>
<th>CRAWL SPACE WALL U-FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.50</td>
<td>0.75</td>
<td>0.035</td>
<td>0.082</td>
<td>0.197</td>
<td>0.064</td>
<td>0.360</td>
<td>0.477</td>
</tr>
<tr>
<td>2</td>
<td>0.40</td>
<td>0.65</td>
<td>0.030</td>
<td>0.082</td>
<td>0.165</td>
<td>0.064</td>
<td>0.360</td>
<td>0.477</td>
</tr>
<tr>
<td>3</td>
<td>0.35</td>
<td>0.55</td>
<td>0.030</td>
<td>0.057</td>
<td>0.098</td>
<td>0.047</td>
<td>0.091&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.136</td>
</tr>
<tr>
<td>4 except Marine</td>
<td>0.35</td>
<td>0.55</td>
<td>0.026</td>
<td>0.057</td>
<td>0.098</td>
<td>0.047</td>
<td>0.059</td>
<td>0.065</td>
</tr>
<tr>
<td>5 and Marine 4</td>
<td>0.32</td>
<td>0.55</td>
<td>0.026</td>
<td>0.057</td>
<td>0.082</td>
<td>0.033</td>
<td>0.050</td>
<td>0.055</td>
</tr>
<tr>
<td>6</td>
<td>0.32</td>
<td>0.55</td>
<td>0.026</td>
<td>0.048</td>
<td>0.060</td>
<td>0.033</td>
<td>0.050</td>
<td>0.055</td>
</tr>
<tr>
<td>7 and 8</td>
<td>0.32</td>
<td>0.55</td>
<td>0.026</td>
<td>0.048</td>
<td>0.057</td>
<td>0.028</td>
<td>0.050</td>
<td>0.055</td>
</tr>
</tbody>
</table>
#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:
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
Key Technical Specifications

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](http://gisatnrel.nrel.gov/PVWatts_Viewer/index.html)
#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.

### Challenge Home Requirements 1-7, con’t

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>≤ 2000</td>
<td>110</td>
<td>40</td>
</tr>
<tr>
<td>≤ 4000</td>
<td>220</td>
<td>60</td>
</tr>
<tr>
<td>≤ 6000</td>
<td>330</td>
<td>80</td>
</tr>
<tr>
<td>&gt;6000</td>
<td>440</td>
<td>100</td>
</tr>
</tbody>
</table>
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:**
Interior Duct Strategies

• 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:
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

- **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/](http://www.crawlspaces.org/)
  - HFH Challenge Home Affiliates
    - Unvented Crawl: Huntington Area HFH (WV)
    - Conditioned Basement: HFH of Greater Cincinnati (OH)

Unvented, Sealed Crawl Space

- Sample procedure (develop QA checklists for tasks occurring 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

Sources:

Florida affiliates Broward County Habitat (left and center), Lakeland Habitat (right)
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
Fur Down Soffit Duct Chase – Alternate Approach

- 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
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
Interior Duct Strategies Recap

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   - Unvented Attic - Manatee County HFH (FL)
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   - Hydronic heating

4. Super-insulate ducts
   - Buried ducts - emerging strategy
Learn More and Next Steps

Website: [www.buildings.energy.gov/challenge/](http://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!

Email: doechallengehome@newportpartnersllc.com
Janet McIlvaine and David Beal  
Florida Solar Energy Center at the University of Central Florida  
DOE Building America Partnership for Improved Residential Construction  
Construction Website: www.ba-pirc.org  
BA-PIRC Habitat page: www.ba-pirc.org/habitat  
janet@fsec.ucf.edu  321-638-1434  
david@fsec.ucf.edu  321-638-1433

Holly Todd  
Habitat for Humanity of Ohio  
Sustainable Building Specialist  
HTodd@OCCH.org

Ray Allnutt, Southeast Volusia County HFH (FL) Construction Manager  
386-689-2119

Bruce Winter, Manatee County HFH (FL) Construction Manager  
bwinter@manateehabitat.org  (941) 748-9100 ext. 106