Zeroing In: The Path to High-Performance May Be Different Than You Think!

EEBA High-Performance Home Summit
October 2, 2019
Denver, CO

Pat Huelman
Cold Climate Housing Coordinator
University of Minnesota Extension

- Part 1: Pathways to High-Performance
  - Programs That Will Get You There
- Part 2: DOE Zero Energy Ready Homes
  - Review Business Case & Requirements
- Part 3: Zero Energy Homes Today
  - Critical Challenges & Keys to Success
  - A reflection on where we have been, where we are, and where we need to go in the future!
CONTEXT AND CAUTION

- A focus on general principles that are fairly universal and apply to most climate zones.
- However, some of the specific details are more oriented to locations with cold winters and warm, humid summers.
  - Primarily Climate Zones 5, 6, 7 with green grass
  - They are intended as guidelines only.
  - Your specific designs, performance targets, or market approach may be quite different.

THE BIGGER SYSTEMS VIEW

- We can and must do better!
  - Must balance efficiency with robust performance.

- Existing technology can get us there!
  - It’s not about products; it’s about execution.

- New technologies will be important
  - But we must be systematic in their evaluation & application.
WHAT IS A HIGH PERFORMANCE HOME?

- It is a deliberate integration of building enclosure, mechanical systems, and controls to provide a comfortable, efficient, durable, and healthy home.

- It demands a “systems approach” to the dynamics of climate, site, and occupants interaction of building enclosure and mechanicals.

- It requires careful planning, teamwork and careful execution in design, construction / installation, and operation.

MAKING THE CASE FOR ROBUST

- We must ensure our high-performance houses meet our expectations today and in the future?

- High-performance houses will push our current approach. Therefore, we must …
  - design and engineer (not just build) our homes.
  - build forgiveness/tolerance into all systems.
  - build redundancy into critical materials.
    - or make it easy to repair and/or replace key components
  - develop a more predictable delivery system.
  - provide continuous feedback to the occupant.
THE POWER OF ZERO ENERGY HOMES

- Are there buyers who would like to reduce their environmental footprint or have their utility bills go away?

- It is absolutely possible – but with a couple of caveats!

- Homes will always require energy.

- Can the home produce as much as it uses?
  - Is it site energy or source energy?
  - Is it dollars or carbon?
PART 1. PATHWAYS TO HIGH-PERFORMANCE

- ENERGY STAR (ver 3.1)
  - gets the wheels moving in the right direction.
- DOE Zero Energy Ready Home (ver 6.0)
  - is a more comprehensive, holistic approach.
- Best Current Practices (according to me)
  - fills a couple of key gaps for market/climate.
- Net Zero Energy Now (by Joe Lstiburek)
  - provides a vision for the future.

PATHWAY TO ZERO: METRICS

- Pathway Comparison
  - Enclosure
  - HVAC
  - Domestic Hot Water
  - Indoor Air Quality
  - Renewables
# PATHWAY TO ZERO: METRICS

<table>
<thead>
<tr>
<th>Enclosure (R-values)</th>
<th>IECC CZ 5/6/7</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE Now (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling</td>
<td>49</td>
<td>49</td>
<td>49</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Walls</td>
<td>20/25/25</td>
<td>20/25/25</td>
<td>20/25/25</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Floors</td>
<td>30/30/38</td>
<td>30/30/38</td>
<td>30/30/38</td>
<td>40</td>
<td>---</td>
</tr>
<tr>
<td>Foundation</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15-20</td>
<td>20</td>
</tr>
<tr>
<td>Slabs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Basement</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>- On-grade</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>15-20</td>
<td>20</td>
</tr>
</tbody>
</table>

* From “BSI-081 Zeroing In” by Joseph Lstiburek

---

# PATHWAY TO ZERO: METRICS

<table>
<thead>
<tr>
<th>Enclosure (U-values)</th>
<th>IECC CZ 5/6/7</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE Now (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows</td>
<td>0.32</td>
<td>0.27</td>
<td>0.27</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>Doors</td>
<td>0.17 – 0.30</td>
<td>0.17 – 0.30</td>
<td>0.20</td>
<td>---</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Enclosure Airtightness</th>
<th>IECC CZ 5/6/7</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACH@50Pa</td>
<td>3.0</td>
<td>3.0</td>
<td>2.0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

© 2018 Regents of the University of Minnesota. All rights reserved.
### PATHWAY TO ZERO: METRICS

#### HVAC (Equipment)

<table>
<thead>
<tr>
<th>Metric</th>
<th>IECC CZ 5/6/7</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE Now (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heating</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- AFUE</td>
<td>80%</td>
<td>90-95%</td>
<td>94%</td>
<td>95%</td>
<td>95%</td>
</tr>
<tr>
<td>- HSPF</td>
<td>8.2</td>
<td>9.5</td>
<td>10.0</td>
<td>10.0</td>
<td>---</td>
</tr>
<tr>
<td><strong>Cooling (SEER)</strong></td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td><strong>Ventilation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- HRV/ERV (Eff)</td>
<td>NR</td>
<td>NR</td>
<td>Balanced</td>
<td>Balanced</td>
<td>Balanced</td>
</tr>
<tr>
<td>- Distribute</td>
<td>NR</td>
<td>NR</td>
<td>60%</td>
<td>70%</td>
<td>---</td>
</tr>
<tr>
<td><strong>Filtration (MERV)</strong></td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>11</td>
<td>---</td>
</tr>
</tbody>
</table>

#### HVAC (Ductwork)

<table>
<thead>
<tr>
<th>Metric</th>
<th>IECC CZ 5/6/7</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE Now (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leakage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Leakage</td>
<td>4cfm/100sf</td>
<td>4cfm/100sf</td>
<td>Condition</td>
<td>Condition</td>
<td>Condition</td>
</tr>
<tr>
<td>- Insulation</td>
<td>R-8</td>
<td>R-8</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

#### Make-Up Air

<table>
<thead>
<tr>
<th>Metric</th>
<th>IECC CZ 5/6/7</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range</strong></td>
<td>NA</td>
<td>NA</td>
<td>Vented</td>
<td>Vent/MUA</td>
<td>Vent/MUA</td>
</tr>
<tr>
<td><strong>Dryer</strong></td>
<td>NA</td>
<td>Vented</td>
<td>Vented</td>
<td>Vent/MUA</td>
<td>Vent/MUA</td>
</tr>
<tr>
<td><strong>Exhaust Fan</strong></td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Small/MUA</td>
<td>---</td>
</tr>
</tbody>
</table>
## PATHWAY TO ZERO: METRICS

### Domestic Hot Water

<table>
<thead>
<tr>
<th></th>
<th>IECC CZ 5/6/7</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE Now (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant (EF)</td>
<td>0.53</td>
<td>0.59 - 0.63</td>
<td>0.67</td>
<td>CSC(combi)</td>
<td>--</td>
</tr>
<tr>
<td>Insulation</td>
<td>R-3</td>
<td>R-3</td>
<td>R-5</td>
<td>R-5</td>
<td>--</td>
</tr>
<tr>
<td>Distribution</td>
<td>NA</td>
<td>NA</td>
<td>WaterSense</td>
<td>WaterSense</td>
<td>--</td>
</tr>
</tbody>
</table>

### Appliances & Lighting

<table>
<thead>
<tr>
<th></th>
<th>IECC CZ 5/6/7</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appliances</td>
<td>NA</td>
<td>E-STAR</td>
<td>E-STAR</td>
<td>E-STAR+</td>
<td>E-STAR+</td>
</tr>
<tr>
<td>Lighting</td>
<td>NA</td>
<td>80% E-STAR</td>
<td>80% E-STAR</td>
<td>90% LED</td>
<td>100% LED</td>
</tr>
</tbody>
</table>

### Indoor Air Quality

<table>
<thead>
<tr>
<th></th>
<th>IECC CZ 5/6/7</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE Now (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>IndoorAir+</td>
<td>NA</td>
<td>Partial</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
</tr>
<tr>
<td>Garage Vent</td>
<td>NA</td>
<td>NA</td>
<td>Yes*</td>
<td>Yes*</td>
<td>--</td>
</tr>
<tr>
<td>Radon</td>
<td>NA</td>
<td>Rn Ready</td>
<td>Rn Ready</td>
<td>ASD</td>
<td>--</td>
</tr>
</tbody>
</table>

### Renewable Ready

<table>
<thead>
<tr>
<th></th>
<th>IECC CZ 5/6/7</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Thermal</td>
<td>NA</td>
<td>NA</td>
<td>Optional</td>
<td>Optional</td>
<td>--</td>
</tr>
<tr>
<td>Solar PV</td>
<td>NA</td>
<td>NA</td>
<td>Yes*</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

© 2018 Regents of the University of Minnesota. All rights reserved.
PART 2: ZERO ENERGY READY HOME

Building America Strategy

Ultra-High Efficiency
- Enclosure
- Low-Load HVAC
- Components

High-Performance
- Affordable
- Comfort
- Health
- Durability
- Renewable Readiness
- Water Conservation
- Disaster Resistance

© 2018 Regents of the University of Minnesota. All rights reserved.
Zeroing In: The Path to High-Performance May Not Be What You Think!

DOE Zero Energy Ready Home Path

High Efficiency
Low Efficiency

Low HERS Code New Home
IECC 2009 Code New Home
Typical Existing Home

Low Performance High Performance

IECC 2009 Code New Home
Energy Star Certified New Home
DOE Zero Energy Ready Home

Building America Strategy

Goal: Homes so efficient, a small renewable energy system can offset all or most energy consumption

Thermal Load
1970 - 1980
1980 - 1990
1990 - 2000
2000 - 2010
2010 - 2020
2020 - 2030

Thermal Enclosure
Water Man.
Ventilation/IAQ
Low-Load HVAC
Eff. Comps./MEL’s
Transaction Process
Bldg. Integr. Renewables

Low-Load HVAC
Eff. Comps./MEL’s
Transaction Process
Bldg. Integr. Renewables

© 2018 Regents of the University of Minnesota. All rights reserved.
Lots of Recognition Choices…

DOE ZERO ENERGY READY HOME

- Provides a solid foundation for high-performance homes!
- In my view, this program is …
  - Built on a technically sound platform
  - Focused on the right things (not just energy)
  - In the right way (performance-based)
  - At the right level (strategic differentiation)
  - With a delivery process that is credible, but not onerous.
Zeroing In: The Path to High-Performance May Not Be What You Think!

The Business Case for ZERH

Risk Management
Zero Differentiation
Exceed Expectations

Why Build: The Value

Risk Management  Zero Differentiation  Exceed Expectations

Lives Better  Works Better  Lasts Better
Engineered Comfort  Ultra-Low Utility Bills  Quality Construction
Healthier Living  Advanced Technology  More Durability

© 2018 Regents of the University of Minnesota. All rights reserved.
Zero Energy Ready Home

Technical Specifications: Putting It All Together

- ENERGY STAR Certified Homes v3.1
- Advanced Windows
- Air-Tight Construction
- 2012 IECC Insulation
- Energy Efficient Components
- Efficient Hot Water Distribution
- Indoor Air Quality
- Renewable Ready Construction
**DOE ZERH Framework**

**Mandatory Reqs.**
- Must Comply
- Trade-Off Flexibility
- ‘Target Home’ Specs
- Size Adjust. Factor

**Zeroing In: The Path to High-Performance May Not Be What You Think!**

**Translating the Value Proposition**

**Homes to the Power of ZERO**

**A Symbol of Excellence**

**Health, Safety, Environment**
- Comfort Plus
- Energy Efficiency
- Ultra Efficiency
- Quality Assurance

**What is the DOE Zero Energy Ready Home**

- It is a symbol of excellence in energy savings, health, safety, quality, and durability endorsed by the U.S. Department of Energy.

- **What is a Zero-Energy Ready Home**
  - A home designed to have zero energy demand or to produce more energy than it consumes.

---

**© 2018 Regents of the University of Minnesota. All rights reserved.**
PART 3: THE FUTURE IS HERE TODAY!

- The technologies, systems, and best practices are in place for high-performance homes today.
- The “Zero Energy Ready Home” has been proven in the market.
- With solar PV prices falling, a small investment can take your energy bill to “zero”.

NET ZERO ENERGY TODAY

- Definition: the total amount of energy consumed is equal to the total amount of energy generated on-site.
- It can be done …
  - But must begin with a careful examination of the trade off between the cost of energy reduction and the cost of solar generation.
NET ZERO ENERGY TODAY

- Be prepared – the whole building solution might look a bit different than you imagined.
  - It isn’t simple adding more of the same.
  - There are several “new things” that will demand your attention as you move to Net Zero Energy.
  - From “BSI-081 Zeroing In” by Joseph Lstiburek
- These are be presented as challenges.
  - But don’t construe these as negatives,
  - Rather as important precautions necessary to ensure your successful pursuit of NZE homes.

ZEROING IN*

- Don’t get carried away with passive solar!
  - The heat gain in the winter may not be needed.
  - The heat gain in the summer will hurt you.
  - Low-load increases need for thermal storage
- But people want windows …
  - So give them window; just use good judgement on orientation, placement, type and treatments.
- Collect the solar energy with PV…
  - Which is needed to satisfy non-thermal loads.
ZEROING IN*

- Ultra-efficiency crushes super-insulated.
- Ultra-tight is critical, but it has consequences!
  - Large exhaust devices require a new approach and/or make-up air.
    - clothes dryer: consider a condensing unit
    - range hood: high capture rate with make-up air
  - Interior wood stoves/fireplaces …
    - simply don't do it!

ZEROING IN*

- Ventilation system must be top-drawer!
  - Balance with heat/energy recovery is required.
  - Use the HRV/ERV to satisfy bathroom exhaust requirements to avoid additional exhaust fans.
  - Be certain to provide fresh air to the bedrooms.
ZEROING IN*

- You must have internal air circulation!
  - Air isn’t moving bottom to top or side to side.
  - You need mixing for thermal comfort.
  - You must distribute fresh/filtered air for IAQ.
- You can choose to do this with your space conditioning or ventilation system.

ZEROING IN*

- Perhaps the greatest challenge will be latent load management!
  - In the swing seasons and under part-load conditions humidity can float out of control.
- Do you think you can do this with your space conditioning or ventilation system?
  - It is tougher than it sounds.
  - Dehumidification may need to be an independent system.
CHALLENGE 1: FORGIVING ENCLOSURE

- The “Perfect” Approach
  - Walls
  - Roof
  - Slab
  - Foundation

- Move the structure to the inside and the control layers to the outside …
  - It simply works and works everywhere!!!
WORKS FOR ROOF & SLAB, TOO!

PUTTING THE LAYERS TOGETHER

- Four Critical Control Layers
  - Water
  - Air
  - Thermal
  - Vapor

- What you use is important, but the where, how, and when (order/sequence) is critical.
  - However, it can be extremely simple!
4 IN 1 CONTROL LAYER

CONTROL LAYERS – PERFECT SLAB

- Dry and Warm Slab w/ RRNC
  - 4” of ¾” and up aggregate; no fines
  - 1 to 3” of extruded polystyrene
  - Poly vapor retarder (optional)
  - 4” high quality slab; all joints and edges sealed
  - Sealed sump basket
  - 3 or 4” passive vent from below slab to the roof
    - with electrical box nearby in attic for fan activation
CONTROL LAYERS – FOUNDATION

- **Dry and Warm Foundation**
  - Cast-in-place (or CMU or wood) foundation
    - capillary break between footing and wall
  - Quality exterior waterproofing
  - Exterior drain tile protected by rock & fabric
  - R-15 exterior insulation
    - extruded polystyrene or semi-rigid fiberglass
  - Good vertical drainage
    - with 6" impermeable cap

CONTROL LAYERS – HYBRID WALL

- **Siding**
  - Installed over 3/4" furring
- **3" Rigid insulation sheathing**
- **Peel-and-stick membrane**
- **OSB sheathing**
- **Rim joint**
- **Batt insulation**
- **Protection board**
  - 12 in. below grade
- **Concrete foundation wall**
CONTROL LAYERS – FENESTRATION

- Windows Designed for Integration
  - Always use the highest quality, low U-value, warm-edge window you can afford that comes with …
    - a custom fit sill pan,
    - head flashing with end dams, and
    - flanges that are air/water tight with tabs to integrate with flashing and air/water control layers
  - Integrate the window air and water tightness at the air and water control plane.

CONTROL LAYERS – ENHANCED ROOF

- Traditional Vented Attic
  - Ceiling drywall direct to raised heel trusses
    - no poly
  - One pass closed-cell spray foam
    - sealed to the top plate, heel sheathing, and chutes
    - approximately 2" (R-12)
  - Blown-in insulation (R-40 to 50)
    - fiberglass @ 16" to 18"
    - cellulose @ 12" to 15"
CONTROL LAYERS – HYBRID ROOF

- For Sloped Roof or Conditioned Attic
  - Interior batt (R-21) between rafters or top chords
  - Structural sheathing
  - Peel and stick membrane
  - Exterior foam (R-30 - usually XPS or polyiso)
  - Flat 2x4 furring strips fastened through to frame
    - provides vent space w/ continuous soffit & ridge vents
  - OSB roof deck
  - Building paper and shingles

CHALLENGE 2: GREAT VENTILATION

- Good is not good enough!
- You have an incredibly tight enclosure
- Start by managing pollutants (and moisture)
- Humid outdoor air will create some special challenges, especially under part-load conditions.
ALWAYS MANAGE THE POLLUTANT

- Safe pollutant levels
  - Avoid and/or encapsulate for material emissions
  - Use point source control, where possible
  - Then employ general ventilation
- Manage fine particulates
  - Whole house
  - Kitchen range
- Protection against biologicals
  - Humidity control
  - Particle filtration

VENTILATION SUMMARY

- Must be balanced heat recovery ventilation
  - Recommend a source point exhaust strategy
  - In most cases, an ERV is preferable
  - Filtration (MERV 11+) for supply air
  - Distribution to all habitable rooms
    - forced air system
    - separate dedicated duct system
- Spot ventilation can be exhaust-only if small and/or rarely used.
CHALLENGE 3: WHAT ARE WE CHASING?

- Heating isn’t the problem any longer!
- Overheating (and cooling) are quickly taking center stage even in colder climates!
  - Internal & solar gains must be carefully managed.
- Natural ventilation/cooling has challenges
  - Cooling when the outside temperature is below the setpoint

SPACE COOLING

- To AC or not to AC?
  - For many reasons, this is changing fast.
  - And for many it isn’t an option any longer.
- Natural ventilation can work many days, but not all days for all people.
  - It might present outdoor IAQ issues including pollen, mold spores, and particulates.
  - It can contribute to indoor moisture and mold issues, especially with cooler interior surfaces.
NET ZERO ENCLOSURE FLIPS THE LOADS

- Heating balance points are very low
  - 40 to 45 degrees
- Space cooling is very different
  - Loads may look lower
  - But cooling demand will be longer
  - And load diversity/ratios between spaces will be much higher

WHAT TO DO IN THE MIDDLE?

- Highly-insulative, airtight enclosures with unmanaged solar and internal gains can easily overheat when outdoor temperatures are below your setpoint.
  - If natural ventilation works for you this is pretty easy.
    - but it must be based on enthalpy, not temperature.
  - If not, you need an economizer cycle
  - Your ERV/HRV could be working against you.
CHALLENGE 4: HUMIDITY MANAGEMENT

- This is critical in low-load homes, as typical air-conditioning doesn’t work.
  - Many times you have high latent loads when there is no significant sensible load.
  - Frequently you need more moisture removal under part-load conditions.

SPACE DEHUMIDIFICATION

- It takes 10 to 15 minutes to wet the coil to the point that condensate is being removed.
  - About the same to re-evaporate, though much shorter if the fan runs continuously.
- It might be possible to downsize the AC and consider reheat to force longer run times.
  - Two-stage or variable capacity AC can help!
- But for best summer humidity control, consider a whole house dehumidifier.
SPACE DEHUMIDIFICATION

- Whole House Dehumidification
  - Since ventilation does not equal humidity control, it is critical to provide systematic dehumidification.
  - Independent control for indoor humidity to control condensation, mold, and dust mites.
  - Huge aid for summer comfort.

CHALLENGE 5: PRESSURE MANAGEMENT

- This becomes increasingly harder with tighter enclosures and larger exhaust devices.
  - Very large negative pressures are very real
- Furthermore, what pressure do we want?
BUILDING ENCLOSURE: PRESSURE

- Optimal Pressures (house wrt outdoors)
  - Building Enclosure: Winter - Summer +
  - Garage Gases: Winter + (or =) Summer = (or +)
  - Radon (Soil Gases): Winter + Summer = (or +)
  - Combustion Safety: Winter + (or =) Summer +
  - Exterior Pollutants: Winter + Summer +
  - Thermal Comfort: Winter + Summer +

MAKE-UP AIR

- How much negative pressure for how long?
- Key equipment concerns
  - Ventilation impact can be minimized by using a balanced ventilation strategy for both continuous and intermittent ventilation.
  - Kitchen range must be carefully managed.
    - designed for improved capture at lower flow rates
  - Clothes dryer is critical because of the flow rate and potential for extended run times.
    - ventless heat pump dryer
MAKE-UP AIR

- Key Strategies
  - All closed, sealed-combustion equipment
  - Minimize exhaust flows
  - Passive make-up air
    - Is limited in size, is not tempered, and will be plugged
  - Blended make-up air
    - Mixes indoor air with outdoor air to increase the temperature of the air delivered to the house.
  - Tempered Make-up Air
    - Outdoor air is tempered (temperature & humidity)

SUPPLY AIR SYSTEMS

- We need to rethink how we can embrace new supply air strategies to actively manage house pressure.
  - Dedicated outdoor air units
  - Economizers,
    - ???
- How do we condition that air simply and economically?
FINAL NOTES & CAUTIONS

▪ Net Zero Energy Homes will require new enclosure strategies and systems:
  – Higher insulation levels
  – Improved integrity of the water, air, and vapor control layers
  – Better drying strategies
  – More robust delivery systems

FINAL NOTES & CAUTIONS

▪ Net Zero Energy enclosures will demand a new approach to the mechanical systems:
  – Integrated systems approach to low-load HVAC+DHW
  – Sharp focus on humidity management
  – Increased attention to indoor air quality
    ▪ source control
    ▪ filtration
    ▪ ventilation & distribution
  – Improved make-up air solutions
Zeroing In: The Path to High-Performance May Not Be What You Think!

RESOURCES

- Your New Partners
  - Home Energy Raters
  - Home Performance Consultants
  - Utility Providers & Programs

- Other Resources
  - ENERGY STAR
  - Building America

RESOURCES

- DOE Building America Resources
  - General Energy Information (EERE)
  - DOE Zero Energy Ready Home (ZERH)
    - Tour of Zero
  - Top Innovations “Hall of Fame”
  - Building America Solution Center
  - Building Science Advisor
Zeroing In: The Path to High-Performance May Not Be What You Think!

World-Class Research...

Building America Solution Center
BASC.energy.gov

...At Your Fingertips

Quick Tour: Guides

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

- BSI-039: The Five Things
  - Joseph Lstiburek
- High-Performance Enclosures
  - John Straube, 2012
- Getting Enclosures Right in ZERH
  - Joe Lsitburek, 2016
- BSI-081: Zeroing In
  - Joseph Lstiburek
- EEBA Ventilation Guide
  - Armin Rudd, 2011

KEEPING OUR EYE ON THE BALL

- Is it possible that we have over-invested in products and under-invested in good design and proper execution?

- Are we not being realistic about the process?
  - Are we investing in risky designs, systems, and materials and hoping for perfect execution?
  - Are we counting on perfect homeowner operation and maintenance?
• Discussion & Questions

Contact Information
Patrick H. Huelman
203 Kaufert Lab; 2004 Folwell Ave.
St. Paul, MN 55108
612-624-1286
phuelman@umn.edu