BetterBuilt[NW]

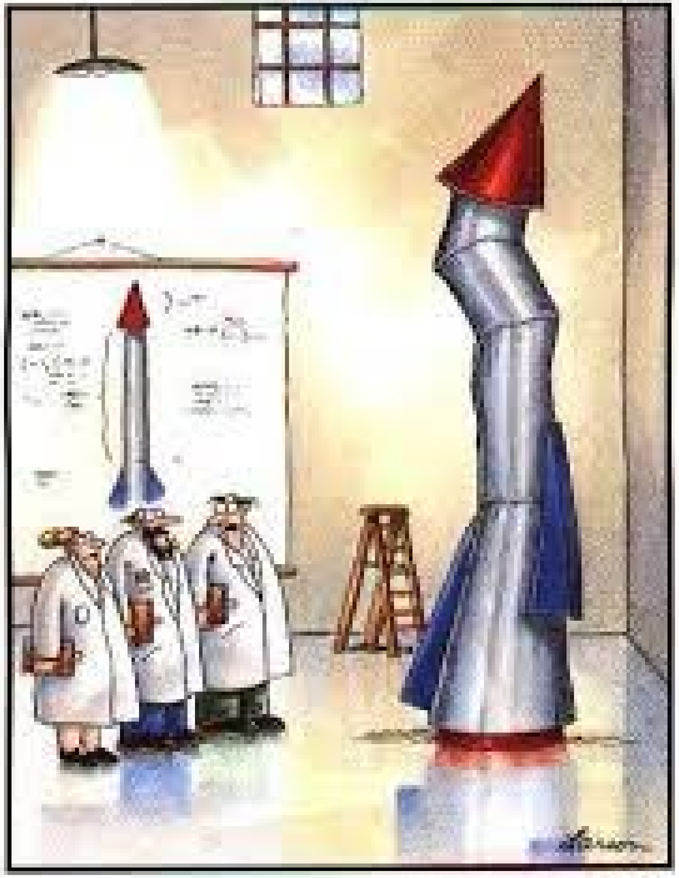
Energy & Environmental Building Alliance

Net-Zero ENERGY COALITION

Options for Advanced Walls

2021 EEBA and NZEC Webinar Series

Short intro



"It's time we face reality, my friends. ... We're not exactly rocket scientists."

BBNW

- **Resources**
  - Case Studies and Research
  - Tools
  - News and Events
  - Training Opportunities and Resources
- **Program information**
  - Voluntary Home Certification Programs
  - New Construction Utility Programs
  - BPA Multi-family, New Construction
- **Features**
  - Find a Professional
  - Find a Utility

Advanced Walls?

Average R/U Values

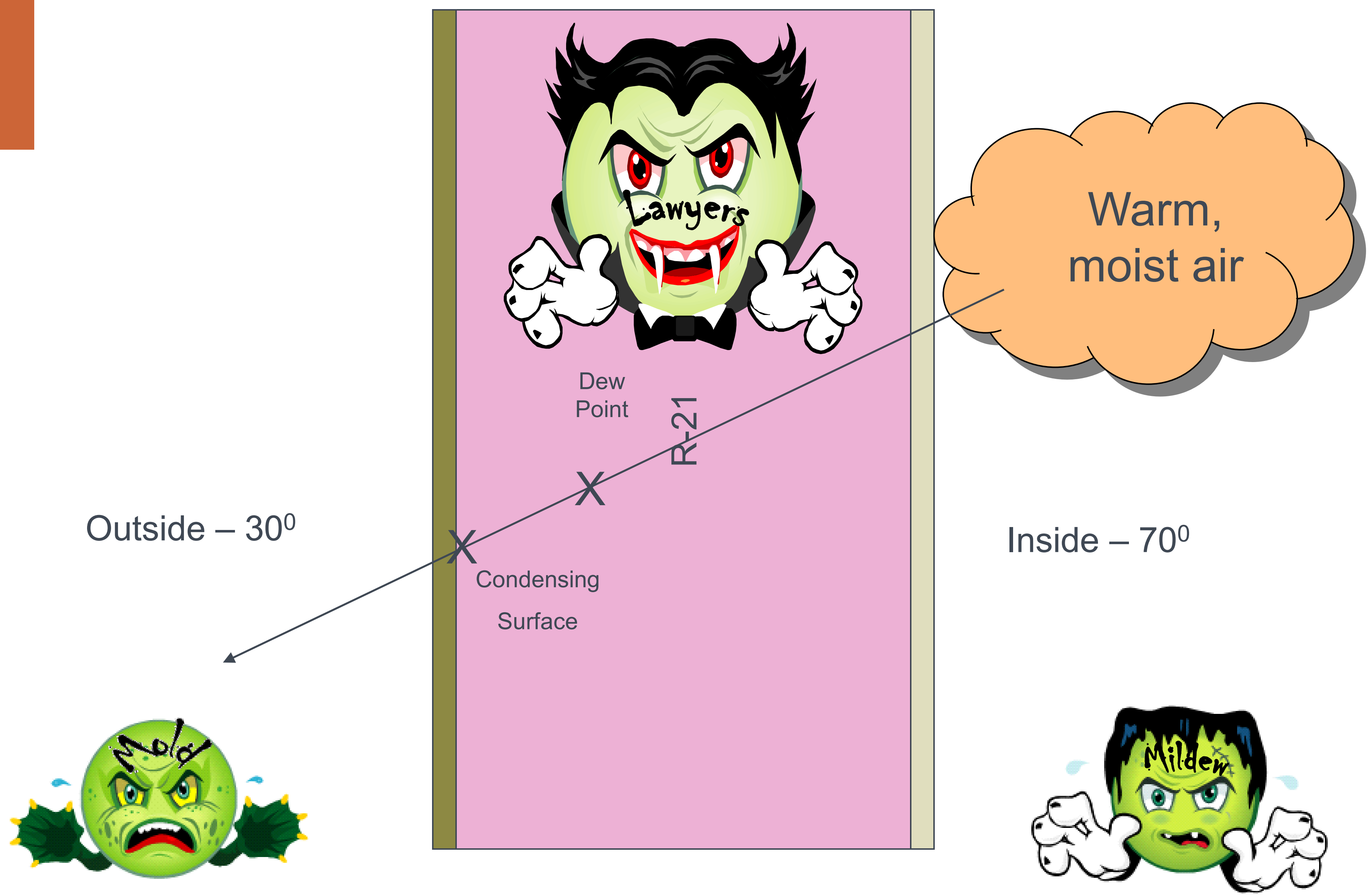
Prescriptive in code

"Additional Measures"

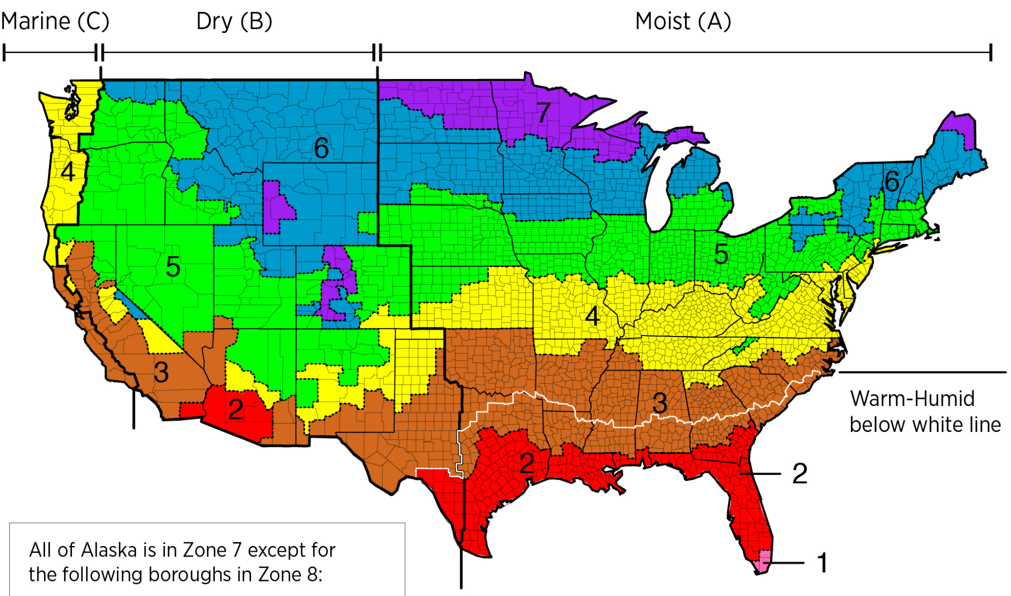
Thermal Bridging

Framing fractions

WuFi analysis


Lawyers
Warm, moist air
Dew Point
R-21
Condensing Surface
Outside – 30^0
Inside – 70^0
Mold
Mildew

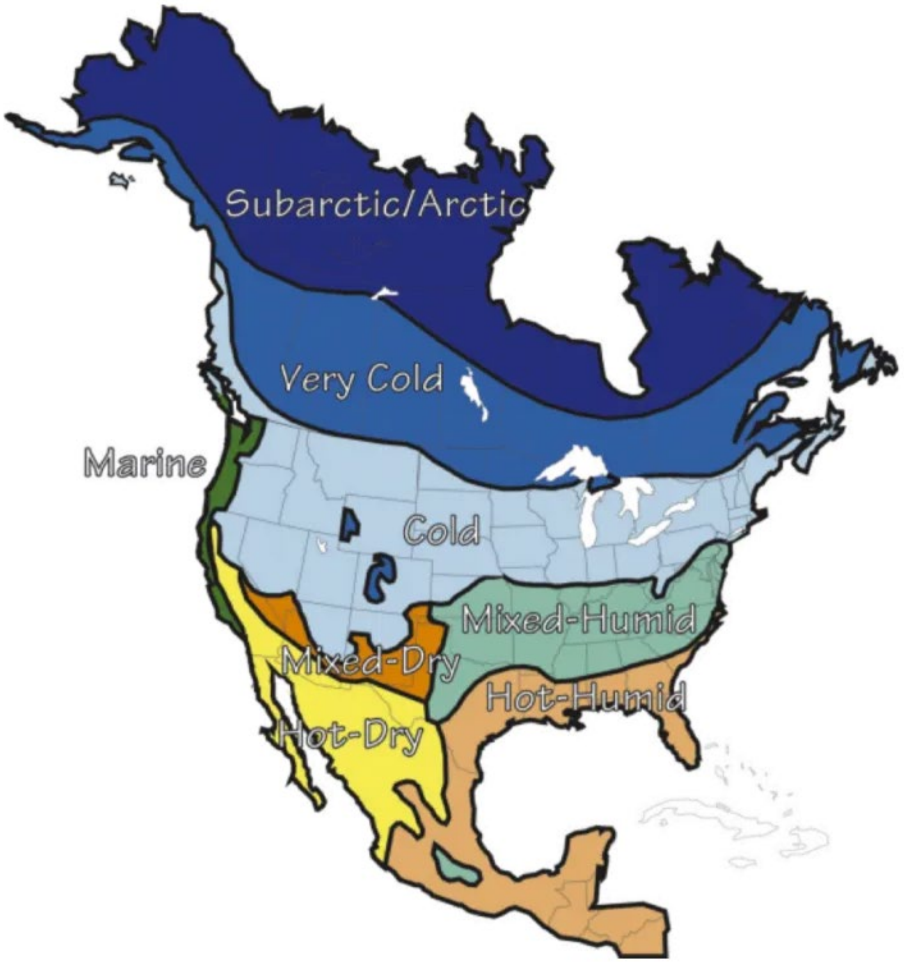
Climate Zones



All of Alaska is in Zone 7 except for the following boroughs in Zone 8:

Bethel, Northwest Arctic, Dellingham, Southeast Fairbanks, Fairbanks N. Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands



Building Science Corporation's map of hygrothermal regions. All of North America is divided into climate zones based on the two parameters of temperature and moisture.
Image Credit: Building Science Corporation

Choices – 2018 IECC

TABLE R402.1.2 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[i]	FLOOR *R*-VALUE	BASEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.32	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	20 or 13+5[h]	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20+5[h] or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20+5[h] or 13+10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

TABLE R402.1.4 EQUIVALENT *U*-FACTORS[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
1	0.50	0.75	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.084	0.165	0.064	0.360	0.477
3	0.32	0.55	0.030	0.060	0.098	0.047	0.091[c]	0.136
4 except Marine	0.32	0.55	0.026	0.060	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	0.026	0.060	0.082	0.033	0.050	0.055
6	0.30	0.55	0.026	0.045	0.060	0.033	0.050	0.055
7 and 8	0.30	0.55	0.026	0.045	0.057	0.028	0.050	0.055

A better view…

CLIMATE ZONE	WOOD FRAME WALL *R*-VALUE	FRAME WALL *U*-FACTOR
1	13	0.084
2	13	0.084
3	20 or 13+5[h]	0.060
4 except Marine	20 or 13+5[h]	0.060
5 and Marine 4	20 or 13+5[h]	0.060
6	20+5[h] or 13+10[h]	0.045
7 and 8	20+5[h] or 13+10[h]	0.045

2021 IECC Changes

CLIMATE ZONE	WOOD FRAME WALL *R*-VALUE[g]	WOOD FRAME WALL *U*-FACTOR
0	13 or 0 + 10	0.084
1	13 or 0 + 10	0.084
2	13 or 0 + 10	0.084
3	20 or 13 + 5ci or 0 + 15	0.060
4 except Marine	20+5 or 13 + 10ci or 0 + 15	0.045
5 and Marine 4	20+5 or 13 + 10ci or 0 + 15	0.045
6	20 + 5ci or 13 + 10ci or 0 + 20	0.045
7 and 8	20 + 5ci or 13 + 10ci or 0 + 20	0.045

2021 IECC Addl Eff Packages

SECTION R408
ADDITIONAL EFFICIENCY PACKAGE OPTIONS

R408.1 Scope.
This section establishes additional efficiency package options to achieve additional energy efficiency in accordance with Section R401.2.1.

R408.2 Additional efficiency package options.
Additional efficiency package options for compliance with Section R401.2.1 are set forth in Sections R408.2.1 through R408.2.5.

R408.2.1 Enhanced envelope performance option.
The total *building thermal envelope* UA, the sum of *U*-factor times assembly area, shall be less than or equal to 95 percent of the total UA resulting from multiplying the *U*-factors in Table R402.1.2 by the same assembly area as in the proposed building. The UA calculation shall be performed in accordance with Section R402.1.5. The area-weighted average SHGC of all glazed fenestration shall be less than or equal to 95 percent of the maximum glazed fenestration SHGC in Table R402.1.2.

R408.2.2 More efficient HVAC equipment performance option.
Heating and cooling *equipment* shall meet one of the following efficiencies:

1. Greater than or equal to 95 AFUE natural gas furnace and 16 SEER air conditioner.
2. Greater than or equal to 10 HSPF/16 SEER air source heat pump.
3. Greater than or equal to 3.5 COP ground source heat pump.

For multiple cooling systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the cooling design load. For multiple heating systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the heating design load.

R408.2.3 Reduced energy use in service water-heating option.
The hot water system shall meet one of the following efficiencies:

1. Greater than or equal to 82 EF fossil fuel service water-heating system.
2. Greater than or equal to 2.0 EF electric service water-heating system.
3. Greater than or equal to 0.4 solar fraction solar water-heating system.

R408.2.4 More efficient duct thermal distribution system option.
The thermal distribution system shall meet one of the following efficiencies:

1. 100 percent of ducts and air handlers located entirely within the *building thermal envelope*.
2. 100 percent of ductless thermal distribution system or hydronic thermal distribution system located completely inside the *building thermal envelope*.
3. 100 percent of duct thermal distribution system located in *conditioned space* as defined by Section R403.3.2.

R408.2.5 Improved air sealing and efficient ventilation system option.
The measured air leakage rate shall be less than or equal to 3.0 ACH50, with either an Energy Recovery Ventilator (ERV) or Heat Recovery Ventilator (HRV) installed. Minimum HRV and ERV requirements, measured at the lowest tested net supply airflow, shall be greater than or equal to 75 percent Sensible Recovery Efficiency (SRE), less than or equal to 1.1 cubic feet per minute per watt (0.03 m^3/min/watt) and shall not use recirculation as a defrost strategy. In addition, the ERV shall be greater than or equal to 50 percent Latent Recovery/Moisture Transfer (LRMT).

Addl Eff Packages

R408.2.1 Enhanced envelope performance

R408.2.2 More efficient HVAC equipment performance

R408.2.3 Reduced energy use in service water-heating

R408.2.4 More efficient duct thermal distribution system

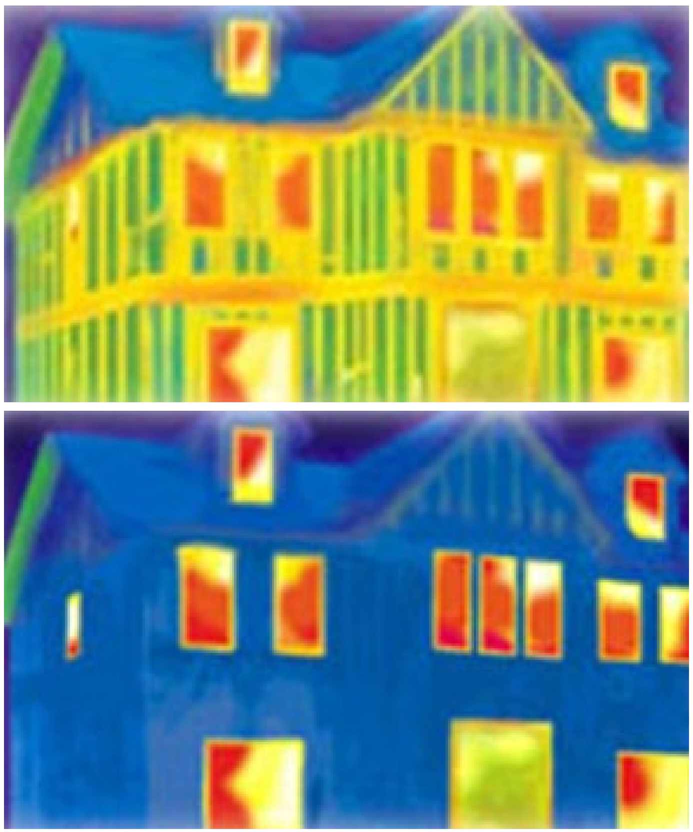
R408.2.5 Improved air sealing and efficient ventilation system

The **total building thermal envelope UA**, sum of U-factor x assembly area, **shall be less than 95% of the total UA** resulting from multiplying prescriptive U-factors by the same assembly area.

Advanced Walls

Framing and wall designs

Primary framing and insulation considerations



Advanced framing	**Staggered studs**	**Continuous insulation**	**Grade 1 cavities**

Advanced wall digest

Three major wall types:

1. Thermal break shear wall (Ex. P&B, Zip Walls)

2. Intermediate framing with exterior rigid insulation

3. 2x4 double stud walls (and staggered stud)

2018 and 2021 Prescriptive

Three major wall types:

1. **Thermal break shear wall (Ex. P&B)**

2. **Intermediate framing with exterior rigid insulation**

3. 2x4 double stud walls (and staggered stud)

2021 Additional Measure

Three major wall types:

1. Thermal break shear wall (Ex. P&B)

2. Intermediate framing with exterior rigid insulation

3. **2x4 double stud walls**

Advanced Walls Research

NEEA Phase 1 Report

NEEA Phase 2 Report

DOE Extended Plate and Beam report

Thermal break shear wall

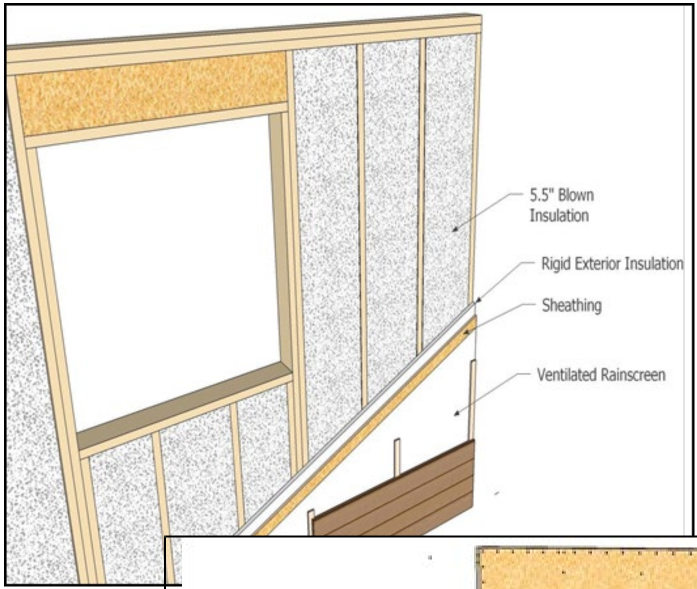
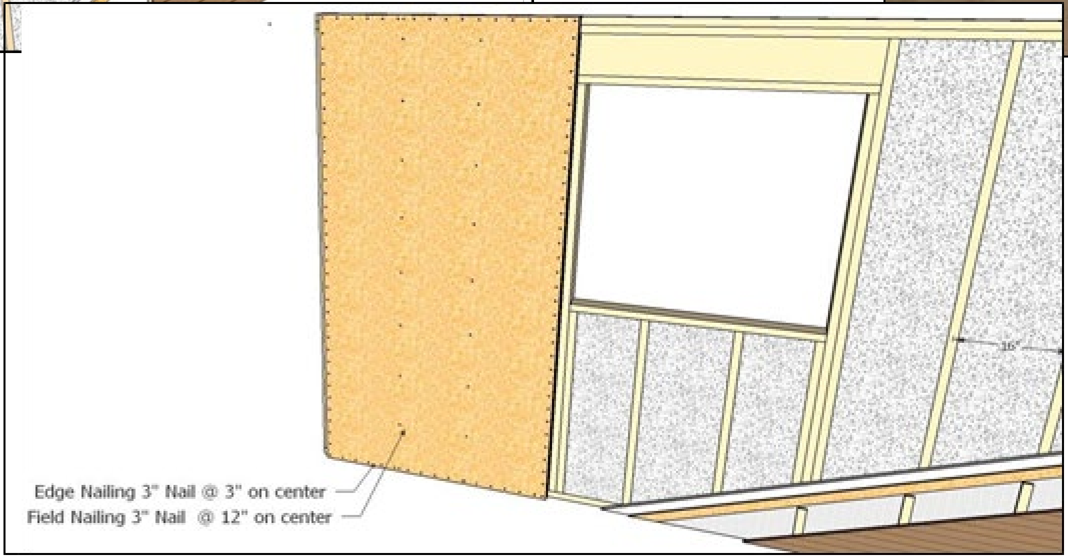
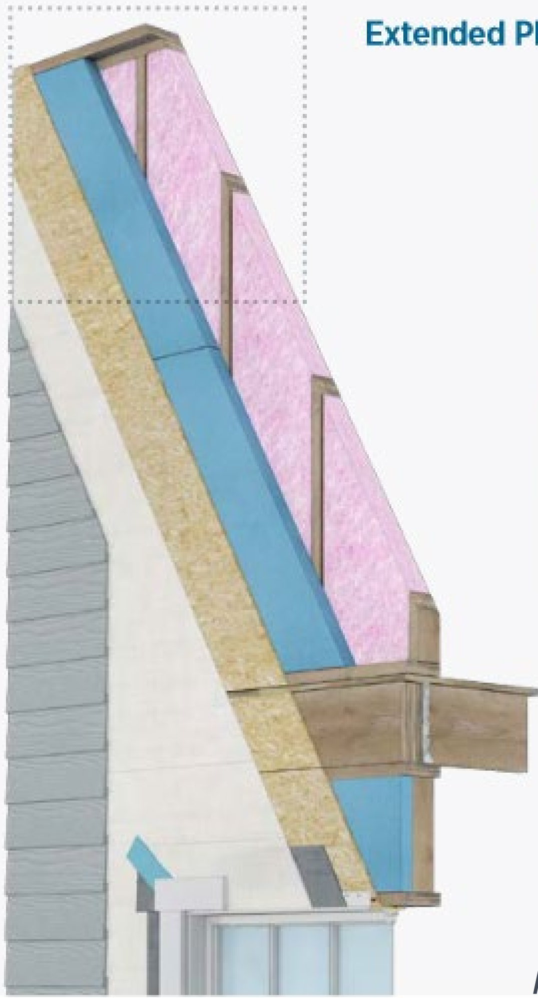


Photo from Green One Construction



Extended plate and beam variation

Extended Plate and Beam



- Plates and studs are different width
- R25 (2 × 4 studs and 2 × 6 plates)
- R30 (2 × 6 studs and 2 × 8 plates)

EP&B WALL SYSTEM

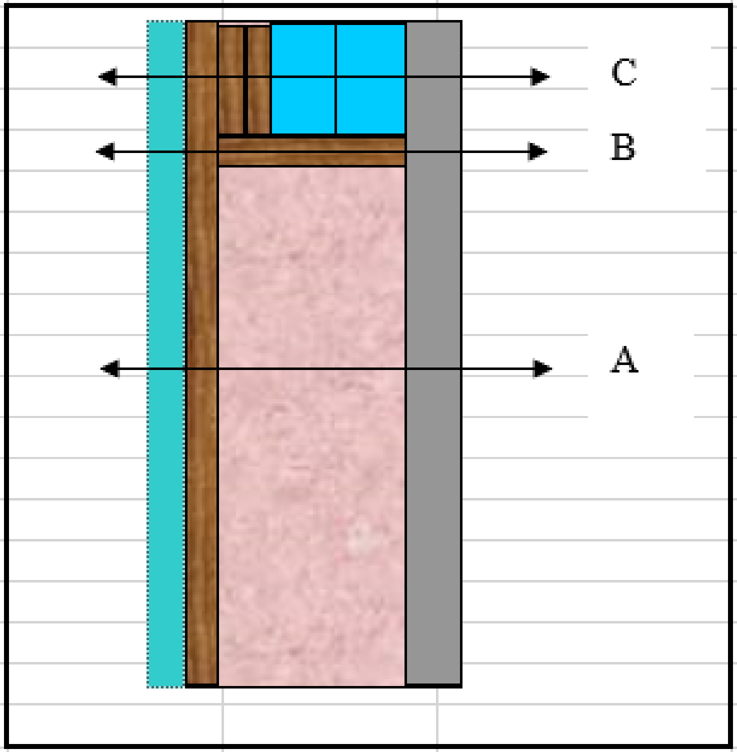
Sheathing over foam wall assembly

Typical wall section installation

Photos courtesy of US DOE and Home Innovation Research Labs

Performance

	Intermediate		
	A	B	C
	Cavity	Framing	Header
Inside Air Film	0.68	0.68	0.68
1/2" GWB	0.45	0.45	0.45
Framing	0	5.5	0
Cavity Ins	21.3	0	0
Double 2x header	0	0	4.375
Insulated Header	0	0	10
Air Space	0	0	0
1/2" plywood sheathing	0.62	0.62	0.62
Ext. Finish (Lap)	1.43	1.43	1.43
Continuous Insulation	4.2	4.2	4.2
Outside Air Film	0.17	0.17	0.17
R Path	28.85	13.05	21.925
U Path	0.035	0.077	0.046
Weighting Factor	0.78	0.18	0.04
U * Weight	0.027	0.014	0.002
Overall u-factor	**0.043**		
Effective R-Value	23.4		



Code challenges

Plywood-over-Foam "Martha Wall" at City Cabins® Homes

Case Study: Published April 17, 2018 | Updated: | | Seattle, Shoreline, Washington | 2770604980

Seattle, WA, USA

Category	category_listing(s)	
Building Type	Residential	
Innovation	Thermal Break Shear Wall	
Jurisdiction	Seattle, Shoreline, Washington	
Parcel	2770604980	
Officials		
Team	Martha Rose | developer .OB Anderson Architects | Designer Matt Schmitter | Designer	
Ratings & Awards		5-Star Built Green Certification 14 local and national awards from 2005 to 2015 2014 NAHB Green Advocate of the Year 2015 King County Green Globe Award for Leader in Sustainability

▾ ABSTRACT

To improve thermal performance of her townhome development "City Cabins" while keeping material and labor costs to a minimum, builder Martha Rose devised a "plywood-over-foam" wall assembly designed to provide greater insulation, air sealing and thermal break. With her engineer's stamp, City of Seattle and Shoreline have accepted her innovative design numerous times through prescriptive code compliance.

▾ PERMITTING & COMPLIANCE

Martha designed her wall to be cost effective and feasible while creating superior energy efficiency. Since framing is usually the most expensive part of the project, Martha decided to take a page from the Seattle framers' playbook and keep it simple. When she was a City of Seattle building inspector in the 1980s she noticed they were framing four story apartment buildings with a sheet of drywall placed over the studs and under the exterior plywood sheathing. At the time this was required to deliver one-hour fire rated exterior walls. Since it was only a slight variation of the familiar fire-rated wall, why not substitute foam for drywall and carry on as usual?

This subtle shift required no new training for the framers and was familiar to the code officials who approved it prescriptively under both 2006 and 2009 Seattle Building Code, Chapter 14 Exterior Walls. The foam weighs almost nothing, so Martha's structural engineer had no problem with signing off on ½" of foam under the plywood. A longer nail would be necessary, but there were no structural changes to shear walls. In 2008 they increased to 1" foam board further improving the insulative effect.

Search ... Search

Building Categories

- All

Building Envelope
Energy
Fires Safety
Heating
Land Use & Development
Materials
Plumbing Systems
Site & Stormwater
Structure

This Project:

Innovation

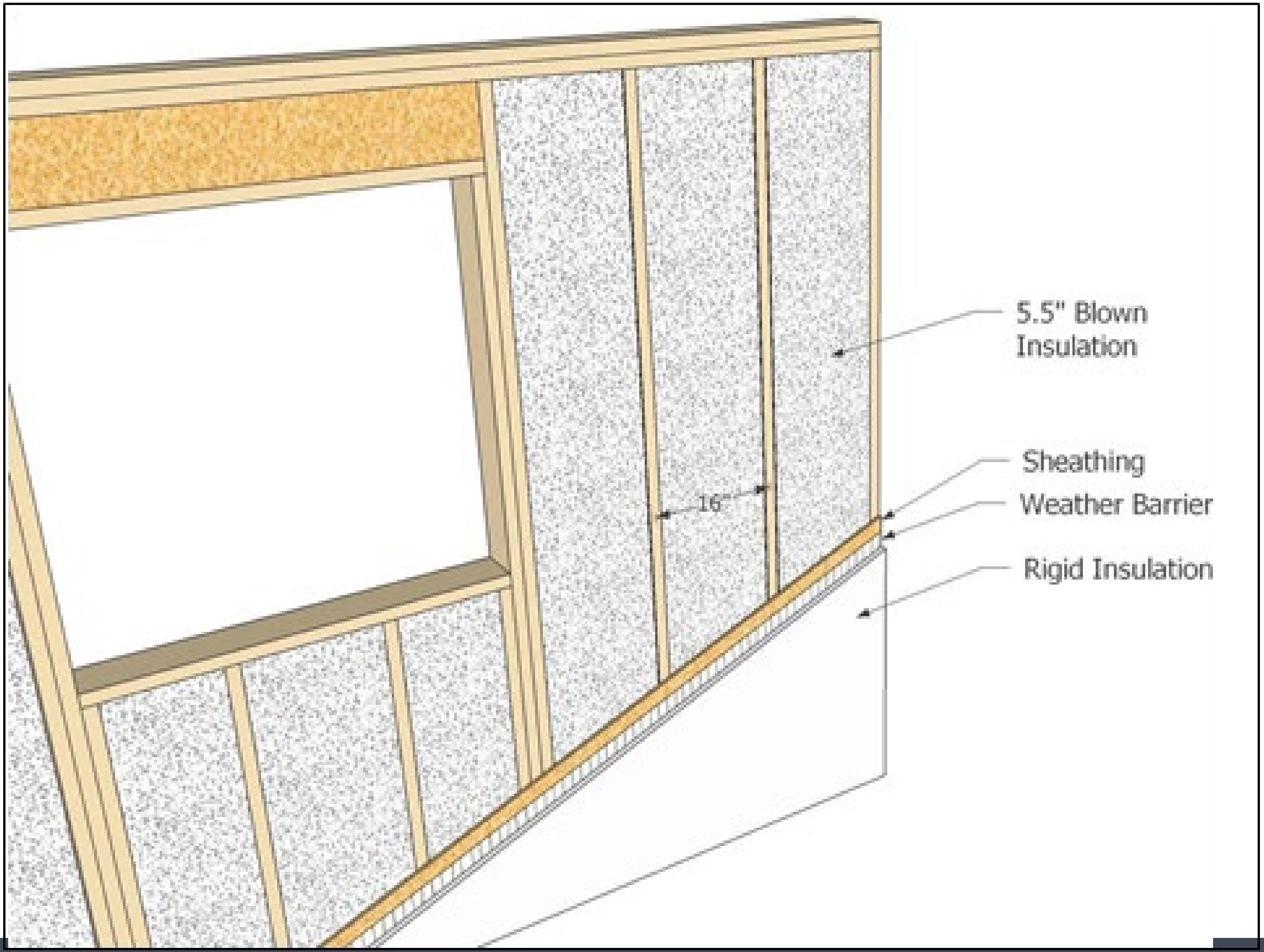
- Thermal Break Shear Wall

Building Type

- Residential

http://www.buildinginnovations.org/case-studies/case-studies-building-envelope/

Intermediate framing with exterior rigid insulation

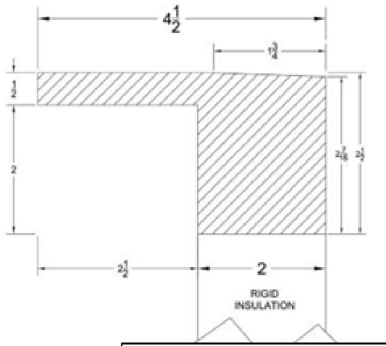


Intermediate framing with exterior rigid insulation

Photo courtesy of Design Build Portland

Photo courtesy of Design Build Portland

Intermediate framing with exterior rigid insulation



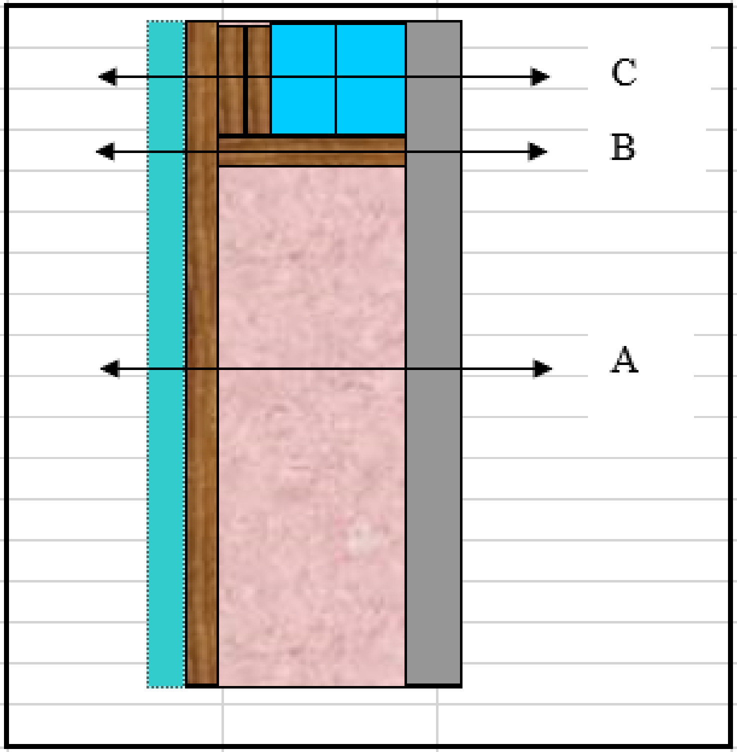
Images from thermalbuck.com

Photo from buildingscience.com

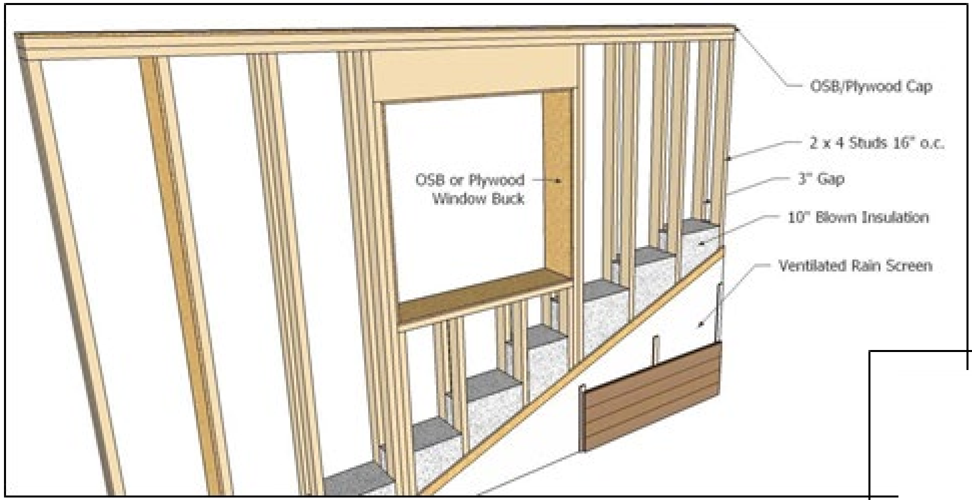
Photo from Small Planet Supply

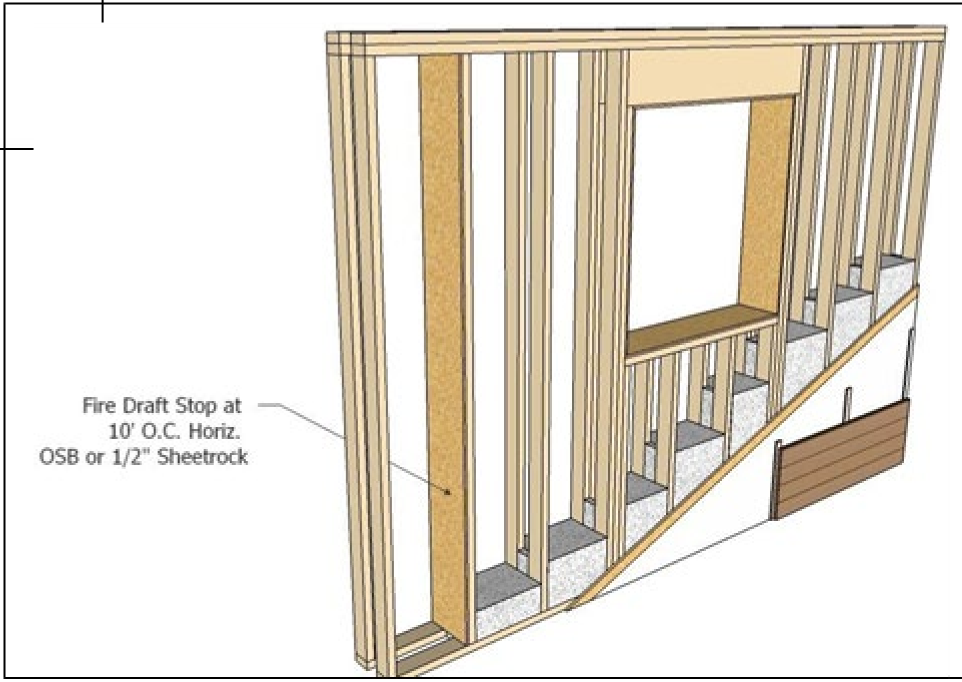
Performance

	Intermediate		
	A	B	C
	Cavity	Framing	Header
Inside Air Film	0.68	0.68	0.68
1/2" GWB	0.45	0.45	0.45
Framing	0	5.5	0
Cavity Ins	21.3	0	0
Double 2x header	0	0	4.375
Insulated Header	0	0	10
Air Space	0	0	0
1/2" plywood sheathing	0.62	0.62	0.62
Ext. Finish (Lap)	1.43	1.43	1.43
Continuous Insulation	4.2	4.2	4.2
Outside Air Film	0.17	0.17	0.17
R Path	28.85	13.05	21.925
U Path	0.035	0.077	0.046
Weighting Factor	0.78	0.18	0.04
U * Weight	0.027	0.014	0.002
Overall u-factor	**0.043**		
Effective R-Value	23.4		

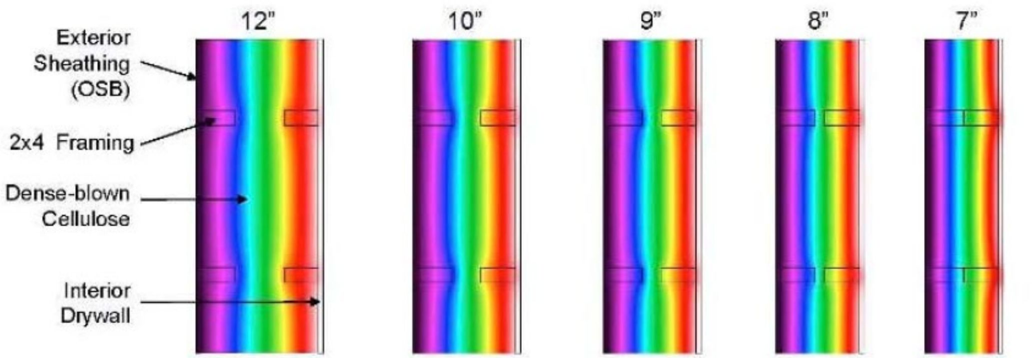


2x4 double stud wall

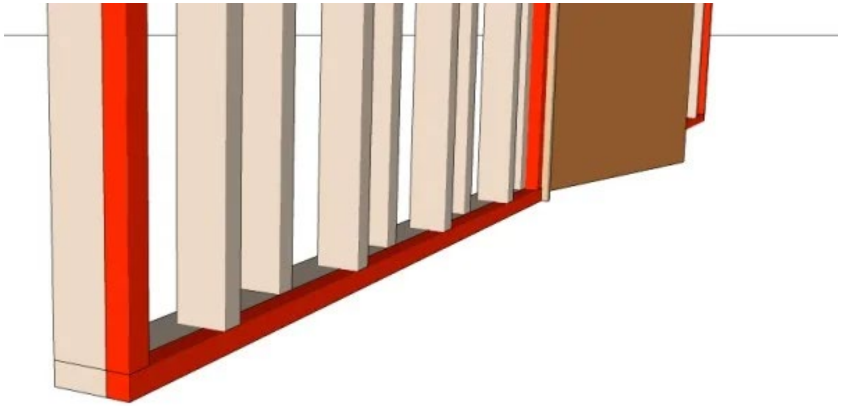




Double Stud Wall

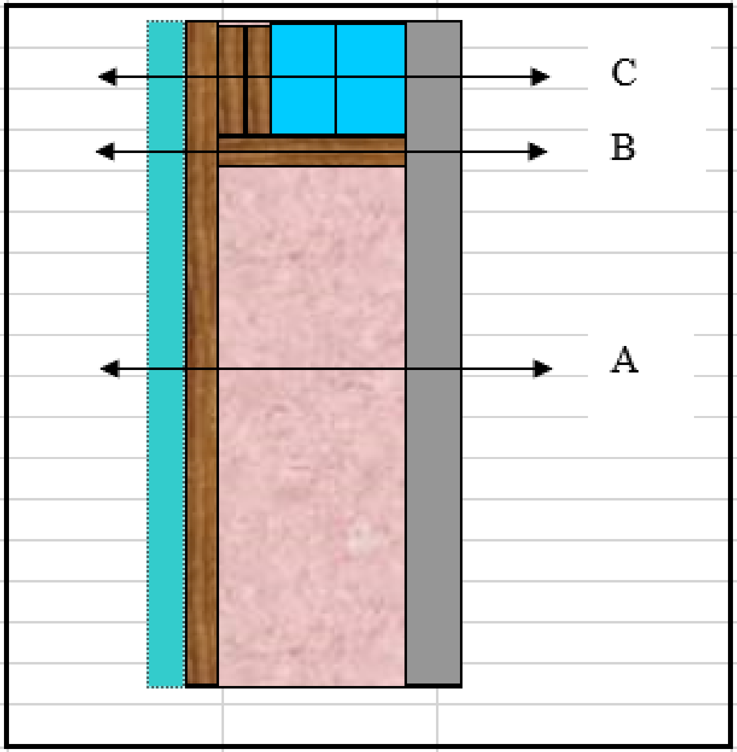


Staggered stud wall



Performance

	Double Wall		
	A	B	C
	Cavity	Framing	Header
Inside Air Film	0.68	0.68	0.68
1/2" GWB	0.45	0.45	0.45
Framing	0	6.68	0
Cavity Ins	25	0	0
Double 2x header	0	0	8
Insulated Header	0	0	8
Air Space	0	0	0
1/2" plywood sheathing	0.62	0.62	0.62
Ext. Finish (Lap)	1.43	1.43	1.43
Continuous Insulation	4	4	4
Outside Air Film	0.17	0.17	0.17
R Path	32.35	14.03	23.35
U Path	0.031	0.071	0.043
Weighting Factor	0.78	0.018	0.04
U * Weight	0.024	0.001	0.002
Overall u-factor	**0.027**		
Effective R-Value	36.9		



Performance

	Double Wall		
	A	B	C
	Cavity	Framing	Header
Inside Air Film	0.68	0.68	0.68
1/2" GWB	0.45	0.45	0.45
Framing	0	6.68	0
Cavity Ins	25	0	0
Double 2x header	0	0	8
Insulated Header	0	0	8
Air Space	0	0	0
1/2" plywood sheathing	0.62	0.62	0.62
Ext. Finish (Lap)	1.43	1.43	1.43
Continuous Insulation	4	4	4
Outside Air Film	0.17	0.17	0.17
R Path	32.35	14.03	23.35
U Path	0.031	0.071	0.043
Weighting Factor	0.78	0.018	0.04
U * Weight	0.024	0.001	0.002
Overall u-factor	**0.027**		
Effective R-Value	36.9		

	Intermediate		
	A	B	C
	Cavity	Framing	Header
Inside Air Film	0.68	0.68	0.68
1/2" GWB	0.45	0.45	0.45
Framing	0	5.5	0
Cavity Ins	23	0	0
Double 2x header	0	0	4.375
Insulated Header	0	0	10
Air Space	0	0	0
1/2" plywood sheathing	0.62	0.62	0.62
Ext. Finish (Lap)	1.43	1.43	1.43
Continuous Insulation	12	12	12
Outside Air Film	0.17	0.17	0.17
R Path	38.35	20.85	29.725
U Path	0.026	0.048	0.034
Weighting Factor	0.78	0.18	0.04
U * Weight	0.020	0.009	0.001
Overall u-factor	**0.030**		
Effective R-Value	33.0		

Performance

Table 5. Summary of Wall Benefits

Wall Type	Ease of Assembly	Aesthetic Benefits (deeper sills)	Less Thermal Bridging	Seismic Resiliency	Noise Attenuation	Moisture Manage-Ment	Estimated Incremental Cost at scale
Thermal Break Shear (TBS) Wall	F		D	D	D	D	$.48/sq ft
Continuous Rigid Insulation (CI)	F		D		D	D	$1.03/sq ft
Double Stud Wall (DSW)	F	F	D		D	D	$.79/sq ft

D = Documented through research
F = Field evidence

Performance

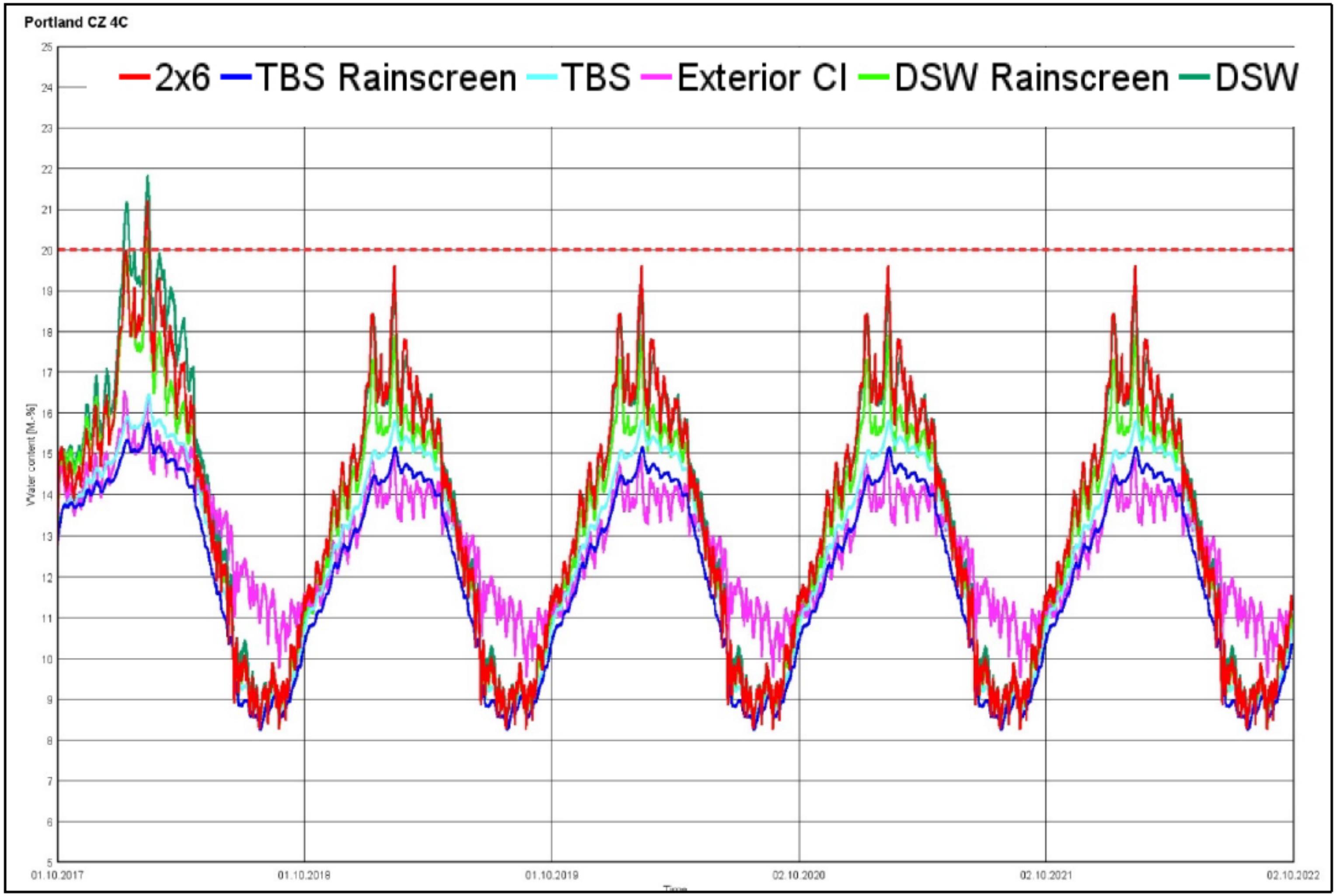


Figure 1. WUFI Results for Portland, OR in Climate Zone 4C

Performance

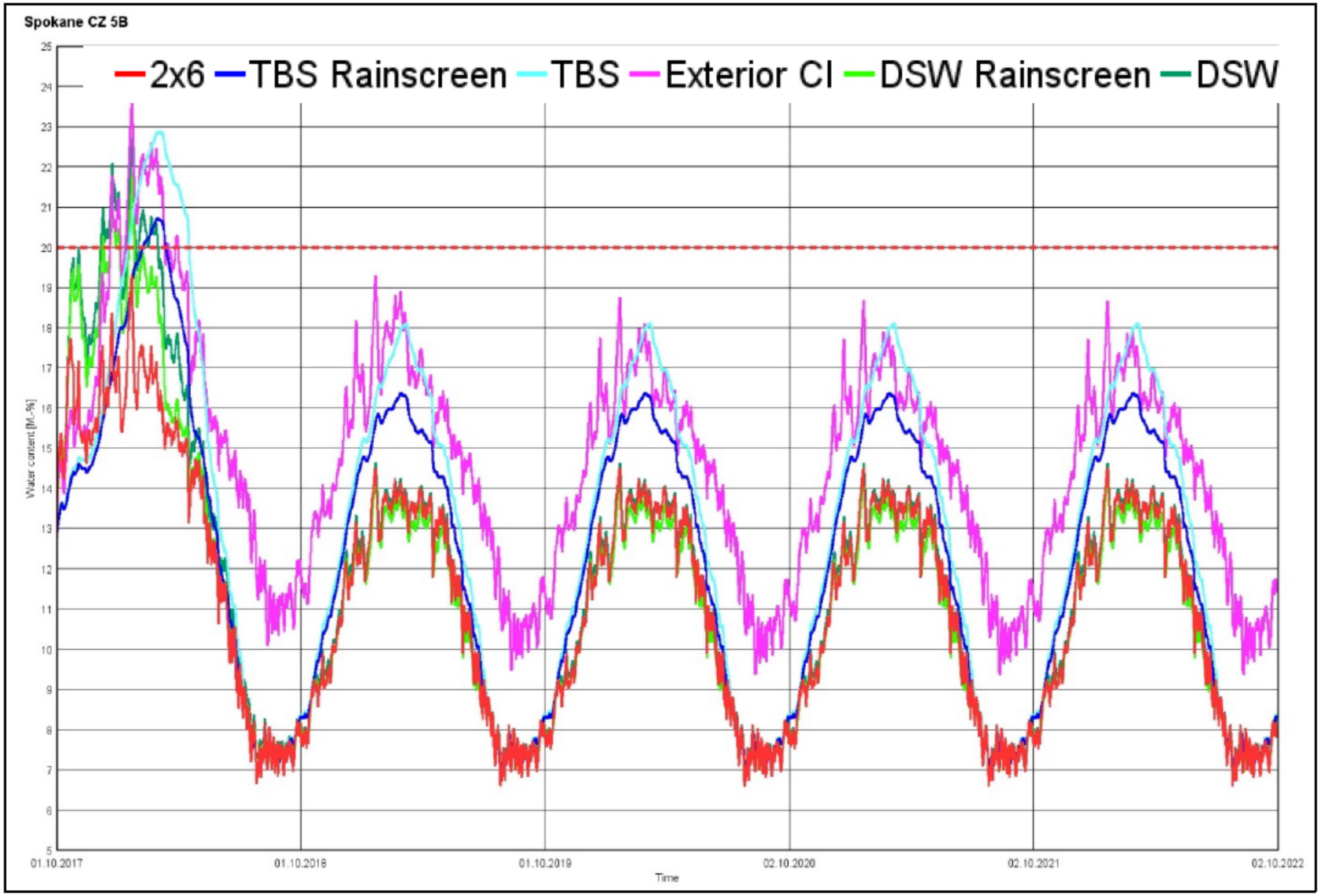


Figure 3. WUFI Results for Spokane, WA in Climate Zone 5B

Windows Matter

ENERGY.GOV

Office of Energy Efficiency & Renewable Energy

DOE Zero Energy Ready Home

November 2014
A note from Sam Rashkin:
It's the Window, Stupid...

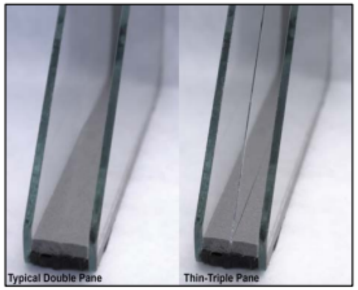
I have personally delivered over 25 zero energy ready home (ZERH) training classes across the country. Consistently, one of the biggest "ah-hah" moments in the four-hour course is the huge impact windows have on overall wall assembly performance. Even with just a 15% window-to-floor-area ratio, windows represent a giant thermal hole that disproportionately upsets all the good work you do on the insulated wall assemblies. Who knew? Below is a table I developed that compares the overall R-Value of the entire wall assembly with various cavity insulation levels. Assuming approximately an R-3 window (e.g., U-value = 0.30) representing 15% of the wall area, we can invest substantial cost to increase the wall cavity insulation from R-18 to R-39 with only a marginal increase in the overall wall assembly R-value (e.g., R-11 vs. R-15). In other words, we've more than doubled the wall insulation at substantial cost and only realized about a 33% improvement in overall wall assembly R-value due to the impact of much lower R-value windows. With these same assumptions, we can increase the R-18 insulated wall over 300% to R-60 and only get a 50% improvement in overall wall assembly R-value (e.g., R-11 vs. R-17). Now look at the power of high-R windows. We get nearly the same overall wall assembly R-value with an R-10 window (e.g., U-value = 0.10) and R-18 insulated wall as an R-3 window and R-60 insulated wall (e.g., R-16 vs. R-17). Yes, windows are a really big deal! There is a desperate need for reasonably priced, high-R windows.

Thin-Glass Triple-Pane Windows

Builder Opportunity

Thin-glass insulating glazing units (IGU) allow builders to deliver high-performance window solutions at incremental costs competitive with other building envelope solutions such as high-performance attics and walls; facilitating their use as an alternative compliance measure to meet energy codes.

The thin-triple design delivers triple-pane performance without the traditional weight or width disadvantages of the technology; keeping their installation costs low. Thin-triple IGUs are "drop-in" replacements for double-pane IGUs, enabling window suppliers and builders to continue utilizing the same window frames, but now with significantly better thermal performance.



Key Benefits

- R-5 (U-0.2) with Double Hung windows
- No significant weight increase over double pane
- Incremental cost comparable to equivalent wall or attic upgrades
- Uses existing window frame designs
- Retrofit existing windows is possible

The Technology Explained

The thin-glass triple-pane IGU allows for R-5 (U-0.20 BTU $hr^{-1}ft^{-2}{}^{\circ}F^{-1}$) or better double hung and R-6.5 (U-0.15) or better picture windows in place of today's R-3.7 ENERGY STAR products. The design uses a combination of thin-glass (0.7 - 1.6 mm) for the center layer, 2 low-e coatings and krypton gas fill. The thin glass keeps IGU weight and width to a minimum, enabling the use of existing frame profiles.

The thin-glass triple-pane concept is based on the novel use of components that have been available for years. This technology is a high-performance solution for the mass-market and is ready for industry adoption.

Digging Deeper

With support from the US Department of Energy, we are collaborating with leading supply chain partners, window manufacturers, and innovative builders to develop and deploy this technology at large scale. Our partners include **Alpen HPP**, **Andersen Corporation**, **Guardian IG**, **Pilkington NA**, **PlyGem**, and many more. Get involved or learn more here:
https://windows.lbl.gov/high-performance-windows

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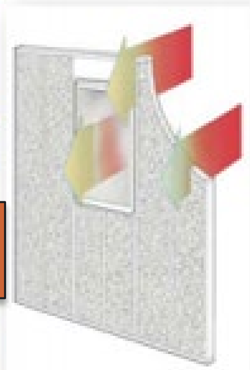
https://www.energy.gov/sites/prod/files/2014/11/f19/ZERH%20Update%20November%202014.pdf

Windows Matter

Window 15% of Wall Area	Wall R-Value with Windows w/Varied Wall Insulation Levels			
U-Value	R-0	R-18	R-39	R-60
0.30	R-5	R-11	R-15	R-17
0.20	R-5	R-13	R-19	R-23
0.15	R-5	R-14.5	R-23	[illegible]
0.10	R-5.5	R-16	R-27	R-34



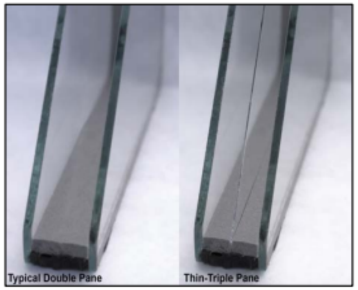
Sources:
"Holes in the Wall: To Improve the Energy Performance of Walls, Look at the Total R-Value," Journal of Light Construction, February 2014;
Multi-Assembly R-Value / U-Value Calculator – Cascadia Windows and Doors;
Michael Blasnik Presentation, 2014 ACI Conference

Thin-Glass Triple-Pane Windows

Builder Opportunity

Thin-glass insulating glazing units (IGU) allow builders to deliver high-performance window solutions at incremental costs competitive with other building envelope solutions such as high-performance attics and walls; facilitating their use as an alternative compliance measure to meet energy codes.

The thin-triple design delivers triple-pane performance without the traditional weight or width disadvantages of the technology; keeping their installation costs low. Thin-triple IGUs are "drop-in" replacements for double-pane IGUs, enabling window suppliers and builders to continue utilizing the same window frames, but now with significantly better thermal performance.



Key Benefits

- R-5 (U-0.2) with Double Hung windows
- No significant weight increase over double pane
- Incremental cost comparable to equivalent wall or attic upgrades
- Uses existing window frame designs
- Retrofit existing windows is possible

The Technology Explained

The thin-glass triple-pane IGU allows for R-5 (U-0.20 BTU $hr^{-1}ft^{-2}{}^{\circ}F^{-1}$) or better double hung and R-6.5 (U-0.15) or better picture windows in place of today's R-3.7 ENERGY STAR products. The design uses a combination of thin-glass (0.7 - 1.6 mm) for the center layer, 2 low-e coatings and krypton gas fill. The thin glass keeps IGU weight and width to a minimum, enabling the use of existing frame profiles.

The thin-glass triple-pane concept is based on the novel use of components that have been available for years. This technology is a high-performance solution for the mass-market and is ready for industry adoption.

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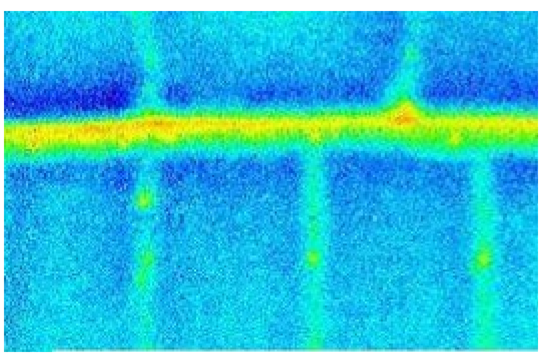
Framing and wall designs

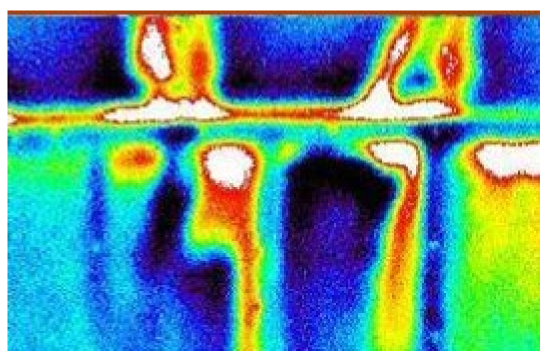
Good wall for climate zone 4

- Intermediate framing details (maximize your insulation space)
- Minimum levels of continuous insulation
- Grade I blown insulation
- Air seal with insulation
- Minimum R-21 energy heel

INFRA-RED BLOWN



INFRA-RED BATT



Framing and wall designs

Best wall for climate zone 4

- Staggered stud framing with blown insulation
- Tight construction
- Energy/raised heel trusses
- Moisture control in the building
- Panelized construction

Framing and wall designs

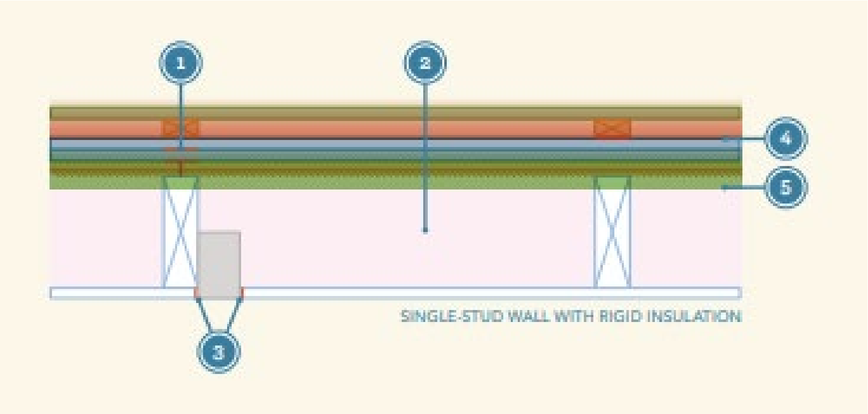
Good Wall for climate zones 5 and up

- Double wall or Staggered studs
- Rigid foam, rockwool or insulated siding as a potential add
- Radiant barriers when cooling loads exceed heating loads
- Medium density wall cavity fill

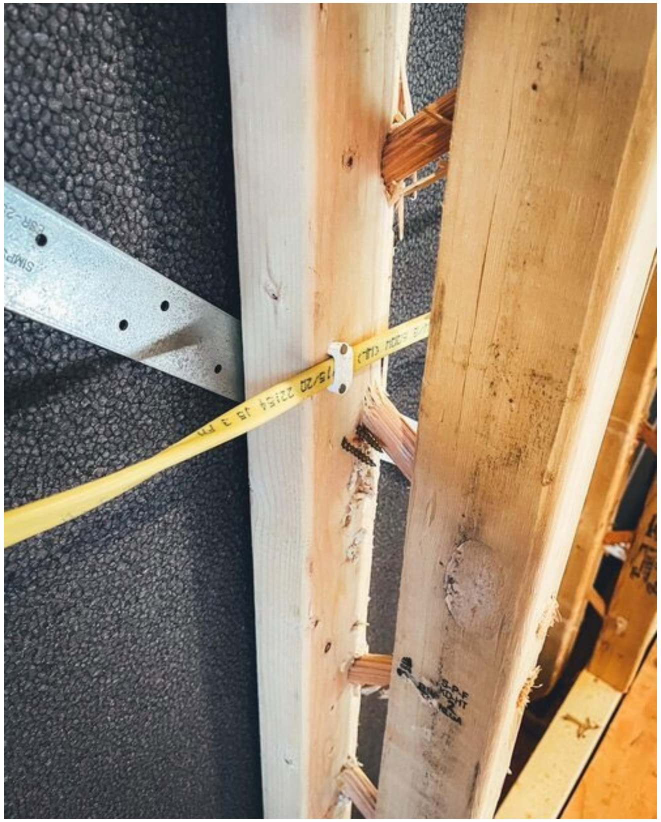
Framing and wall designs

Best wall for climate zones 5 and up

- Advanced framing, TGI framing, or Tstud
- Continuous insulation (R-7 to R-16)
- Tight construction
- Drainage plane
- “Perfect wall” alternative



Tstud



https://www.tstud.com/

Framing and wall designs

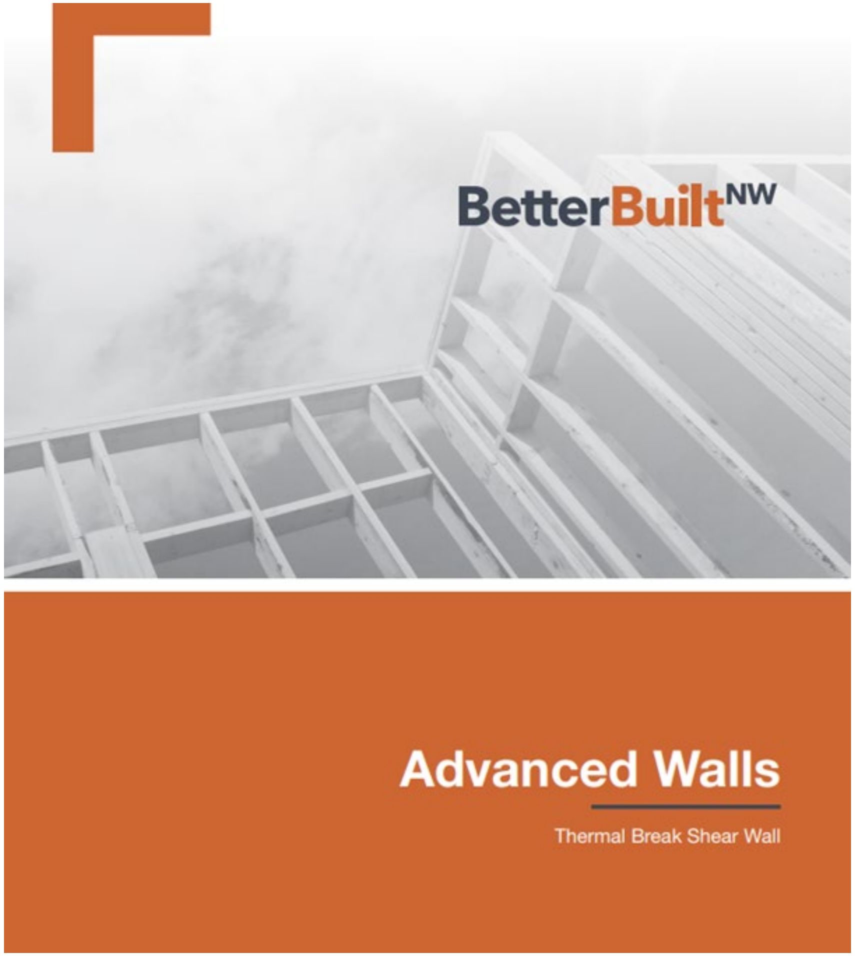
Key considerations on walls

- Walls with exterior insulation will require longer nails, washers when foam is outboard, and framing out around windows and doors
- In cooler climate zones, keeping the exterior sheathing dry, or capable of drying to the exterior is critical to building durability
- Advanced framing will require looking at hangers and integrating roof truss tie downs, and may necessitate 5/8" drywall for exterior walls

Coming soon!

TBS, CI exterior, and Double Walls to have Tech Fact Sheets containing:

- Description
- Benefits
- Energy performance
- Pricing
- Trade's checklist
- Challenges
- Case studies/exterior support
- Code application



https://betterbuiltnw.com/assets/uploads/resources/NEEA_TRC_TBS-Wall-Technical-Fact-Sheet_Final.pdf

Resources to enjoy

- https://betterbuiltnw.com/resources/advanced-framing-debranded
- https://betterbuiltnw.com/resources/advanced-thermal-enclosure
- https://betterbuiltnw.com/assets/uploads/resources/High-Performance-Walls.pdf
- https://betterbuiltnw.com/assets/uploads/resources/Thermal-Enclosure_Efficent-WallsAirtightness.pdf
- https://neea.org/resources/thin-triple-pane-windows-a-market-transformation-strategy-for-affordable-r5-windows

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