EEBA High-Performance Home Summit 2019

October 2, 2019, Denver, CO

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

Zero Made Easier

Theresa Gilbride, Joe Nebbia

Pacific Northwest National Laboratory,

Newport Partners

DOE ZERH is taking off!

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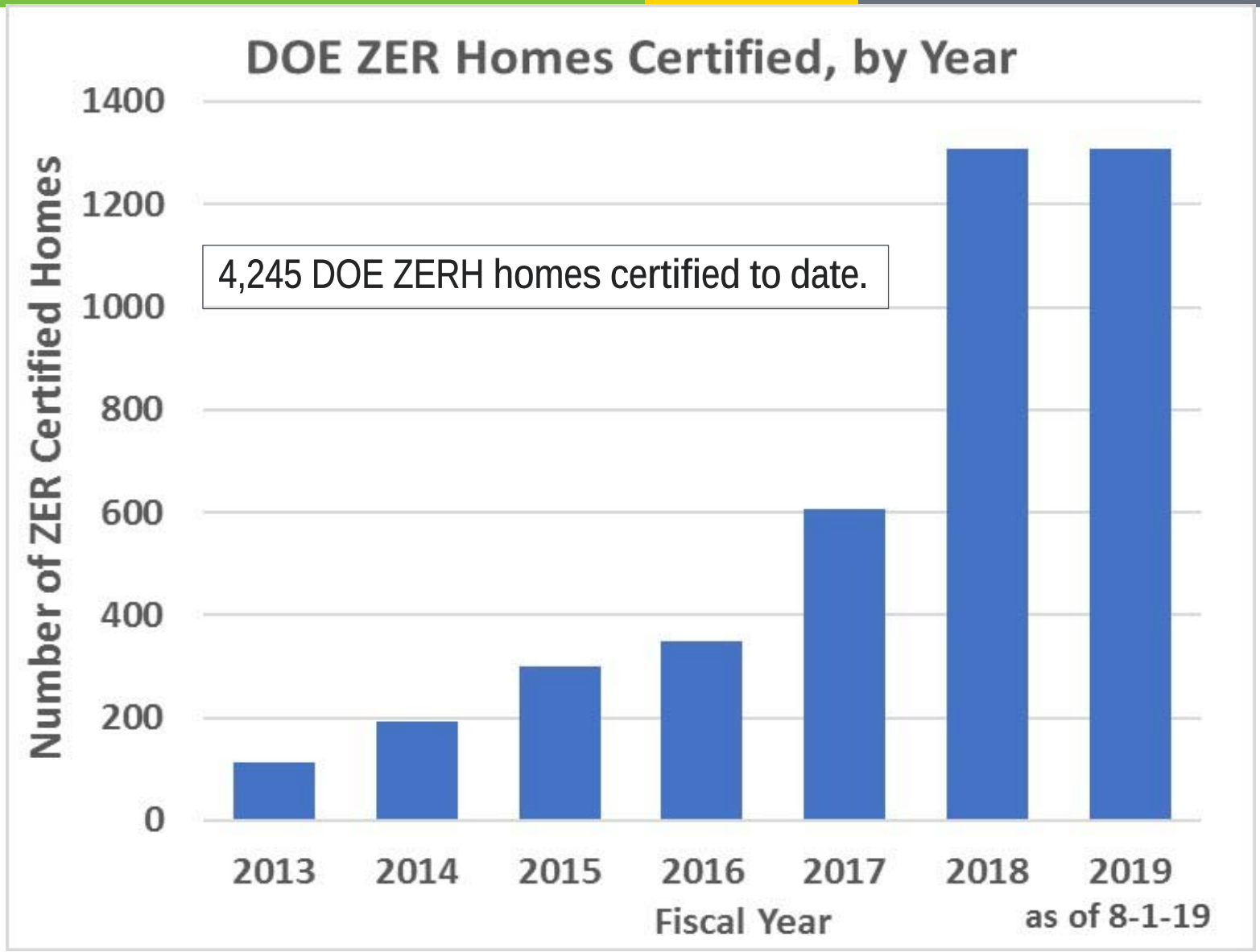

Zero Coming Soon to a City Near You

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CA Building Code Takes Big Step Toward Net-Zero Energy

May 09, 2018 | Pierre Delforge

Image courtesy of Wakeland Housing and Development Corporation

DOE ZERH Program Requirements

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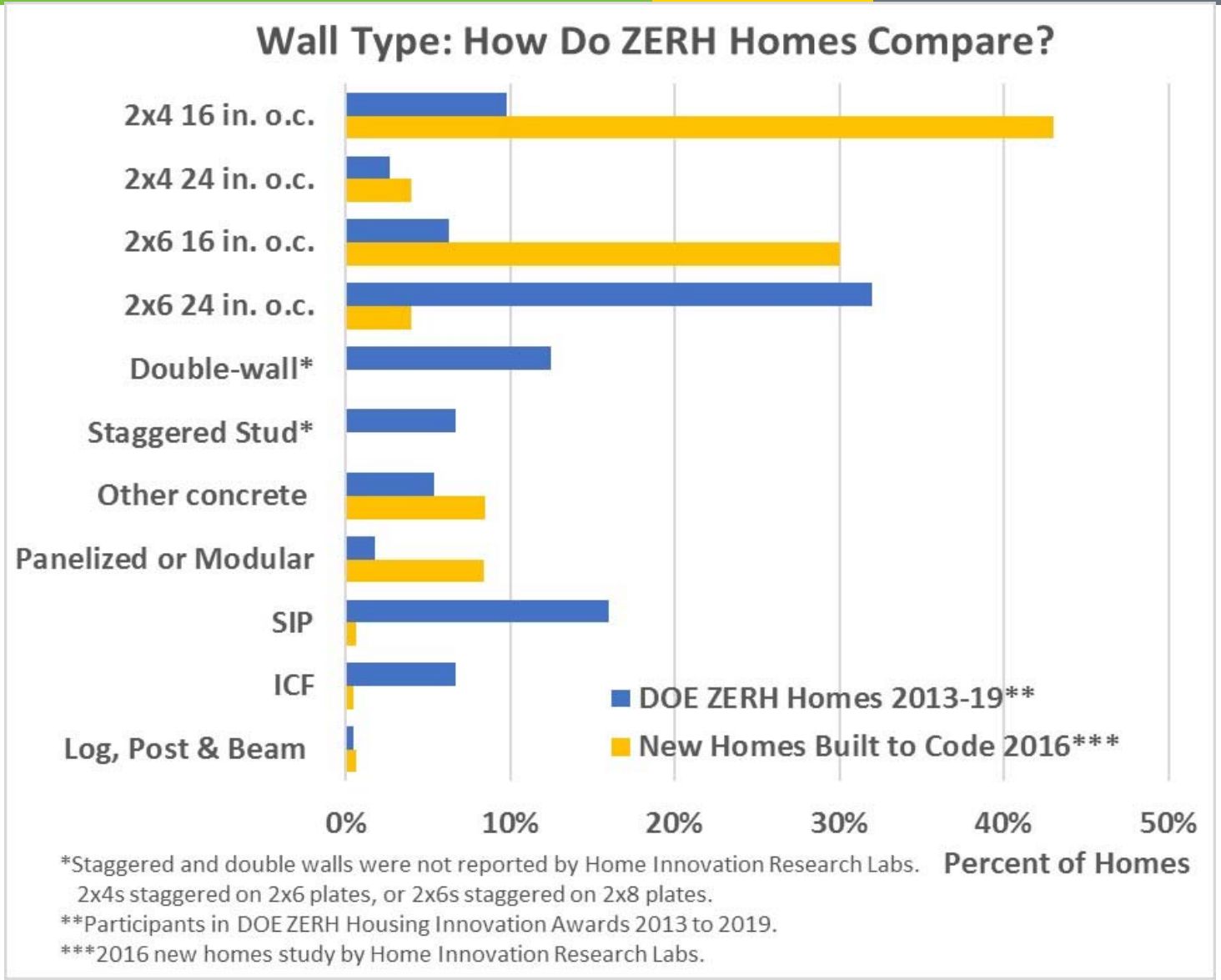
ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

How to Achieve a DOE Zero Energy Ready Home

- **START WITH** ENERGY STAR Certified Homes V. 3.0
- **ENVELOPE** meets or exceeds 2012 IECC levels
- **DUCT SYSTEM** located within the home's thermal boundary
- **WATER EFFICIENCY** meets WaterSense hot water distribution spec.
- **LIGHTING AND APPLIANCES** ENERGY STAR qualified
- **INDOOR AIR QUALITY** meets or exceeds the EPA Indoor airPLUS Verification Checklist
- **SOLAR** meets PV Ready Checklist
- **HVAC, HW,** and **ACH50** meet specs or tradeoff
- **BUILD,** Label, Sell

Wall Type


Wall Type: How Do ZERH Homes Compare?
2x4 16 in. o.c.
2x4 24 in. o.c.
2x6 16 in. o.c.
2x6 24 in. o.c.
Double-wall*
Staggered Stud*
Other concrete
Panelized or Modular
SIP
ICF
Log, Post & Beam
DOE ZERH Homes 2013-19**
New Homes Built to Code 2016***
0%
10%
20%
30%
40%
50%
Percent of Homes
*Staggered and double walls were not reported by Home Innovation Research Labs. 2x4s staggered on 2x6 plates, or 2x6s staggered on 2x8 plates.
**Participants in DOE ZERH Housing Innovation Awards 2013 to 2019.
***2016 new homes study by Home Innovation Research Labs.

A Better Stud Wall

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Advanced Framing

- 2-foot grid
- Less lumber, Less time, Less waste
- More room for insulation

Advanced Framing

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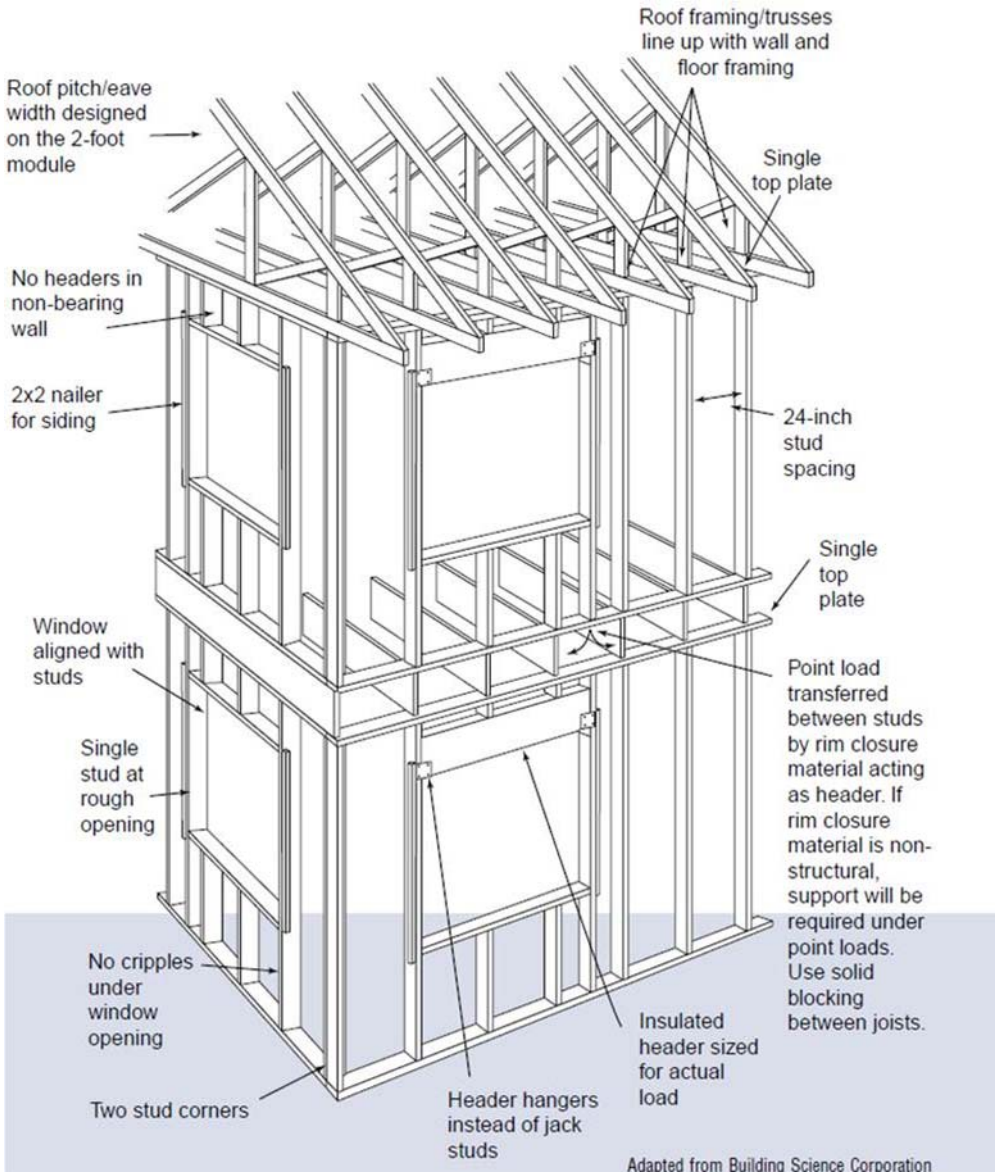

Advanced framing on a 2-foot grid.

Advanced Framing

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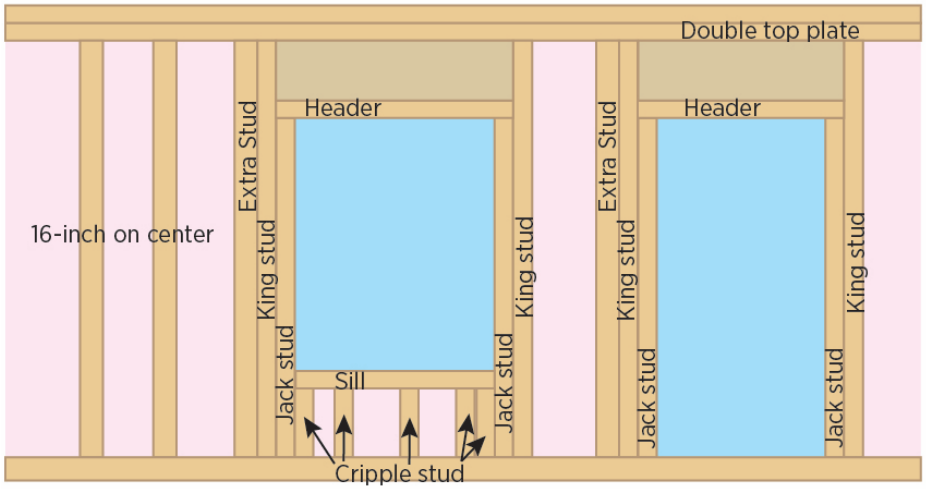
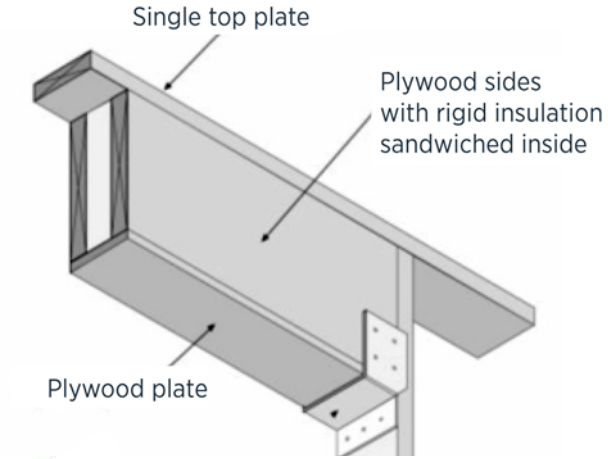
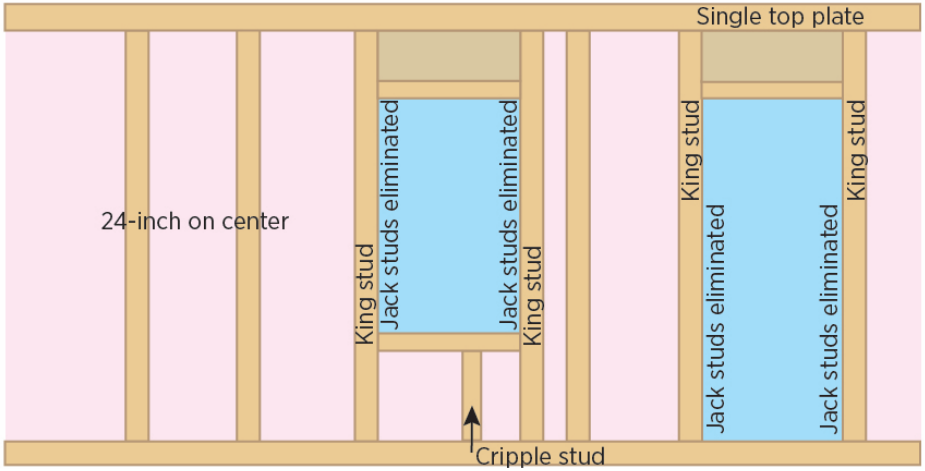
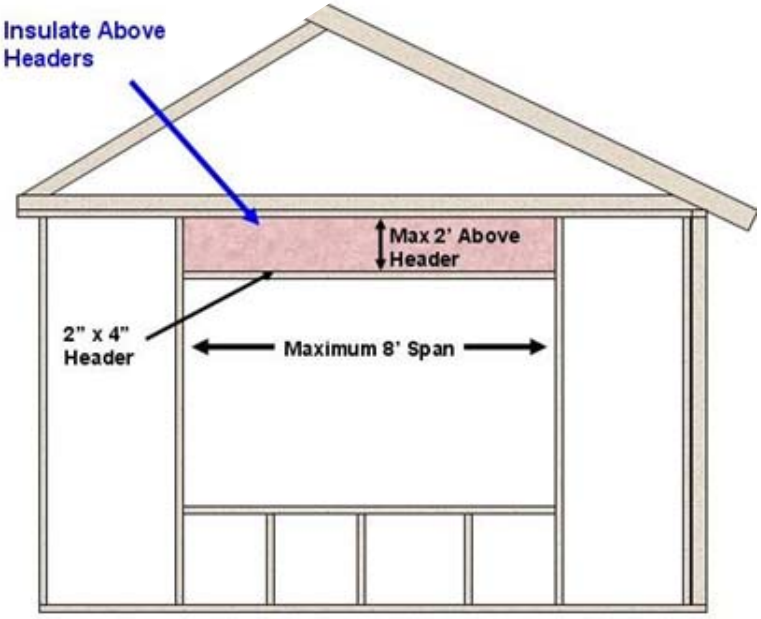
Traditional Framing





Advanced Framing Techniques





More Advanced Frame

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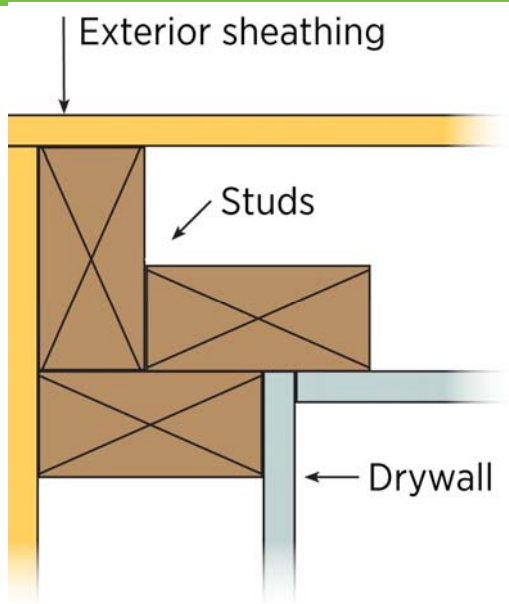

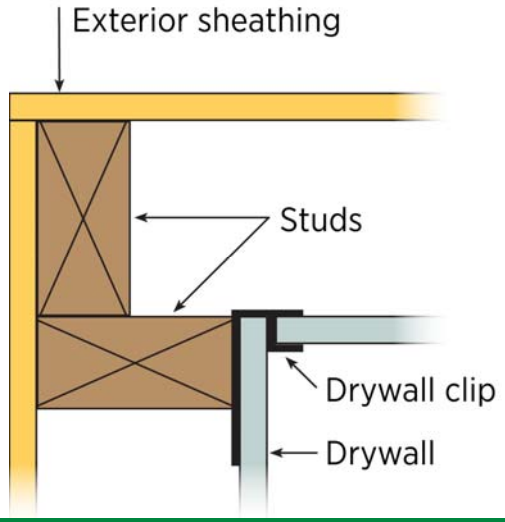

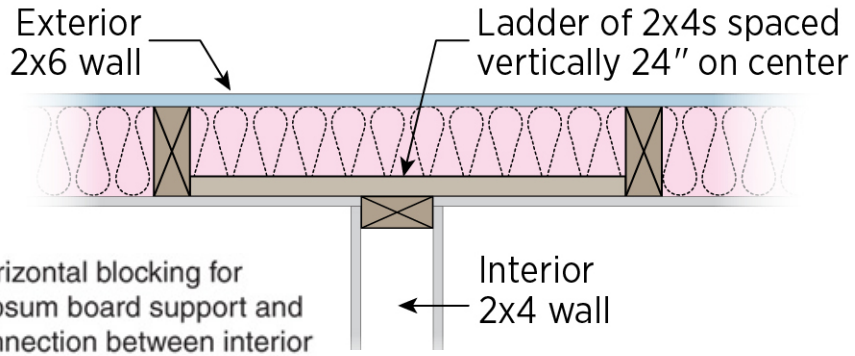

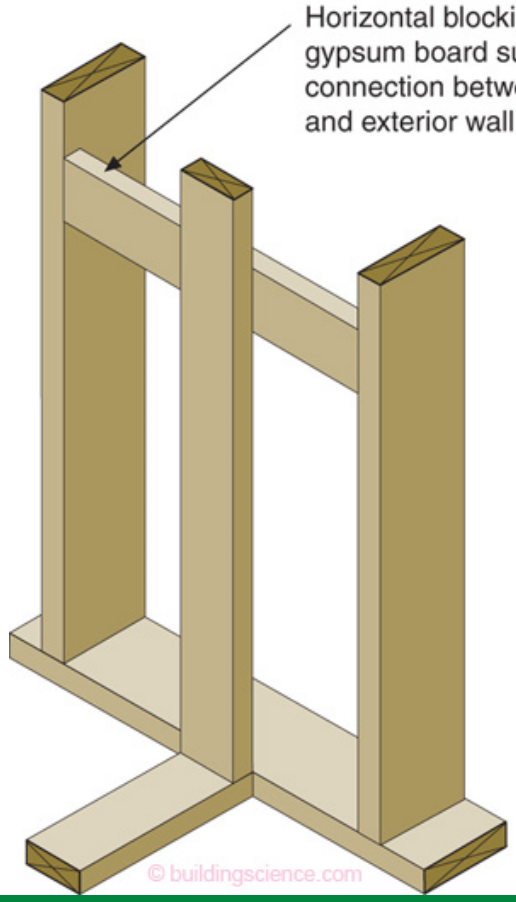

2-ft grid top to bottom

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An uncommon 6.55/12 roof pitch provides space for exactly 4 ½ sheets of 4-foot-wide roof sheathing with just one cut and optimal PV angle.

Stud Walls are Great - Except for Thermal Bridging

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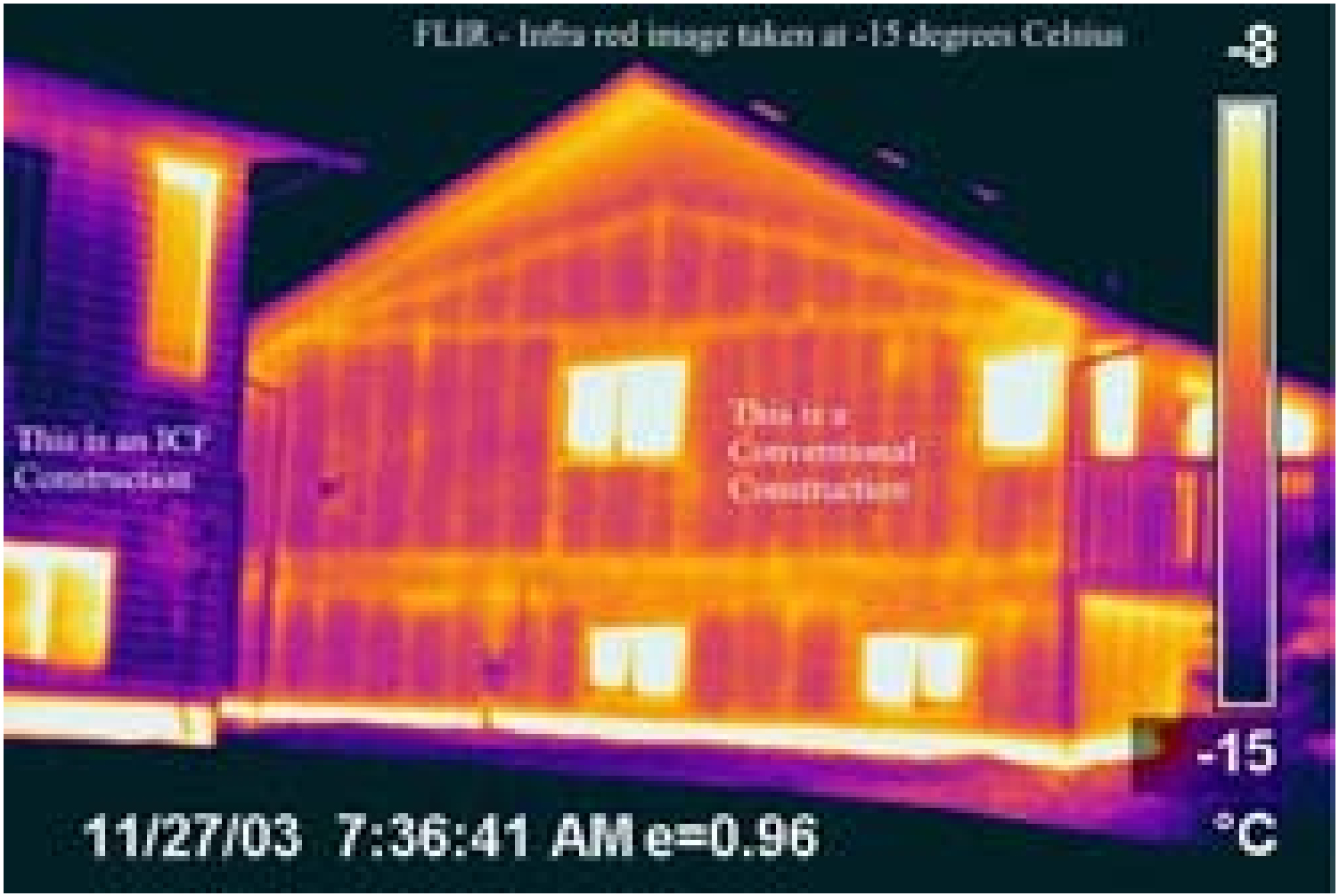

Stop Thermal Bridging – Put on a Sweater

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Builders use rigid foam exterior insulation to stop thermal bridging.

Rigid Foam Sheathing – all in one

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Rigid foam can serve as insulation, sheathing, and weather-resistant barrier, all exterior insulation to stop thermal bridging.

Rigid Foam Sheathing

Builders use rigid foam exterior insulation to stop thermal bridging.

Extended Plate and Beam

2x4 on 2x6 Plate

Provides solid nailing surface at top and bottom plate

Staggered Studs

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Staggered studs: Builders weave insulation around the studs to stop thermal bridging.

Double Walls

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SIPs

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SIPs

Graphite SIPs

EPS and Steel panels

ICF Igloos

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It's a Marshmallow World in the Winter

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Just like Legos

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Habitat Volunteers build an ICF house in Florida

DIY ICF Foundation

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AAC – a different kind of concrete

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Modular - Modern

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Modular - Traditional

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Traditional Dutch colonial made from traditional materials in nontraditional factory setting.

Modular with I Beams

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Panelized factory construction with 9.5-inch I-joist wall studs.

Panelized

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Panelized homes – Insight Production Homes
Deltec the new Sears Roebuck House.

Insulated Concrete Panels

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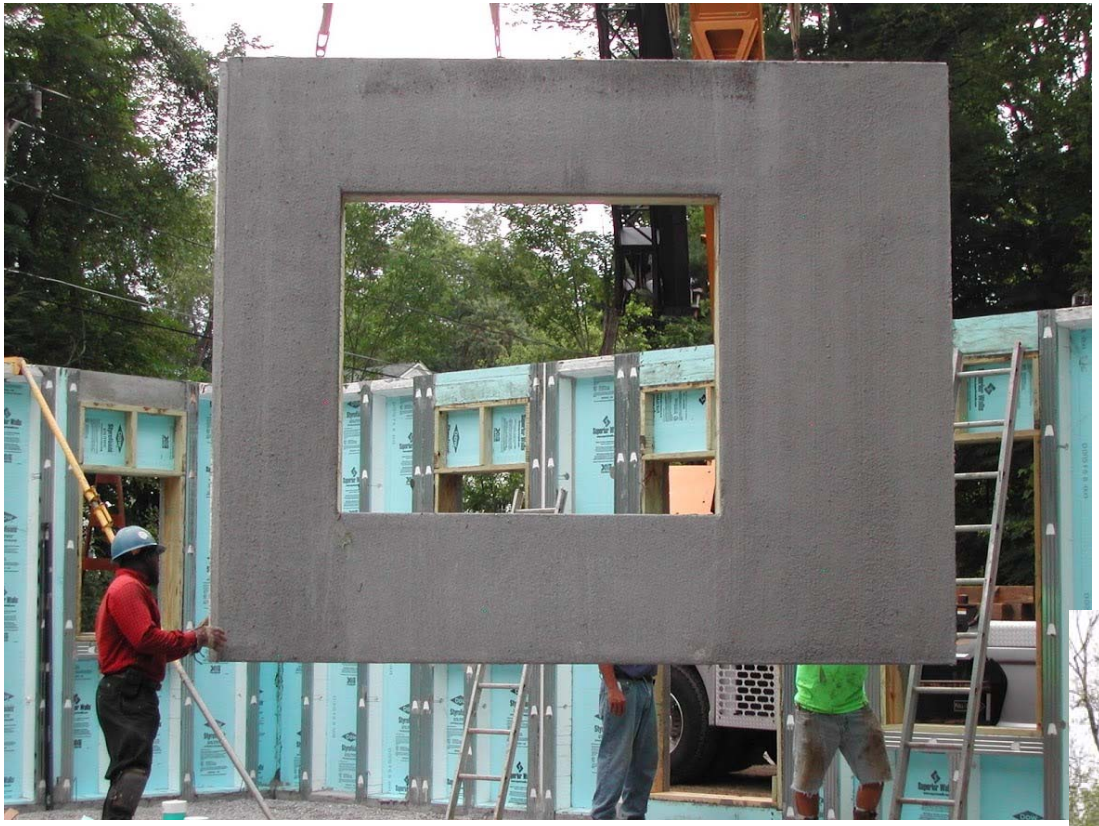
Concrete Panel House



Insulated concrete panels assemble quickly on site, sit on gravel, no foundation is poured.

Spray Foam Slab Edge

Spray Foam Just where you need it.

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Judicious use of spray foam

Paint-On Flashing

Paint-on flashing and weather-resistant barrier.

Extraordinary Air Sealing

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Air Sealing Tape and Caulk Details

No Holes Up There

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Aerosol Sealing

Air seal everywhere all at once.
Aerosol sealant seals off every nook and cranny.

Air Sealing

Buy your own or build your own blower door.

HVAC ZERH-New Homes-EIA

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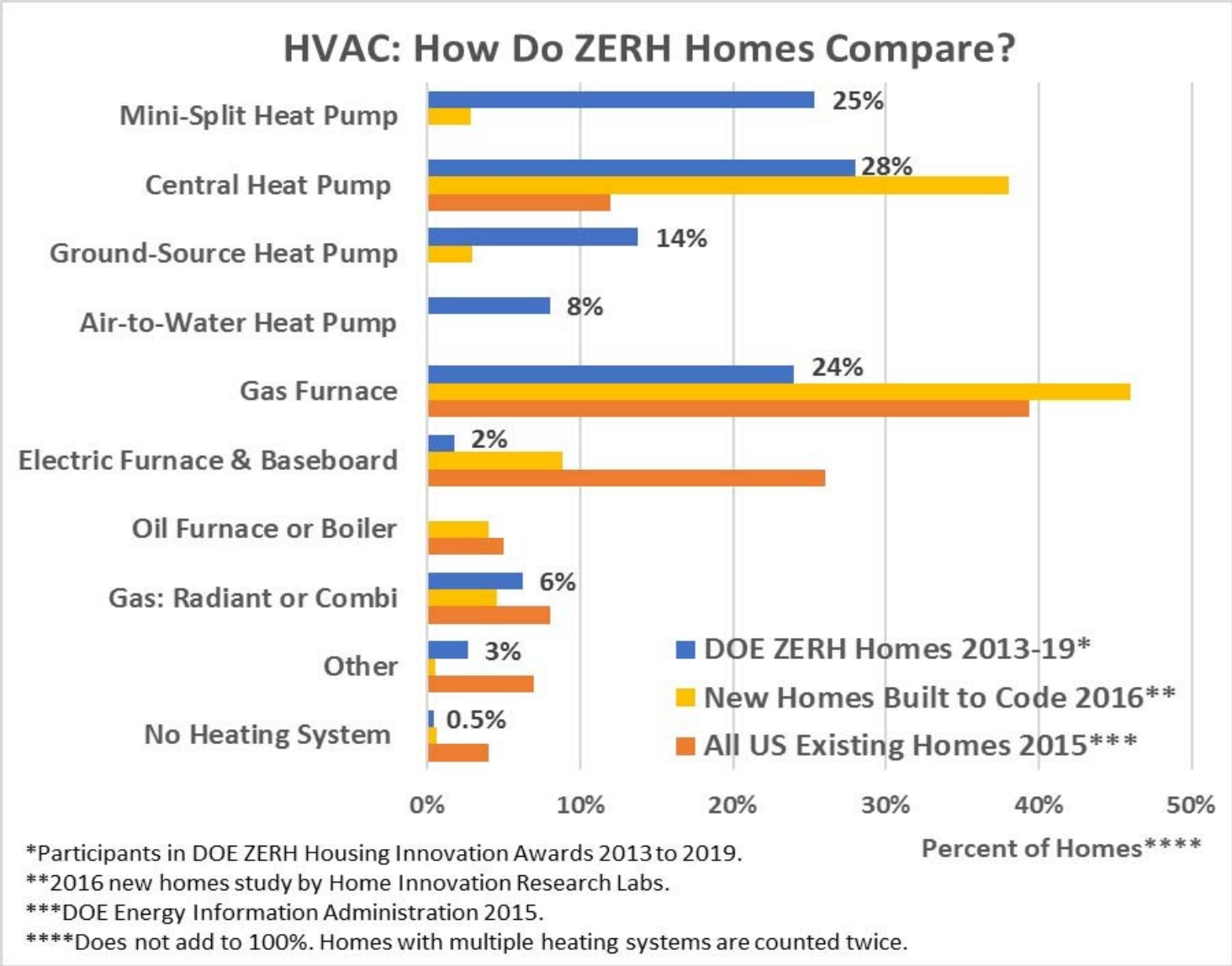
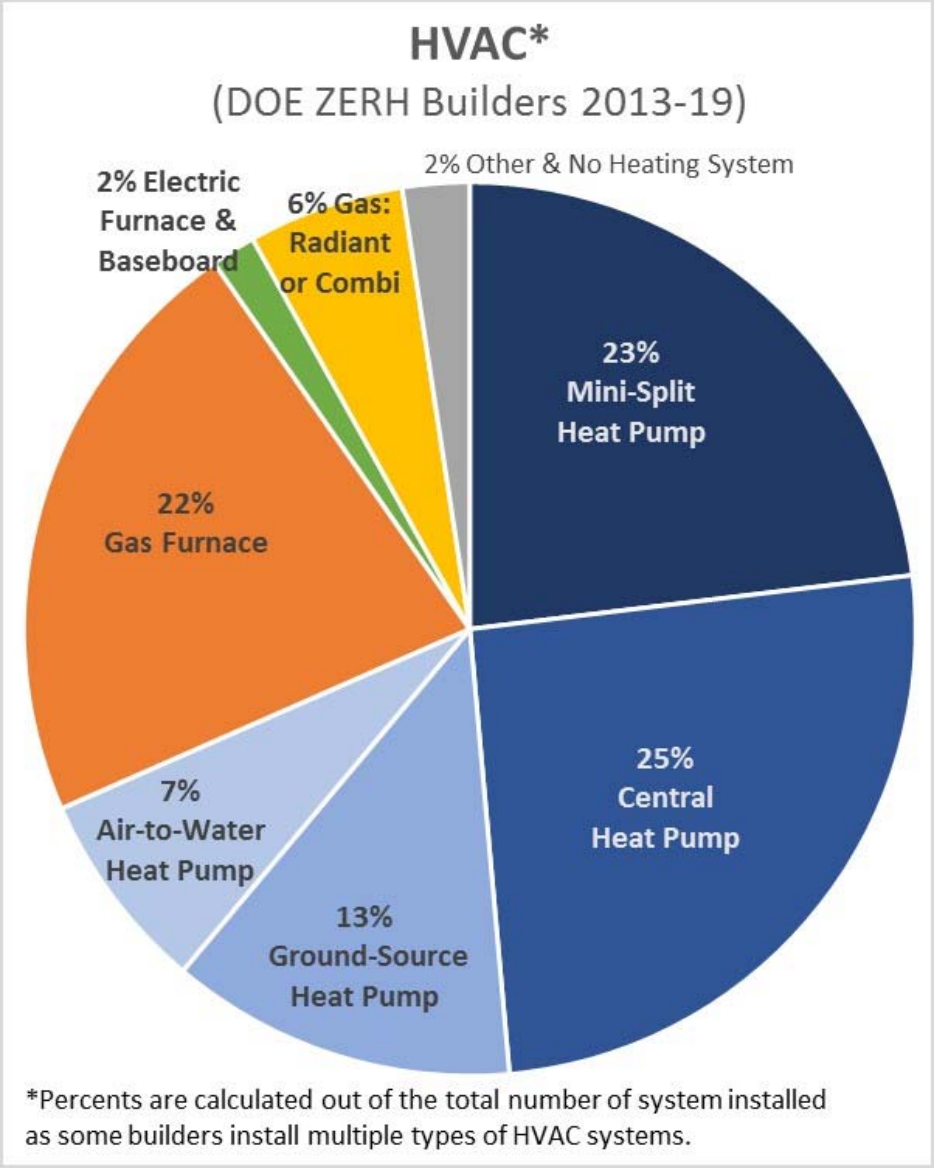
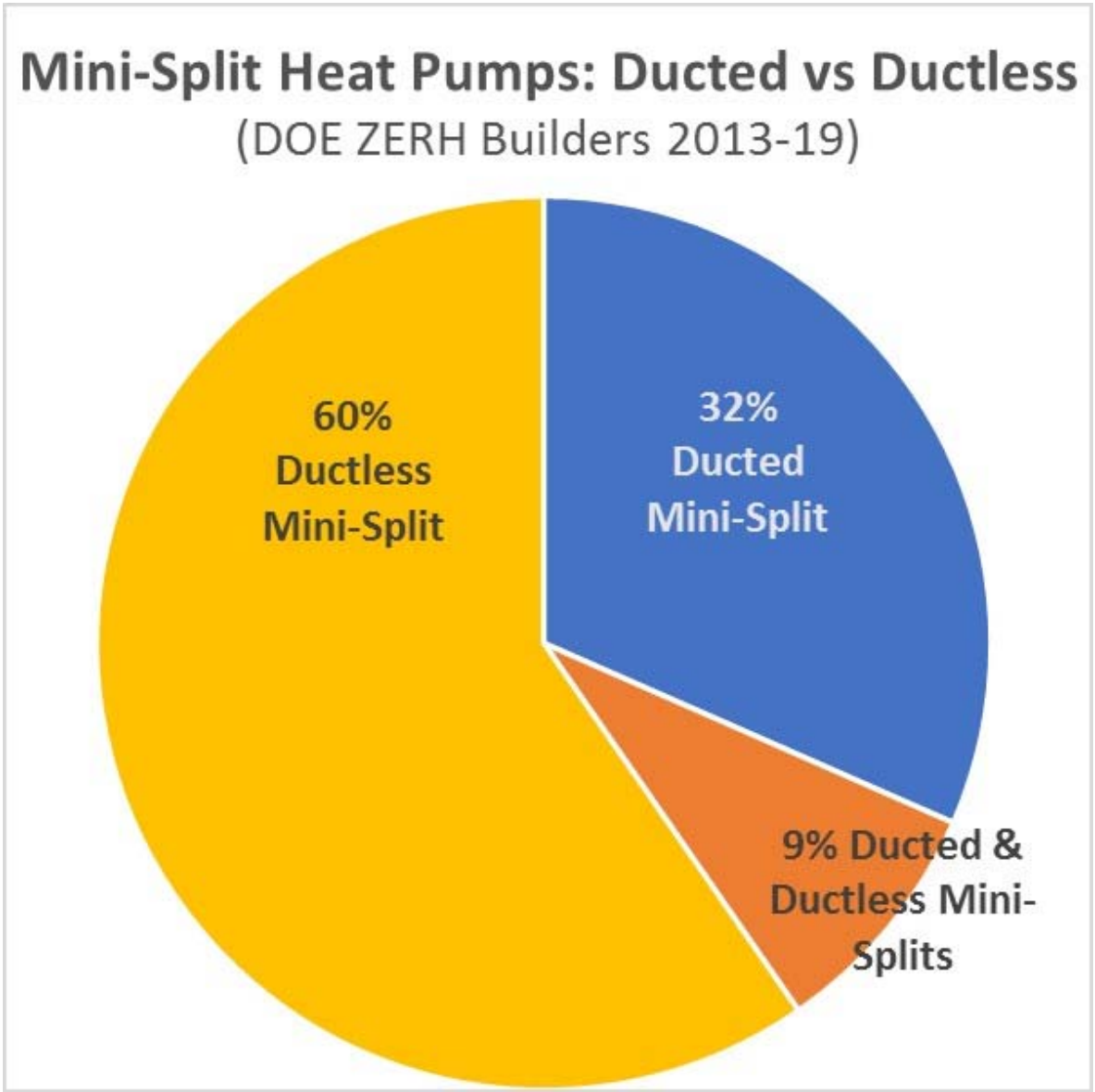


HVAC (DOE ZERH Builders 2013-19)



Heat Pumps


Mini-Split Heat Pumps: Ducted vs Ductless
(DOE ZERH Builders 2013-19)
60% Ductless Mini-Split
32% Ducted Mini-Split
9% Ducted & Ductless Mini-Splits

Heat Pumps

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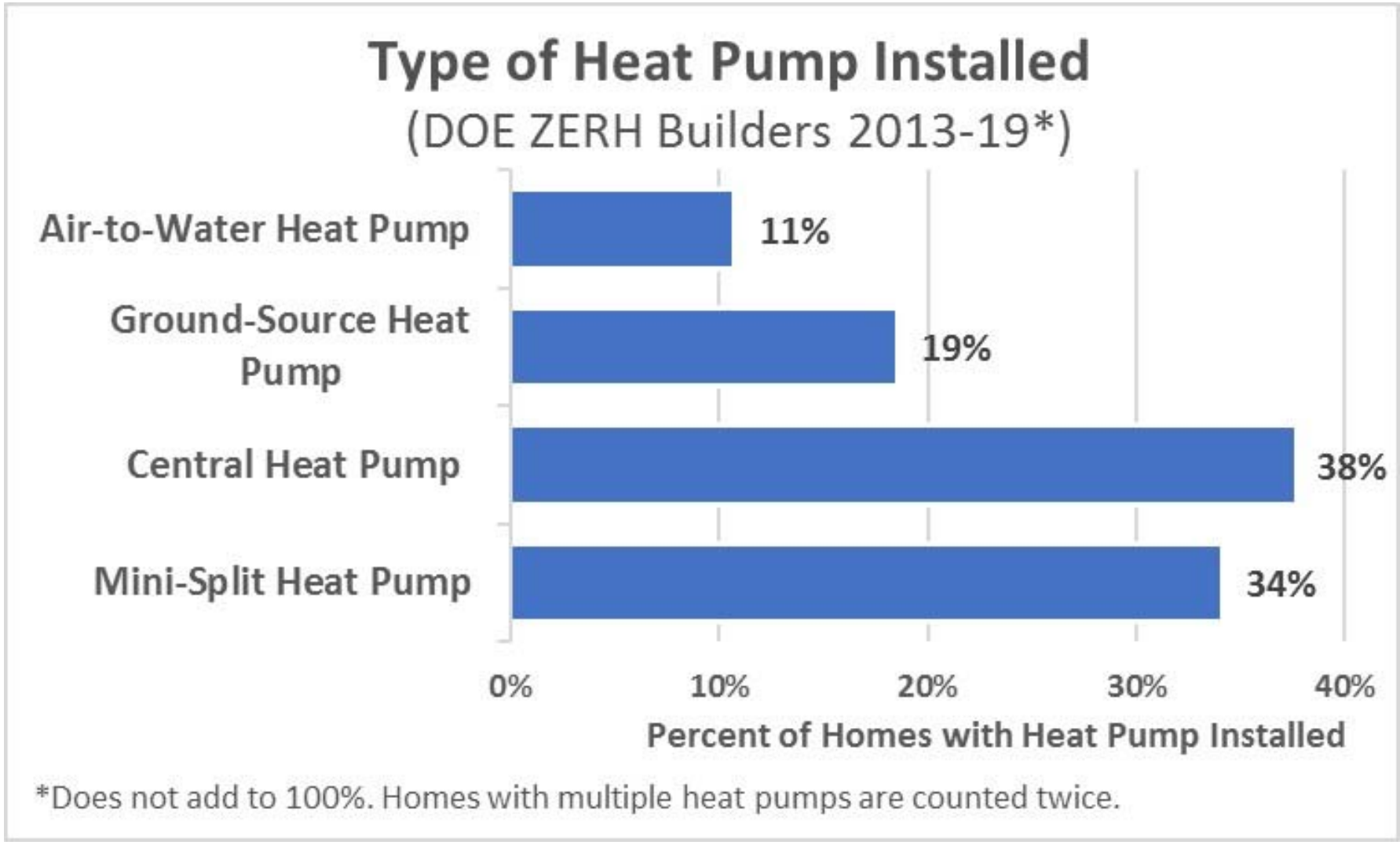

Where's the minisplit?

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Find the mini-split.

Mini-Split Heat Pumps

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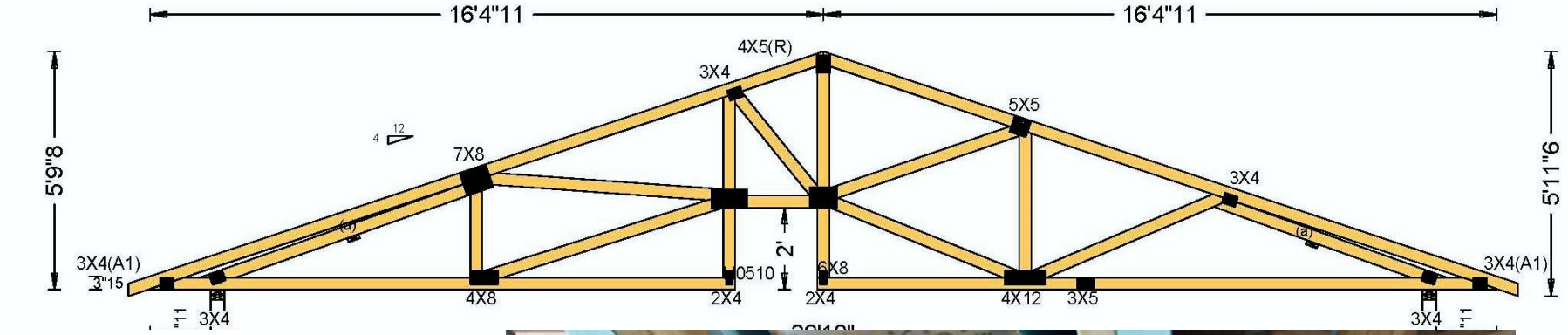
Just one ductless

Maximizing mini-splits, with exhaust fans?!

Air Sealed Chase

Trunk ducts are inside conditioned space in a dropped ceiling chase.

Tucked in Ducts



Trunk ducts are inside conditioned space in a dropped ceiling chase.

Attic Chase for Ducts

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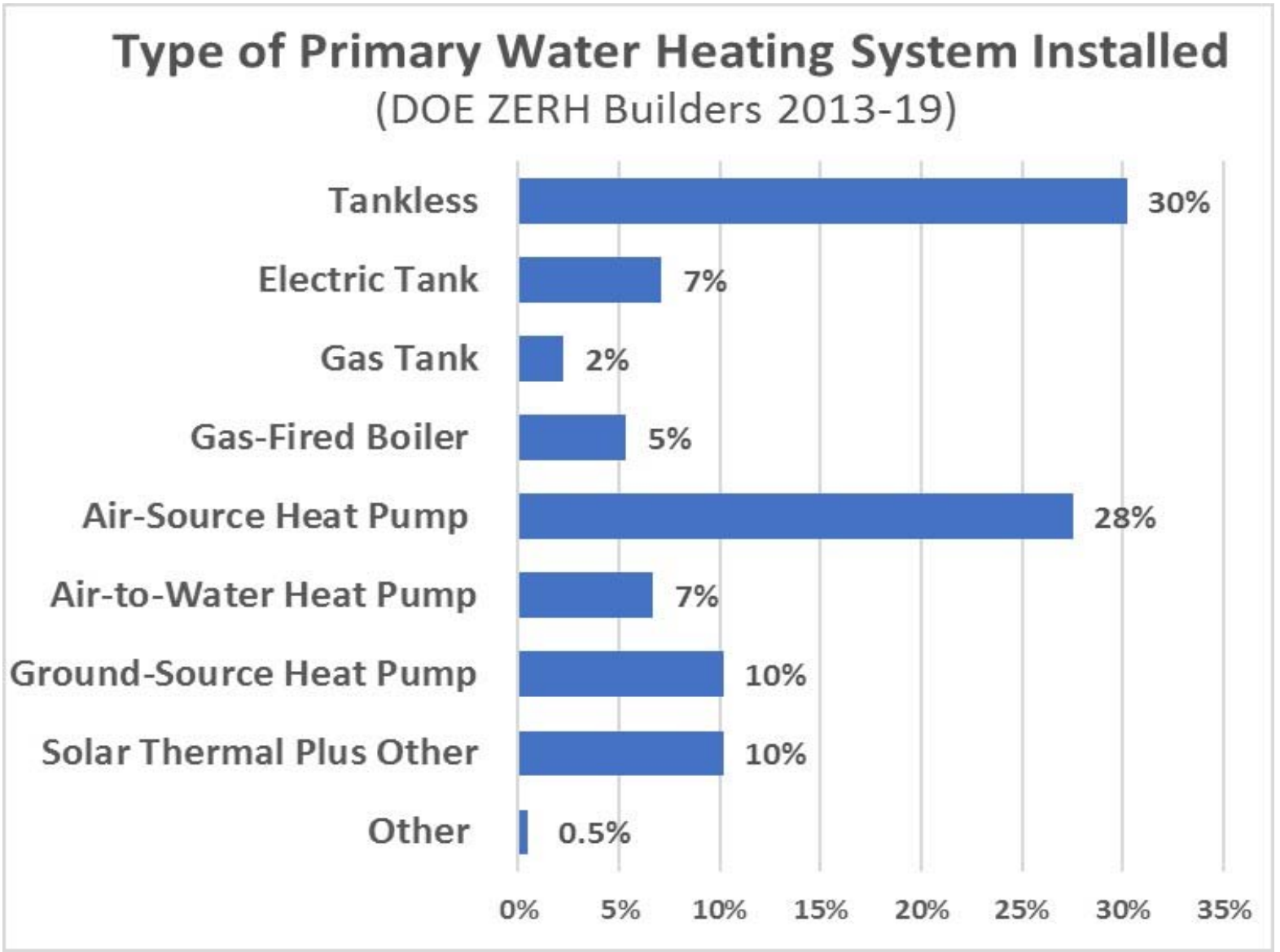
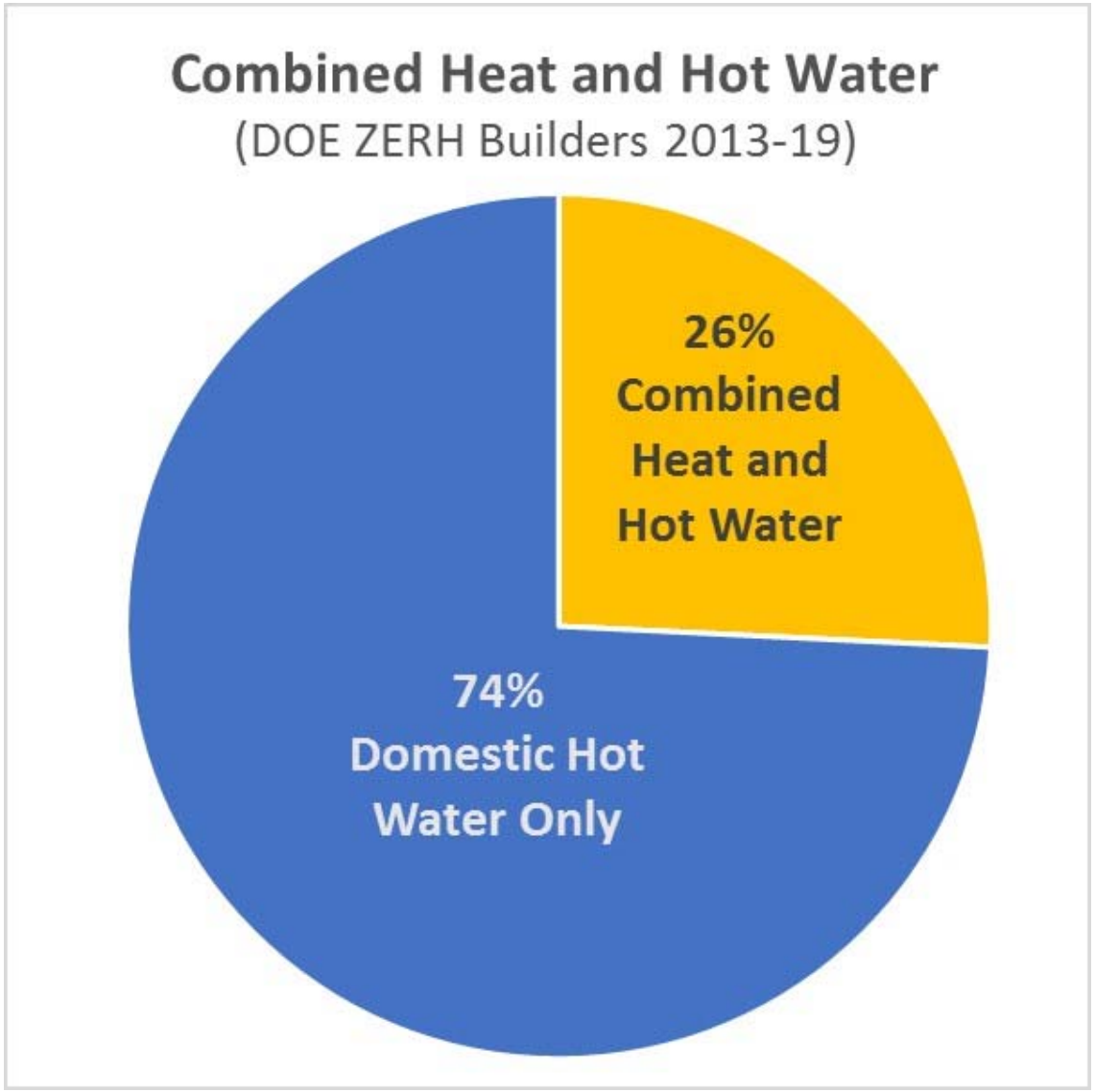
Water Heating



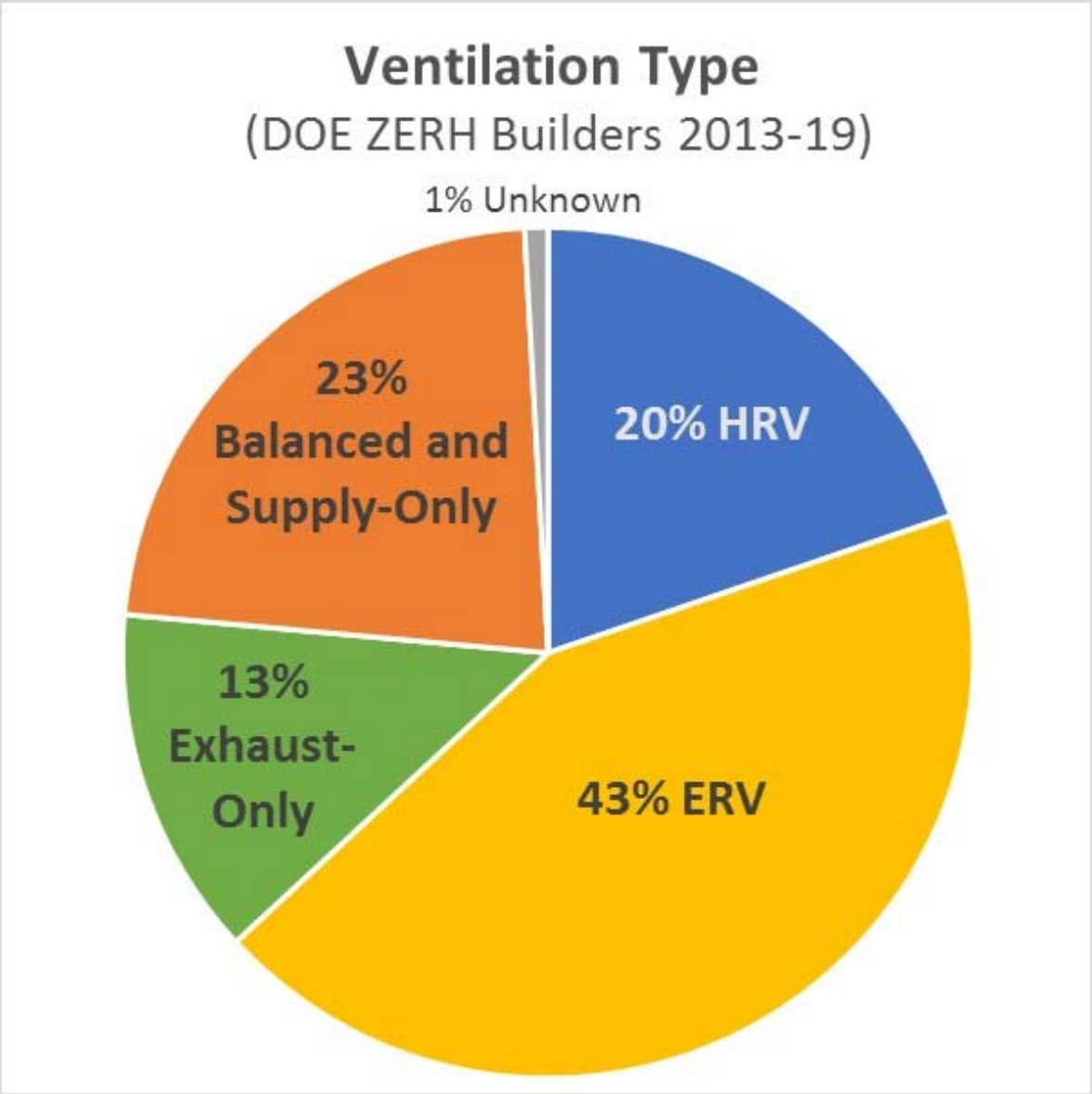
Hot Water (DOE Builders 2013-19)



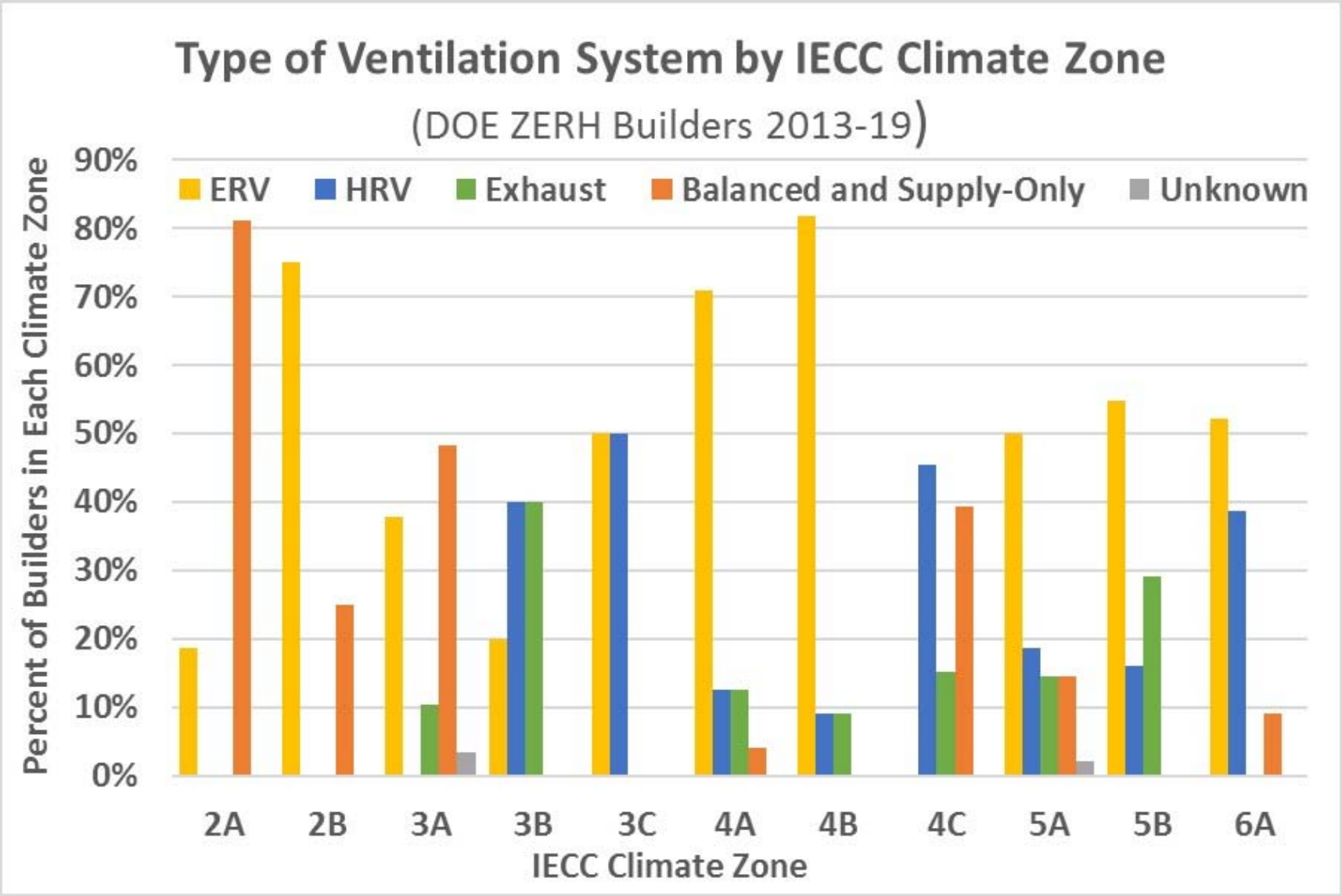
Ground Source Water Heater

Ground source heat pump plumbed to heat for domestic water first then space heat

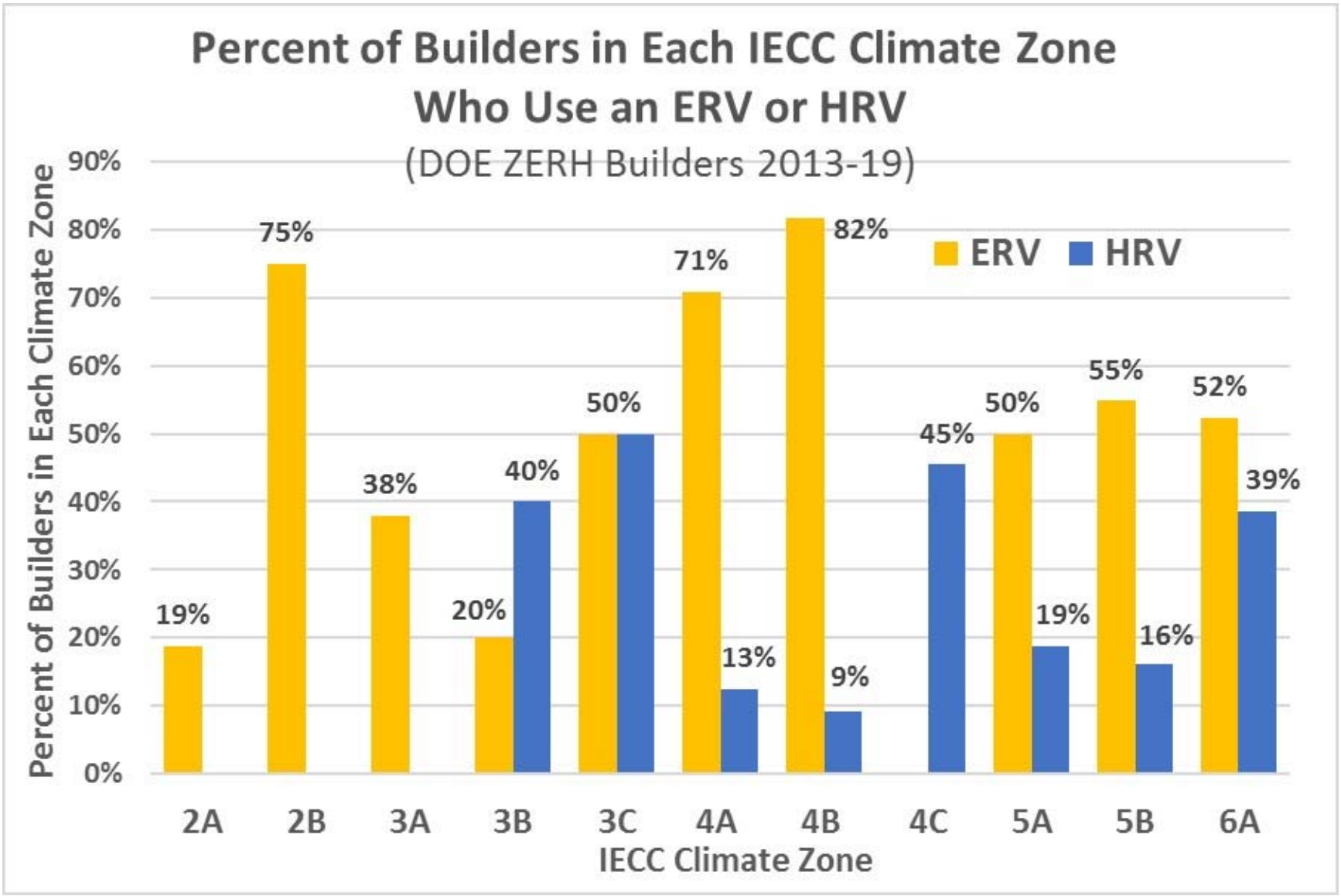
Ventilation



Ventilation



HRV vs ERV


Percent of Builders in Each IECC Climate Zone
Who Use an ERV or HRV
(DOE ZERH Builders 2013-19)
Percent of Builders in Each Climate Zone
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
ERV
HRV
19%
75%
38%
20%
40%
50%
50%
71%
13%
82%
9%
45%
50%
19%
55%
16%
52%
39%
2A
2B
3A
3B
3C
4A
4B
4C
5A
5B
6A
IECC Climate Zone

Do It Yourself HRV

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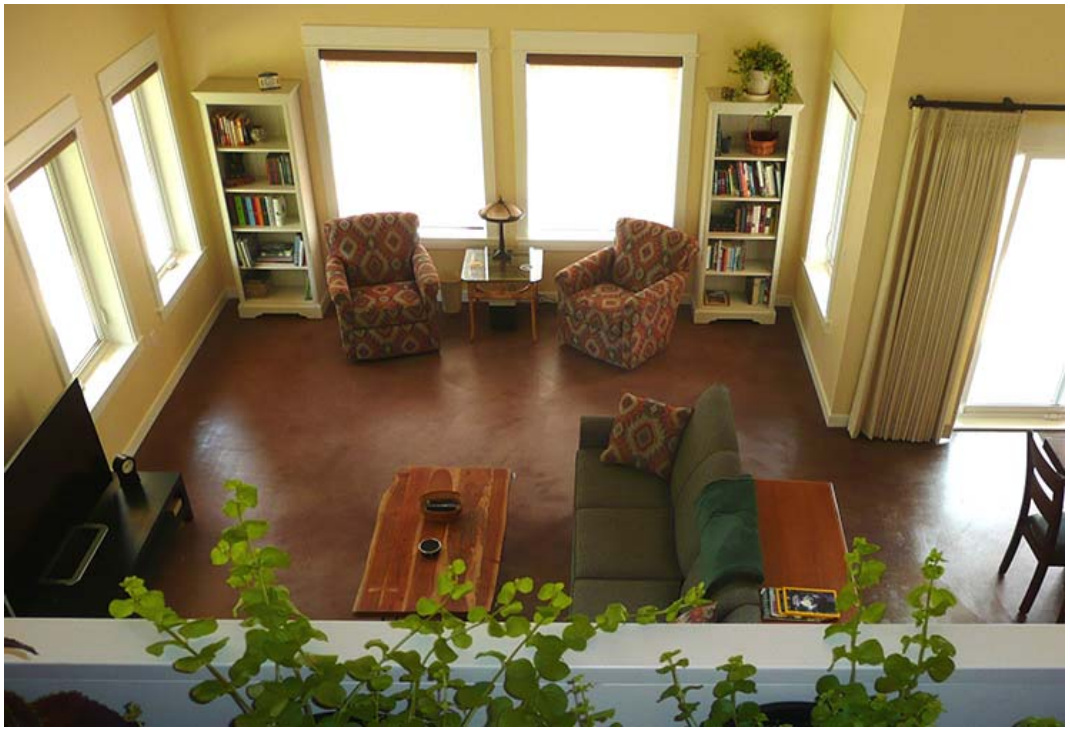

Stained concrete - Fashion statement or heating system?

Earth Tubes

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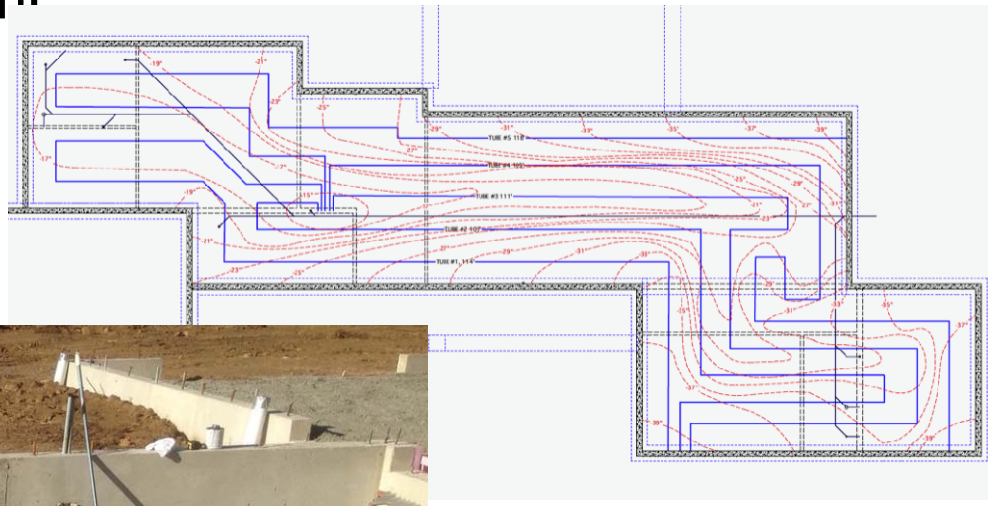
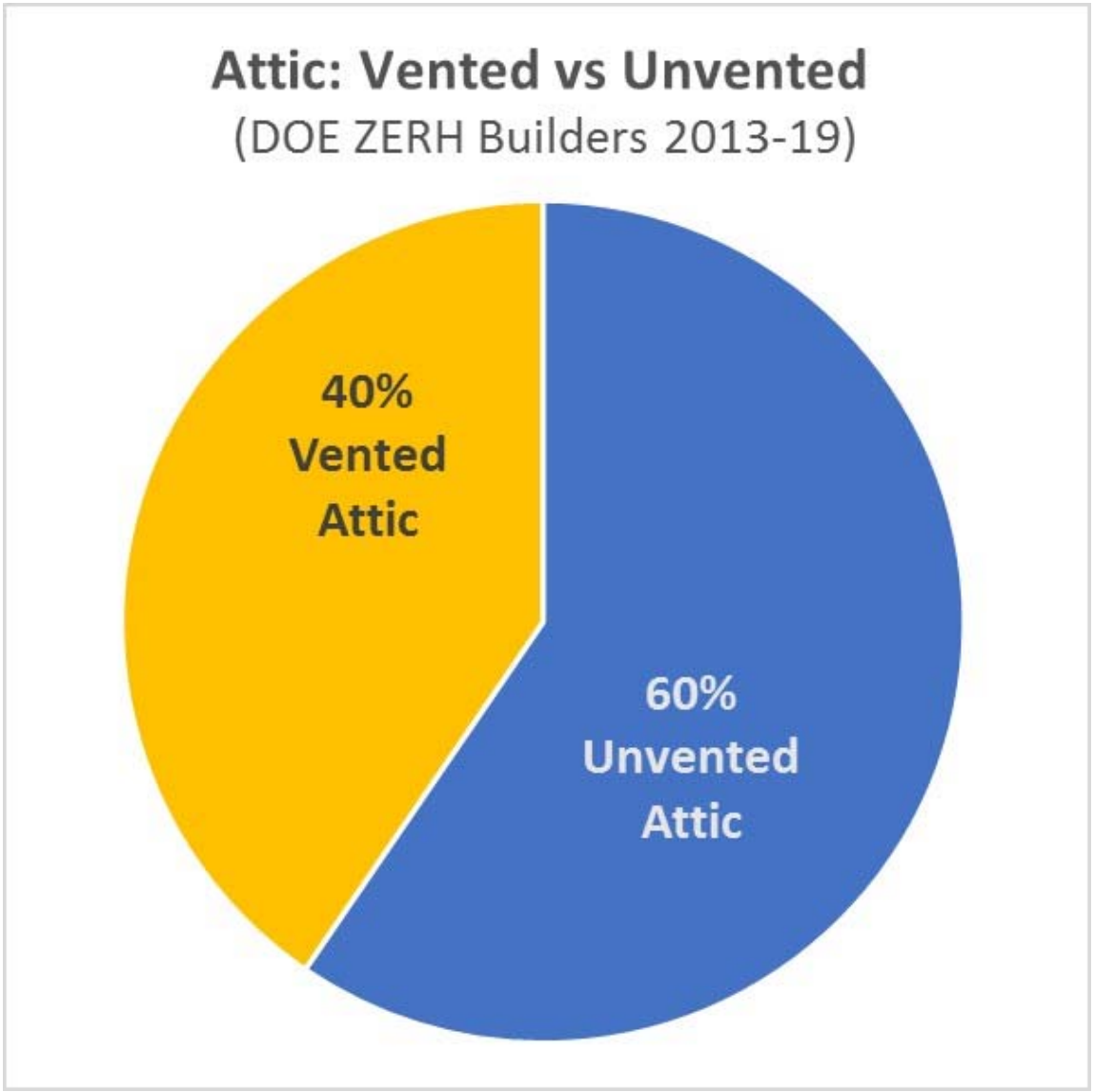
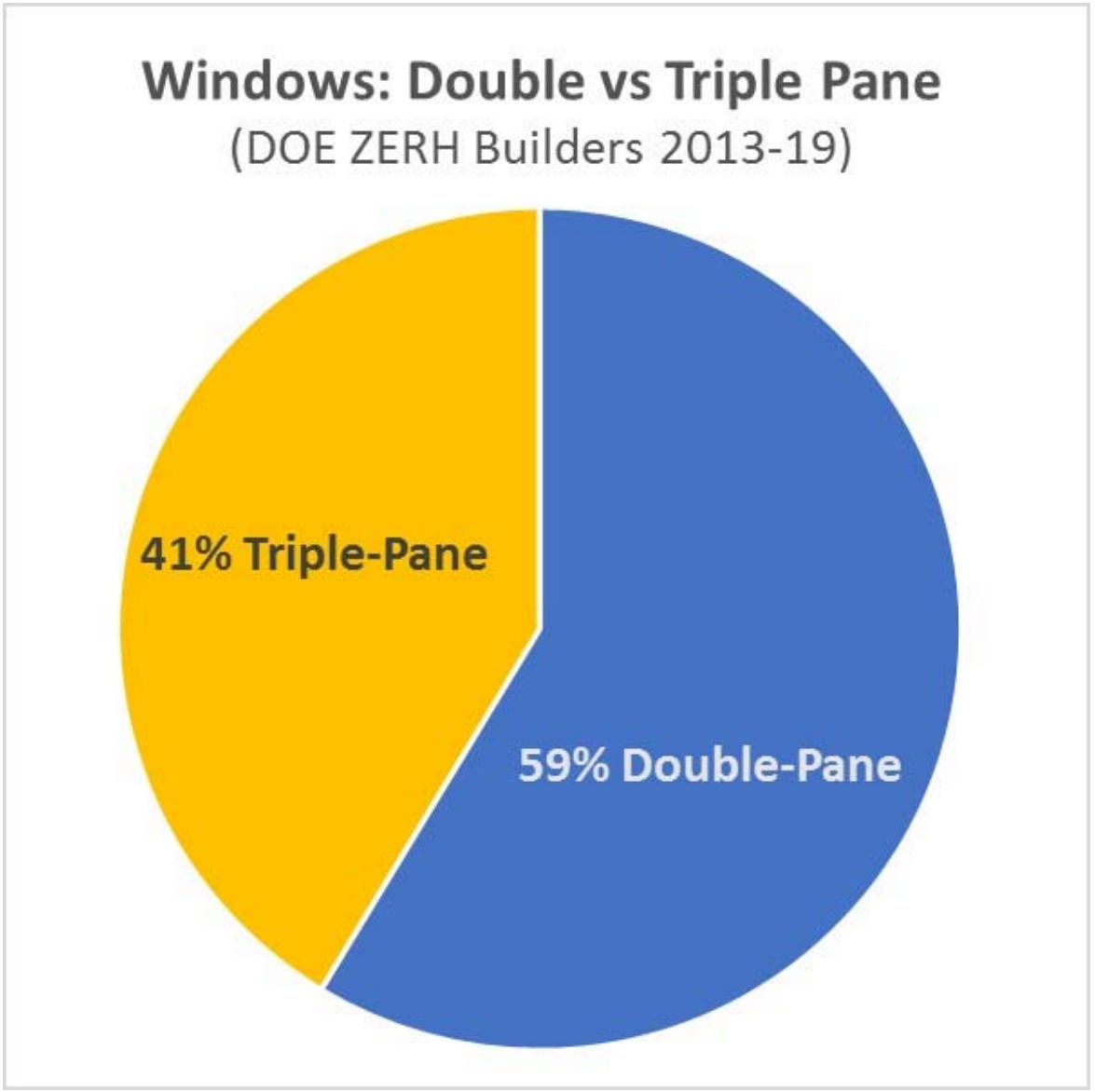
Now for something completely different



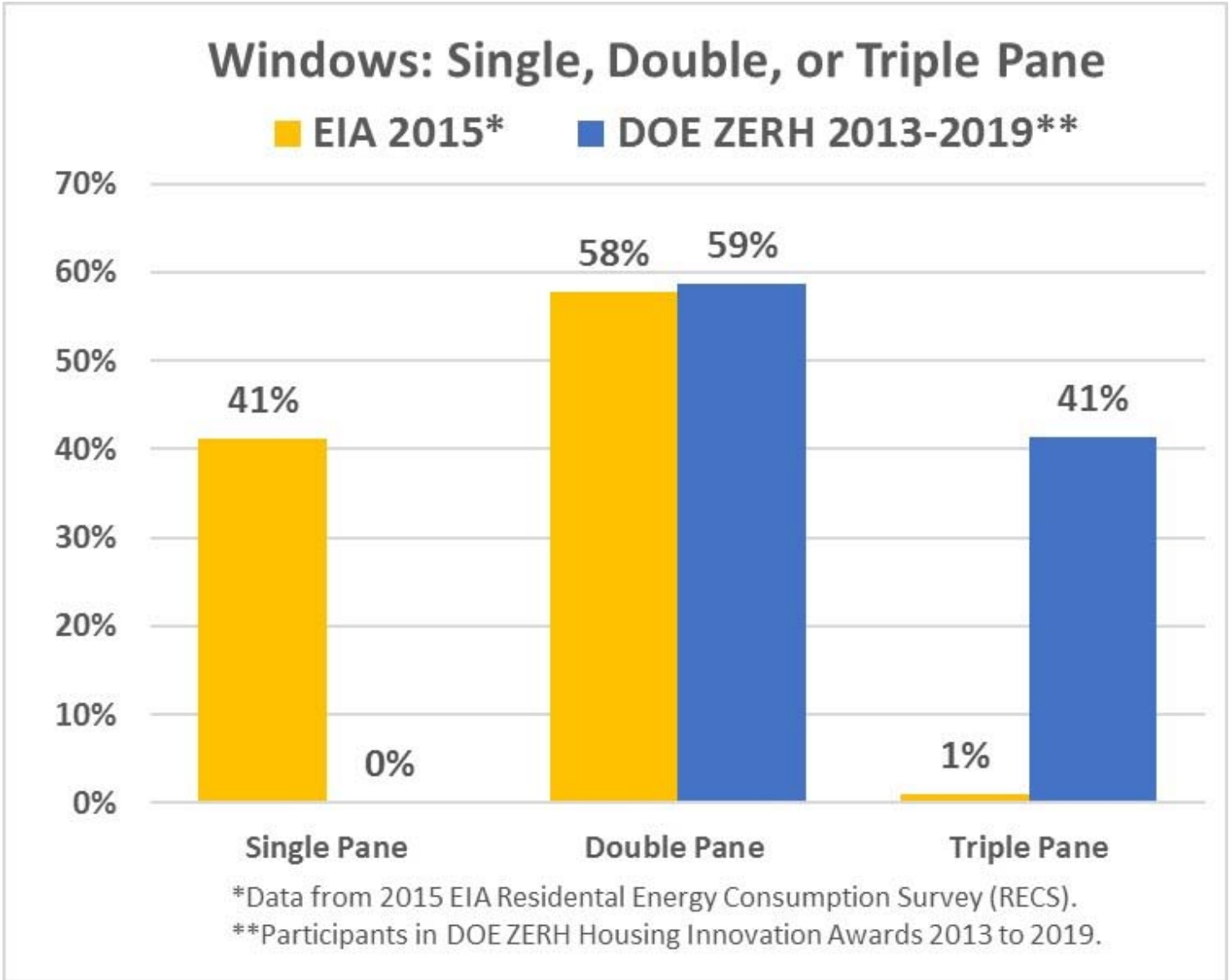
Attics


Attic: Vented vs Unvented
(DOE ZERH Builders 2013-19)
40%
Vented
Attic
60%
Unvented
Attic

Windows


Windows: Double vs Triple Pane
(DOE ZERH Builders 2013-19)
41% Triple-Pane
59% Double-Pane

Windows


Windows: Single, Double, or Triple Pane
EIA 2015*
DOE ZERH 2013-2019**
70%
60%
50%
40%
30%
20%
10%
0%
41%
0%
58%
59%
1%
41%
Single Pane
Double Pane
Triple Pane
*Data from 2015 EIA Residental Energy Consumption Survey (RECS).
**Participants in DOE ZERH Housing Innovation Awards 2013 to 2019.

Windows – thin triples

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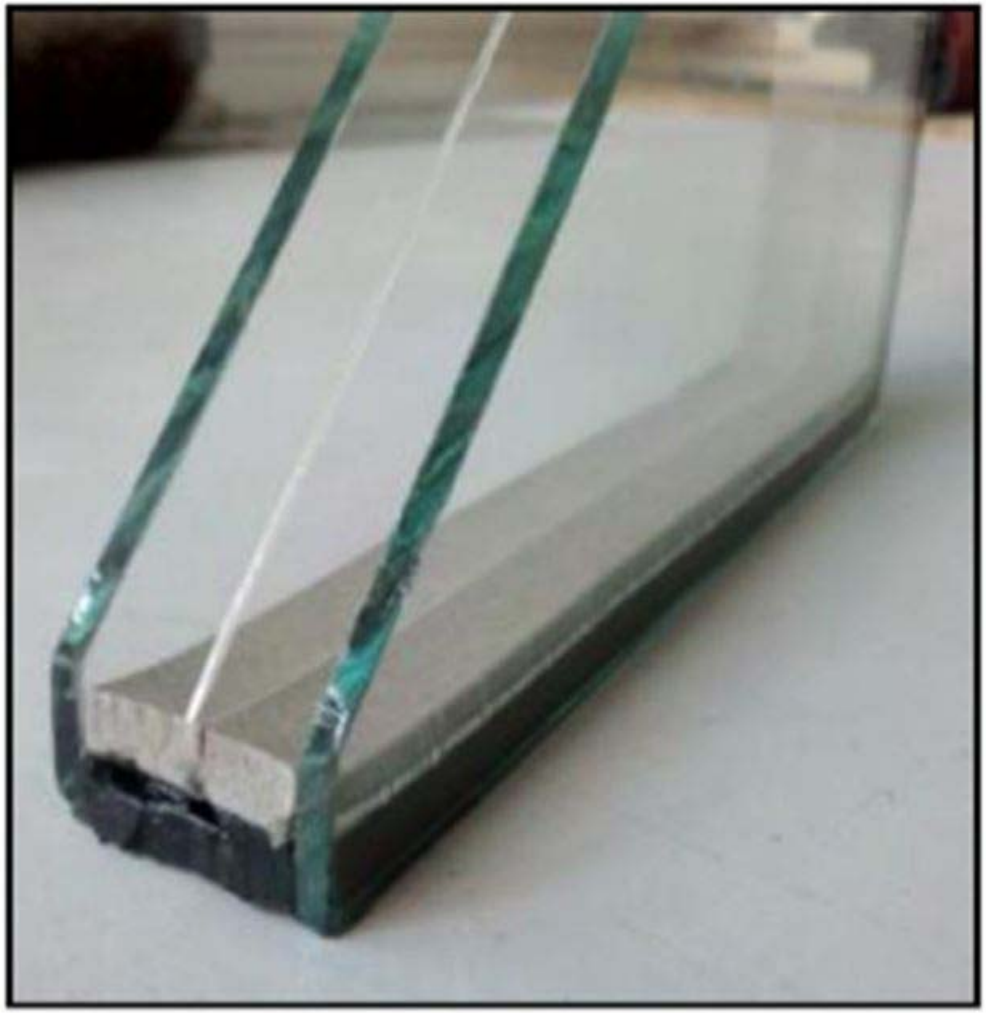
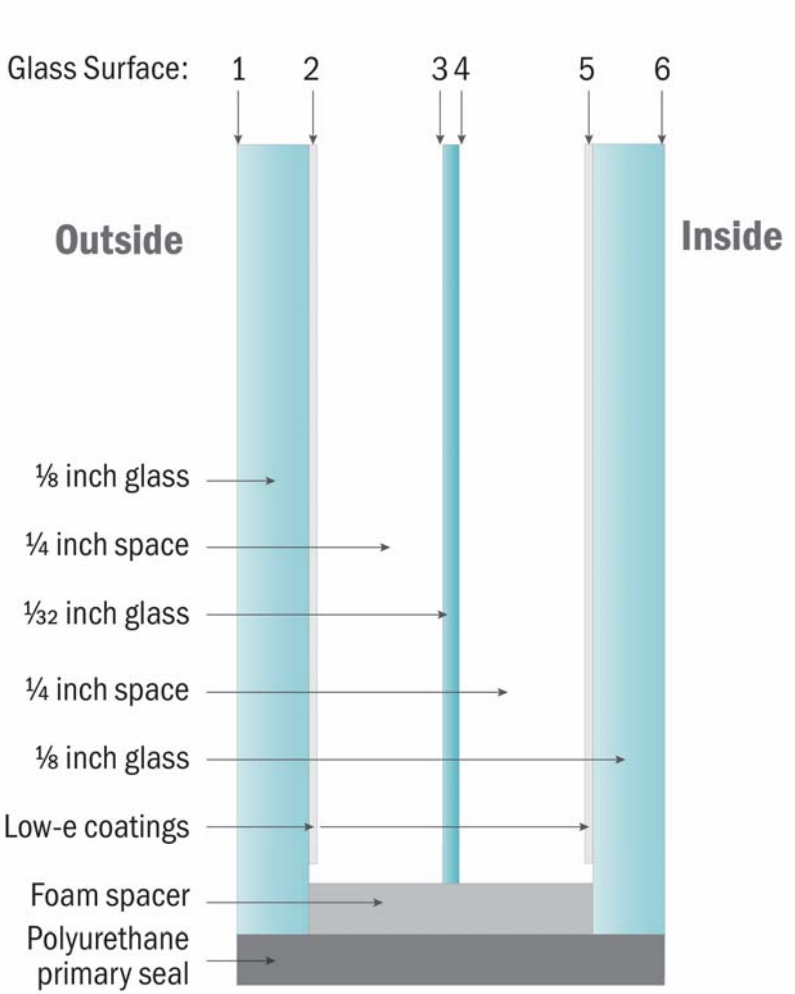
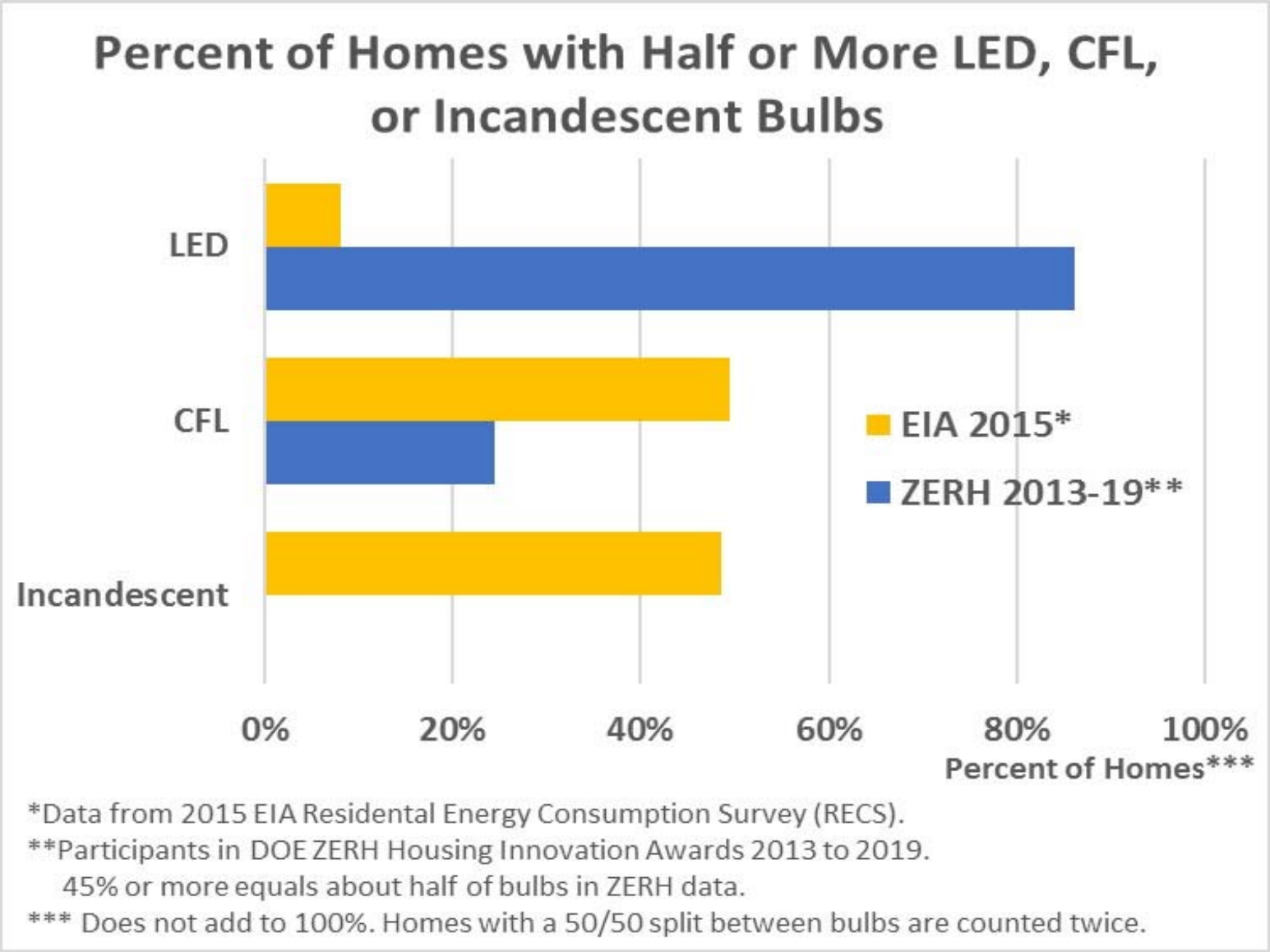


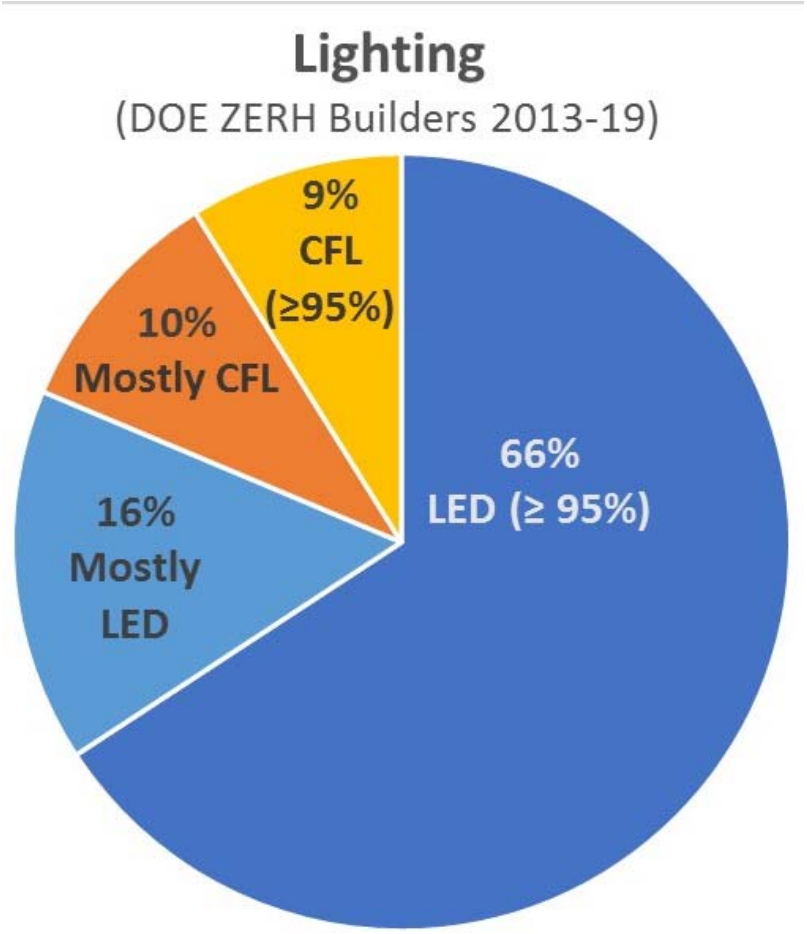


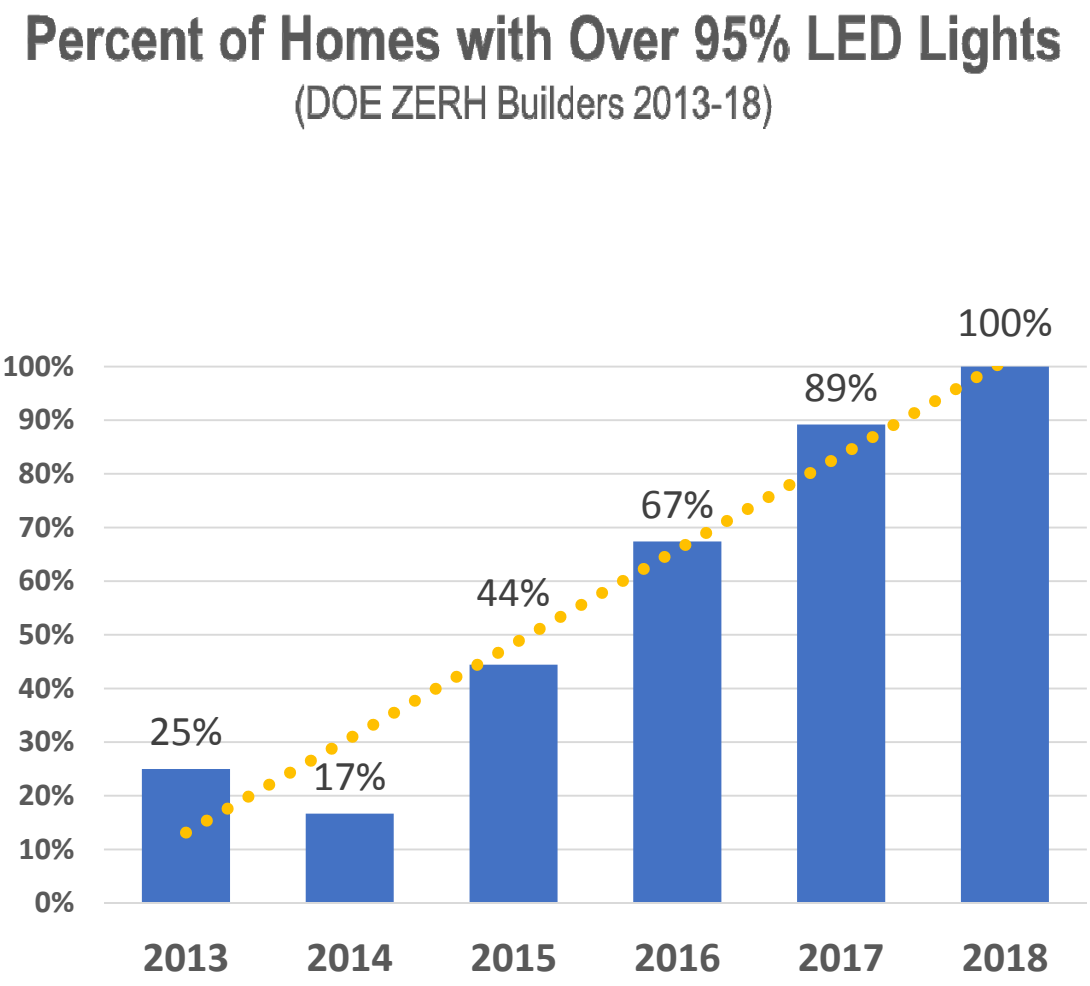
Lighting



*Data from 2015 EIA Residental Energy Consumption Survey (RECS).
**Participants in DOE ZERH Housing Innovation Awards 2013 to 2019.
45% or more equals about half of bulbs in ZERH data.
*** Does not add to 100%. Homes with a 50/50 split between bulbs are counted twice.

Lighting


Lighting
(DOE ZERH Builders 2013-19)
9%
CFL
(≥95%)
10%
Mostly CFL
16%
Mostly
LED
66%
LED (≥ 95%)


Percent of Homes with Over 95% LED Lights
(DOE ZERH Builders 2013-18)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
25%
17%
44%
67%
89%
100%
2013
2014
2015
2016
2017
2018

Pseudo Can Lights

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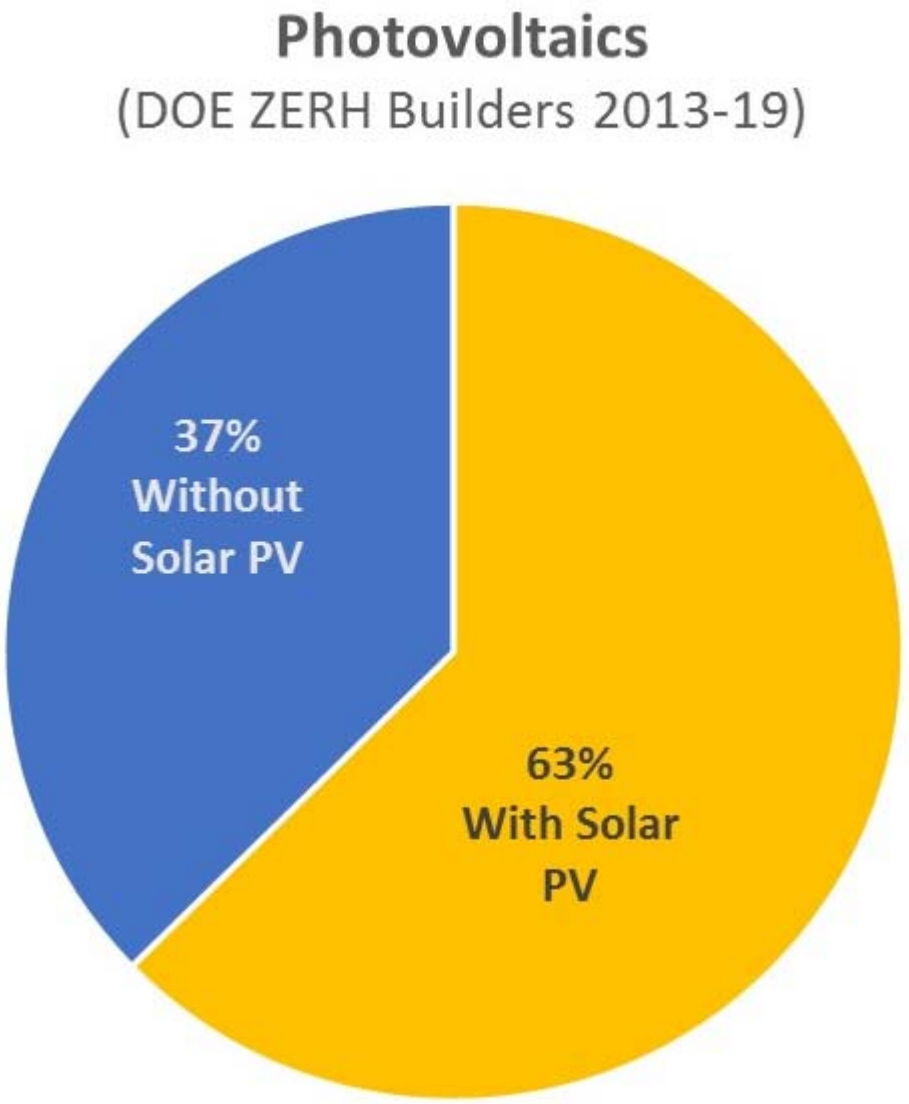
Photovoltaics



Clever Hacks – Solar

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Tip the hat to solar.

Solar Slope

Asymmetrical for more solar access. PV tray is water proof and vented.

Clever Hacks – Solar

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Solar shingles blend in with the roof tiles.

Asymmetrical garden shed houses solar panels.

PV Roofs

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PV ***IS*** the roof for this back porch and covered roof-top deck.

PV + Battery Storage

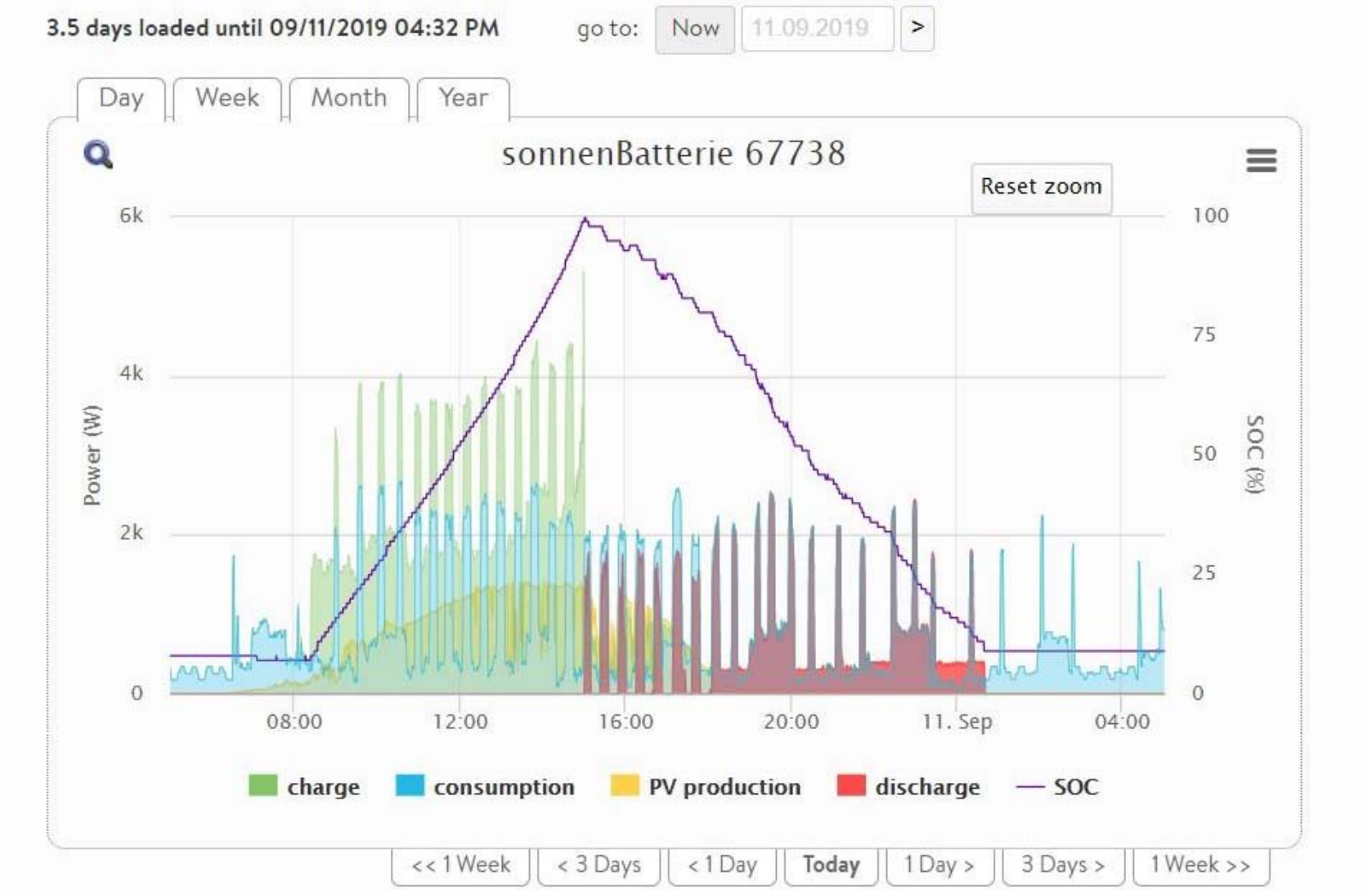
Battery storage =
more net zero with less PV

For example:

6.2-kW PV = Net Zero

3.6-kW PV = Net Zero
+ 10-kW battery

PV + Battery Storage



Clever Hacks –
Expect what you Inspect

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Good performance
= good materials +
good installation

Questions?

For more information contact

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office: 509-371-6047

Production Builders

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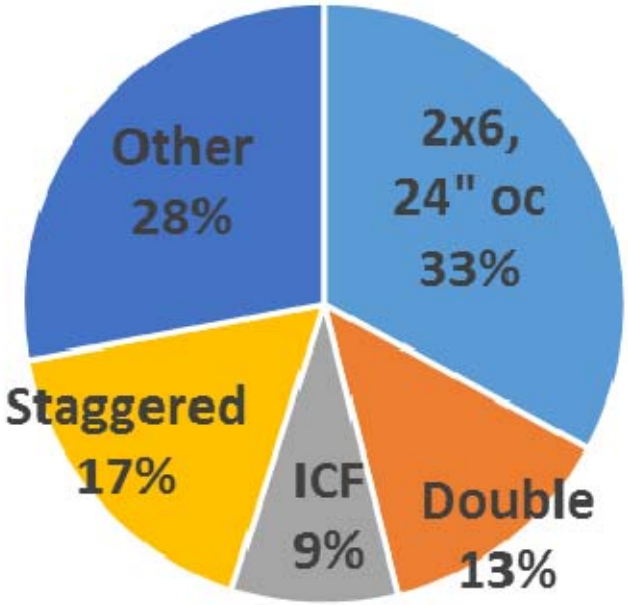
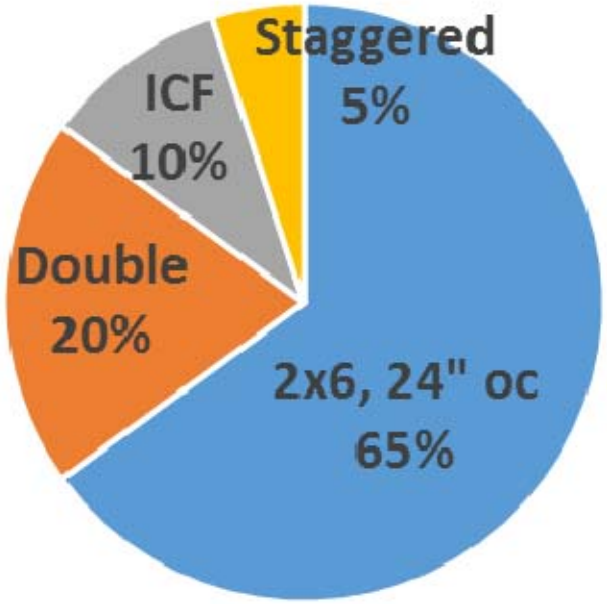
Wall Type Choices for all ZERH Builders



Production Builder Wall Type Choices



Insulation Reqs IECC

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Table **1**. Minimum Insulation Requirements for New Homes as Listed in the 2009, 2012, 2015, and 2018 IECC and 2009, 2012, 2015, and 2018 IRC.[a]

Climate Zone	Ceiling R-Value		Wood Frame Wall R-Value		Mass Wall R-Value[i*] (2009 IRC: k)		Floor R-Value		Basement[c] Wall R-Value		Slab[d] R-Value & Depth		Crawl Space[c] Wall R-Value	
	2009 IECC	2012 2015 2018 IECC	2009 IECC	2012 2015 2018 IECC	2009 IECC	2012 2015 2018 IECC	2009 IECC	2012 2015 2018 IECC	2009 IECC	2012 2015 2018 IECC	2009 IECC	2012 2015 2018 IECC	2009 IECC	2012 2015 2018 IECC
1	30	30	13	13	3/4	3/4	13	13	0	0	0	0	0	0
2	30	38	13	13	4/6	4/6	13	13	0	0	0	0	0	0
3	30	38	13	20 or 13+5[h]	5/8	8/13	19	19	5/13[f]	5/13[f]	0	0	5/13	5/13
4 except Marine	38	49	13	20 or 13+5[h]	5/10	8/13	19	19	10/13	10/13	10, 2 ft	10, 2 ft	10/13	10/13
5 and Marine 4	38	49	20 or 13+5[h]	20 or 13+5[h]	13/17	13/17	30[g]	30[g]	10/13	15/19	10, 2 ft	10, 2 ft	10/13	15/19
6	49	49	20 or 13+5[h]	20+5[h] or 13+10[h]	15/19	15/20	30[g]	30[g]	15/19* IRC: 10/13	15/19	10, 4 ft	10, 4 ft	10/13	15/19
7 and 8	49	49	21	20+5[h] or 13+10[h]	19/21	19/21	38[g]* IRC: 30[g]	38[g]	15/19* IRC: 10/13	15/19	10, 4 ft	10, 4 ft	10/13	15/19

For SI: 1 foot = 304.8 mm

Insulation Reqs IECC

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IECC code table footnotes

For SI: 1 foot = 304.8 mm.

*The IRC code requirement differs from the IECC code requirement, as noted.

a. Table adapted from Table R402.1.1 in the 2009 and 2012 IECC and Table R402.1.2 in the 2015 and 2018 IECC (Table N1102.1 in 2009 IRC, Table 1102.1.1 in 2012 IRC, and Table N1102.1.2 in 2015 and 2018 IRC).
2012, 2015, and 2018 IECC: R-values are minimums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed R-value of the insulation shall not be less than the R-value specified in the table.
2009 IECC: R-values are minimums. R-19 batts compressed into a nominal 2x6 framing cavity such that the R-value is reduced by R-1 or more shall be marked with the compressed batt R-value in addition to the full thickness R-value.

b. Refers to fenestration requirements not shown on this excerpted table.

c. 2009-2018 IECC: "10/13" means R-10 continuous insulation (called "insulated sheathing" in 2009 IECC) on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall. "15/19" means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. Alternatively, compliance with "15/19" shall be R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home.
2009 IRC Only: The first R-value applies to continuous insulation, the second to framing cavity insulation; either insulation meets the requirement.

d. 2018 IECC: R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation R-value for slabs, as indicated in the table. The slab edge insulation for heated slabs shall not be required to extend below the slab.
2009, 2012, and 2015 IECC: R-5 shall be added to the required slab edge R-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Climate Zones 1 through 3 for heated slabs.

e. Refers to fenestration requirements not shown on this excerpted table.

f. 2009-2018 IECC: Basement wall insulation is not required in warm-humid locations as defined by Figure R301.1 and Table R301.1 (Figure/Table N1101.2 in 2009 IRC and Figure/Table N1101.10 in 2012, 2015, and 2018 IRC).

g. 2009-2018 IECC: Alternatively, insulation sufficient to fill the framing cavity and providing not less than an R-value of R-19.

h. 2015 and 2018 IECC: The first value is cavity insulation, the second value is continuous insulation. Therefore, as an example, "13+5" means R-13 cavity insulation plus R-5 continuous insulation.
2012 IECC: First value is cavity insulation, second value is continuous insulation or insulated siding, so "13+5" means R-13 cavity insulation plus R-5 continuous insulation or insulated siding. If structural sheathing covers 40 percent or less of the exterior, continuous insulation R-value shall be permitted to be reduced by no more than R-3 in the locations where structural sheathing is used – to maintain a consistent total sheathing thickness.
2009 IECC: "13+5" means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25 percent or less of the exterior, insulating sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25 percent of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.

i. 2018 IECC: Mass walls shall be in accordance with Section R402.2.5 (N1102.2.5 in 2018 IRC). The second R-value applies where more than half of the insulation is on the interior of the mass wall.
2009, 2012, and 2015 IECC: The second R-value applies where more than half of the insulation is on the interior of the mass wall.
(In the 2009 IRC, footnote "k" addresses mass wall insulation while footnote "i" and "j" address fenestration.)

j. 2009 IECC Only: Refers to fenestration requirements not shown on this excerpted table.