February 17, 2014 - RESNET Conference

High Hanging Fruit:

The Two Hardest ZNE Measures in the 2016 Code

1. High Performance Attics
2. High R-Value Walls

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Don’t put ducts in hot places

“Putting [ducts] in the attic is the worst place in the house you can install ducts” – Allison Bailes, Energy Vanguard

“Building a home in a hot climate with ducts located in the attic is a bad idea.” – David Roberts, NREL

“Putting heating and air conditioning ducts in an unconditioned attic is stupid. Don’t be stupid.” – News Editor, Treeline Homes

“Ductwork in an uninsulated [attic] is a dumb idea.” – Tim Snyder, My Home Science

“Installing the system in the attic is actually the #1 Top 10 Dumb Things to do in the South” Joe Lstiburek, ASHRAE Fellow

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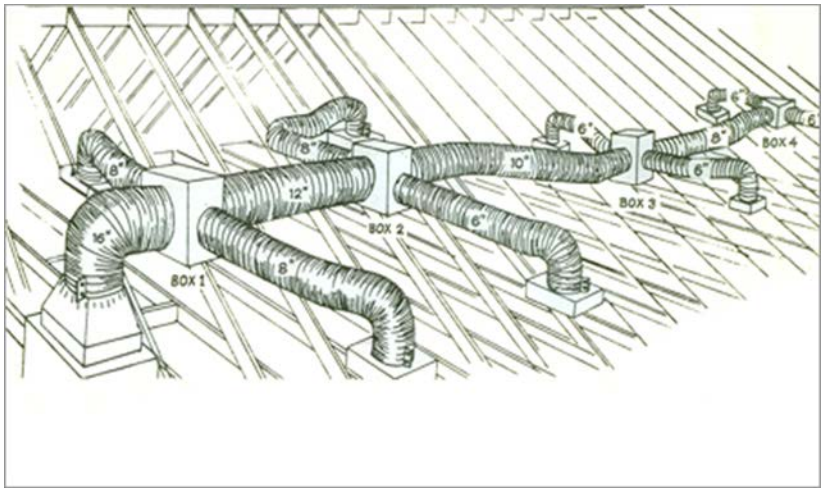
Ducts waste a ½ ton of cooling (literally)



Back of the envelope math:

23% × 2,100 ft² ≈ 500 ft²

Q = U A ΔT

= 500 ft² × R-6 (Btu/hr ft² °F) X (130 °F - 55 °F)

≈ 6,000 Btu/hr

≈ ½ Ton =

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Ducts in Unconditioned Attics are Wasteful

- Take the entire southern wall of your house (≈ 500 ft^2)
- Strip the cavity insulation (leaving ≈ R-6 assembly)
- Move the southern wall from Dublin to Death Valley (increase ΔT by 45 °F)

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Strategies to Reduce Duct Loss

Recommendations to meet the 2016 Title 24 standards

1. Cool attic (High Performance Attic or HPA)
2. Sealed attic (move the thermal envelope)
3. In the house (plenum, drop-ceiling or between floors)
4. Go ductless

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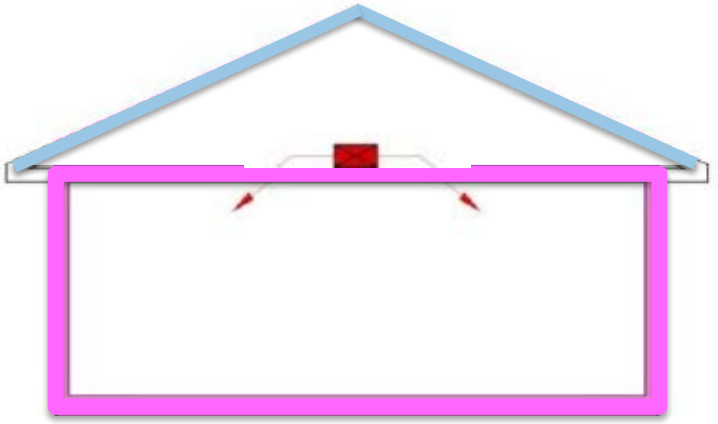
Duct Location #1: High Performance Attic

Basic Design:

- Ducts and air handler in their normal location
- Vented attic as normal
- Add insulation to the roof deck
  - Below deck between rafters (R-13)
  - or, Above deck rigid foam (R-6)
- Use a cool roof (specs vary by CZ)
- 5% duct leakage
- Radiant barrier with above deck
- R-8 duct insulation



Source: http://www.ductsinside.org/

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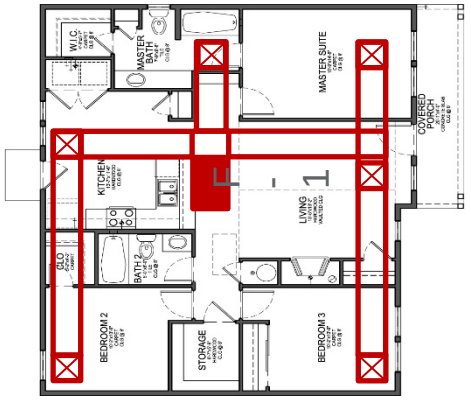
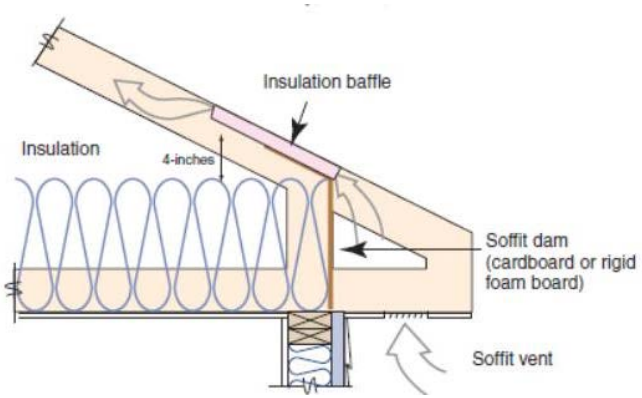
Duct Location #1: High Performance Attic

Advanced Options

- Reduced duct surface area
- Raised heel truss
- Rigid foam interior finish
- Insulated roof tiles





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Duct Location #1: High Performance Attic

Benefits

- Reduce attic temperatures (reducing both duct and ceiling losses)
- Incremental change to standard practice
- No change to duct and air handler location

Challenges

- Careful consideration of moisture mitigation
- Minimal installation experience
- Concrete tile ventilation strategies

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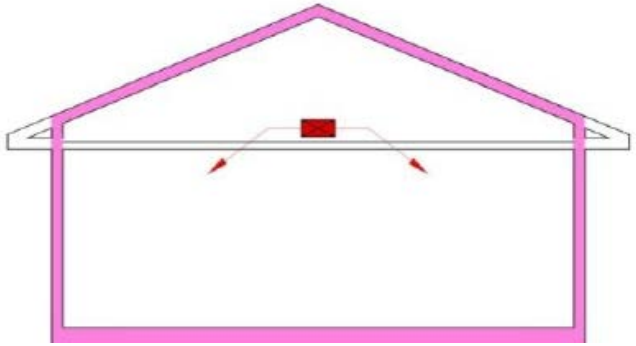
Duct Location #2: Sealed Attic

Basic Design

- Ducts and air handler in their normal location
- Unvented Attic
- R-30 roof deck assembly R-Value
  - Above deck rigid foam
  - Below deck between rafters
  - Rigid foam interior finish
  - Spray foam below deck, beyond studs



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Duct Location #2: Sealed Attic

Benefits:

- No need to seal ceiling plane (can lighting, sprinklers, etc.)
- Some attic space can be a home space (e.g., storage, kids play space, writing desk, bedroom)

Challenges:

- Sealing the attic-to-deck junction
- Requires sealed combustion equipment

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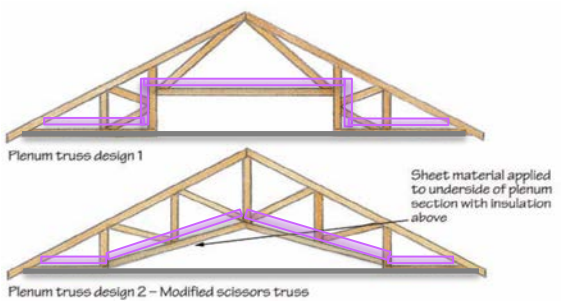
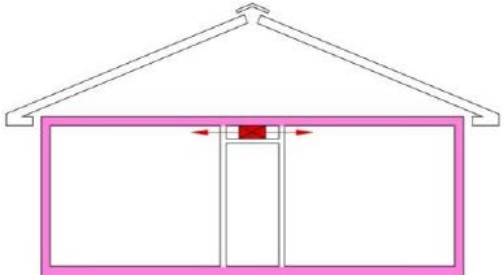
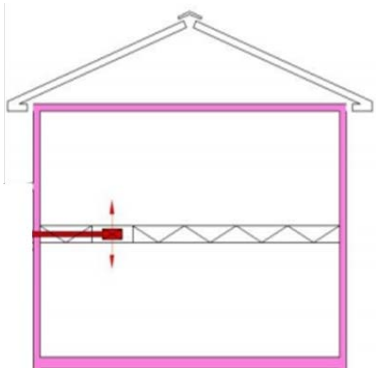
Duct Location #3: In the House

- Basic Design – 3 Options

In a plenum (box or scissor)	Dropped ceiling	Open-Web floor truss
		

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Duct Location #3: In the House

Benefits:

- Incremental changes to standard practice, vented attics
- Multiple buildable options

Challenges:

- Requires early planning and design
- Sealing the soffit-plenum-truss perimeters
- Requires sealed combustion equipment
- Finding space for FAU
- Extra framing needed

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Duct Location #4: No Ducts

System types:
- Mini-splits
- Hydronic
- Packaged terminal heat pump

Benefits:
- Elimination of duct losses
- Higher system efficiency
- No need for DCS or HPA measures

Challenges:
- Modeled benefit is conservative relative to other measures*

*This may change over time with improved knowledge of benefits

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Conclusions

Benefits of Ducts in Conditioned Space

- Save energy: more than any other individual measure available
- Save money: downsize HVAC equipment needs, with early intervention and design planning, incremental costs can be $0
- Increase CAHP incentives ≈ $400 to $800 more
  - Potential to stack CAHP points, up to a $2,500 more
- Prepare for 2016 Title 24 and align with other top-tier building standards

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Additional Resources

- Building America Solution Center
  - https://basc.pnnl.gov/
  - FREE: CAD files, images, case studies, design guides
- Building Science Corporation Bookstore
  - http://www.buildingsciencepress.com/
  - Advanced design guides
- PG&E's Pacific Energy Center
  - http://www.pge.com/en/mybusiness/services/training/pec/index.page
  - Classes, resource library
- Free Design Guides
  - *Building with Ducts Inside*, NEEA, EarthAdvantage - http://ductsinside.files.wordpress.com/2011/04/ducts-inside-training-manual.pdf
  - *Ducts in Conditioned Space*, PATH - http://www.toolbase.org/pdf/techinv/ductsinconditionedspace_techspec.pdf
  - Many more: Google Ducts in Conditioned Space Design Guide

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Questions?

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High R-Value Walls

Recommendations to meet the 2016 Title 24 standards

1. Traditional Wall Assemblies
2. Alternative Wall Systems

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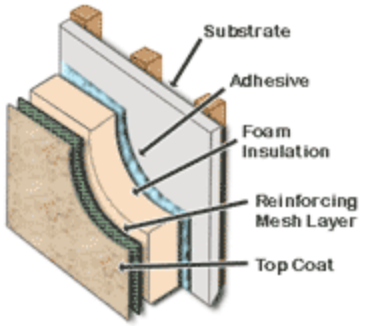
Anticipated 2016 Code Change

2013 Code - Residential Package A Prescriptive Standard

- Assembly U-Factor of **0.065** in all climate zones
- R-15 + 4, 2x4 @ 16oc ***or*** R-19 + 2, 2x6 @ 16oc

2016 Code – Anticipated code change

- Assembly U-Factor of **0.050** in all climate zones other than CZ 7
- R-15 + 8, 2 x 4 @ 16oc, ***or*** R-19+6, 2x6 @ 16oc



Prescriptive Change; *performance tradeoffs will be possible and common.*

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Traditional Wall Assembly Table

Table 4.3.1 – U-factors of Wood Framed Walls

Spacing	Cavity Insulation	Nominal Framing Size		Rated R-value of Continuous Insulation [2]						
				R-0	R-2	R-4	R-5	R-6	R-7	R-8
				A	B	C	D	E	F	G
16 in. OC	None	Any	1	0.356	0.209	0.146	0.127	0.113	0.101	0.092
	R-11	2x4	2	0.110	0.088	0.074	0.068	0.064	0.060	0.056
	R-13	2x4	3	0.102	0.082	0.069	0.064	0.060	0.056	0.053
	R-15 [1]	2x4	4	0.095	0.077	0.065	0.060	0.056	0.053	0.050
	R-19	2x6	5	0.074	0.063	0.055	0.051	0.049	0.046	0.044
	R-21[1]	2x6	6	0.069	0.059	0.051	0.048	0.046	0.043	0.041
	R-22	2x6	7	0.072	0.062	0.054	0.051	0.048	0.045	0.043
24 in. OC	None	Any	12	0.362	0.211	0.148	0.128	0.114	0.102	0.092
	R-11	2x4	13	0.106	0.086	0.072	0.067	0.062	0.059	0.055
	R-13	2x4	14	0.098	0.079	0.067	0.062	0.058	0.055	0.052
	R-15	2x4	22	0.091	0.074	0.063	0.059	0.055	0.052	0.049
	R-19	2x6	15	0.071	0.061	0.053	0.050	0.048	0.045	0.043
	R-21[1]	2x6	16	0.066	0.057	0.050	0.047	0.045	0.042	0.040
	R-22	2x6	17	0.069	0.060	0.052	0.049	0.047	0.044	0.042

Notes

1. Higher density fiberglass batt is required in these cases.
2. Continuous insulation may be installed on either the inside or the exterior of the wall, or both.

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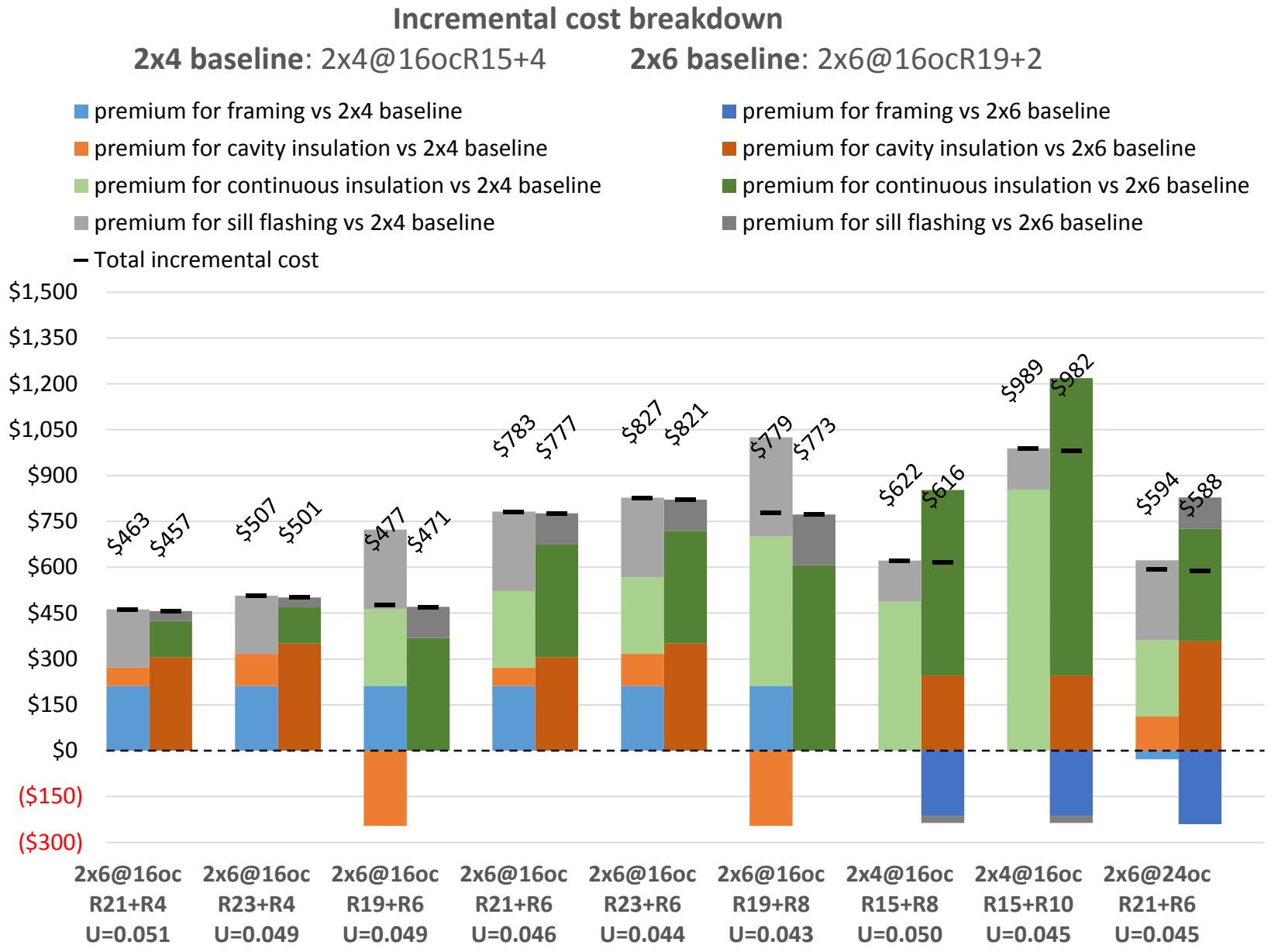
Incremental Cost Breakdown Relative to Two Baselines



New High R-Value Rigid Foam Board Options

CEC – *"The problem is we can't get R-6 at only 1 inch thick, so we'll need different windows."*

"That's easy, we can make that now" **- Insulation Manufacturer**

CEC - *"Why don't you sell it?"*

"We never knew anyone wanted it" **- Insulation Manufacturer**

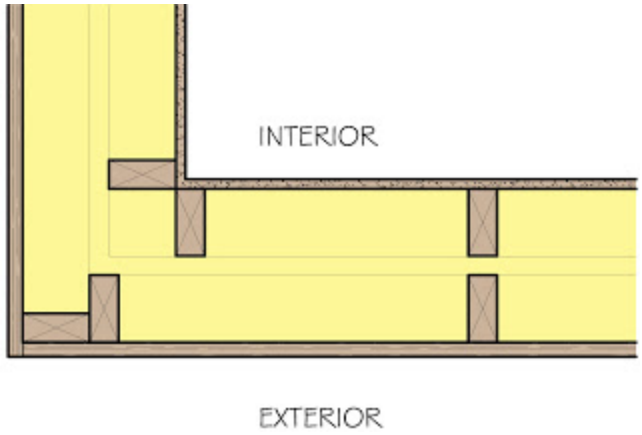
[A paraphrased conversation]

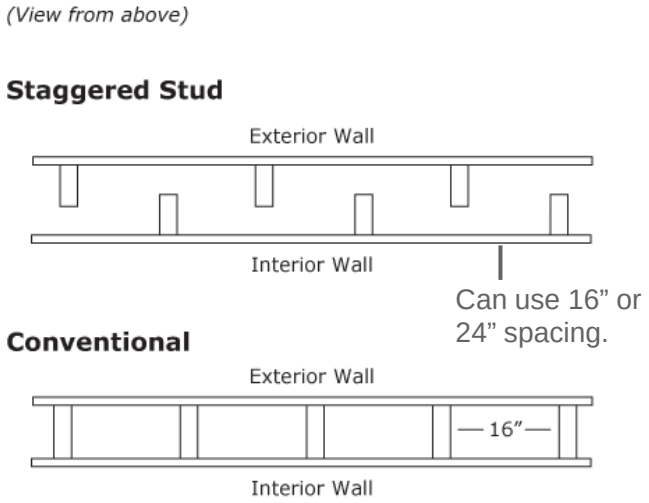
R-6 and R-5 will become commonly available at 1"

R-6 to R-9 will become commonly available at 1 ½"

Alternative Wall Systems

Double Wall	Staggered Stud Wall





Benefits:

- Can use 2x4 studs for a 6”, 8”,10”, (or more) cavity
- Greater thickness for cavity insulation
- Reduced thermal bridging, 8” staggered cavity reach 0.041 U-Factor

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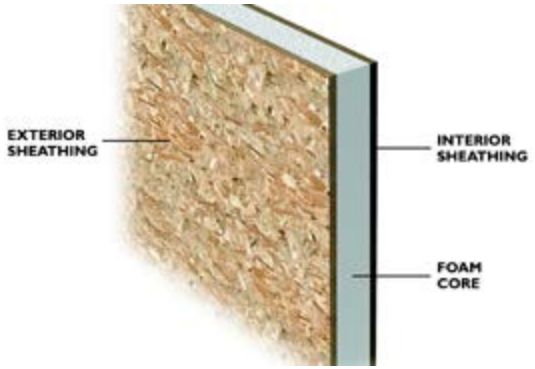
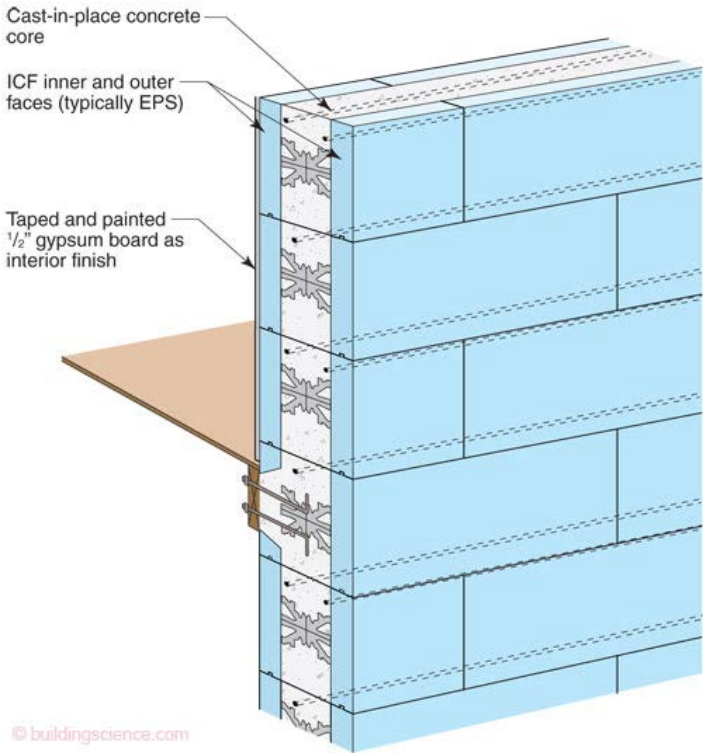
Alternative Wall Systems

Structurally Insulated Panels (SIPS)



Insulated Concrete Forms (ICF)



Benefits:

- Minimal thermal bridging
- Factory fabricated
- Lower labor costs
- Seismic durability

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Questions?

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Departing Thought – Quality Matters

- R-19, 2x6 @ 16”
- Quality insulation installation (QII) credit taken

This does not break any Title 24 rules!

Thank you to the T24 consultants and HERS raters who think *beyond* the code

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Thank you!

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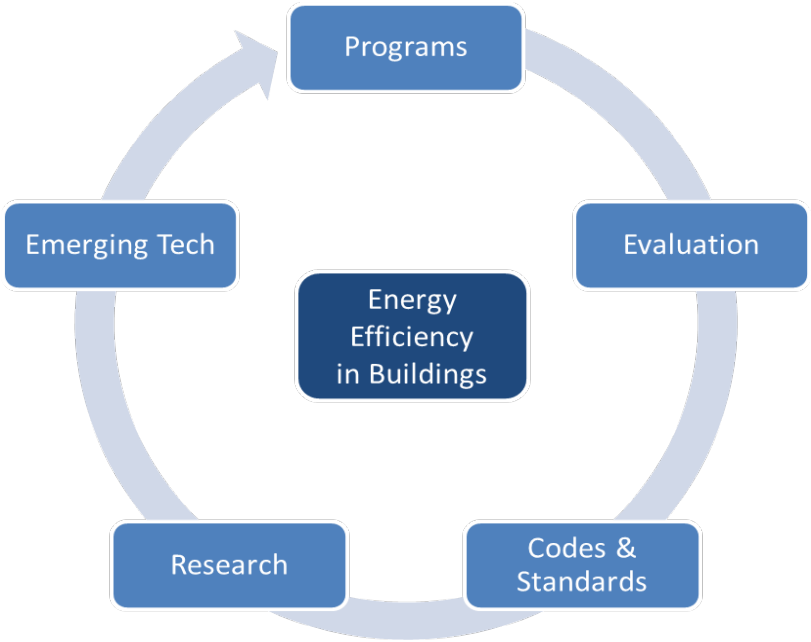

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