Zeroing In*: The Path to High-Performance

* with credit to Joe Lstiburek, Building Science Corporation

28th Energy Design Conference
February 20, 2018
Duluth, MN

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CONTINUING EDUCATION CREDITS

- In accordance with the Department of Labor and Industry’s statute 326.0981, Subd. 11,

“This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying 1.5 hours of credit toward Building Officials and Residential Contractors continuing education requirements.”

For additional continuing education approvals, please see your credit tracking card.
ZEROING IN*: 
THE PATH TO HIGH-PERFORMANCE

- Part 1: The Why of Zero Energy Homes
  - Building Science + Systems Approach = High-Performance
- Part 2: DOE Zero Energy Ready Home Program
  - Business Case
  - Technical Requirements
- Part 3: Going to Net Zero Energy Today
  - Keys to Success

- A reflection on where we have been, where we are, and where we can go!
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?
A GROWING EPIDEMIC: NOTMYJOBITIS
THE CONTEXT: FIVE THINGS*

- How did we get here?
- What is driving these changes?
- What does it mean for building design and construction practices?

* BSI:-039: The Five Things by Jospeh Lsitburek
FIVE FUNDAMENTAL CHANGES

- Increase thermal resistance
  - more insulation => less heat flow => less drying!
- Changes in permeability of linings
  - while this may mean less wetting,
  - it also can lead to very slow drying!
- Increased water/mold sensitivity of materials
- Moisture storage and redistribution
- Complex 3-D airflow networks in buildings
FIVE KEY DRIVERS FOR CHANGE

- Demand for Increased Comfort
- Drive for Improved Energy Efficiency
- Interest in Low-Maintenance Homes
- Concerns for Indoor Air Quality
- Rising Cost of Housing
FIVE INEVITABLE TRENDS

- Building Airtightness
  - getting tighter everyday; not certain where it will stop
- Mechanical Ventilation
  - must include air distribution; moving towards balanced
- Exterior Control Layers
  - especially insulation with vented cladding
- Ducts in Conditioned Space
  - will drive use of conditioned crawl spaces/attics
- Active Pressure Management
  - integrated make-up air
FIVE CHANGES WE MUST EMBRACE

- Step Back & Take a Broader Systems View
- Demand Performance Over Prescriptive
- Use Building Science, Engineered Approach
- Place a Premium on Robust
- Focus on Total Cost of Ownership
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 their utility bills to go away?
  - How much is that worth to them?
  - Can it be done?
  - What does it cost?
THE POWER OF ZERO ENERGY HOMES

- Absolutely – 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?
  - If dollars, don’t forget the $20 per month in fees.
THE ENERGY PICTURE IN THE U.S.

Source: LLNL 2015. Data is based on DOE/EIA-0035(2015–03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527
ENERGY USE IN OUR HOMES

Total energy use in homes

1978
quadrillion Btu and percent

- Appliances and Electronics 1.77 (17%)
- Water Heating 1.53 (14%)
- Air Conditioning 0.32 (3%)
- Space Heating 6.96 (66%)

Total 10.58

2005
quadrillion Btu and percent

- Appliances and Electronics 3.25 (31%)
- Water Heating 2.12 (20%)
- Air Conditioning 0.88 (8%)
- Space Heating 4.30 (41%)

Total 10.55

FUNDAMENTAL ENERGY STRATEGIES

- Conservation
  - Lowest cost; best return

- Efficiency
  - Moderate expense; good return

- Alternatives
  - Most expensive; lowest return
ENERGY SAVED VS. DOLLAR SPENT
ENERGY EFFICIENT HOME FORMULA

- Passive Design
  - Simple shapes, good orientation

- Building Enclosure
  - More insulation
  - Efficient windows & doors
  - Airtight construction

- Mechanical Systems
  - High-efficiency equipment
  - Efficient appliances & lighting

- Proper Operation & Maintenance
BUT THAT IS THE EASY PART

- The tougher part is how to save energy, without causing moisture and indoor air quality concerns?
  - When you remove heat flow you are also removing drying potential.
  - When you air seal (to retard moisture flows) you have less dilution of indoor pollutants.
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.
THE PATHWAY TO NET ZERO ENERGY

- 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 our market/climate.
- Net Zero Today (by Joe Lstiburek)
  - provides a vision for the future.
PATH TO ZERO: METRICS

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

<table>
<thead>
<tr>
<th>Enclosure (R-values)</th>
<th>MN Code</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>60</td>
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<tr>
<td>Walls</td>
<td>20/21</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>40</td>
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<tr>
<td>Floors</td>
<td>30/38</td>
<td>30/38</td>
<td>30/38</td>
<td>40</td>
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<td>Foundation</td>
<td>15(10)</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>20</td>
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<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</td>
<td>20</td>
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## PATH TO ZERO: METRICS

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<thead>
<tr>
<th>Enclosure (U-values)</th>
<th>MN Code</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE (JL)*</th>
</tr>
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<tbody>
<tr>
<td>Windows</td>
<td>0.32</td>
<td>0.30</td>
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<td>Doors</td>
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<th>MN Code</th>
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<th>NZE (JL)*</th>
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<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>
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## PATH TO ZERO: METRICS

<table>
<thead>
<tr>
<th>HVAC (Equipment)</th>
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<th>DOE ZERH</th>
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<tr>
<td>Heating</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>- AFUE</td>
<td>80%</td>
<td>90%</td>
<td>94%</td>
<td>94%</td>
<td>95%</td>
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<tr>
<td>- HSPF</td>
<td>8.2</td>
<td>8.2</td>
<td>10.0</td>
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<td>Cooling (SEER)</td>
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<td>13</td>
<td>13</td>
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<td>Ventilation</td>
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<td></td>
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<tr>
<td>- Type</td>
<td>Balanced</td>
<td>NR*</td>
<td>Balanced</td>
<td>Balanced</td>
<td>Balanced</td>
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<tr>
<td>- HRV/ERV (Eff)</td>
<td>NR</td>
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<td>60%</td>
<td>70%</td>
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<tr>
<td>- Distribute</td>
<td>All Rooms</td>
<td>NR*</td>
<td>NR*</td>
<td>All Rooms</td>
<td>All Rooms</td>
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<td>Filtration(MERV)</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>11</td>
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# PATH TO ZERO: METRICS

<table>
<thead>
<tr>
<th>HVAC (Ductwork)</th>
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<tr>
<td>Leakage</td>
<td>4cfm/100sf</td>
<td>4cfm/100sf</td>
<td>Condition</td>
<td>Condition</td>
<td>Condition</td>
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<tr>
<td>Insulation</td>
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<td>NA</td>
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<table>
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<th>Make-Up Air</th>
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<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE (JL)*</th>
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<tbody>
<tr>
<td>Range</td>
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<td>NA</td>
<td>Vented</td>
<td>Vent/MUA</td>
<td>Vent/MUA</td>
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<td>Dryer</td>
<td>???</td>
<td>Vented</td>
<td>Vented</td>
<td>Vent/MUA</td>
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<tr>
<td>Exhaust Fan</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Small/MUA</td>
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## PATH TO ZERO: METRICS

<table>
<thead>
<tr>
<th></th>
<th>Domestic Hot Water</th>
<th>Plant (EF)</th>
<th>Insulation</th>
<th>Distribution</th>
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<tbody>
<tr>
<td><strong>MN Code</strong></td>
<td>MN Code</td>
<td>???</td>
<td>R-3</td>
<td>NA</td>
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<tr>
<td><strong>ENERGY STAR</strong></td>
<td>ENERGY STAR</td>
<td>0.67</td>
<td>R-3</td>
<td>NA</td>
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<tr>
<td><strong>DOE ZERH</strong></td>
<td>DOE ZERH</td>
<td>0.67</td>
<td>R-5</td>
<td>WaterSense</td>
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<tr>
<td><strong>BCP (PH)</strong></td>
<td>BCP (PH)</td>
<td>CSC(combi)</td>
<td>R-5</td>
<td>WaterSense</td>
</tr>
<tr>
<td><strong>NZE (JL)</strong>*</td>
<td>NZE (JL)*</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Appliances &amp; Lighting</th>
<th>Appliances</th>
<th>Lighting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MN Code</strong></td>
<td>MN Code</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>ENERGY STAR</strong></td>
<td>ENERGY STAR</td>
<td>E-STAR</td>
<td>80% E-STAR</td>
</tr>
<tr>
<td><strong>DOE ZERH</strong></td>
<td>DOE ZERH</td>
<td>E-STAR</td>
<td>80% E-STAR</td>
</tr>
<tr>
<td><strong>BCP (PH)</strong></td>
<td>BCP (PH)</td>
<td>E-STAR+</td>
<td>90% LED</td>
</tr>
<tr>
<td><strong>NZE (JL)</strong>*</td>
<td>NZE (JL)*</td>
<td>E-STAR+</td>
<td>100% LED</td>
</tr>
</tbody>
</table>
# PATH TO ZERO: METRICS

<table>
<thead>
<tr>
<th>Indoor Air Quality</th>
<th>MN Code</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>IndoorAir+</td>
<td>NA</td>
<td>Partial</td>
<td>Yes</td>
<td>Yes</td>
<td>NS</td>
</tr>
<tr>
<td>Garage Vent</td>
<td>NA</td>
<td>NA</td>
<td>Yes*</td>
<td>Yes*</td>
<td>NS</td>
</tr>
<tr>
<td>Radon</td>
<td>Rn Ready</td>
<td>Rn Ready</td>
<td>Rn Ready</td>
<td>ASD</td>
<td>NS</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Renewable Ready</th>
<th>MN Code</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>NS</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>
### PATH TO ZERO: COST SUMMARY

<table>
<thead>
<tr>
<th></th>
<th>MN Code</th>
<th>ENERGY STAR</th>
<th>DOE ZERH</th>
<th>BCP (PH)</th>
<th>NZE (JL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost Premium</strong></td>
<td>Base</td>
<td>$5,000</td>
<td>$10,000</td>
<td>$15,000</td>
<td>$20,000</td>
</tr>
<tr>
<td><strong>Energy $/yr</strong></td>
<td>$2,000</td>
<td>$1,500</td>
<td>$1,250</td>
<td>$1,000</td>
<td>$750</td>
</tr>
<tr>
<td><strong>PV for NZE</strong></td>
<td>20 kW</td>
<td>15 kW</td>
<td>12 kW</td>
<td>10 kW</td>
<td>8 kW</td>
</tr>
<tr>
<td><strong>PV System $</strong></td>
<td>$60,000</td>
<td>$45,000</td>
<td>$36,000</td>
<td>$30,000</td>
<td>$24,000</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td>$60,000</td>
<td>$50,000</td>
<td>$46,000</td>
<td>$45,000</td>
<td>$44,000</td>
</tr>
</tbody>
</table>
In my view, this program is …

– Built on a technically solid 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.
Building America Strategy

Ultra-High Efficiency

- Enclosure
- Low-Load HVAC
- Components

High-Performance

- Affordable
- Comfort
- Health
- Durability
- Renewable Readiness
- Water Conservation
- Disaster Resistance
## Building America Strategy

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

<table>
<thead>
<tr>
<th>Thermal Load</th>
<th>Resulting Research Priorities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970 - 1980</td>
<td>Thermal Enclosure</td>
</tr>
<tr>
<td>1980 - 1990</td>
<td>Thermal Enclosure</td>
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<tr>
<td>1990 - 2000</td>
<td>Thermal Enclosure</td>
</tr>
<tr>
<td>2000 - 2010</td>
<td>Thermal Enclosure</td>
</tr>
<tr>
<td>2010 - 2020</td>
<td>Thermal Enclosure</td>
</tr>
<tr>
<td>2020 - 2030</td>
<td>Thermal Enclosure</td>
</tr>
</tbody>
</table>

- Thermal Load
- Thermal Enclosure
- Water Management
- Ventilation/IAQ
- Low-Load HVAC
- Efficiency Components/MELs
- Transaction Process
- Building Integration
- Renewables

**Thermal Load**

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

**Resulting Research Priorities**

- Thermal Enclosure
- Water Management
- Ventilation/IAQ
- Low-Load HVAC
- Efficiency Components/MELs
- Transaction Process
- Building Integration
- Renewables
Lots of Recognition Choices…

[Images of various certification logos and badges, including Energy Star, NAHB Research Center, Zero Energy Ready Home, WaterSense, PHIUS, LEED for Homes, EarthCraft, and Fortified Home.]
What’s In It For You?

By constructing DOE Zero Energy Ready Homes, you will be:

• **in a select group of builders**
  Only the top one percent of builders in the country meet the extraordinary energy efficiency, comfort, health, safety, durability, and quality levels associated with the DOE Zero Energy Ready Home.

• **providing unprecedented value**
  Your customers will receive immediate energy savings of 40-50% and a home that can be easily adapted to net-zero performance with a small renewable energy system.

• **differentiated from the competition**
  About 12 in 13 homes sales nationwide are ‘used’ homes. In addition, the majority of new homes are constructed to minimum code. Based on a foundation of comprehensive home performance, including ENERGY STAR Qualified Home v.3 and the latest proven innovations from DOE Building America, this program provides a path to constructing zero net-energy ready homes that none of your competition has.
Zero Energy Ready Home
Why Build:
The Business Case
Why Build: The Business Case

Risk Management

Zero Differentiation

Exceed Expectations
Risk Driver

Risk Management

Zero Differentiation

Exceed Expectations

More Rigorous Specs:
- Latest Energy Codes
- Low HERS Scores
- Voluntary Labels

Adv. Thermal Enclosure:
- Adv. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Advanced Windows
- More Air Tightness
Risk 1: Ensured Comfort

Risk Management

Zero Differentiation

Exceed Expectations

Ultra Low HVAC Loads:
- Lower Air Flow/Mixing
- Longer Swing Seasons
- Less Humidity Control

Adv. Thermal Enclosure:
- Adv. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Advanced Windows
- More Air Tightness
Risk 1: Ensured Comfort Strategy

Risk Management | Zero Differentiation | Exceed Expectations

Ultra Low HVAC Loads:
• Lower Air Flow/Mixing
• Longer Swing Seasons
• Less Humidity Control

Optimized Low-Load Comfort System
• Right-Sized
• Properly Installed
• Complete (Htg., Clg. + RH)
• Tested
Risk 2: Moisture Man.

Risk Management

Zero Differentiation

Exceed Expectations

More Wetting Risk
- Colder Walls
- Less Drying Potential

Adv. Thermal Enclosure:
- Adv. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Advanced Windows
- More Air Tightness
Risk 2: Moisture Man. Strategy

Risk Management  |  Zero Differentiation  |  Exceed Expectations

More Wetting Risk
- Colder Walls
- Less Drying Potential

Comprehensive Water Protection
- Roofs
- Walls/Openings
- Site/Foundation
- Materials
Risk 3: Ensured IAQ

Risk Management
Zero Differentiation
Exceed Expectations

IAQ Risk:
- Less Dilution
- Less Filtration

Adv. Thermal Enclosure:
- Adv. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Advanced Windows
- More Air Tightness
Risk 3: Ensured IAQ Strategy

Risk Management | Zero Differentiation | Exceed Expectations

IAQ Risk:
- Less Dilution
- Less Filtration

Comprehensive IAQ System:
- Contaminant Control
- Fresh Air System
- High-Capture Filtration
Zero Strategy 1: Minimize Loads

Risk Management  |  Zero Differentiation  |  Exceed Expectations

Ultra Low HVAC Loads:
- Components and MELs 50+% of Energy Use

Adv. Thermal Enclosure:
- Adv. Insulation System
  - More Insulation
  - Quality Installation
  - Complete System
- Advanced Windows
- More Air Tightness

- 50+% of Energy Use
- Quality Installation
- Complete System
Zero Strategy 1: Minimize Loads

Risk Management

Zero Differentiation

Exceed Expectations

Ultra Low HVAC Loads:
• Components and MELs
  50+% of Energy Use

Efficient Components:
• Space Conditioning
• Water Heating
• Lighting
• Appliances
• Fans
Zero Strategy 2: Solar Ready

Solar Opportunity:
- Energy Loads So Low, All or Most Consumption Can be Offset with Renewable Energy
- Decreasing Solar Cost
- Rising Energy Costs

- Solar Ready Home
Zero Energy Ready Home Spec

Risk Management

Zero Differentiation

Exceed Expectations

Optimized Enclosure

Risk Management:
- Optimized Comfort System
- Complete Water Protection
- Comprehensive IAQ System

Zero Differentiation:
- Efficient Components
- Solar Ready Construction
High-performance home, so energy efficient, all or most annual energy consumption can be offset by renewable energy.
‘Green’ vs. Zero Energy Ready

Risk Management Zero Differentiation Exceed Expectations

What’s Missing in Green Definition

Complete Systems that Ensure

Bankable Value Propositions

What’s Included in Zero Energy Ready Definition
Why Build: The Value

Risk Management | Zero Differentiation | Exceed Expectations

Lives Better
- Engineered Comfort
- Healthier Living
- Exclusivity

Works Better
- Ultra-Low Utility Bills
- Advanced Technology
- Visionary

Lasts Better
- Quality Construction
- More Durability
- Smart
Zero Energy Ready Homes
Made Simple
Zero Energy Ready Home Systems

Building Science
- Thermal Enclosure
- HVAC QI
- Water Management

Best Practices
- Ducts in Condit. Sp.
- 2012 IECC Insulation
- Super Air-Tight
- Super Windows
- Low-Load Eff. HVAC

Efficient Components
- HVAC System
- Water Htg. System
- Lighting/Appliances

Indoor Air Quality
- Source Control
- Dilution
- Filtration

Solar Ready
- Solar Electric
- Solar Thermal

Water Efficiency
- Hot Water Distribution
- Indoor Fixtures
- Outdoor Irrigation

Disaster Resistance
- Weather
- Natural Events
- Pests

Quality Management
- Int. Design Process
- Construction Documents
- QM Program

Encouraged in Challenge Home
Zero Energy Ready Home

**Technical Specifications:** Putting It All Together
Technical Specifications

• ENERGY STAR Certified Homes v3
• Advanced Windows
• Air-Tight Construction
• 2012 IECC Insulation
• Energy Efficient Components
• Efficient Hot Water Distribution
• Indoor Air Quality
• Renewable Ready Construction
IECC Climate Zones

All of Alaska in Zone 7 except for the following Boroughs in Zone 8:
- Bethel
- Dillingham
- Fairbanks N. Star
- Nome
- North Slope
- Northwest Arctic
- Southeast Fairbanks
- Wade Hampton
- Yukon–Koyukuk

Zone 1 includes:
- Hawaii
- Guam
- Puerto Rico
- and the Virgin Islands

Warm–Humid Below White Line
Align with ENERGY STAR for Homes v3:

- Comprehensive Building-Science System
- Variable vs. Fixed HERS Index Score
- House Size Adjustment to HERS Score
Zero Energy Ready Home

Technical Specifications

Mandatory Requirements:
**Mandatory Requirements**

### Exhibit 1: DOE Challenge Home Mandatory Requirements for All Labeled Homes

<table>
<thead>
<tr>
<th>Area of Improvement</th>
<th>Mandatory Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. ENERGY STAR for Homes Baseline</strong></td>
<td>☐ Certified under ENERGY STAR Qualified Homes Version 3⁵</td>
</tr>
<tr>
<td><strong>2. Envelope⁶</strong></td>
<td>☐ Fenestration shall meet or exceed latest ENERGY STAR requirements ⁷ ⁸</td>
</tr>
<tr>
<td></td>
<td>☐ Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels⁹</td>
</tr>
<tr>
<td><strong>3. Duct System</strong></td>
<td>☐ Ducts located within the home’s thermal and air barrier boundary¹⁰</td>
</tr>
<tr>
<td><strong>4. Water Efficiency</strong></td>
<td>☐ Hot water delivery systems shall meet efficient design requirements¹¹</td>
</tr>
<tr>
<td><strong>5. Lighting &amp; Appliances¹²</strong></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><strong>6. Indoor Air Quality</strong></td>
<td>☐ EPA Indoor airPLUS Verification Checklist and Construction Specifications¹³</td>
</tr>
<tr>
<td></td>
<td>☐ EPA Renewable Energy Ready Home Solar Thermal Checklist and Specifications¹⁶</td>
</tr>
</tbody>
</table>

**Encouraged:**
- WaterSense Label (indoor and outdoor)
- Disaster Resistance (IBHS Fortified Home)
- Quality Management
Zero Energy Ready Home

Technical Specifications

Mandatory Requirements:

ENERGY STAR for Homes Version 3 Baseline
Climate Zone 6:
Walls: R-20+5 or R-13+10
Ceiling: R-49
Floor: R-30
Basement: R-15/19
Crawl Space: R-15/19
Slab: R-10 for 4 ft. depth
Zero Energy Ready Home

Performance Threshold
### ‘Target Home’ vs. Energy Star Spec

#### HVAC Equipment

<table>
<thead>
<tr>
<th></th>
<th>Hot Climates (2012 IECC Zones 1,2)</th>
<th>Mixed Climates (2012 IECC Zones 3,4)</th>
<th>Cold Climates (2012 IECC Zones 5,6,7,8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFUE</td>
<td>80%</td>
<td>90%</td>
<td>94%</td>
</tr>
<tr>
<td>SEER</td>
<td>18</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>HSPF</td>
<td>8.2</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

**ASHRAE 62.2 Whole-House MV System Performance**

- Half ACH50

**ENERGY STAR EER and COP Criteria**

- 1.4 cfm/W; no heat exchange
- 1.4 cfm/W; no heat exchange
- 1.2 cfm/W; heat exchange with 60% SBE

#### Insulation and Infiltration

- Insulation levels shall meet the 2012 IECC and achieve Grade 1 installation, per RESNET standards.
- Infiltration²⁰ (ACH50): 3 in CZ's 1-2 | 2.5 in CZ's 3-4 | 2 in CZ's 5-7 | 1.5 in CZ 8

#### Windows

<table>
<thead>
<tr>
<th></th>
<th>Hot Climates (2012 IECC Zones 1,2,)</th>
<th>Mixed Climates (2012 IECC Zones 3,4)</th>
<th>Cold Climates (2012 IECC Zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHGC</td>
<td>0.25</td>
<td>0.27</td>
<td>any</td>
</tr>
<tr>
<td>U-Value</td>
<td>0.4</td>
<td>0.3</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Homes qualifying through the Prescriptive Path with a total window-to-floor area greater than 15% shall have adjusted U-values or SHGCs.²⁴

#### Water Heater

- ENERGY STAR minimum

#### Thermostat & Ductwork

- Programmable thermostat (except for zones with radiant heat)

#### Lighting & Appliances

- For purposes of calculating the DOE Challenge Home Target Home HERS Index, homes shall be modeled with an ENERGY STAR dishwasher, ENERGY STAR refrigerator, ENERGY STAR ceiling fans, and ENERGY STAR lamps (bulbs) in 80% of sockets or 80% of lighting fixtures are ENERGY STAR Qualified.
Target Home Avg. HERS Scores

Average DOE Challenge Home HERS Index by Climate Zone
(Overall Average = 55.5)

Based on 1800, 2400, and 3600 ft\(^2\) prototypes on climate-appropriate foundations.
Note: Renewable energy systems may not be used to qualify for the Zero Energy Ready Home HERS Index Target Score, but may be used for the incremental HERS Index points needed for the Size Adjustment Factor.
Homes larger than the benchmark home size must use the size adjustment factor to determine the target HERS index.

**Note:** Renewable energy systems may not be used to qualify for the Zero Energy Ready Home HERS Index Target Score, but may be used for the incremental HERS Index points needed for the Size Adjustment Factor.

**Size Mod. Factor =** $\left[ \frac{\text{CFA}_{\text{Benchmark Home}}}{\text{CFA}_{\text{Home to Be Built}}} \right]^{0.25}$

[Not to Exceed 1.0]
Recognition with
DOE Zero Energy Ready Home
Process Overview

**Registration and training** – builders and raters register as partners and take orientation training to learn requirements.

**Plan Evaluation** – rater evaluates plans and pinpoints improvements to meet the DOE Zero Energy Ready Home requirements.

**Construction** – builder constructs home to meet all DOE Zero Energy Ready Home National Program Requirements

**Field Verification** – rater conducts independent inspections and testing required to earn the label.

**Certification** – rater submits verification information to HERS Provider; rater/provider submits rating to National Building Registry; and rater prints certificate and label for Builder.

A critical element of partnering with DOE Zero Energy Ready Home as a builder is working with a Home Energy Rating System (HERS) Rater.
ZERH Partner Registration Process

• Review
  – Technical Guidelines
  – Partnership Agreement Terms

• Register
  – Electronically Sign Agreement

• Choose Optional Commitments:
  100% of homes meet DOE ZERH Guidelines
  Homes meet EPA’s WaterSense Guidelines
  Homes meet IBHS’s Fortified Home Guidelines
  Meet DOE Home Quality Management Program
ZERH Partner Benefits

• **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 Zero Energy Ready Home Web Site Locator Tool
Partner Locator Tool

- **Attract Buyers**
  DOE maintains a Partner Locator tool that homebuyers can use to find DOE Challenge Home builders in their area.

- **Builder Listings**
  All active partners are listed on the Partner Locator. Builder partners can differentiate their company listing on the Partner Locator through the optional commitments.

- **Number of Homes that Meet the Challenge**
  The number of homes displayed on the Partner Locator come from the RESNET National Registry.

- **Website link**
  A link to your website.
Translating the Value Proposition

Homes to the Power of ZERO

A Symbol of Excellence
- HEALTHFUL ENVIRONMENT
- COMFORT PLUS
- ADVANCED TECHNOLOGY
- ULTRA EFFICIENT
- QUALITY BUILT
- DURABILITY

What is the DOE Zero Energy Ready Home™ Label?
It is a Symbol of Excellence for energy savings, comfort, health, quality, and durability met by a select group of leading builders meeting U.S. Department of Energy Guidelines.

What is a Zero Energy Ready Home?
It is a high-performance home so energy efficient, all or most annual energy consumption can be offset with renewable energy. In other words, it is the Home of the Future.

KEY
- DOE Zero Energy Ready Home
- ENERGY STAR® Certified Home
- Existing Home

This graphic comparison chart demonstrates relative performance of this DOE Zero Energy Ready Home to existing homes (built between 1990 and 2010) and ENERGY STAR Certified Homes. Actual performance may vary.

303-231-4567
NewTown@net.com
123 Main Street, Denver, CO 34567

NEW TOWN BUILDERS
Translating ZERH Value with Clarity

Lives Better

Works Better

Lasts Better

A Symbol of Excellence

Every Zero Energy Ready Home offers a cost-effective, high-performance package of energy savings, comfort, health, and durability unparalleled in today's marketplace.

HEALTHFUL ENVIRONMENT
Every DOE Zero Energy Ready Home has a comprehensive package of measures to minimize dangerous pollutants, provide continuous fresh air, and effectively filter the air you breathe.

COMFORT PLUS
Superior insulation, windows, air sealing and space conditioning systems included in every DOE Zero Energy Ready Home surround you with even temperatures, low-humidity, and quiet in every room on every floor.

ADVANCED TECHNOLOGY
Every DOE Zero Energy Ready Home begins with solid building science specified by ENERGY STAR for Homes, and then adds advanced technologies and practices from DOE's world-class research program, Building America.

ULTRA EFFICIENT
Compared to a typical home, an ultra efficient Zero Energy Ready Home is inexpensive to own. In fact, every DOE Zero Energy Ready Home is so energy efficient, a small solar electric system can easily offset most, or all, of your annual energy consumption. We call this Zero Net-Energy Ready.

QUALITY BUILT
Advanced construction practices and technologies are specified for every DOE Zero Energy Ready Home. Then they are enforced by independent verifiers with detailed checklists and prescribed diagnostics.

DURABILITY
The advanced levels of energy savings, comfort, health, durability, quality and future performance in every DOE Zero Energy Ready Home provide value that will stand the test of time, and will meet and exceed forthcoming code requirements.

LEARN MORE AT: buildings.energy.gov/zero

The Future of Housing—Today

Only a select group of the top builders in the country meet the extraordinary levels of excellence and quality specified by U.S. Department of Energy guidelines.

LEARN MORE AT: buildings.energy.gov/zero

A Symbol of Excellence

HEALTHFUL ENVIRONMENT

COMFORT PLUS

ADVANCED TECHNOLOGY

ULTRA EFFICIENT

QUALITY BUILT

DURABILITY
BA Top Innovations “Hall of Fame”

**ADVANCED TECHNOLOGIES**
- Building Science Solutions
- Energy Efficient Components
- Assured Health and Safety

**HOUSE-AS-A-SYSTEM BUSINESS CASE**
- New Homes with Whole-House Packages
- Existing Homes with Whole-House Packages

**EFFECTIVE GUIDANCE AND TOOLS**
- High Performance Home Solutions
- High Performance Home Metrics
- Research Tools

**INFRASTRUCTURE DEVELOPMENT**
- Educating Professionals
- Recognizing Value in Transaction Process
- Informing Codes and Standards
World-Class Research...

Building America Solution Center
BASC.energy.gov

...At Your Fingertips
Multiple Interfaces
Quick Tour: Component Explorer

Walls/Openings
- Water
- Managed Walls
- Minimum Thermal Bridging
- Insulation
- Air Sealing
- Fully Aligned Air Barriers

Behind Showers and Tubs
Behind Fireplaces
Attic Knee Walls
Skylight Shaft
Walls Adjoining Porch
Double Walls
Garage Rim/Band Joist
**Scope:** Clearly defines and bounds the topic in a way builders and remodelers can contractually obligate their subcontractors.
For More Information

for more Information:

www.buildings.energy.gov/zero/

e-mail contact:

zero@newportpartnersllc.com
THE FUTURE IS ALREADY HERE!

- 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 their energy bill to “zero”.
MINNESOTA’S 1ST DOE-ZERH HOME

- Amaris Custom Homes
  - Ray Pruban

- Debuted in 2013 BATC Fall Parade of Homes
  - Rambler with full walkout basement
  - 3,542 sq. ft. conditioned
  - 5 bedrooms, 4 baths
  - St. Paul, MN (CZ=6)

- HERS = 41 w/o PV
- HERS = 4 w/ 10 KW PV
AMARIS CUSTOM HOMES: 2013

- ICF foundation
- 2x6 w/ ccSPU + 1” XPS
- Raised heel truss w/ 2” ccSPU + R-48 fiberglass
- Windows: U = 0.25
- Airtightness = 465@50PA
- 95% AFUE furnace & boiler
- 16 SEER AC
- ERV & source exhausts
- ENERGY STAR Appliances
- 90% LED; 10% CFL

- Good shape & orientation
- Passive solar design
- In-floor heating w/ tile
- No/Low VOC materials
AMARIS CUSTOM HOMES: 2015

- Fall Parade of Homes
  - Afton, MN
  - Model #299
  - $899,000
- Custom Ranch
  - 3,800 sq. ft.
  - DOE ZERH w/ solar PV
  - “No utility bill guarantee” for 10 years (gas, elec, water)
PART 3: 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 start by paying attention to the trade off between the cost of energy reduction and the cost of solar generation.
Next be prepared – the whole building solution might look a bit different than you imagined.
- There are a few other things that need your attention to as you move to Net Zero Energy.
- From “BSI-081 Zeroing In” by Joseph Lstiburek
Don’t get carried away with passive solar!

– The heat gain in the winter is not needed.
– The heat gain in the summer will hurt you.
– But people want windows -- so pay attention and use good judgement on the window orientation, placement, and type.

Ultra-efficiency crushes super-insulated.

Collect the solar energy with PV.
ZEROING IN*

- 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 …
    - don’t even think about it!
Ventilation system must be top-drawer!

- Balance with heat/energy recovery is required.
- Run the bathroom exhaust(s) through the HRV/ERV 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 moisture 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.
HIGH- PERFORMANCE HOUSES WILL REQUIRE NEW ENCLOSURE STRATEGIES AND SYSTEMS:

- Higher insulation levels
- Improved water, air, and vapor control layers
- Better drying strategies
- More robust delivery systems
High-performance enclosures will demand a new approach to the mechanical systems:

- Integrated systems approach to low-load HVAC +DHW
- Increased attention to indoor air quality
  - source control
  - ventilation
  - filtration
  - distribution
- Improved make-up air solutions
RESOURCES

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

- Other Resources
  - ENERGY STAR
  - Building America
KEY 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
KEY RESOURCES

- BSI-039: The Five Things
  - Joseph Lstiburek

- BSI-081: Zeroing In
  - Joseph Lstiburek

- High-Performance Enclosures
  - John Straube, 2012

- Getting Enclosures Right in ZERH
  - Joe Lsitburek, 2016
  - http://energy.gov/eere/buildings/doe-zero-energy-ready-home-resources

- EEBA Ventilation Guide
  - Armin Rudd, 2011
• Discussion & Questions

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phuelman@umn.edu