BetterBuilt NW

The Building Science of Efficient Envelopes

Home Efficiency Forum

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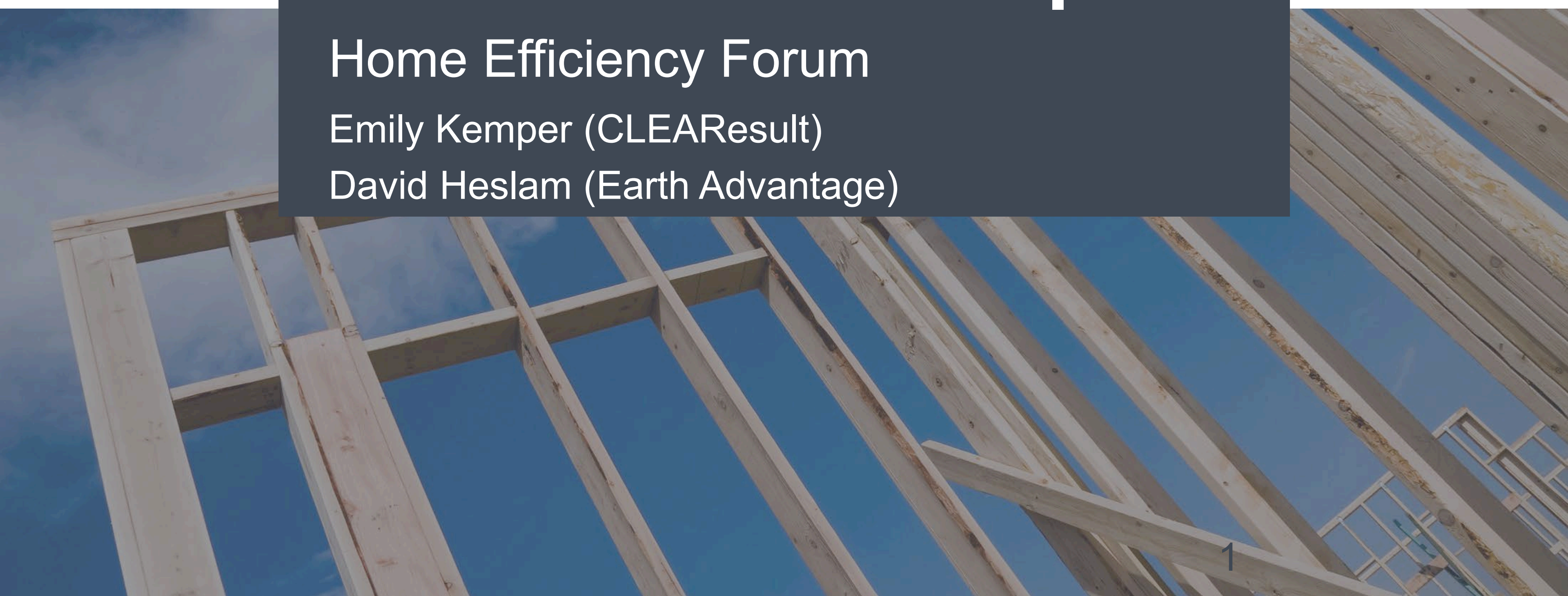
David Heslam (Earth Advantage)



Presenters

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Agenda

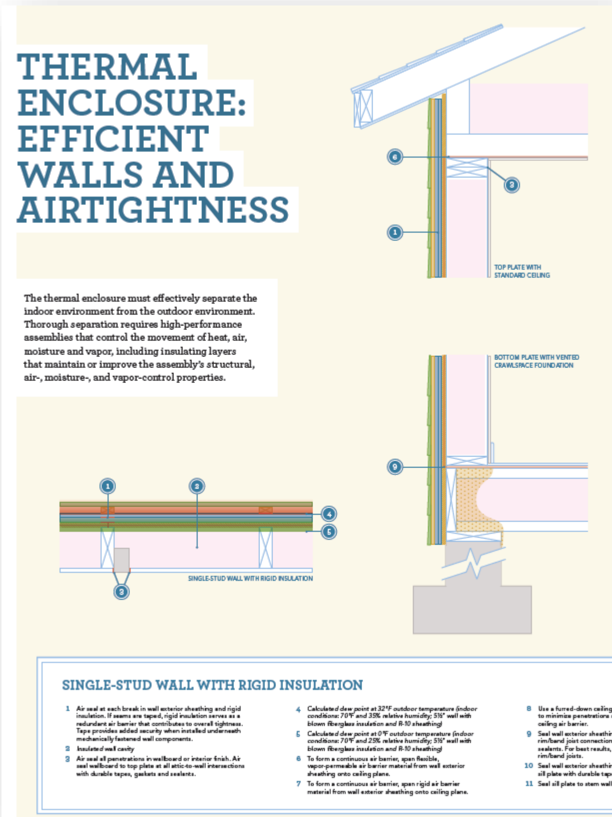
- Why are efficient envelopes important in homes?
- Thermal Break Shear Wall + New Con Case Studies
- TBS Wall – Piloting a Retrofit Project
- Other Efficient and Resilient Building Envelopes

Why are efficient envelopes important in homes?

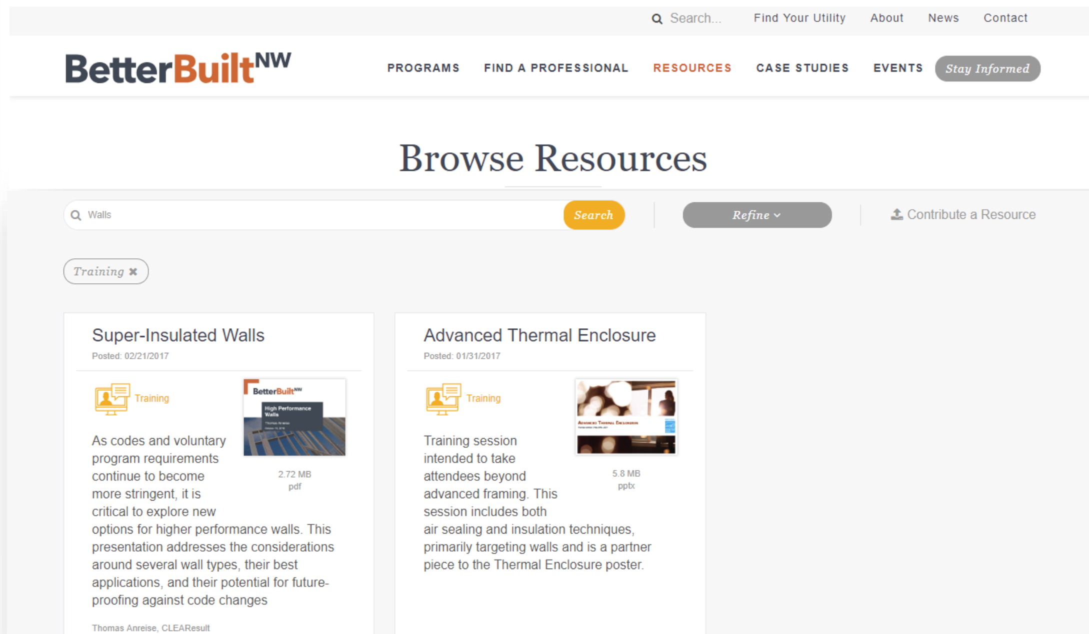
Why build an efficient envelope?

- Improving the walls of the house will make it more efficient before any systems are designed
  - The more efficient the house design, the lower HVAC loads are necessary for the house
  - The lower the HVAC loads, the lower initial and operating costs
- The largest areas of opportunity for improving shell efficiency are:
  - Air sealing / infiltration
  - Wall U-value (including windows)

BetterBuiltNW Resources for Efficient Envelopes and Advanced Enclosures



BetterBuilt NW website is full of resources to help builders and designers create more efficient envelopes, including trainings for rigid insulation and advanced framing



Thermal Break Shear Wall + New Con Case Studies

What is TBS Wall?

Thermal Break Shear Wall

"A continuous layer of rigid foam insulation between the structural sheathing and standard framing with an enhanced nailing pattern"

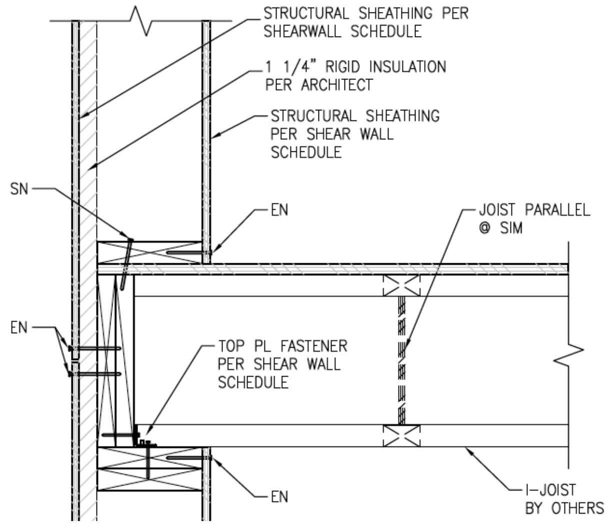
- Studied by NEEA through **new homes market transformation work** and based on PNW builder practices
  - Therefore, originally looked at for new construction
- Now being considered / recommended for retrofit projects

New Construction Example

- Net Zero development
- Used Thermal Break Shear (TBS) walls
- 1.25” EPS foam board between the lumber frame and plywood sheathing

New Construction Example

- Greater total lateral load capacity & earthquake resilience
- Sheathing nailing: 3" o.c. edges, 12" o.c. in the field
- Cost-effective solution to thermal bridging



New Construction Example

TBS NEEA Report for New Homes

- Use of foam as a thermal break = **25-40% improvement in energy performance**
  - + created a continuous air barrier
- Enhanced nailing pattern = **increased seismic resilience outperformed cyclic load testing**
  - Conventional assemblies reach capacity at 1-3/4” of deflection, whereas TBS reached protocol max deflection of 5”

neea

February 22, 2016

REPORT #E16-296

Thermal Break Shear Wall:

A Case Study of Rigid Foam Insulation between Frame and Sheathing

TABLE 1. COST COMPARISONS[6]

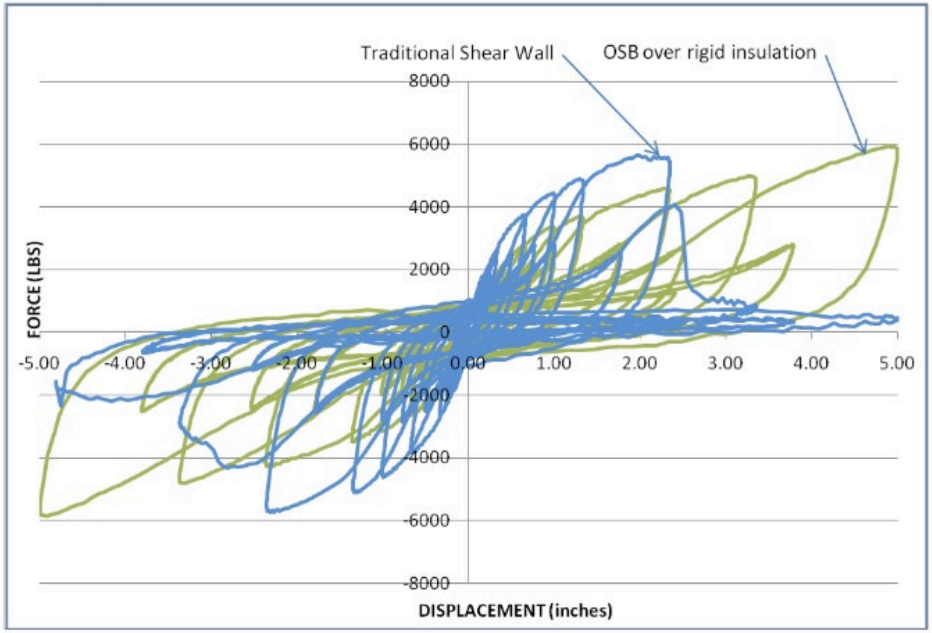
Wall	Stud Cavity	Batt Type	Insulation ($/ft²)	Materials ($/ft²)	Labor ($/ft²)	Wall Total Cost	Incre-mental Cost	Cost/ft² Floor Area	30-Year Savings	Bang: Buck
Code Minimum	2x6	HD	$0.62	$1.55	$1.85	$7,477	$-	$-	$-	0%
2x6 Standard	2x6	BIB	$0.92	$1.85	$1.85	$8,132	$655	$0.33	$674	103%
2x8 Standard	2x8	HD	$0.82	$1.78	$2.15	$8,638	$1,162	$0.58	$1,700	146%
2x6 TBS	2x6	HD	$1.15	$2.00	$1.95	$8,684	$1,207	$0.60	$2,452	203%
2x8 TBS	2x8	HD	$1.35	$2.35	$2.25	$10,109	$2,633	$1.32	$3,188	121%
2x6 Xrigid	2x6	HD	$1.42	$2.47	$2.55	$11,054	$3,577	$1.79	$2,862	80%

Notes: For Batt Type, HD = high density; BIB = blown-in blanket, XPS rigid refers to an exterior rigid insulation system.

Cyclic Lateral Load Test Results

- Revealed major changes to structural characteristics compared to conventional light-frame walls
- Much more flexible
- Higher lateral load capacity
- Greater resilience in the face of the racking motion typical of seismic events

Figure 3. Comparison of Traditional Shear Wall with TBS Wall

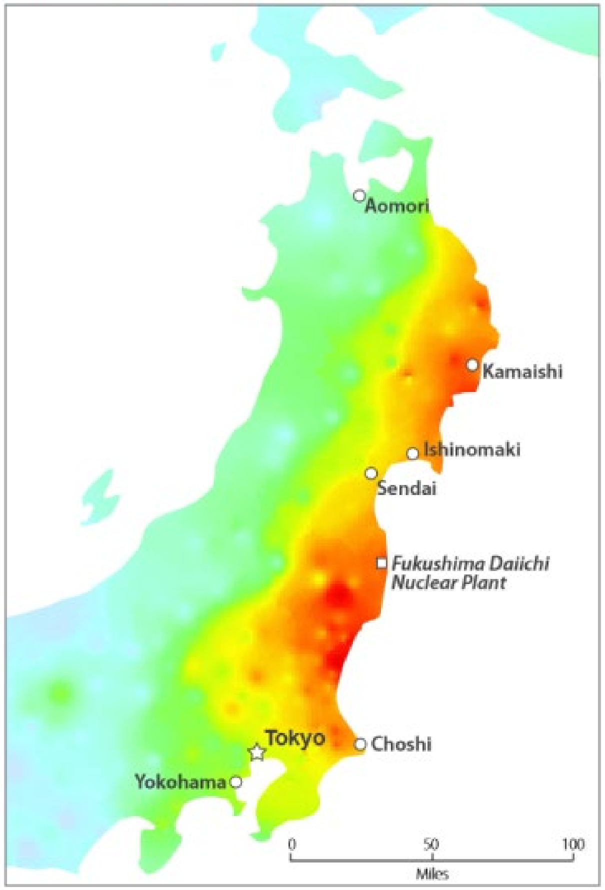


Why is seismic performance important in the PNW?

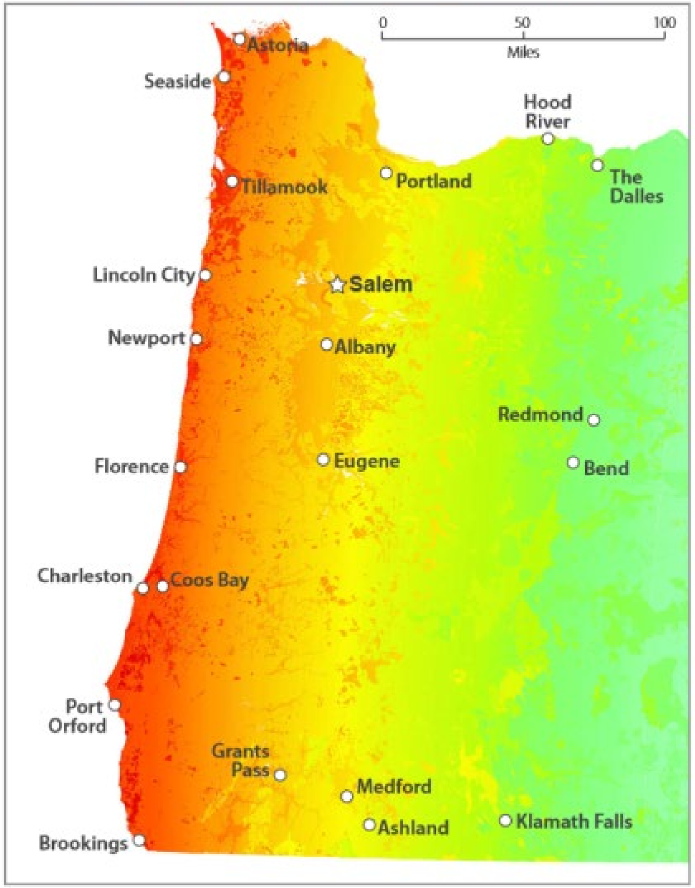
20% chance northern Oregon will be hit by a magnitude 8.0 quake in the next 50 years

Cascadia Earthquake zone

ShakeMap for March 11, 2011 Tōhoku M9 earthquake



ShakeMap for SIMULATED M9 Cascadia earthquake



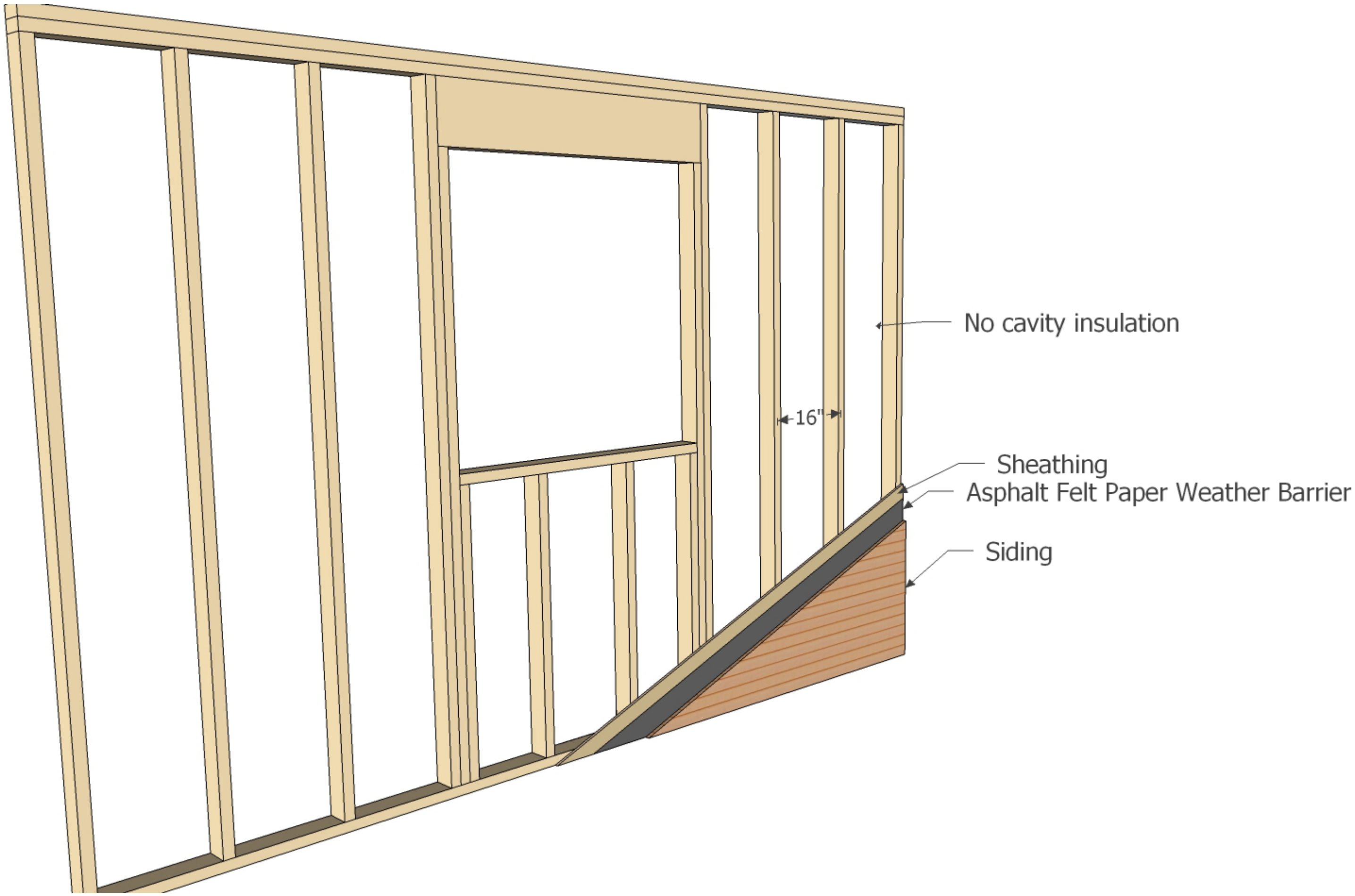
TBS Wall – Piloting a Retrofit Project

Retrofit Possibilities with the TBS Wall: Project Inquiries

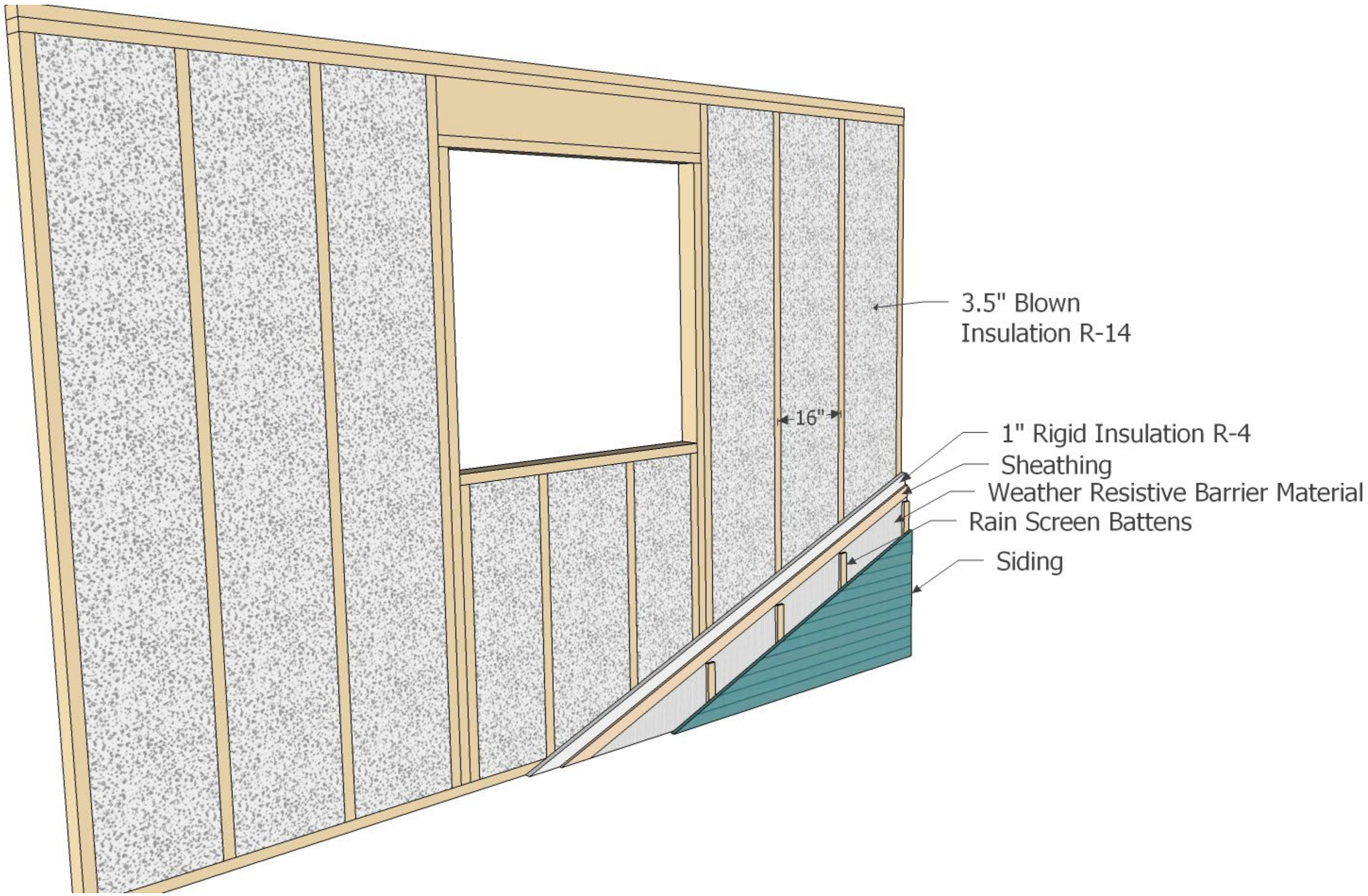
This has been done several times in new construction; could we do it in a retrofit project?

Barrier	Project Inquiry
Energy-efficiency retrofits rarely go beyond "low hanging fruit" opportunities.	Could the twin benefits of resilience and greater energy efficiency in the TBS wall assembly address this barrier?
Most ultra-energy efficient and seismic solutions are high cost options.	Could the TBS wall assembly prove a relatively affordable option for wood-frame structures already undergoing a siding and/or window replacement?
Product manufacturers, residential contractors, engineering firms, and government agencies are largely unaware of the TBS wall assembly option.	Could market awareness increase with this project example?

Standard (Older House) Wall Construction



Thermal Break Shear Wall



The Retrofit Project Site

Spoiler alert: this is Emily's House

- Identified a retrofit opportunity of a single-family wood-frame house in urban location.
- 1906 house within South Portland Historic District.
- Excellent prototype of siding replacement project (although complicated by location in historical district)
- Site altered from originally proposed location/type (small multifamily).

Overview: Steps to complete the retrofit

1. Remove existing siding.
2. Insulate the exterior walls from the outside in - adding layer of rigid foam insulation with plywood sheathing to create shear wall.
3. Nail sheathing with enhanced nailing pattern.
4. Adjust sills and flashing around the existing windows.
5. Install new siding and painting it.

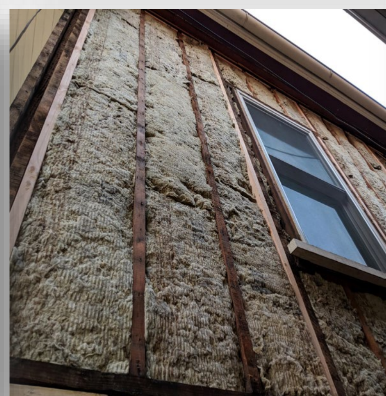
TBS Wall System: Product and Components

- 1" rigid Extruded Polystyrene Board Insulation (XPS) was specified.
- Owens Corning provided 1” x 48” x 96” panels of their FOAMULAR™ 150 product. Closed cell, moisture-resistant rigid foam board
- 7/8" Oriented Strand Board (OSB) was used for sheathing.
- TBS wall components are cut and assembled with standard products, tools, and fasteners.
- Sheathing at the exterior of the wall assembly provides a base layer that is compatible with tested fastener schedules for standard siding materials.
- The nailing pattern included field nailing with 16d nails at 12” on center and edge nailing with 16d nails at 3” on center.
- Additional 2x4 wall studs as needed.
- Window sill and door jamb extensions.

Estimated Energy Savings

Energy Consumption		
Annual kWh consumption in 12 months preceding start of project:	13447	kWh
Approximate original area of conditioned space (with 2 indoor DHP heads):	1090	sq. ft.
kWh / sf prior to renovation:	12.34	kWh / sq. ft.
New total conditioned square footage:	1586	sq. ft.
Modeled / predicted annual consumption (with blower door test) after TBS installed (including new square footage):	9265	kWh

TBS Wall Installation: January 2018



TBS Wall Installation: February – March 2018








Project Timeline

January 2017 – Project Identified
March 2017 – MOUs Finalized
March 2017 – Structural Engineer Engaged
April 2017 – Preliminary Cost Info
April 2017 – Energy Assessment Of Existing Structure
May 2017 – Architectural Elevations
May 2017 – Historical District Design Submission
July 2017 – Historical District Design Review Completed
August 2017 – Structural Engineering Analysis
August 2017 – Building Permit Submission
October 2017 – Building Permits Approved
November 2017 – Project Construction Initiated
January 2018 – TBS wall Construction Initiated
March 2018 – TBS wall Construction Complete

TBS Wall Cost Breakdown

Baseline or Incremental Cost?	Job Type	Line Item	Total costs	North Wall sf 820	East Wall sf 210	South Wall sf 620	West Wall sf 336	Total area of exterior wall 1,986.0	Cost / sf
Baseline	This is a basic siding replacement job, no added insulation or sheathing	New Siding & Rainscreen - Materials cost	$6,269.04	$2,588.43	$662.89	$1,957.10	$1,060.62		$3.16
Baseline		Labor to install siding & rainscreen	$7,200.00	$2,972.81	$761.33	$2,247.73	$1,218.13		$3.63
			Baseline Cost per sf of Exterior Wall Area for Siding Replacement:						**$6.78**
Incremental-ish	This is more than just siding... this is if someone wants to replace siding and then they add sheathing and weatherproof barrier	Labor to install OSB or plywood	$3,249.00	$1,341.48	$343.55	$1,014.29	$549.68		$1.64
Incremental-ish		OSB material costs	$702.00	$289.85	$74.23	$219.15	$118.77		$0.35
			Incremental-ish Costs per sf of Exterior Wall Area for Sheathing-only project:						**$1.99**
Incremental - TBS Wall	This adds in the rigid insulation: with the OSB, rainscreen, and new siding, this constitutes a complete envelope retrofit project	Labor to install Rigid foam insulation	$3,249.00	$1,341.48	$343.55	$1,014.29	$549.68		$1.64
Incremental - TBS Wall		Rigid Foam insulation	$799.20	$329.98	$84.51	$249.50	$135.21		$0.40
			Full Incremental Cost per sf of Exterior Wall Area for whole TBS Wall project:						**$4.03**

Key Performance Indicators

- **Impact on permit approval** – TBS Wall has no impact on project permit approval. Would likely require permit in cases were basic siding replacement would not.

- **Projected energy savings** - Energy efficiency estimated to be improved by 31%. (actual energy savings to be analyzed post-occupancy) Air tightness of construction: there was a 21% reduction in infiltration rates solely from the TBS wall assembly.

- **Incremental cost** - Reasonable incremental cost of $1.99 - $4.03 / sq. ft.

- **Impact on construction timeline** - No impact on the original project timeline. Estimated time difference between TBS wall assembly and basic siding replacement project is 7-14 days

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Takeaways

- **This is not hard**. Site assembled TBS wall is a relatively basic construction concept: to achieve performance, follow instructions, and it will go relatively quickly.
- We should try to apply this to **larger multi-unit structures.**
- **Also: other people are doing this.** TBS wall is being used in Habitat for Humanity builds in East Portland.

Takeaways

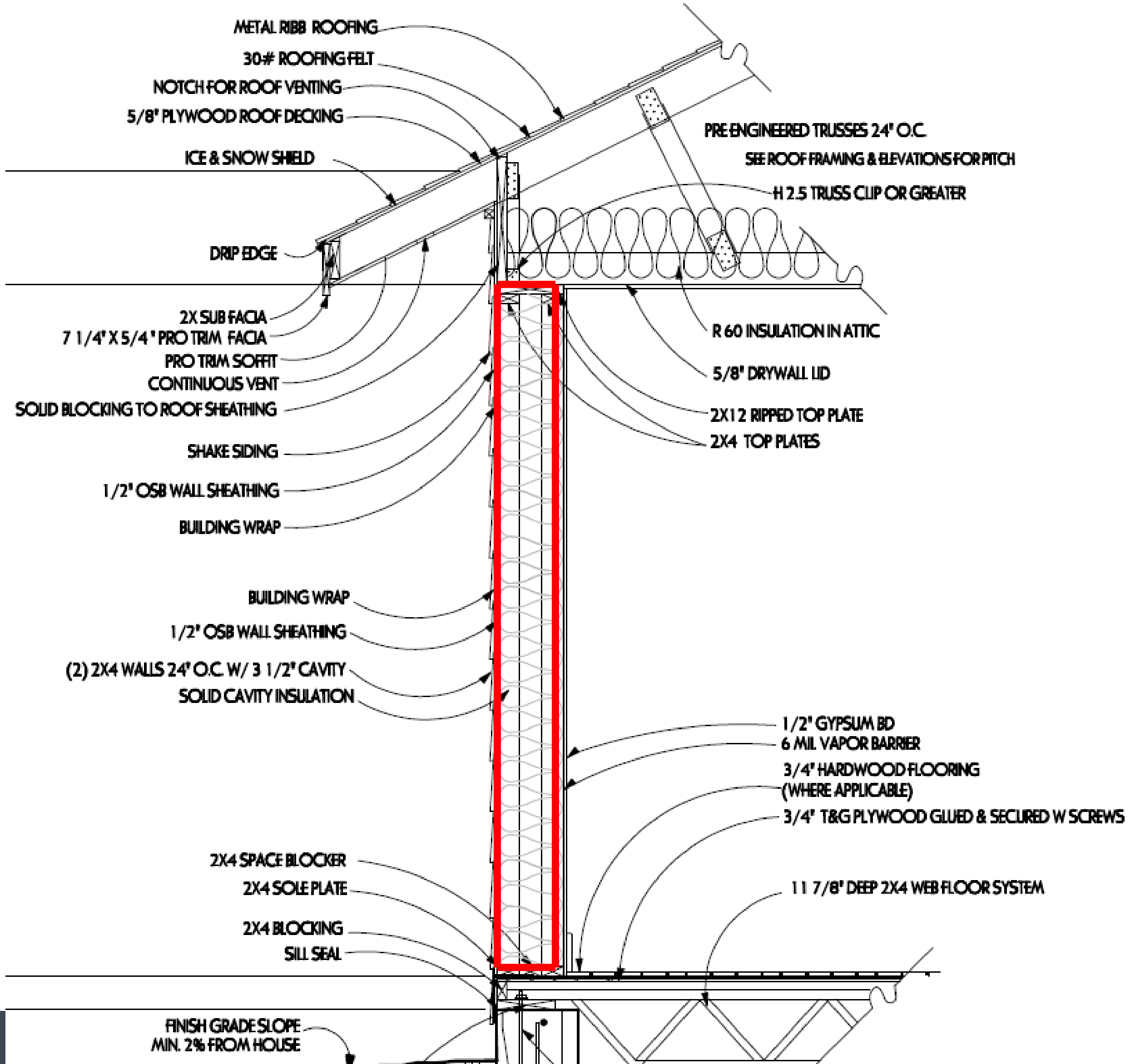
- Average people want to know about this. **Documenting the project on social media** has garnered interest amongst many people interested in how they can make these kinds of improvements.
- **This could also be used in modular construction.**
- **What other types of efficient walls could be adjusted and used in resilient construction?** We should start considering other environmental events and factors when we are building efficient new homes.

Other Efficient and Resilient Envelopes

Efficient & Sturdy Wall Types

- Wall spec: 2- 2x4 framed walls with 3 ½" gap between, Blown cellulose insulation
- Conditioned crawlspace with ICF walls
- Challenges:
  - Air barrier framing
  - Air sealing details
- Success:
  - 1.3 ACH_{50}
- ICF walls – less susceptible to seismic or high wind loads

Double Wall Section



Efficient Wall Types with Wildfire Resistance

- Many existing efficient wall types can be made more resistant to wildfires
- The key is using non-combustible materials on exterior surfaces of the house, particularly with wall sheathing and exterior cladding
    - **For siding,** specify non-combustible, ignition-resistant material, such as fiber-cement siding, brick, or stucco
    - **For roofing,** use Class A, fire-rated materials such as standing seam, tile, slate, or cementitious composite roofing
    - Design eave soffit spaces and underside of roof rafters to resist building ignition from airborne embers

Efficient Wall Types with Wildfire Resistance

Oregon Residential Specialty Code considering adoption of Appendix W – Wildfire Hazard Mitigation

- Wood shingle and shake roofs not permitted in wildfire hazard zones
- Minimum 5/8" Type X gypsum sheathing can be applied behind exterior covering as a fire-resistant option

Ignition-Resistant Roof Edge Detail

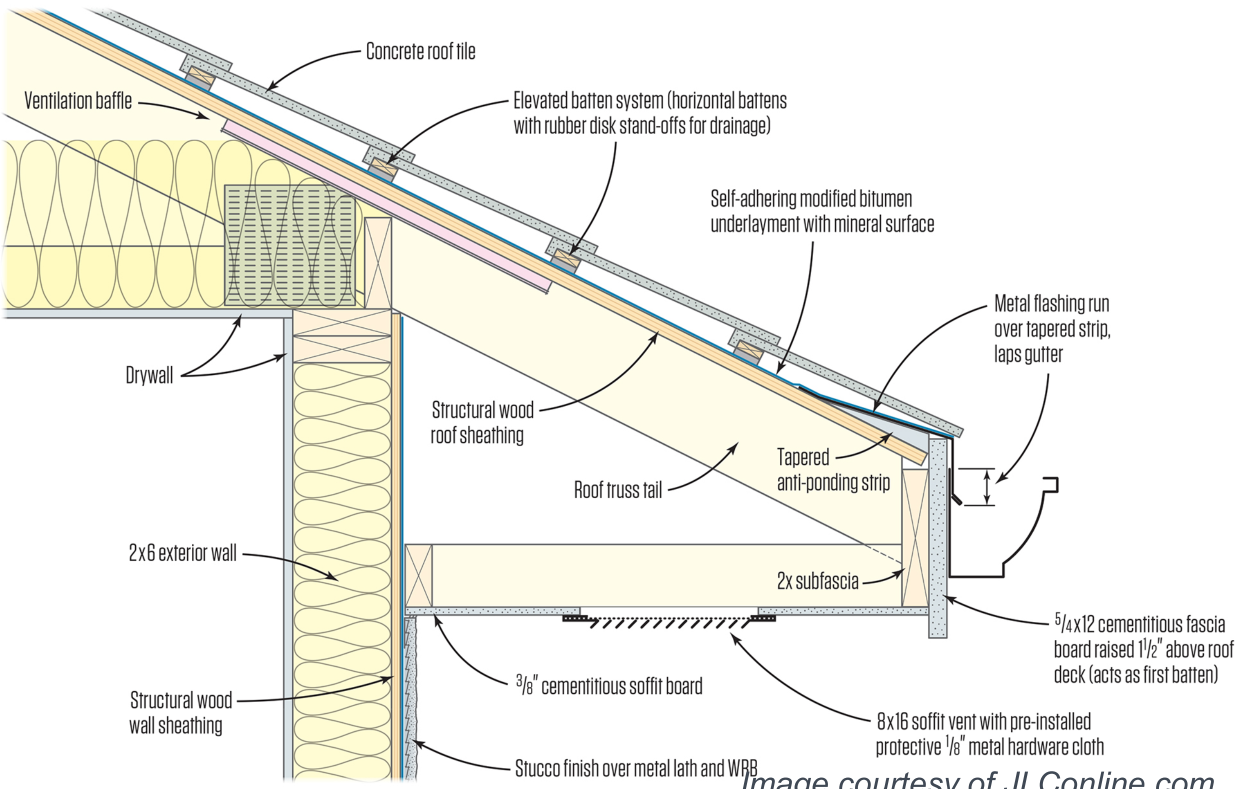
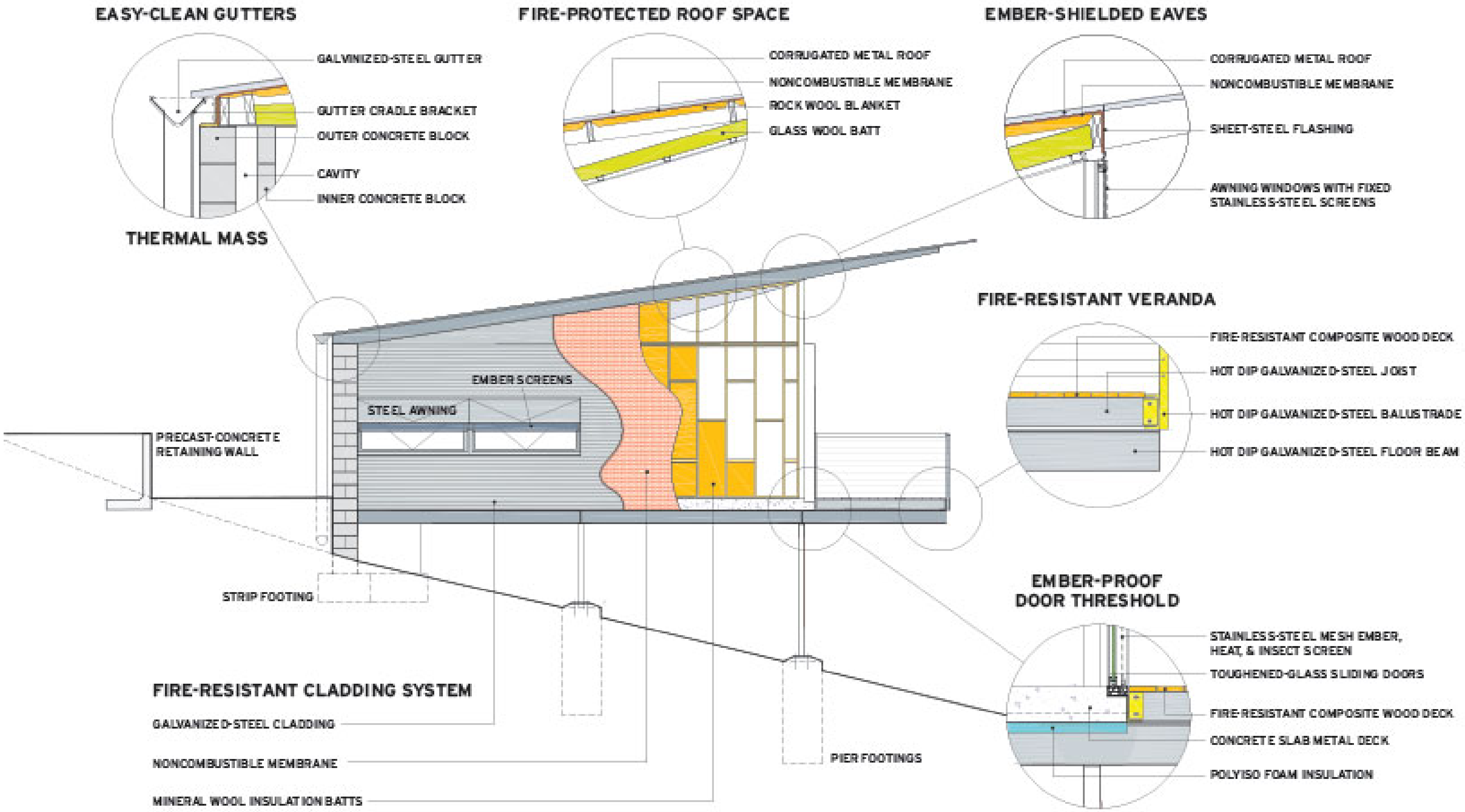


Image courtesy of JLConline.com

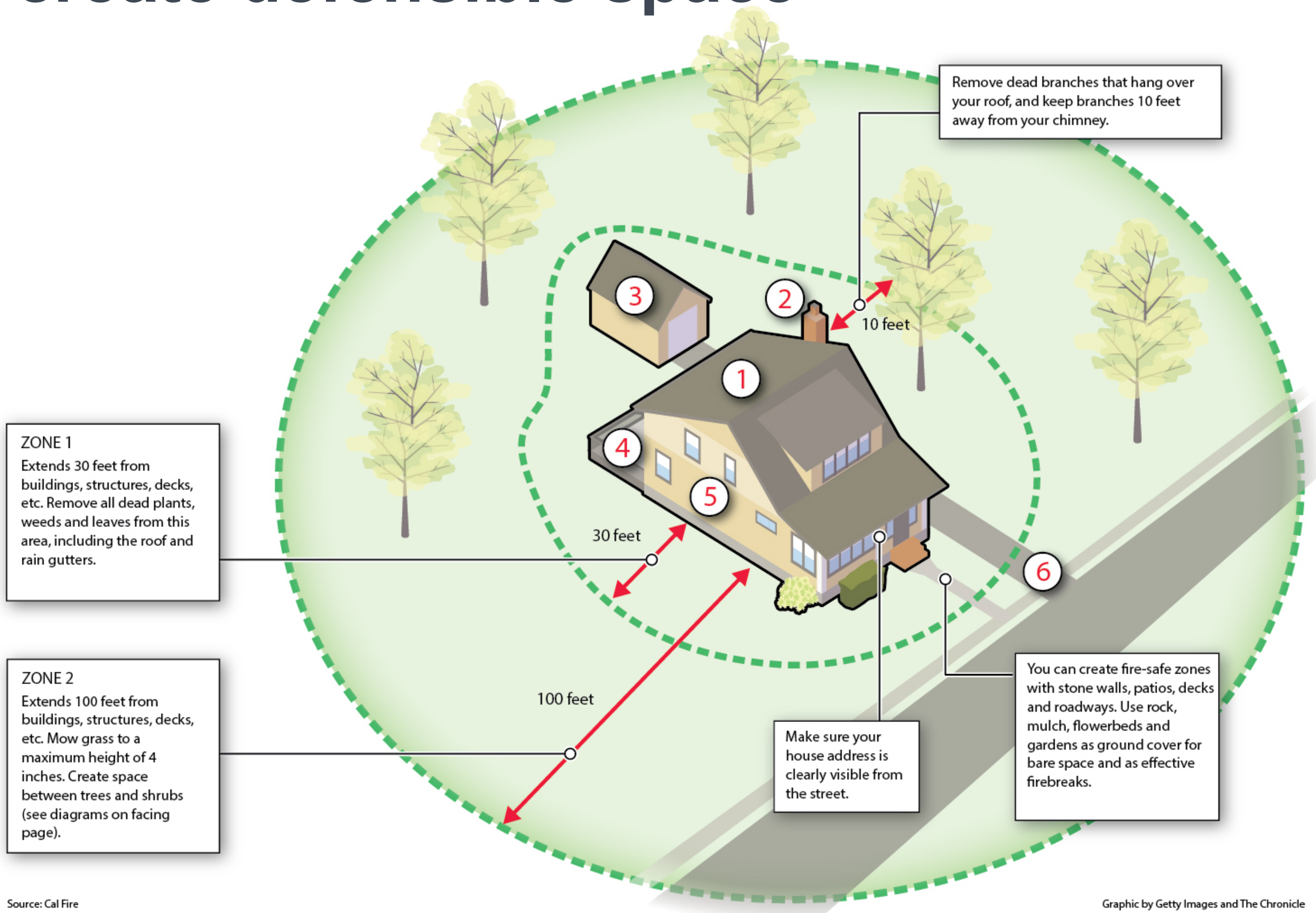
Wildfire Resistant Design Strategies



KARRI FIRE HOUSE'S FIRE-RESISTANT STRATEGIES

Image courtesy of Architectural Record

Don't forget site design strategies – create defensible space

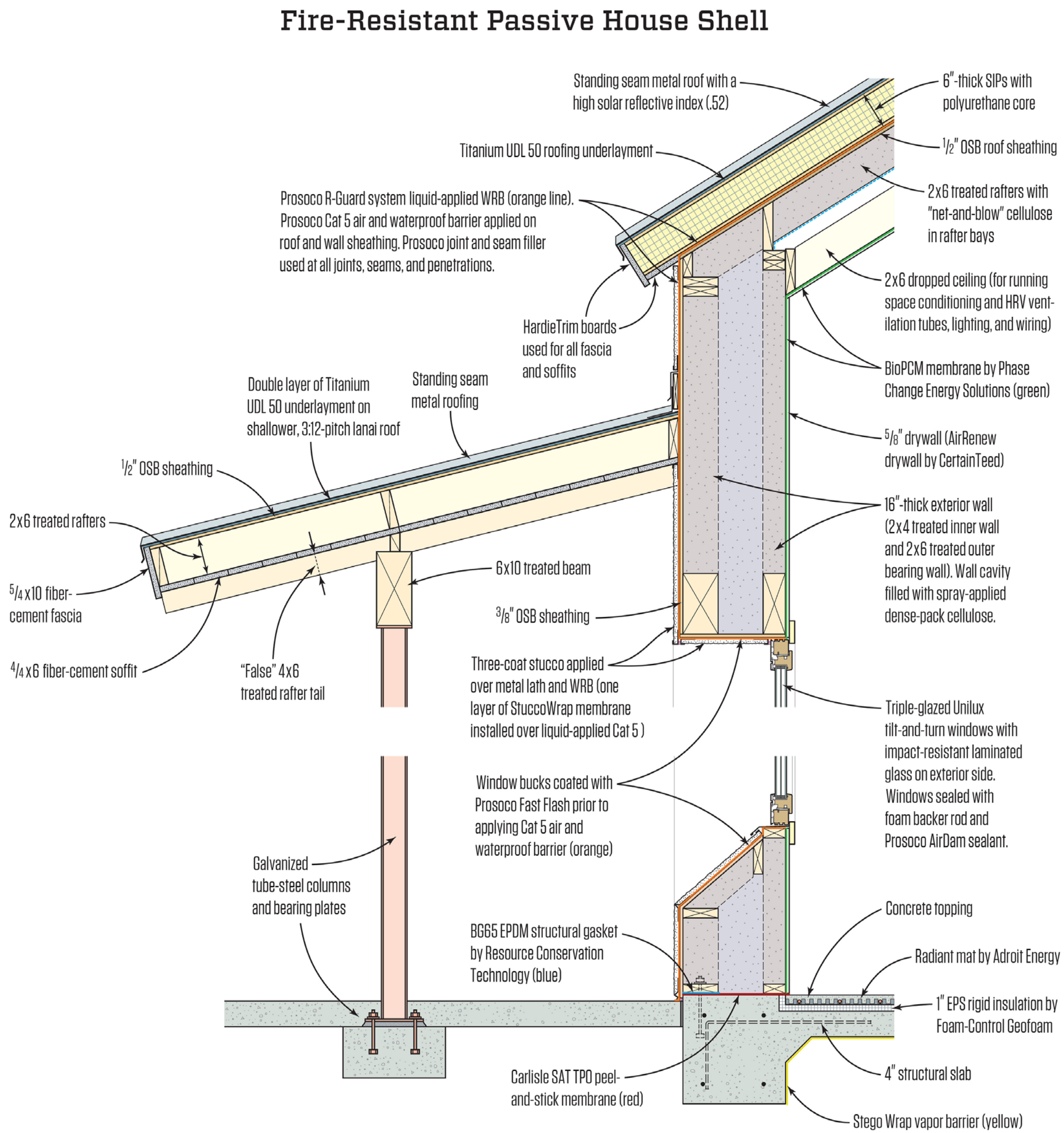


Source: Cal Fire

Graphic by Getty Images and The Chronicle

Passive House + Fire Resistance

- The ultra-efficient, ultra-fire resistant wall construction!



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Thanks!

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