10:15–11:45 a.m. Focus Sessions

- T2: Building Science for Sustainable Asset Management.

- Asset managers looking for sustainable ways to reduce utility and other costs at their properties will find natural allies in the world of building science.
- This presentation will explain what is possible using building science techniques and what kinds of analysis can be done on new and existing buildings. John Straube will review strategies for the design and construction of very low load, durable new mid-rise residential buildings and for improving the energy and durability performance of existing building enclosures.

Building Science for Sustainable Asset Management

Dr John Straube, P.Eng.

Building Science Consulting

University of Waterloo

Outline

- Buildings as asset
- What makes then sustainable assets?
- How can Building science help
- Applications to residential projects
  - Single homes
  - Wood-frame multis
  - Concrete and masonry mid-rise

Scope of Presentation

- Energy and Durability
- Large multi-unit
- Wood frame

- New construction
- Retrofit
  - Significant
- Importantly, not repairs/small changes

Buildings

- Largest asset class
- Increasing awareness of possible long-term stable income (e.g. pensions / demographics)
- Requires significant on-going investment to maintain value

A Sustainable Asset

- Low-energy operation
  - Enclosure, mechanical/DHW, appliances
- Low-cost maintenance
  - Enclosure, mechanical/DHW, appliances
  - Finishes, door/window/cabinet hardware
- Easy, affordable repairs
  - As above, minimize need
- Comfortable, quiet for occupants
  - Enclosure, mechanical, appliances, suite isolation

Available Energy-saving Strategies

- Siting (small impact)
  - Orient with sun, wind, rain, earth shelter?
- Shape and Form (small to moderate impact)
  - Small, Compact, Simple
- Exceptional building enclosure (mod to large impact)
  - Insulated, airtight, durable, solar control
- Efficient Equipment (mod impact)
  - Not installed or off is best, *simple* controls help
- Renewable Energy Generation (impact varies)
  - Only after very significant reductions

How to get there?

- Learn from past experience / observation
  - What works, what does not
- Apply scientific understanding
  - You can’t always extrapolate
  - Science can often predict outcomes

- This is “building science”.. the overlap of field experience and physics

Quality / Reliability

- Principle quality factors
  1. Design (& selection of Materials / Systems)
  2. Construction Workmanship/Management
  3. Maintenance / Operation
- Best Investment is in Design
  - Low cost, high impact
  - Simplify construction, acknowledge workforce
  - Understand deterioration and plan for it
  - Don’t expect perfection, accommodate tolerance

New Construction

- *Should be* easy to cut energy use while enhancing durability
- Requires change in thinking and setting targets
- Materials, and equipment is available for very high performance at modest cost premium
- **Systems** (enclosure/HVAC) are the key

Building Science: Back to Basics

- The Enclosure remains a large energy user
  - More Insulation (less thermal bridging)
  - More Airtightness
  - Better Windows
- Lets tolerance of mistakes
  - Control interior humidity!
  - Avoid and dry rain leaks, construction moisture
- Simpler HVAC
- Good Appliances

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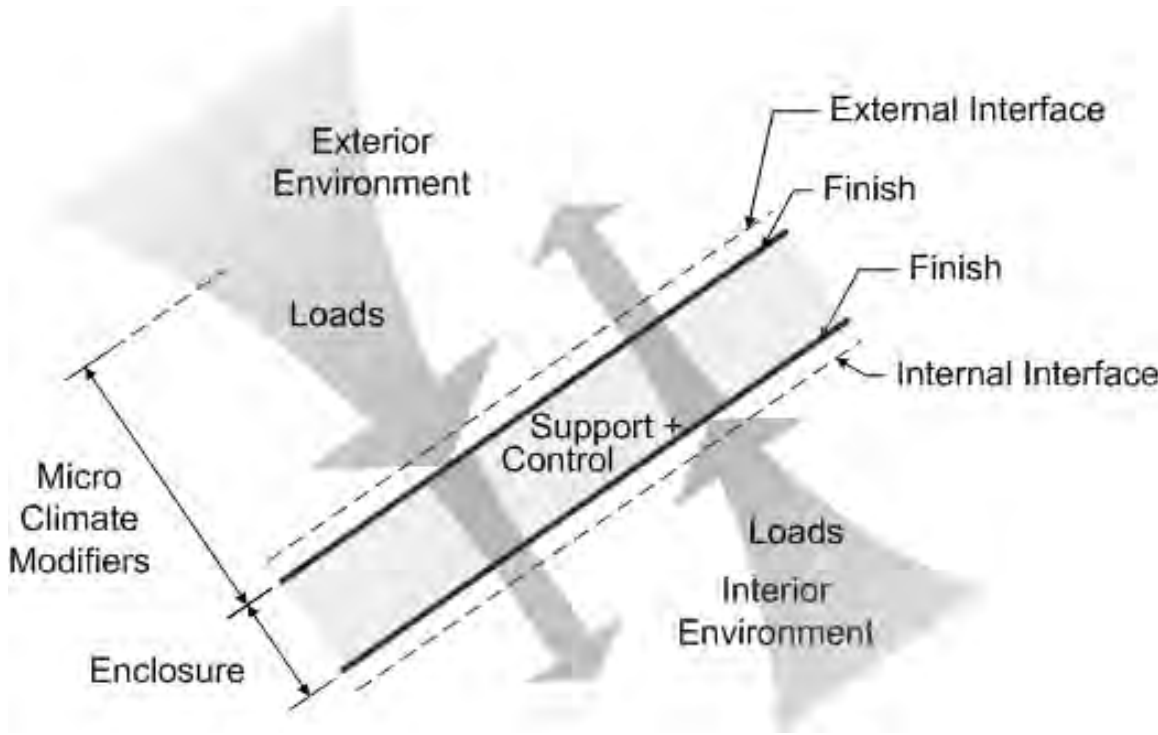
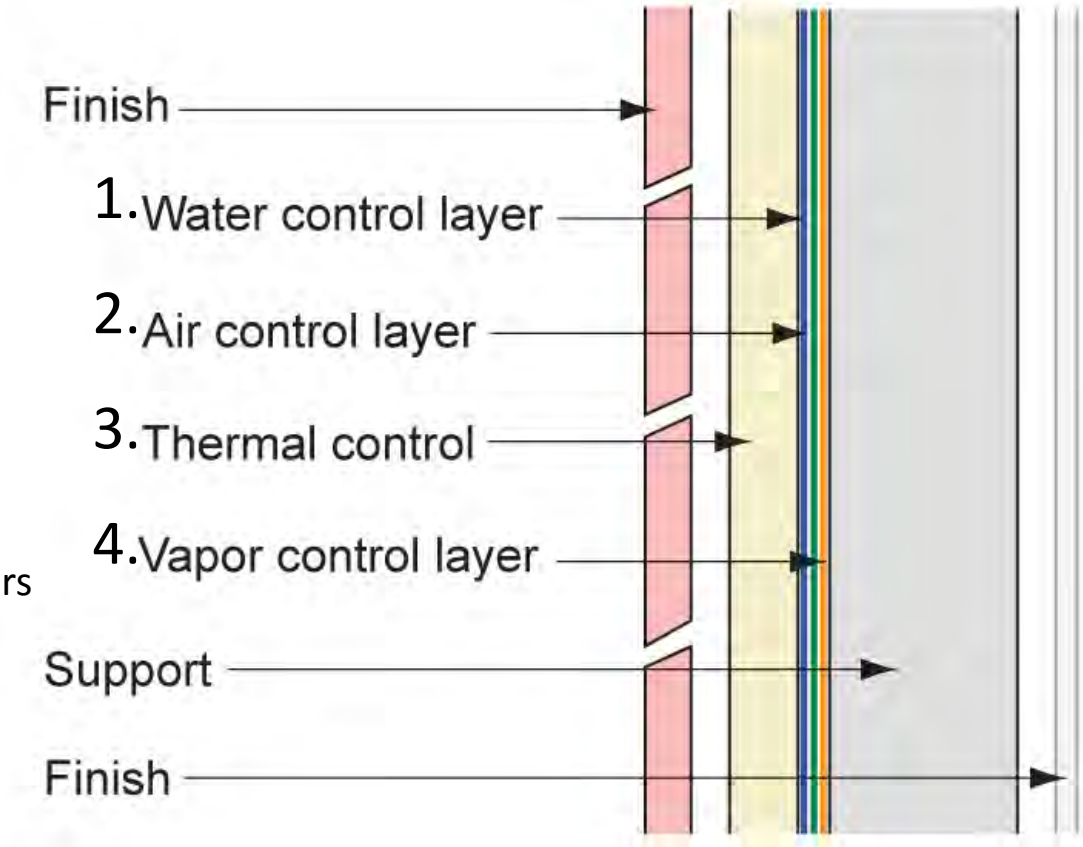
Building Enclosure

- Environmental Separators
  - Enclosure: separate interior environment from exterior environment
  - Separate two different interior environments



The “Perfect Wall”

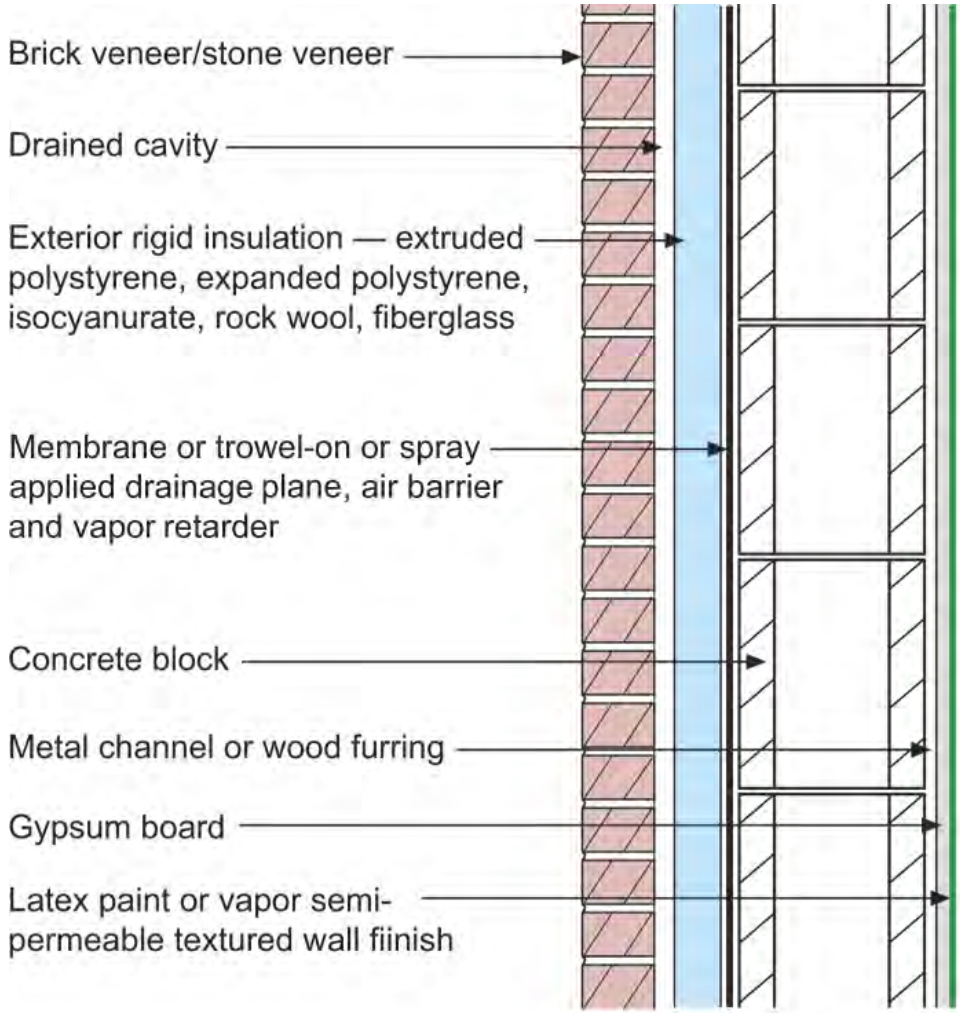
- Finish/cladding: whatever
- Control
  - Rain control layer
    - Perfect barrier
    - Drained with gap
    - Storage
  - Air control layer
    - Air barrier
  - Thermal control layer
    - Aka insulation, radiant barriers
  - Vapor control layer
    - Retarders, barriers, etc
- Structure: anything that works



Fire Control may be needed
Sound Control optional

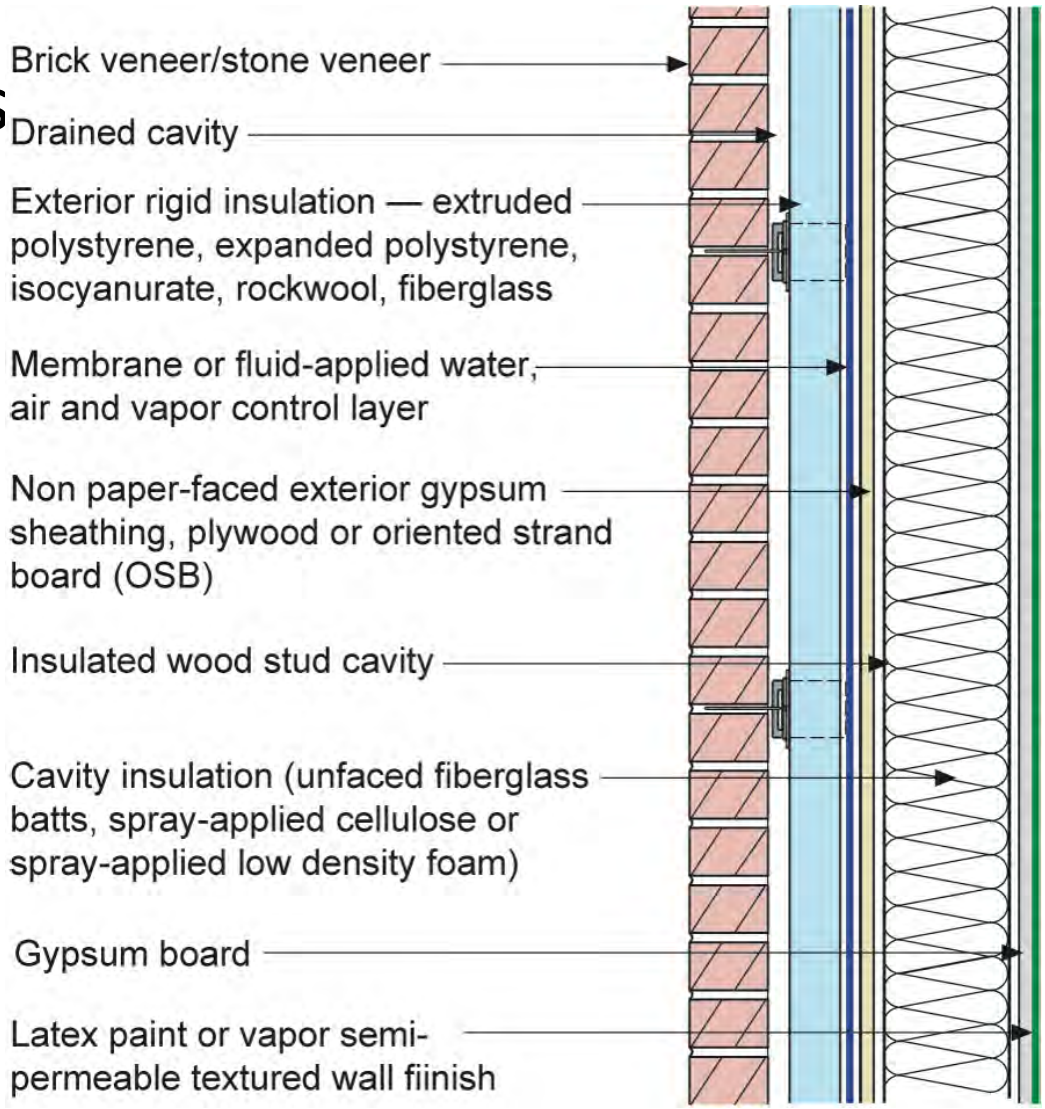
All layers obvious

- Durable
- High-performance



Wood-framed wall

- Wood studs are not bad thermal bridges



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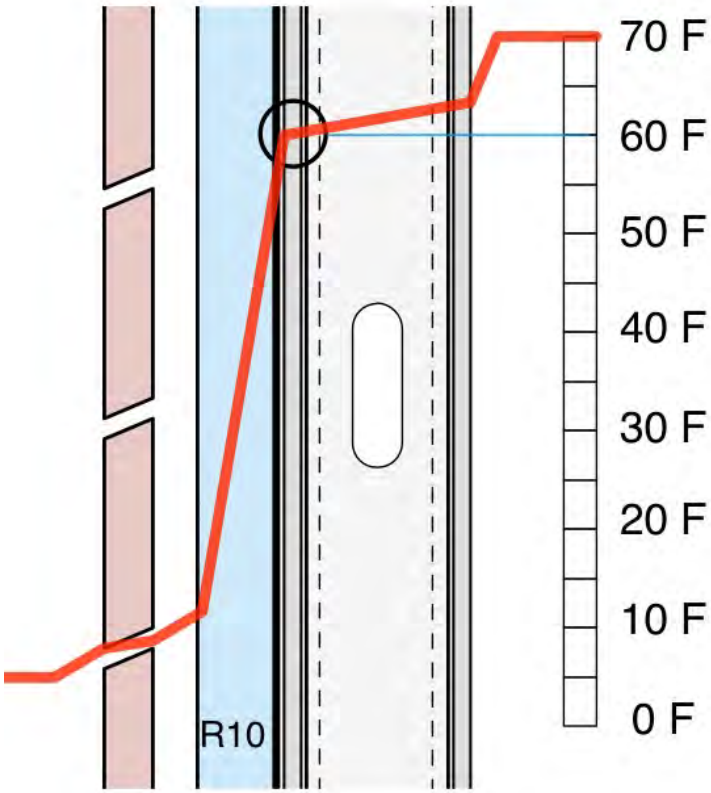
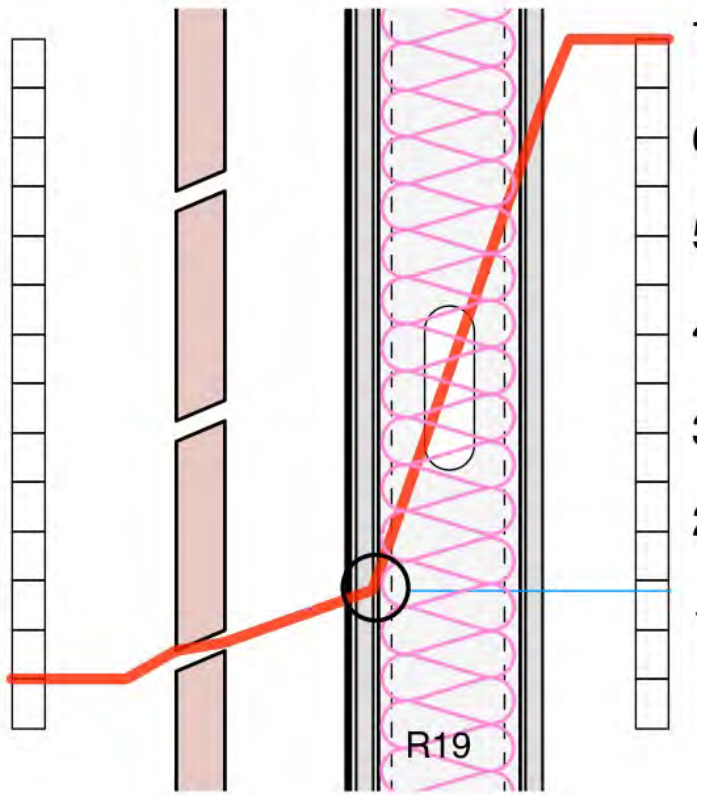
Condensation Control

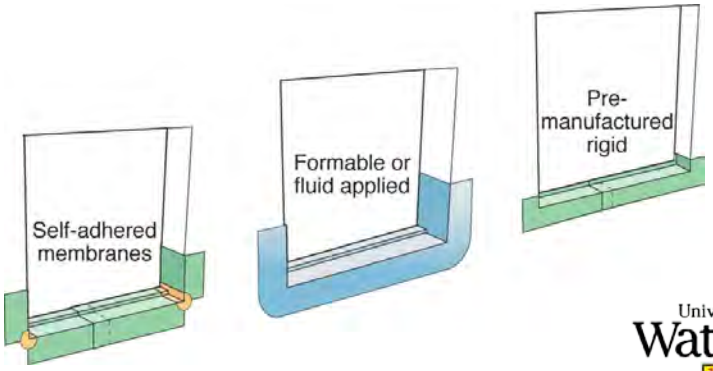




BSD-163 on www.BuildingScience.com

Continuity

- Key to higher performance/repair is **continuity**
  - No holes
- Water control
  - Esp. windows, doors, low-roof-to-wall
- Air Control
  - Esp. rim joists, garages, party walls
- Thermal Control
  - Thermal bridge



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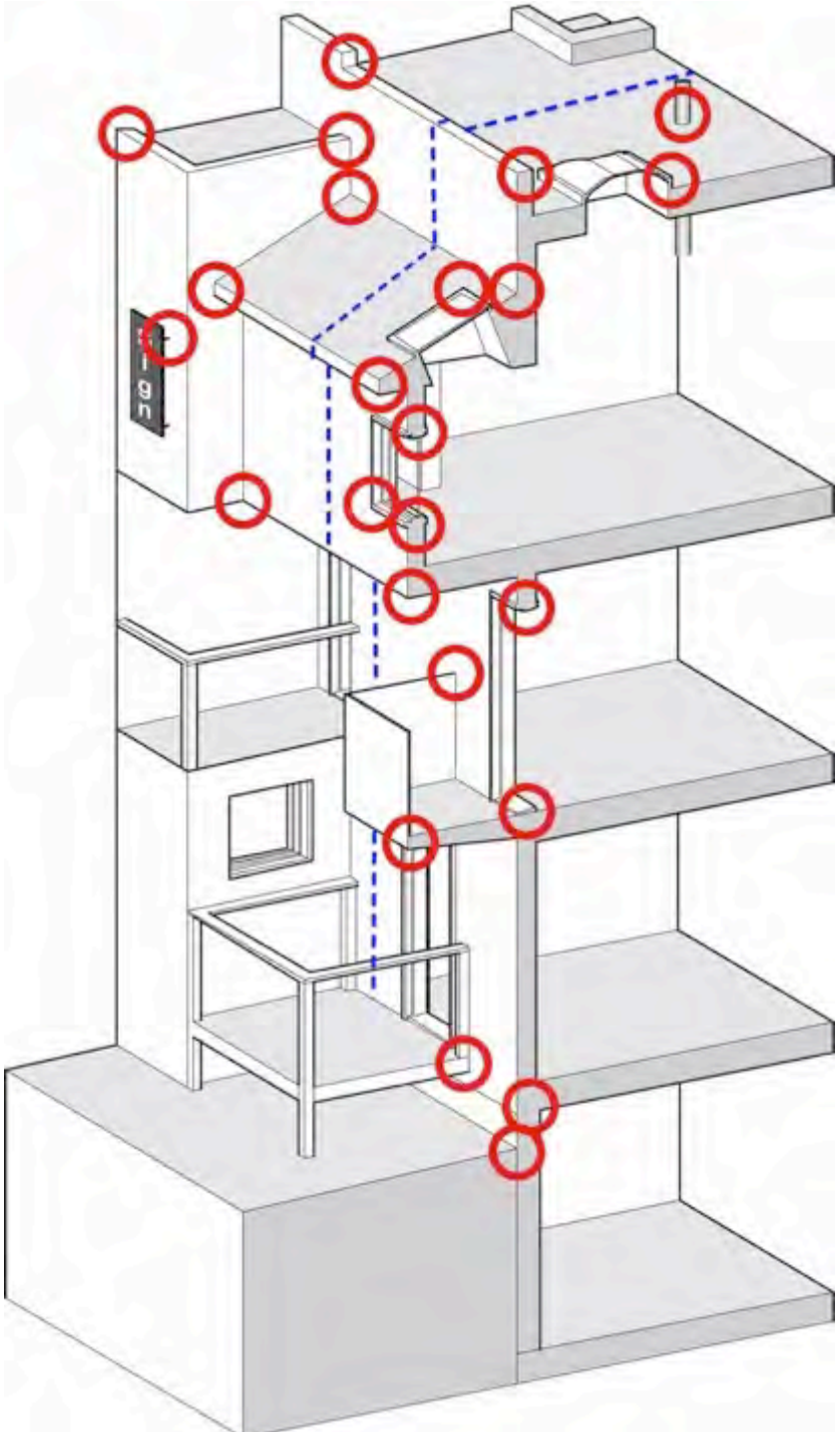
Prefab, “affordable” housing
50

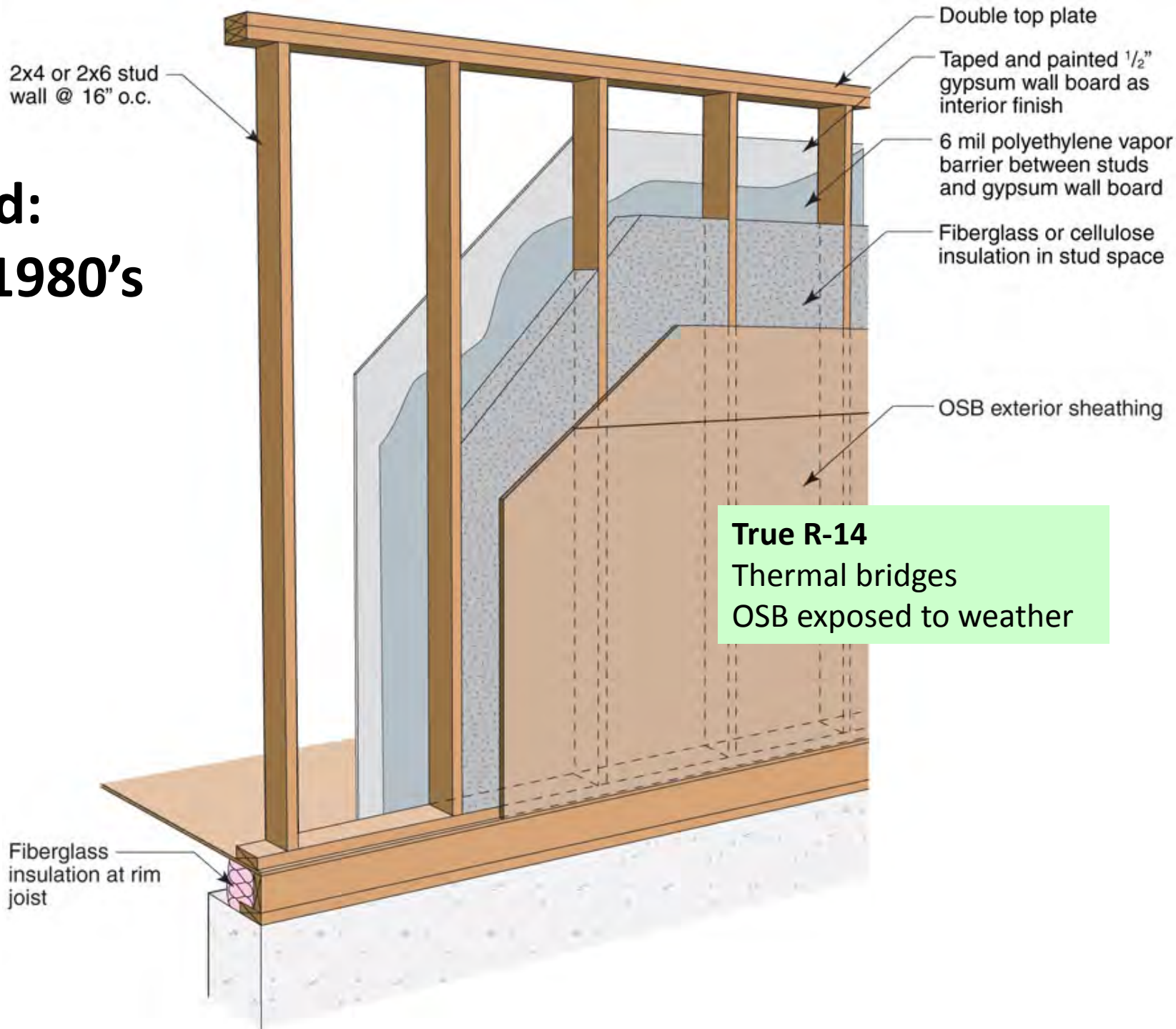
Enclosure Design: Details

- Details demand the same approach as the enclosure.

- Scaled drawings required at ○
  - change in plane
  - change in material
  - change in trade

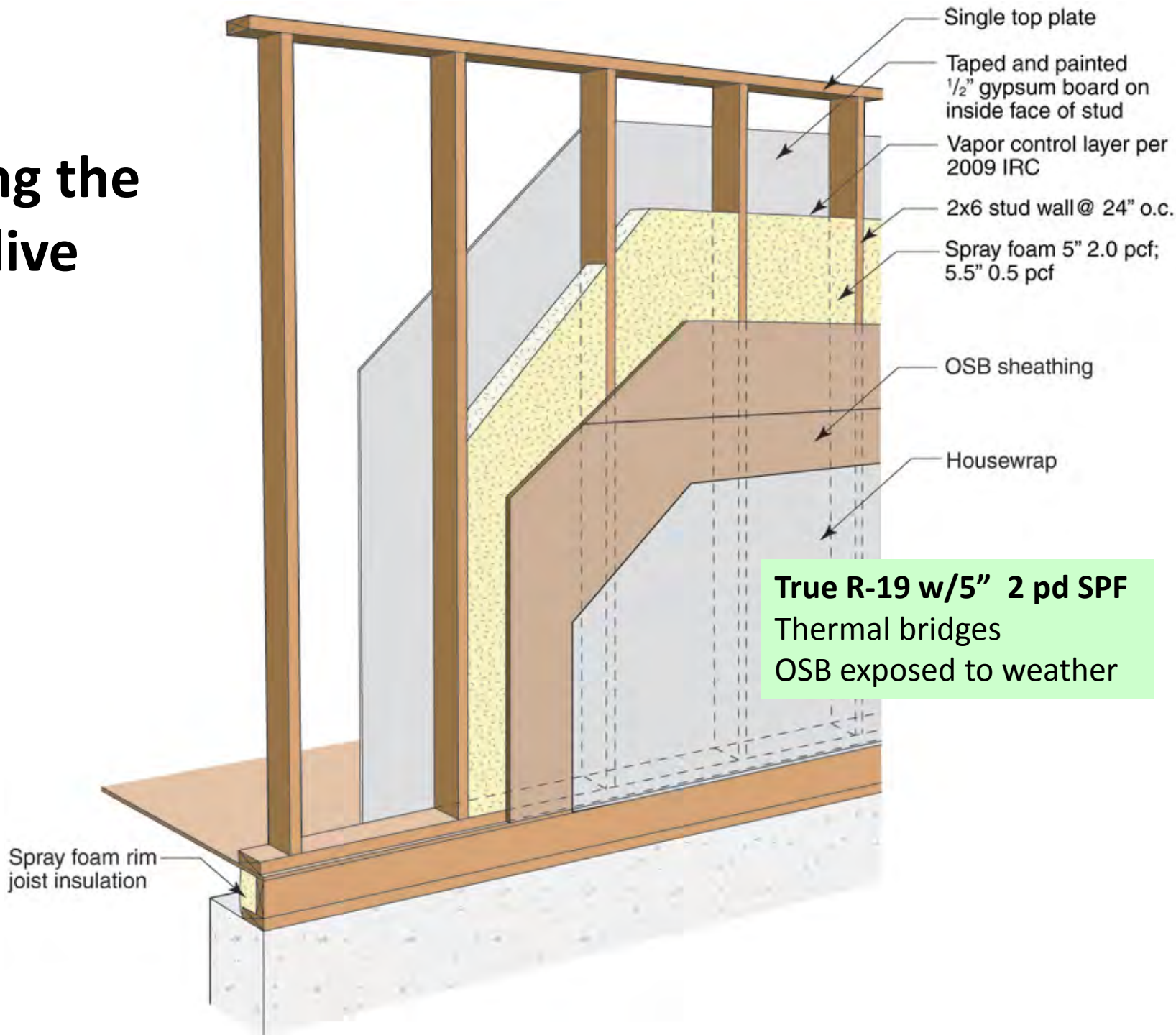


The old:
Since 1980's



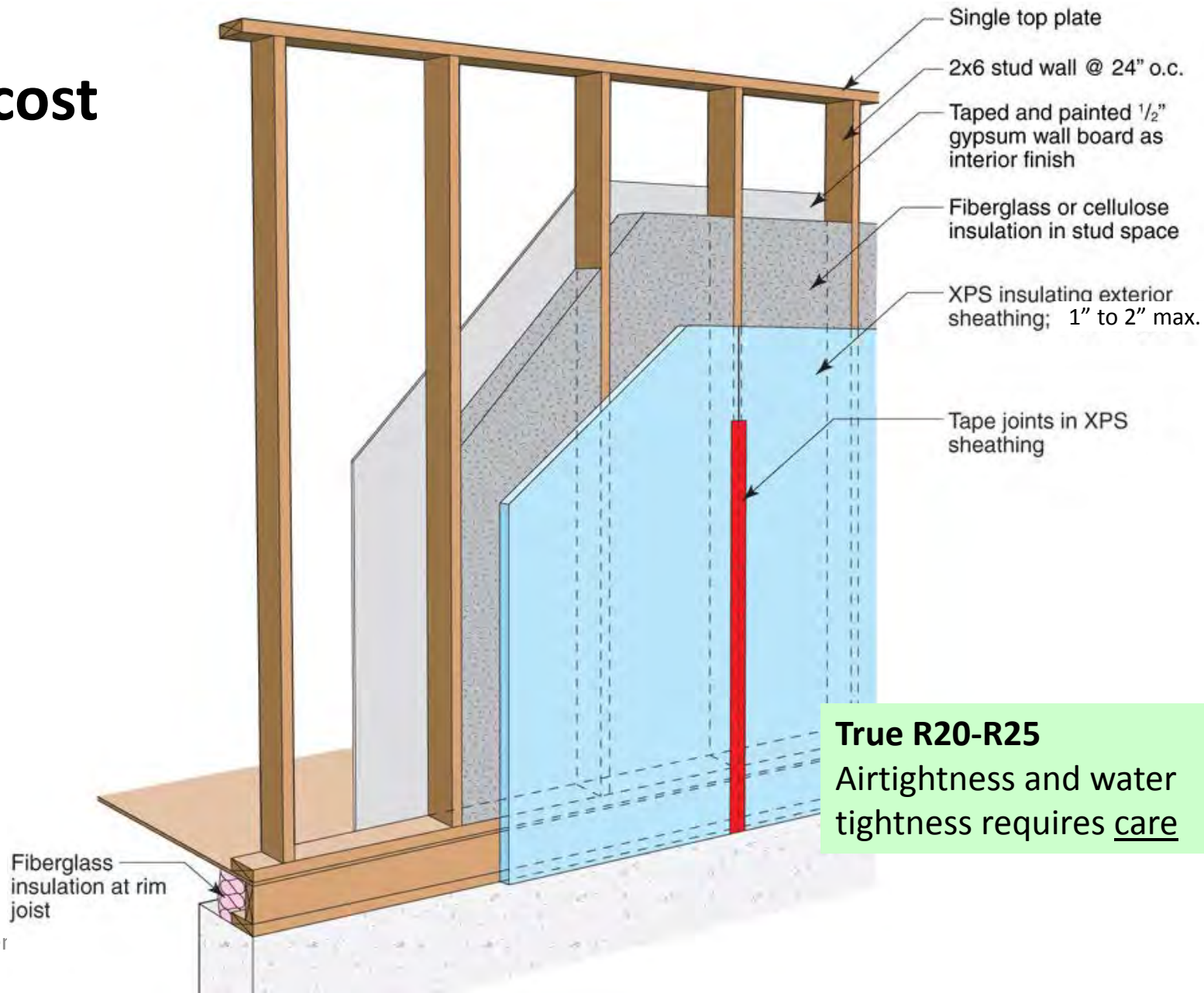
True R-14
Thermal bridges
OSB exposed to weather

Keeping the past alive



True R-19 w/5" 2 pd SPF
Thermal bridges
OSB exposed to weather

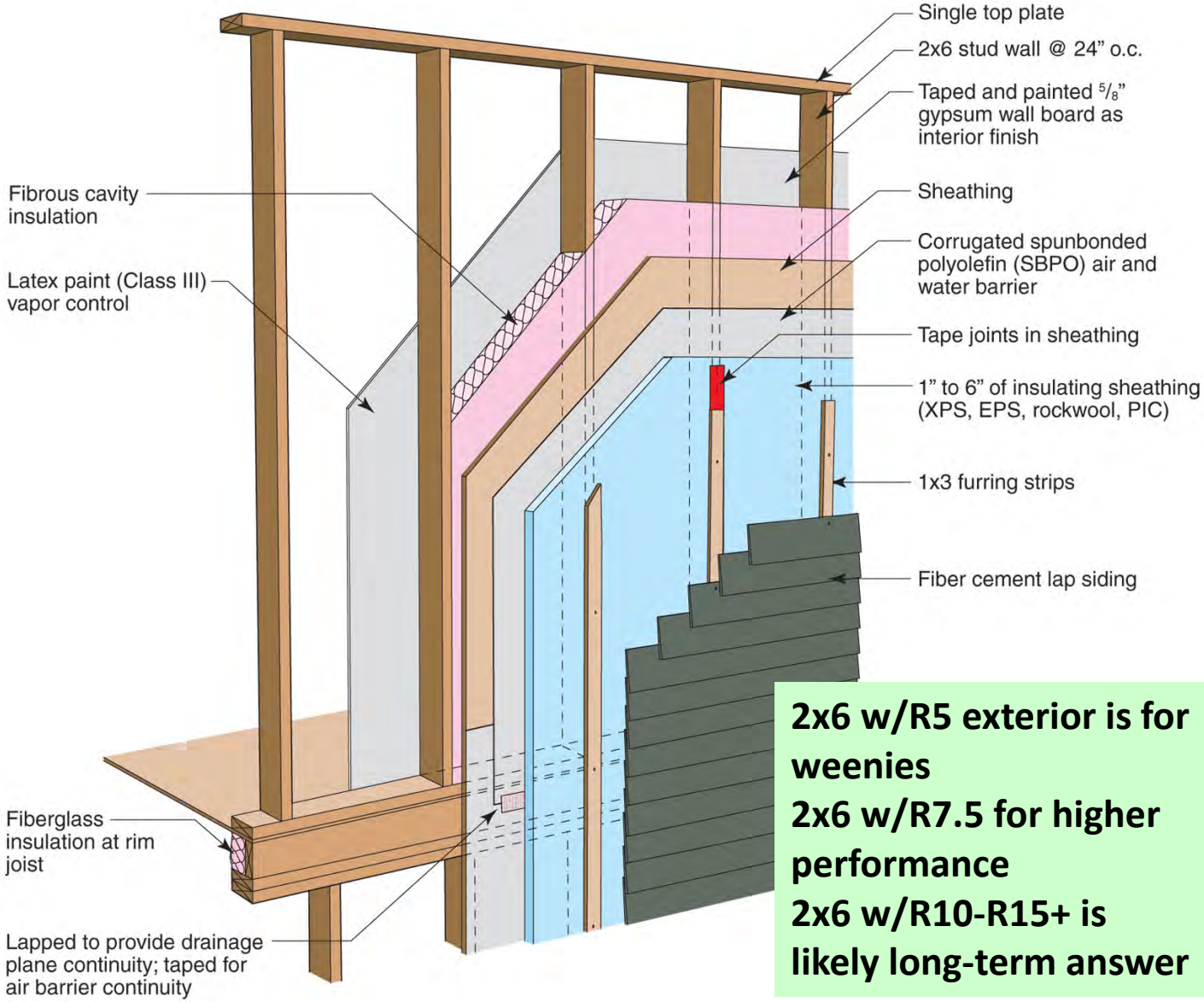
The low-cost next step



True R20-R25
Airtightness and water tightness requires <u>care</u>

Wood Framed

The future "norm"?



Increasing ratio of Exterior to Cavity insulation reduces risk and improves performance

2x6 w/R5 exterior is for weenies
2x6 w/R7.5 for higher performance
2x6 w/R10-R15+ is likely long-term answer

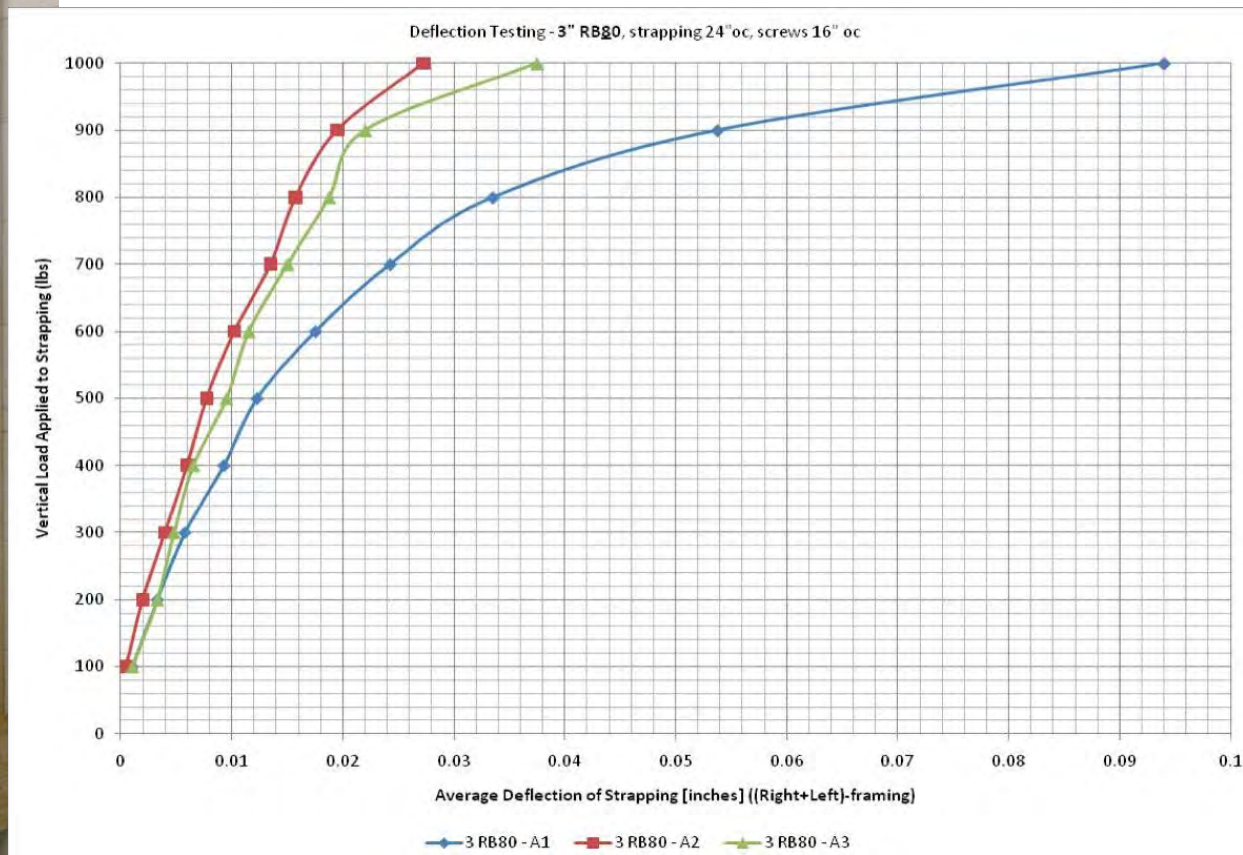
Foam sheathing field testing

Testing

- It works

Rockwool

1x3 furring @ 24” o.c.
#10 screws @ 16” o.c. vertically
Result: 20 psf cladding weight with < 2/100” deflection



18 Williams Avenue Westford, MA

1.5 Story Single Family Home with Conditioned Basement (2200 ft^2 total)

Sunrise Company

C. Nelson Homes

Habitat for Humanity

Integrated Green Building Solutions

GreenCraft Builders

David Weekley Homes

Catholic Charities

ICI Homes

Landmark Fine Homes

Project Home Again

18 Williams Avenue Under Construction

Front Elevation

Tested Air Leakage 2 ach@ 50 Pascals

Building Science Corporation. Architect: Betsy Pettit

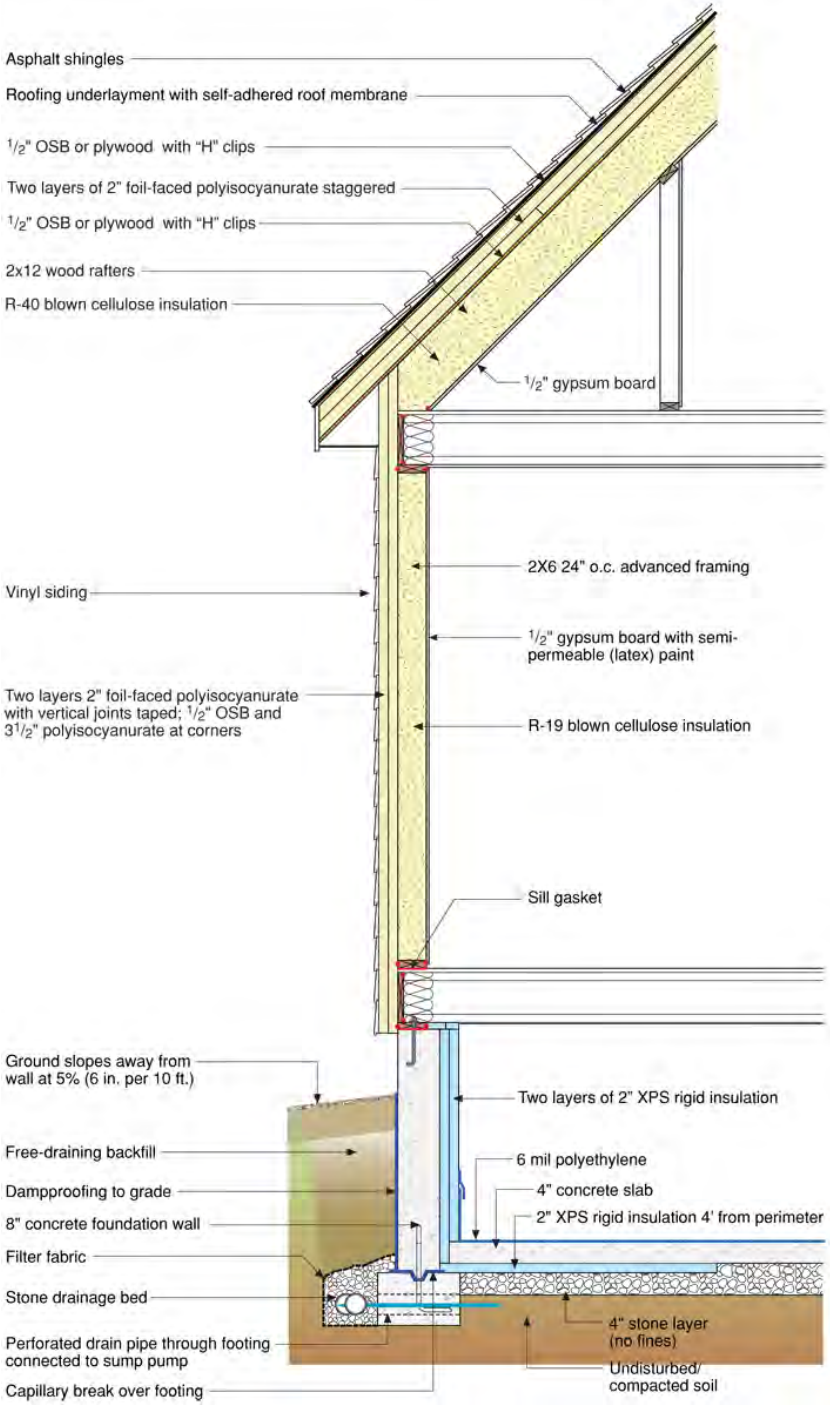
Lowell Habitat for Humanity Westford, MA
2,200 sq. ft. @ $85/sq. ft. HERS 49

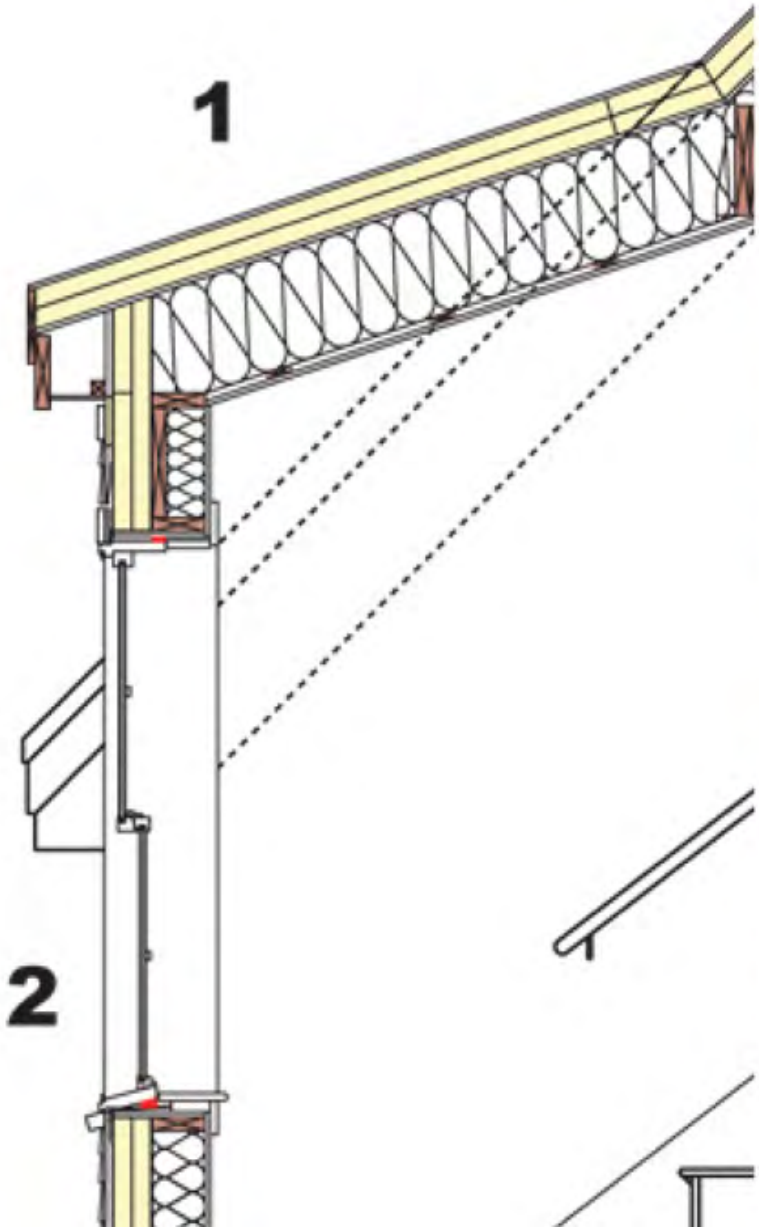
Gas = $50/month @ $1.50 /therm
Electric = $50/month @ $.15/kWh Average = $3.30 per day

With 4 kW PV and 94 sq. ft. solar hot water
Electric = $0 Gas = $37.50/month Average = $1.25/day

Building Science Corporation. Architect: Betsy Pettit

Building Section



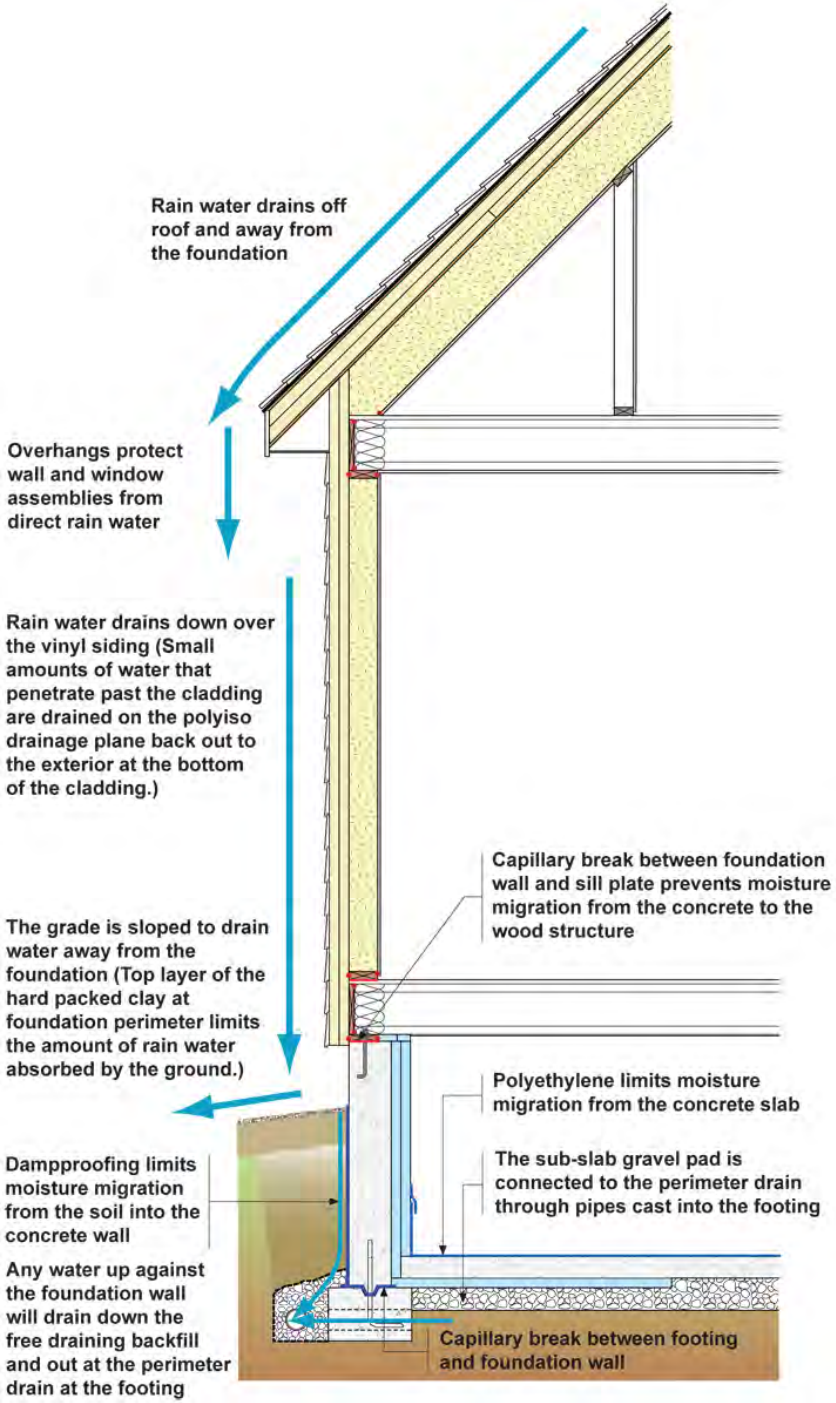

1
2

1

2

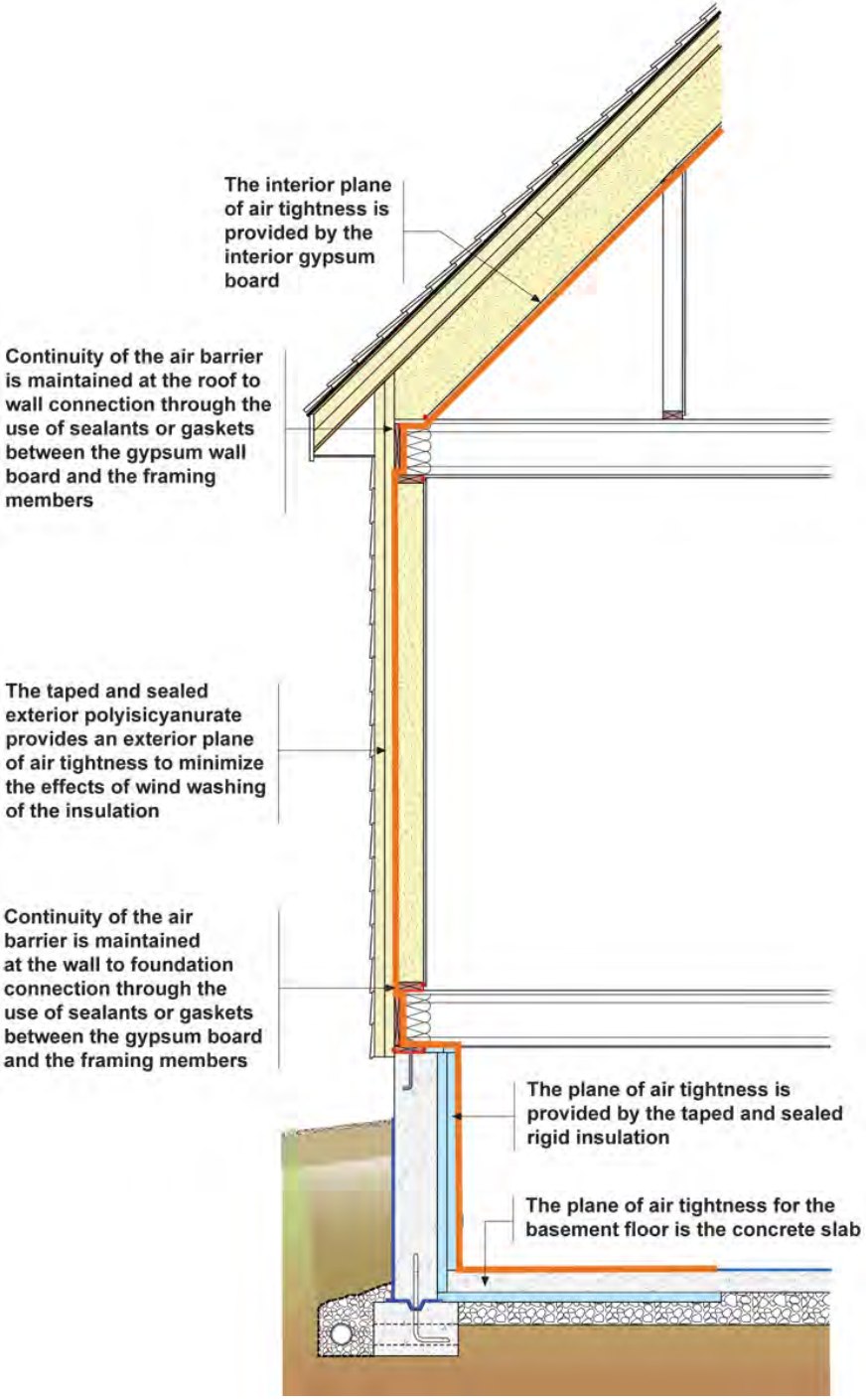
Rain Water Control

- Drained claddings
- Drained openings



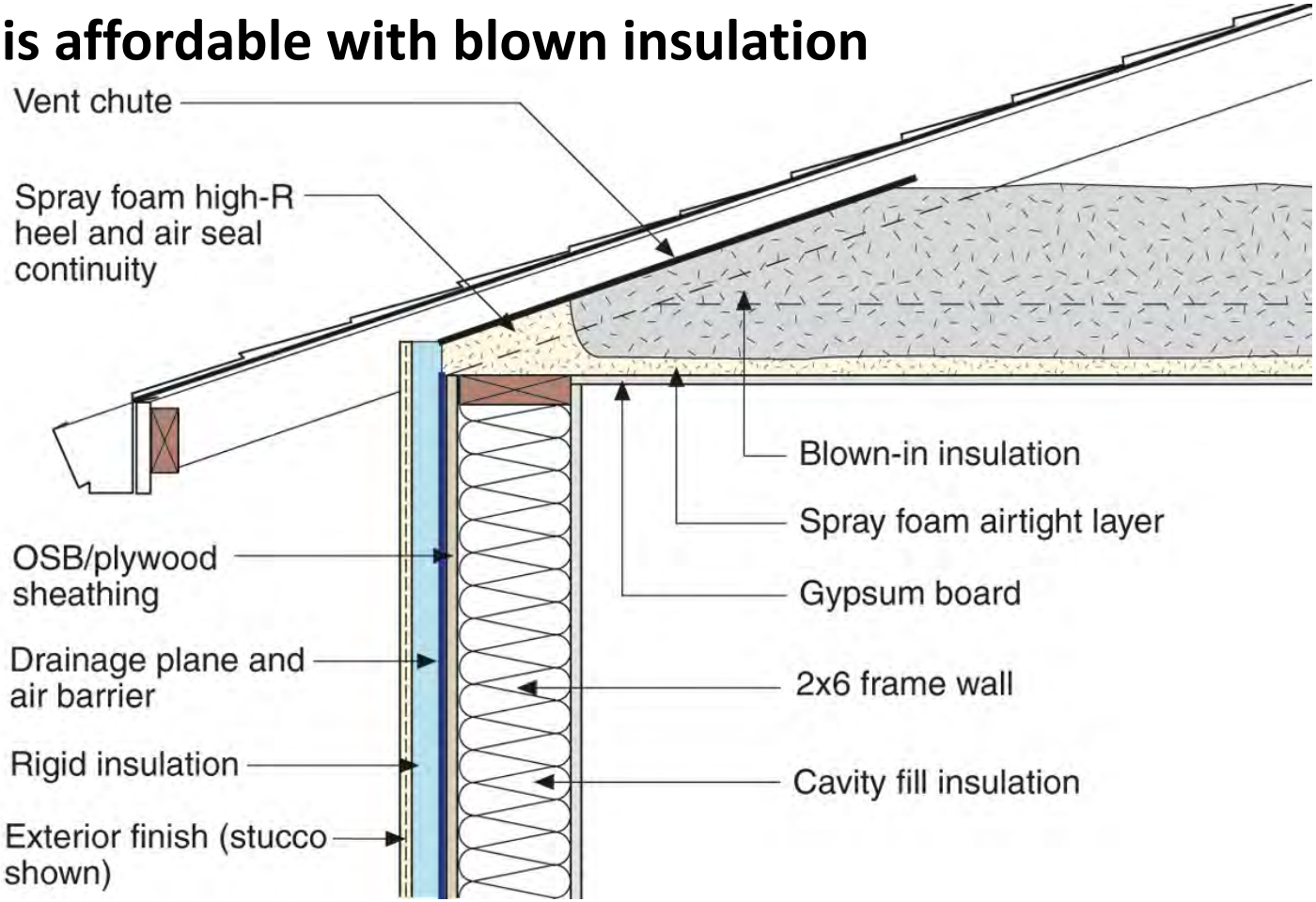
Total Thermal Coverage
(Only screws pass through)

- Airflow control (Air barrier)



Ventilated Attics (less $)

Sprayfoam as airseal, then
R60-R75 is affordable with blown insulation



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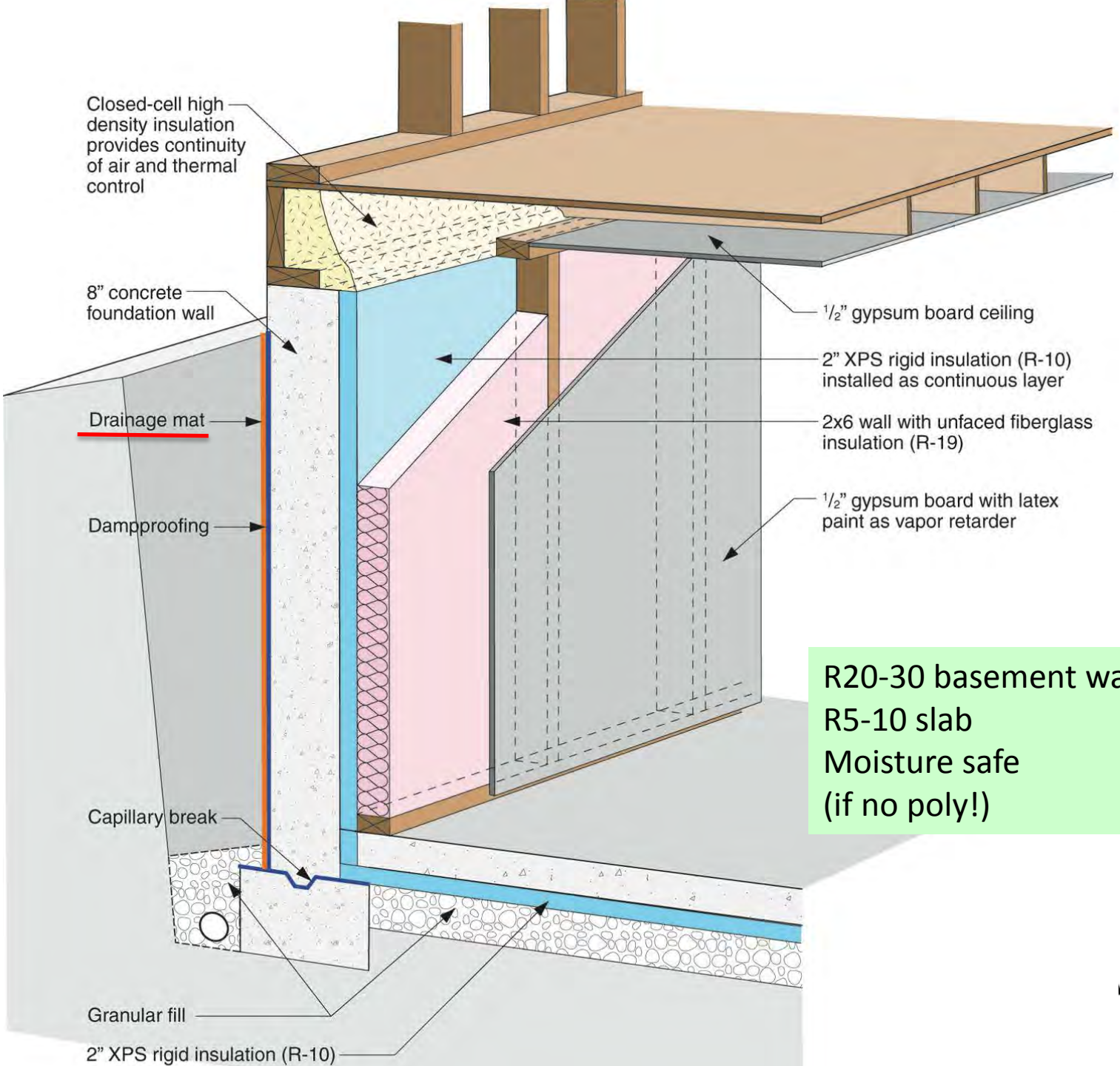

R20-30 basement wall
R5-10 slab
Moisture safe
(if no poly!)

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Retrofits

- Millions of housing units need to be retrofit
- Single- and mulit-family
- Wood-framed and masonry/steel

Deep Retrofits

An opportunity to address:

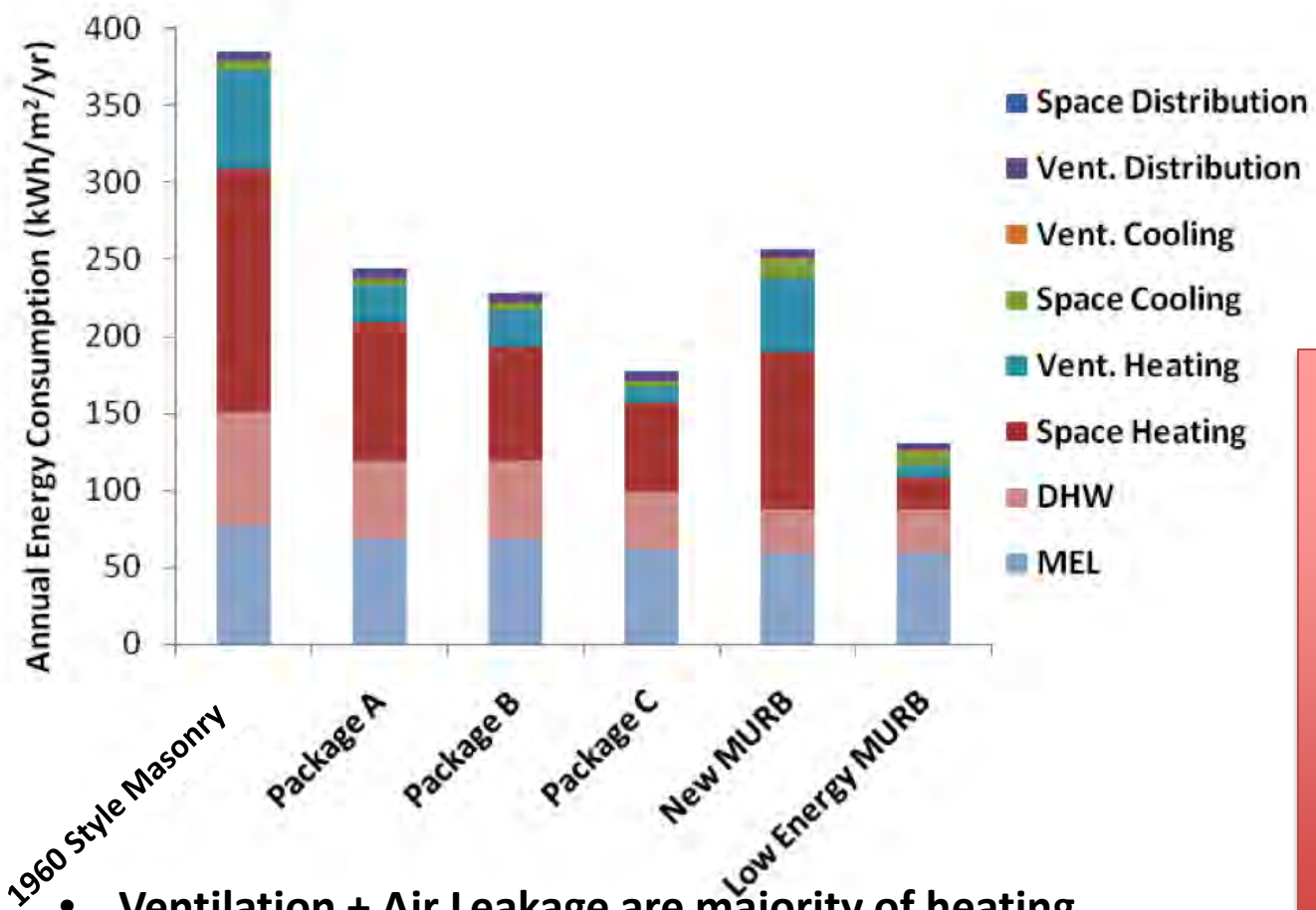
- Comfort problems
- Persistent moisture problems (e.g. wet basement, leaky roof)
- Leaky walls or windows
- Making an attic and/or basement a truly useable space
- Stuffy air
- Siding you're tired of painting
- Tired aesthetics

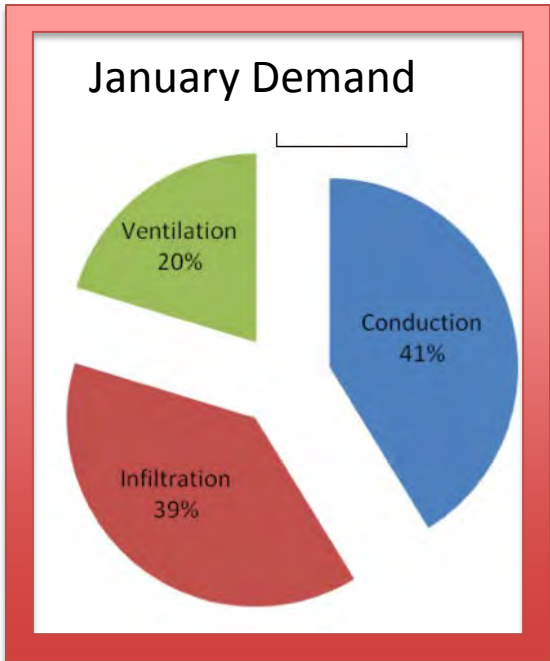
Multi-unit Residential

- How different than row-house / single-family?
  - less enclosure area per unit
  - More fridges/TVs/kitchens, per sf
  - Many different construction techniques, more framing
  - Fire control may be stricter
  - Higher wind and rain exposure

Toronto Multi-unit Example

- Heating is biggest load (50%) in old bldgs
- Major reductions possible, but MELs are hard to reduce …





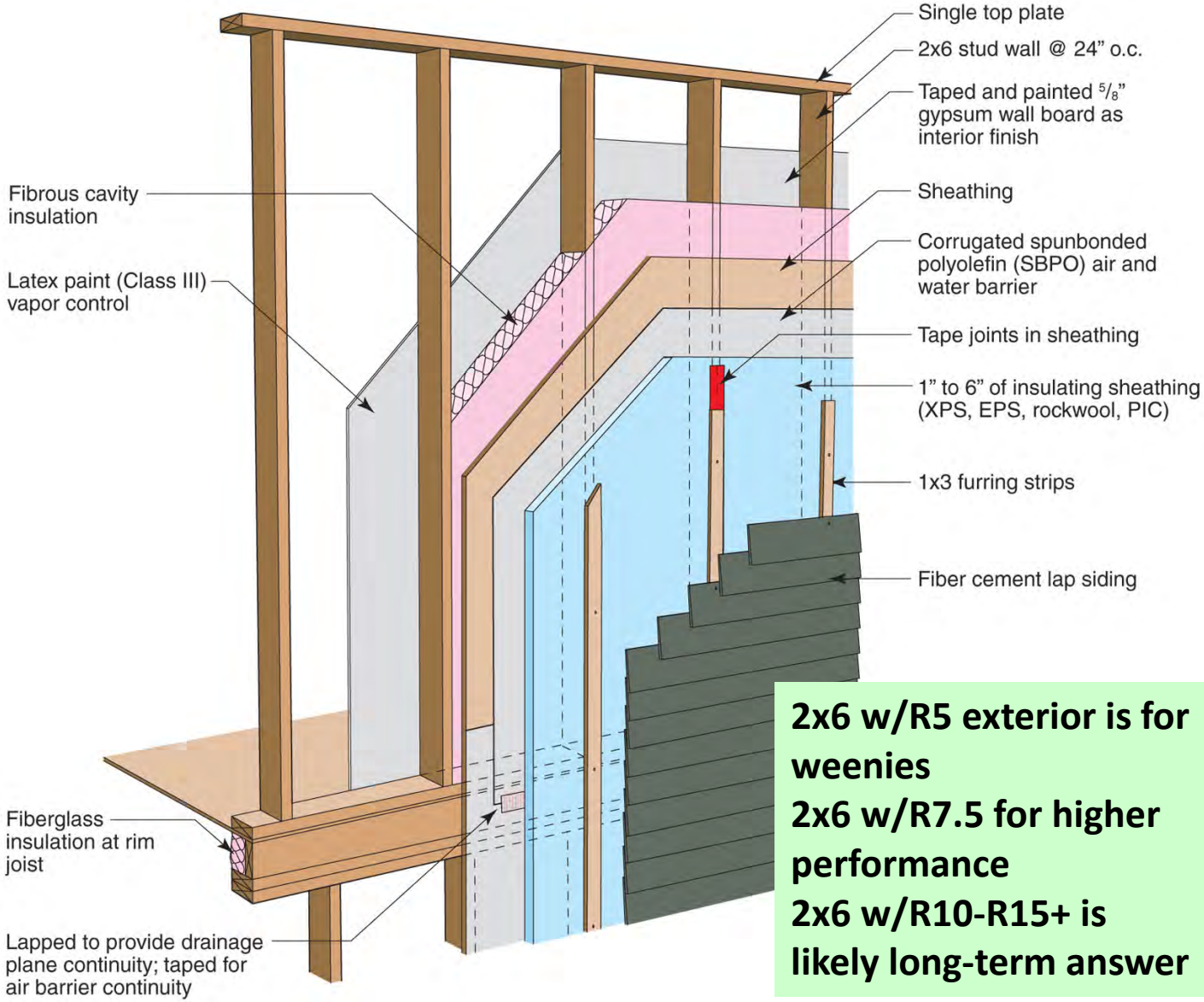
- **Ventilation + Air Leakage are majority of heating demand in cold weather**

Wood-Framed Multi's

- Beware higher exposure
- More complexity = high risk of air/rain leaks
- Respond with more robust design, better quality control

Wood Framed

The future "norm"?



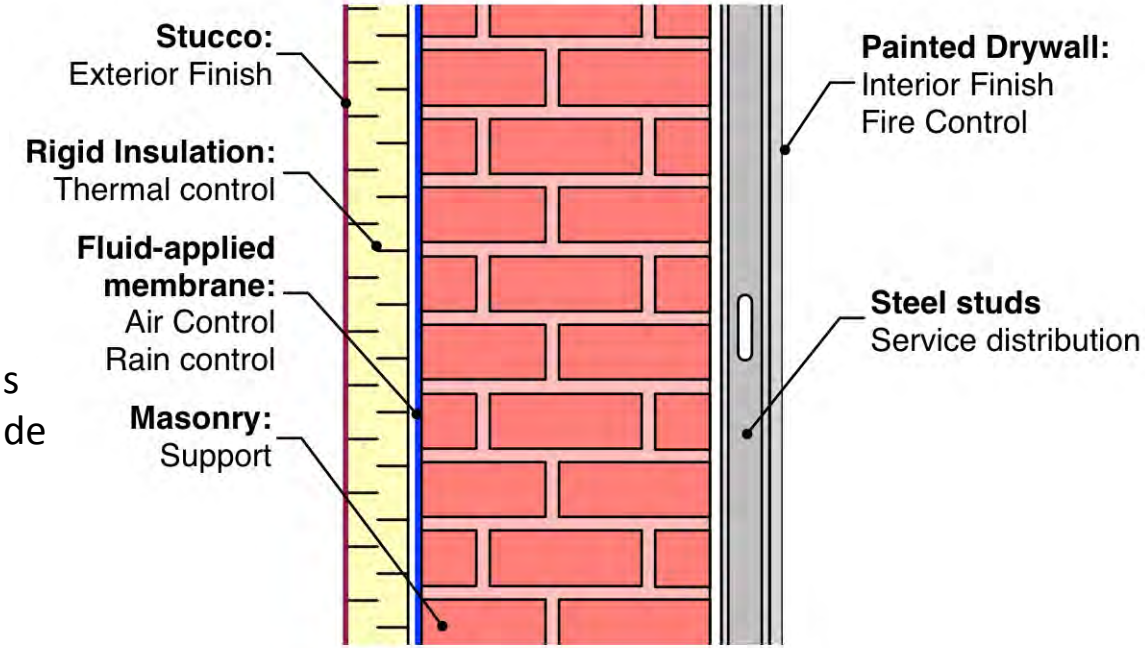
Increasing ratio of Exterior to Cavity insulation reduces risk and improves performance

2x6 w/R5 exterior is for weenies
2x6 w/R7.5 for higher performance
2x6 w/R10-R15+ is likely long-term answer

Load-bearing solid masonry

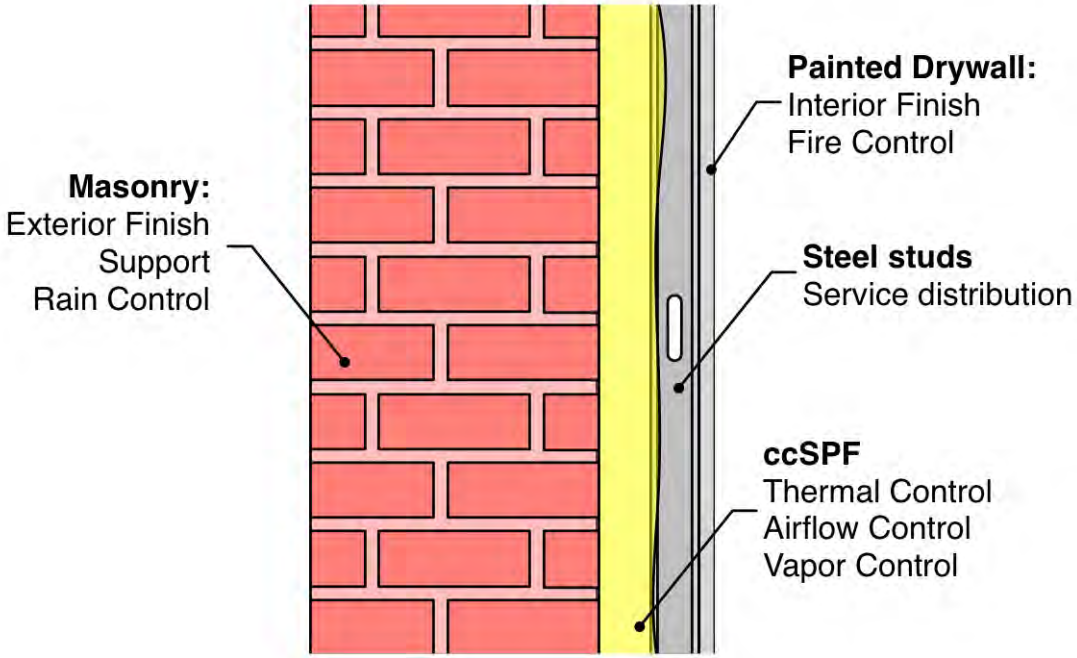
Preferred

- Improve durability,
- change aesthetics,
- solve moisture problems
- Excellent thermal upgrade



If required

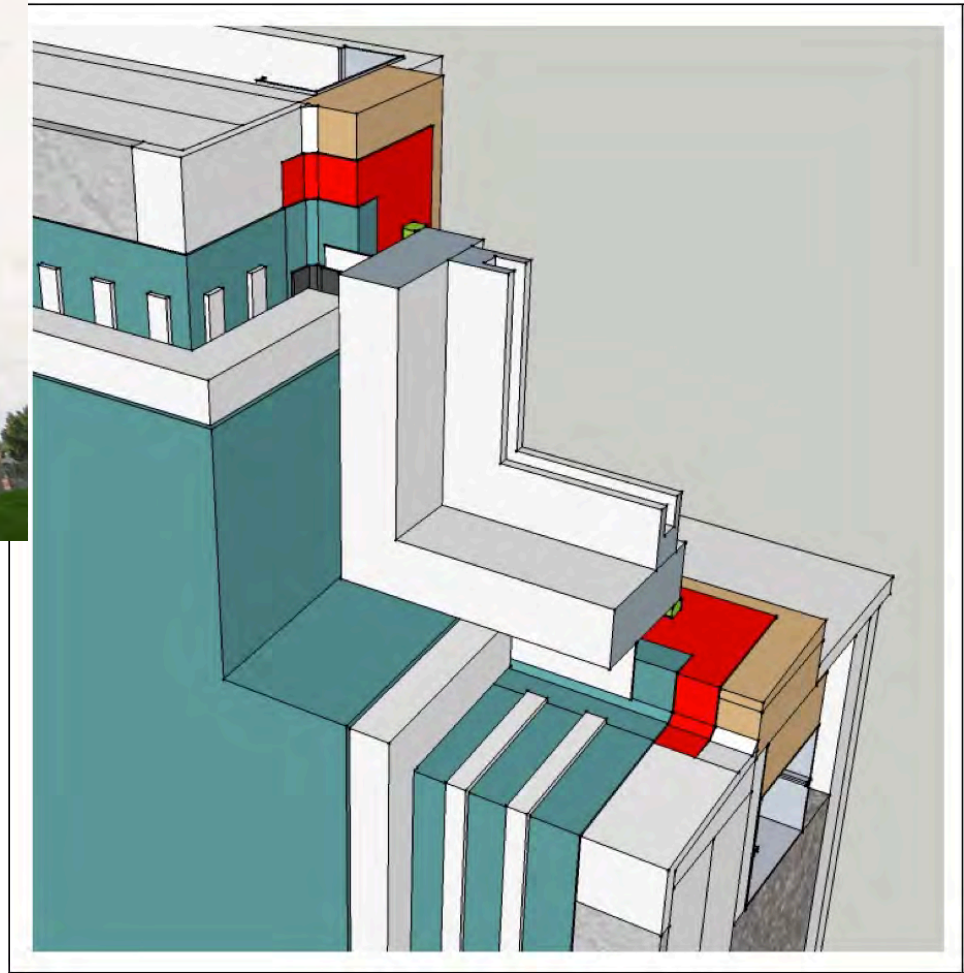
- Maintains aesthetics
- Durability risks
- Thermal bridges remain



Exterior Retrofit

- <u>Preferred</u> Building Science solution
- Great for ugly buildings

Drained EIFS, Window Detail



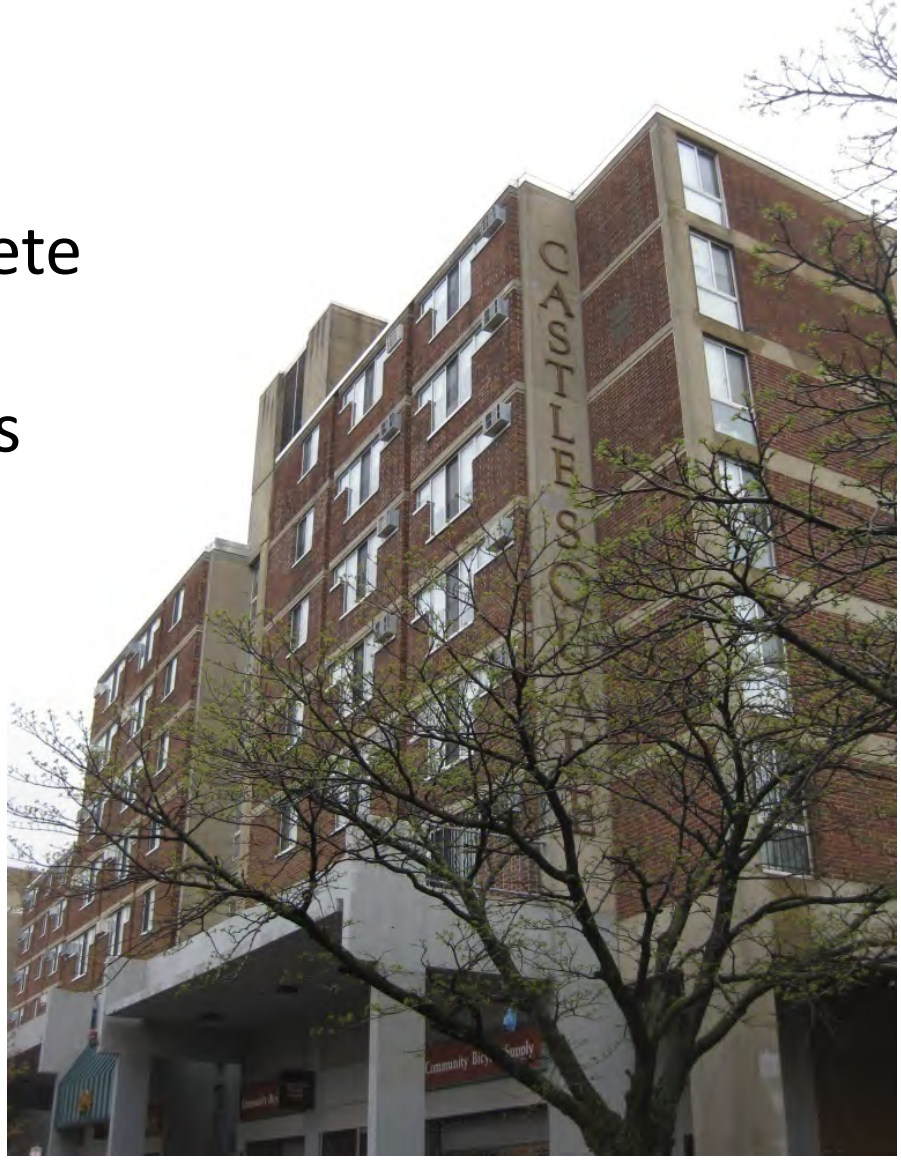
Case Study

- Multi-unit mid-rise retrofit
- Context: serious investment only for redevelopment / renewal of building
- Goal:
  - Leapfrog current performance (50%)
  - ensure another 35-50 yrs durability

Castle Square (Boston)

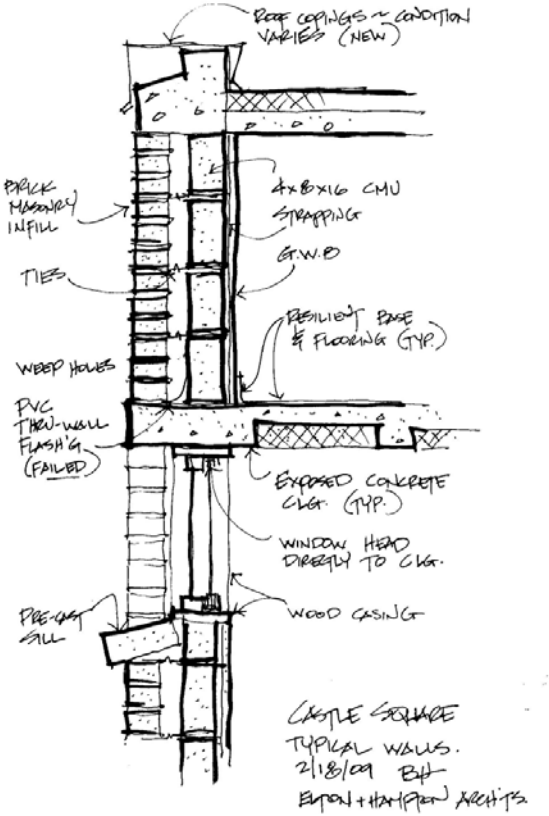
Project overview

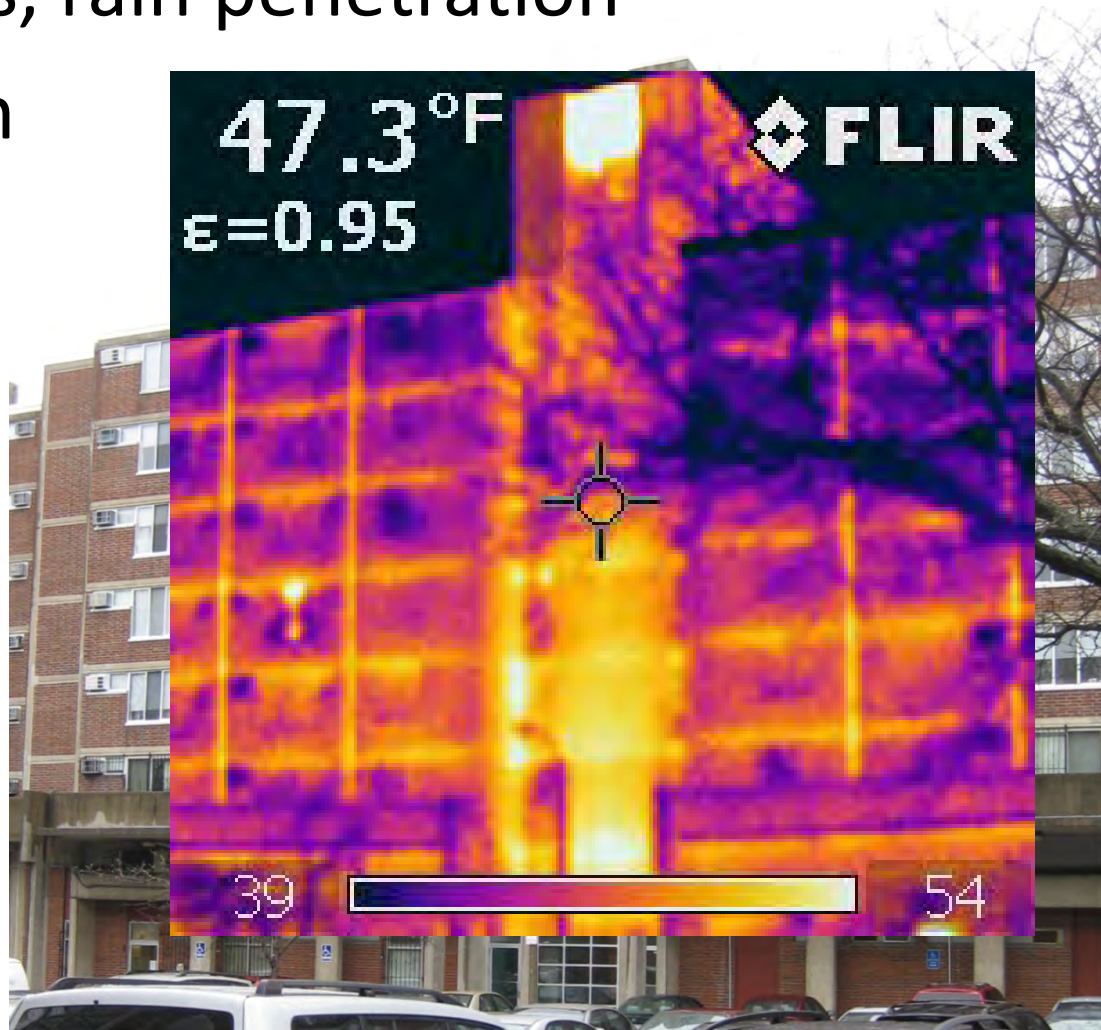
- Occupied renewal
- 1960's era, brick and concrete public housing structure
- Majority owned by residents association
- 192 units, 7 stories



Problems

- heat loss, air leaks, rain penetration
- Incipient corrosion





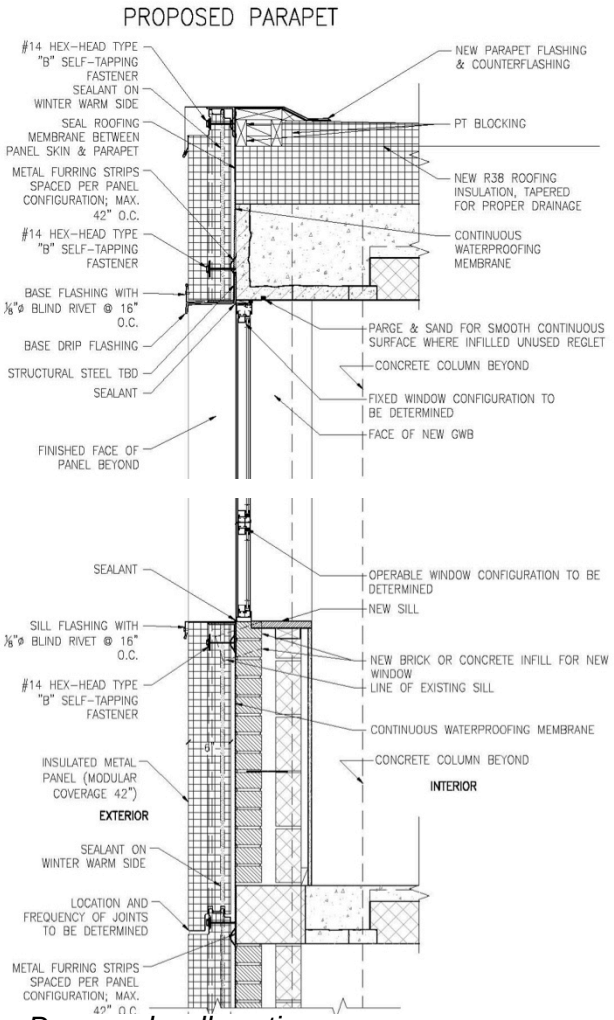
Chosen Solution

- Exterior recladding (new look, insulation, rain)
  - Insulated metal panels
- New windows (integrated)
- Air separation (compartmentalization) of suites
  - Required suite-by-suite work
- New HVAC

Castle Square Mid-Rise Retrofit

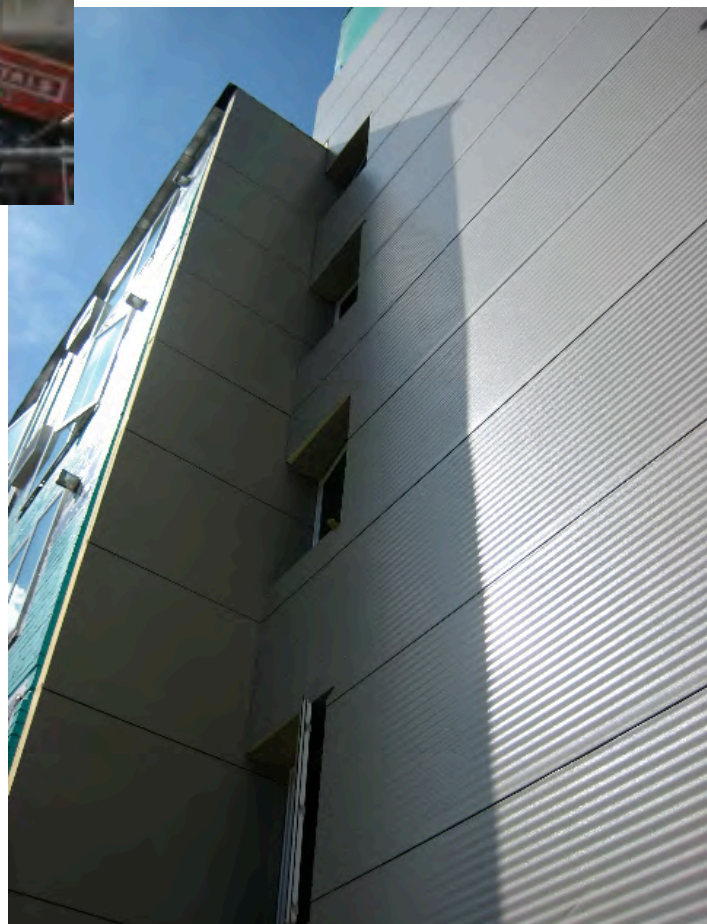
Boston, MA

- Retrofit Enclosure Design
  - R-40 Roof Insulation
  - R-40 Walls
    - Air and water control membrane applied to exterior
    - Insulated metal panel cladding system
    - mineral fiber convection suppressant layer
  - R-5 Windows
    - Low-E triple pane argon filled, fiberglass/vinyl/composite frame

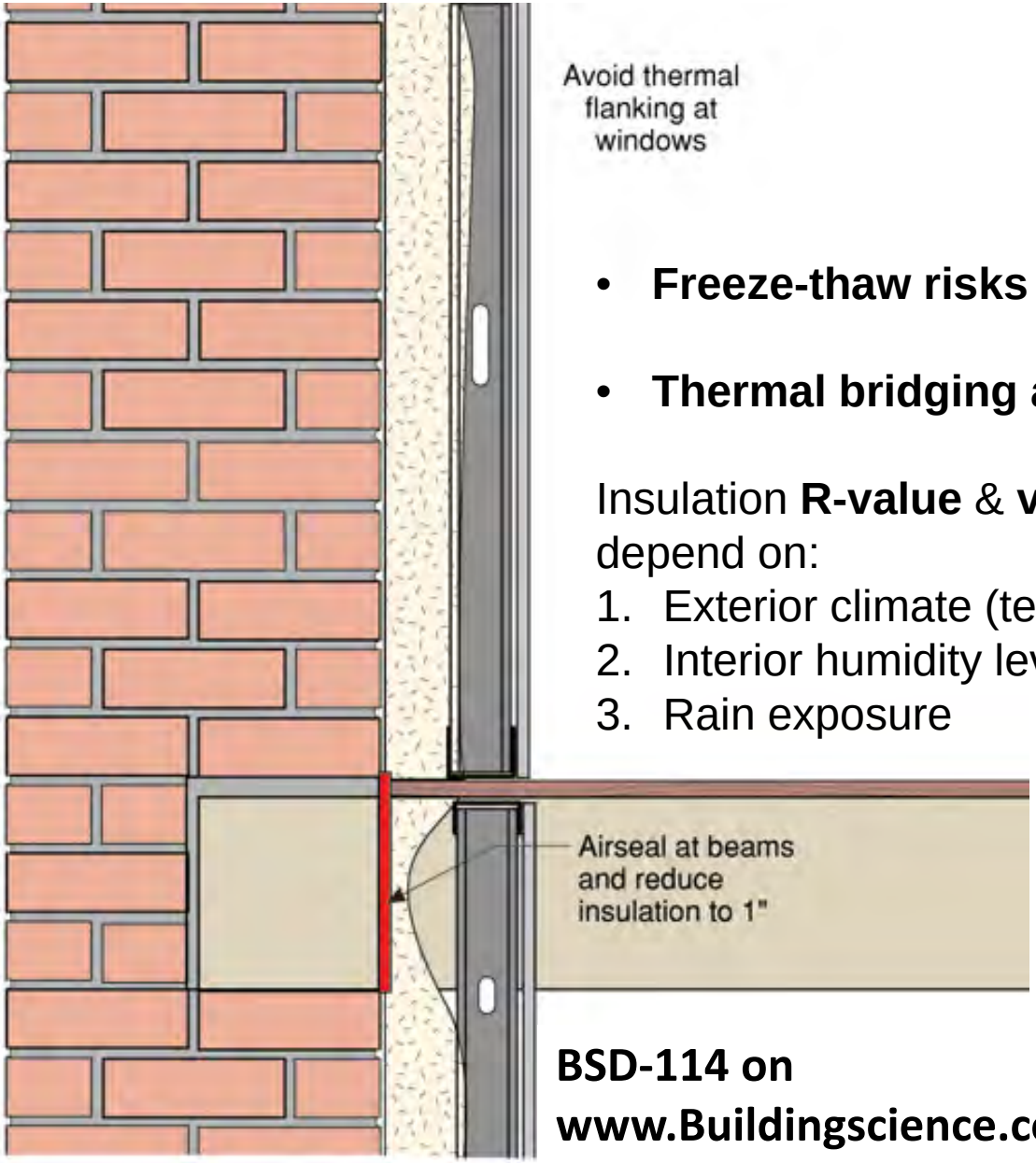


Proposed wall section

Lull



Common Interior Solution



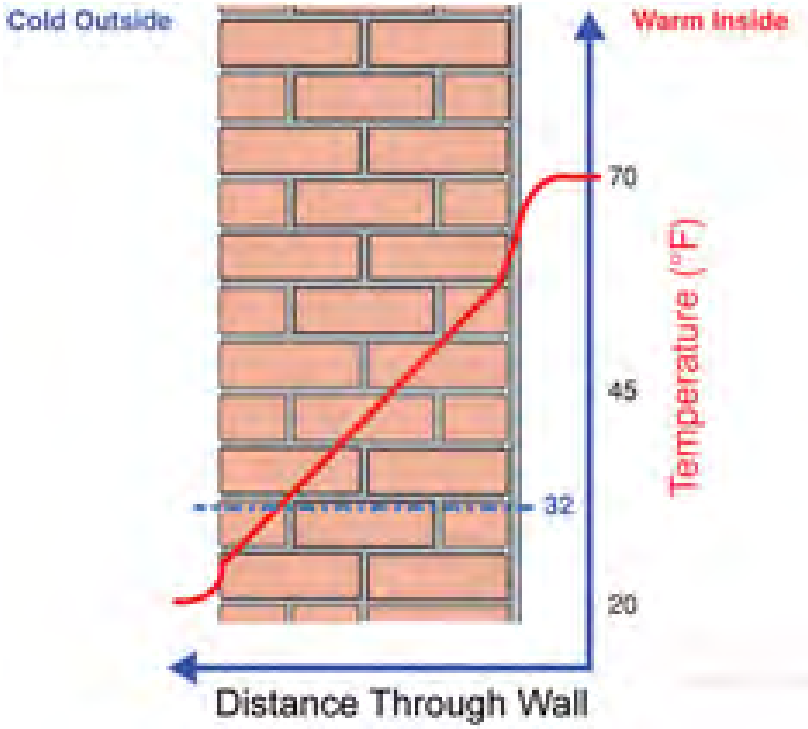
- **Freeze-thaw risks in cold climates**
- **Thermal bridging at floors / walls**

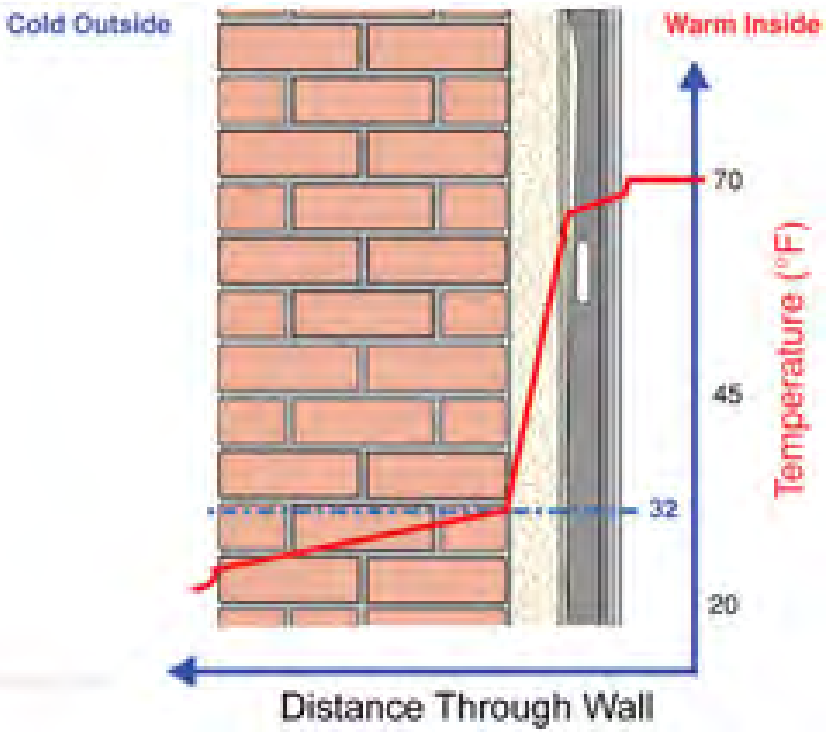
Insulation **R-value** & **vapor permeance** depend on:

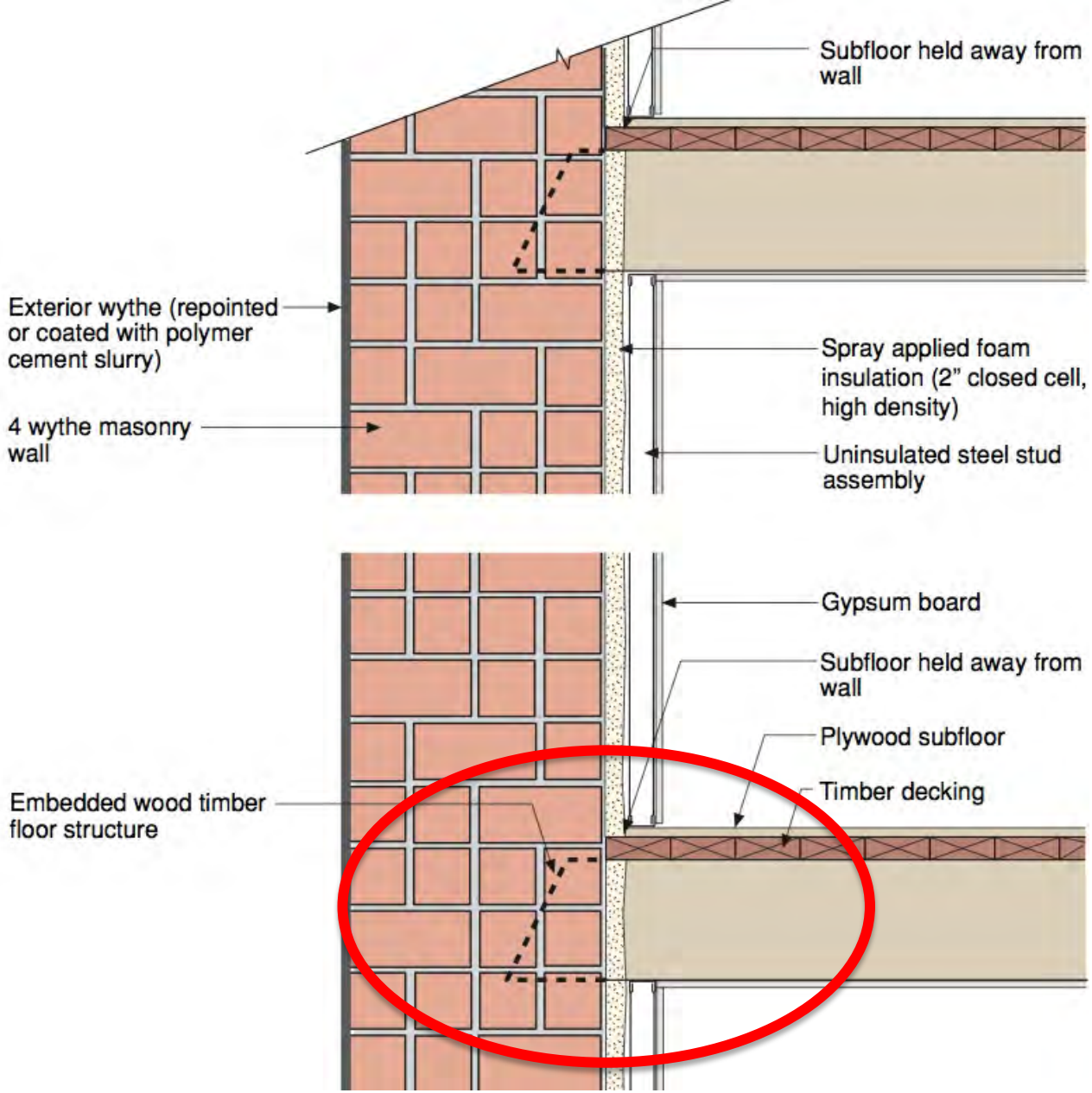
1. Exterior climate (temp / drying)
2. Interior humidity levels
3. Rain exposure

BSD-114 on www.Buildingscience.com

Interior Insulation





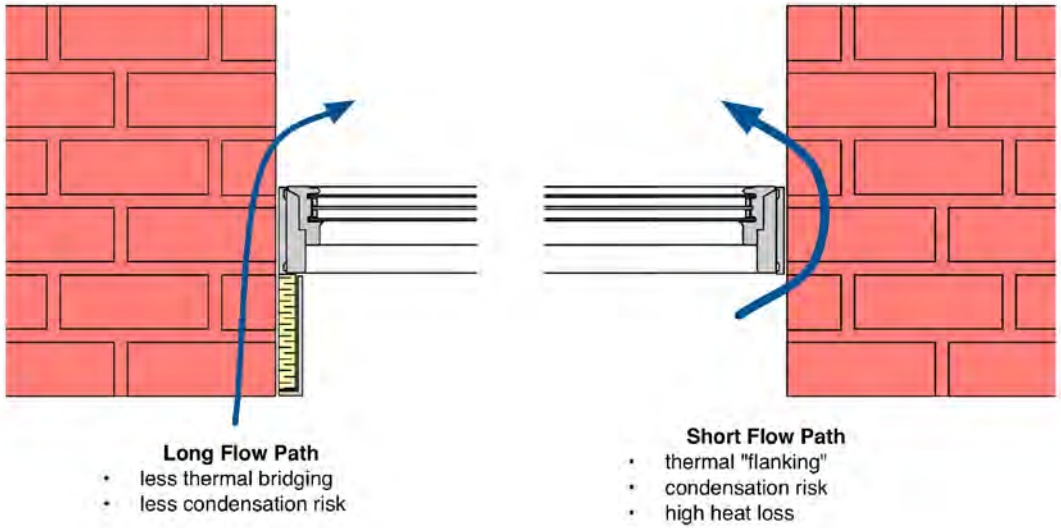


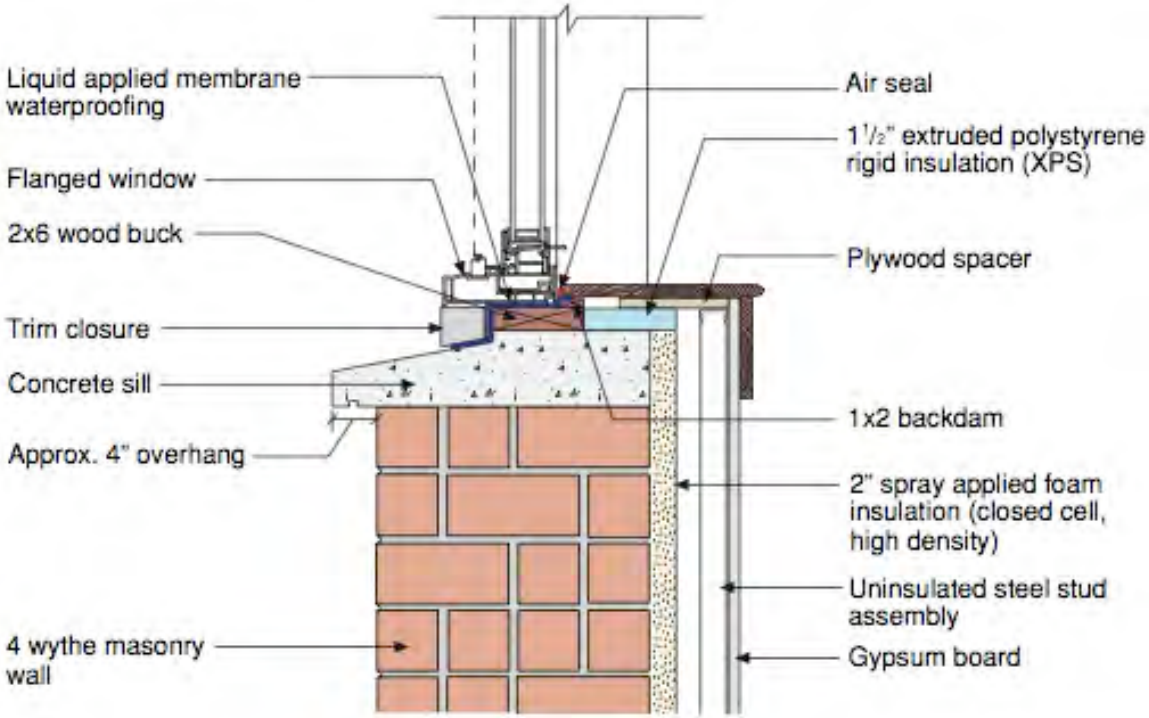
Solutions:

1. Treat material
2. Add local heat
3. Add interior structure

Windows

- Rain control and thermal continuity





HVAC

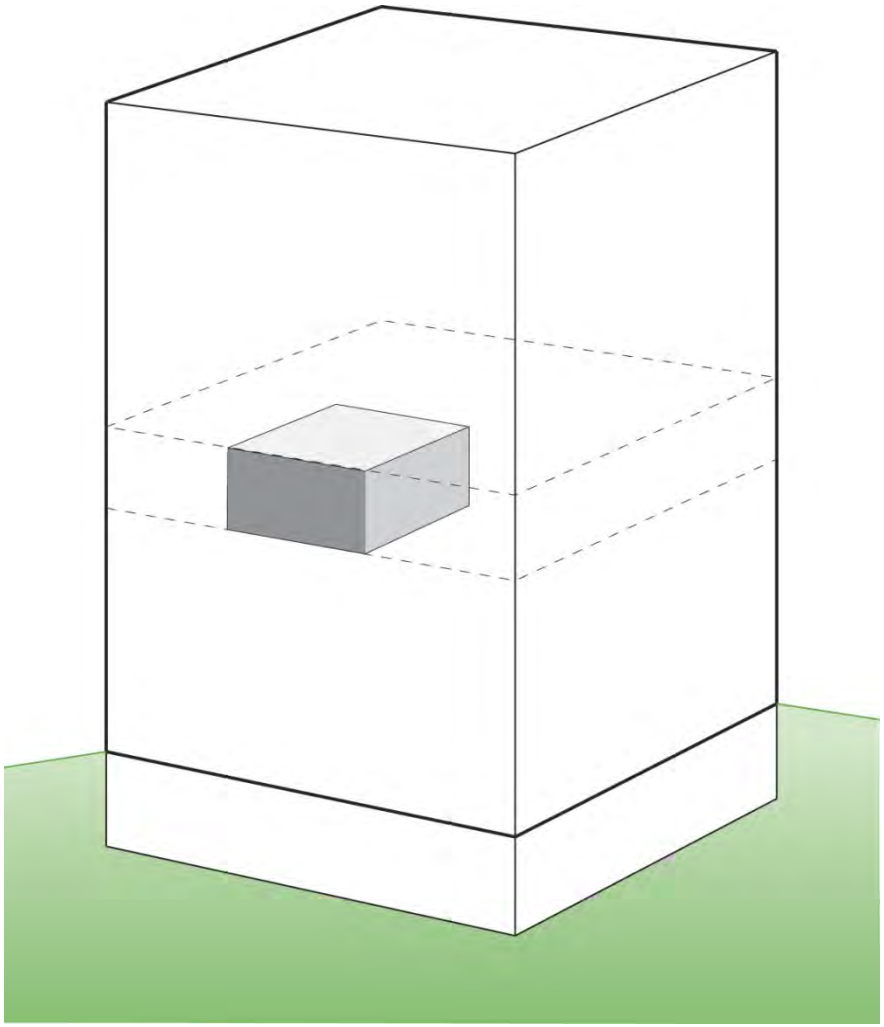
- Major topic on its own
  - HVAC is a bad acronym
- Heating
- Cooling
- Ventilation
- DHW

Mechanical Systems

- Beware replacement timing vs enclosure upgrades
- Many systems are *inefficient*, even with efficient *equipment*
- Large central heating/chilling often far less efficient than assumed

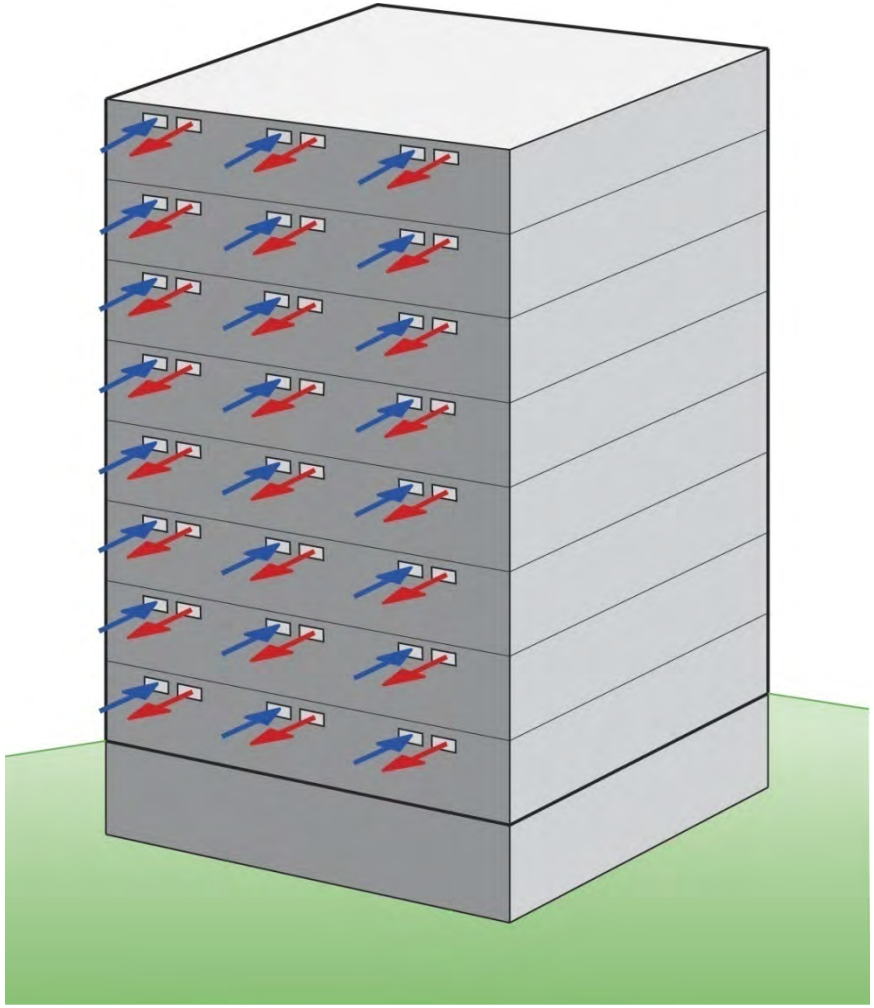
Compartmentalize each suite

- Major sound, odor, fire & smoke benefits!
- Part of airsealing



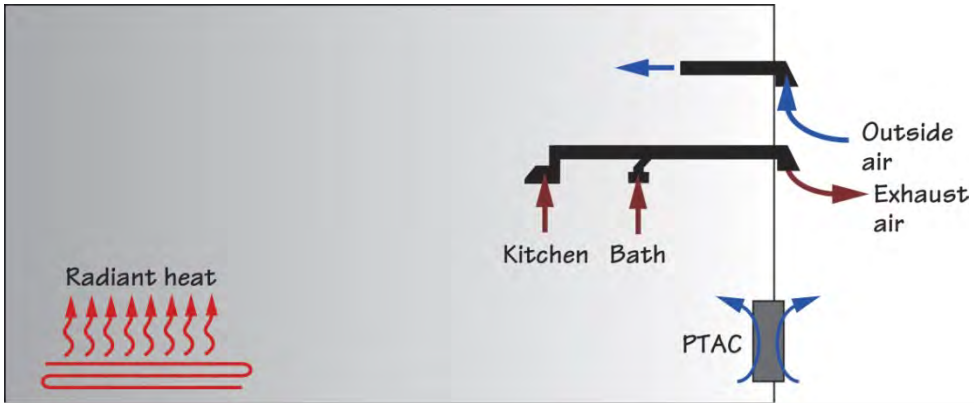
HVAC Compartmentalization

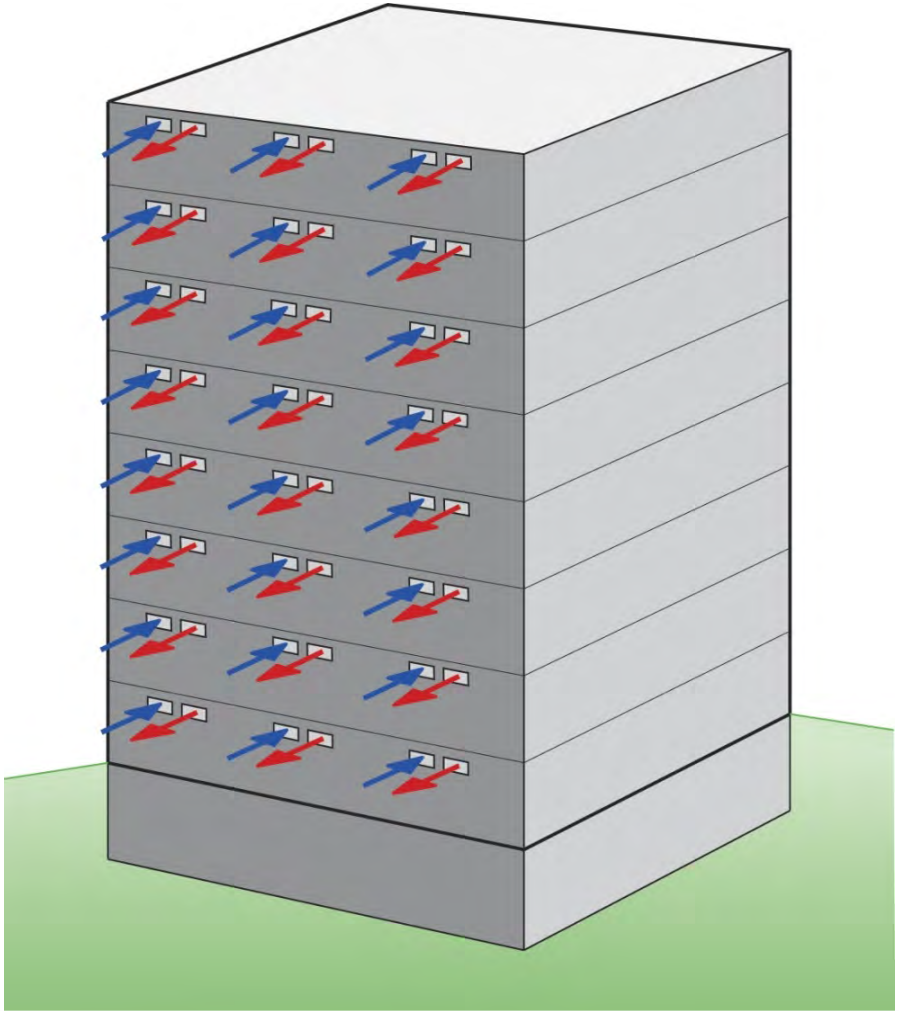
- Suite-by-suite is often the lowest cost, AND highest efficiency system
- Only Hotwater offers capital cost savings if central
- But Hotwater distribution losses are often large



Ventilation

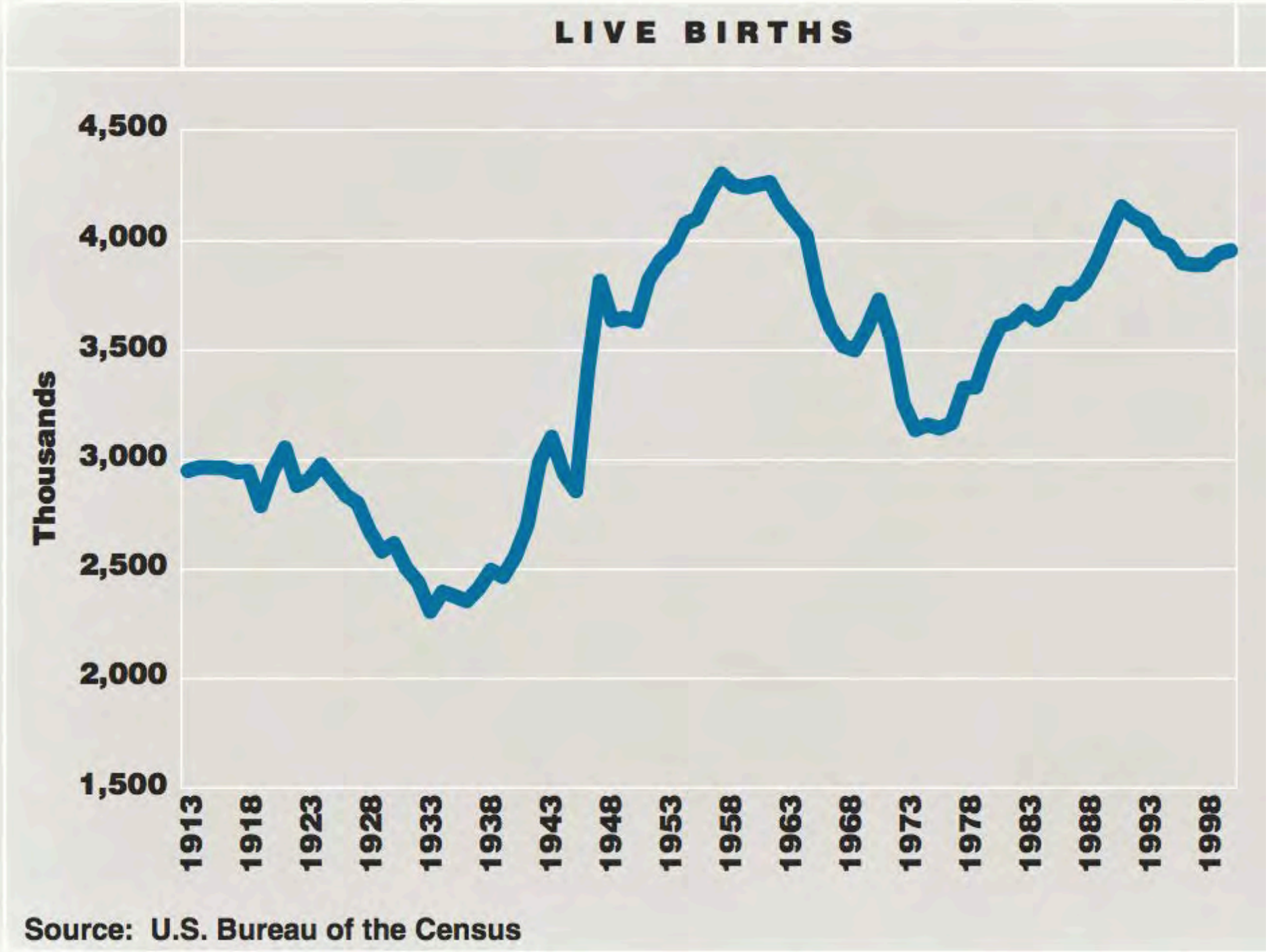
- **Each suite should have controlled supply flow and exhaust**
- **Most systems don't do this and work poorly and waste energy**

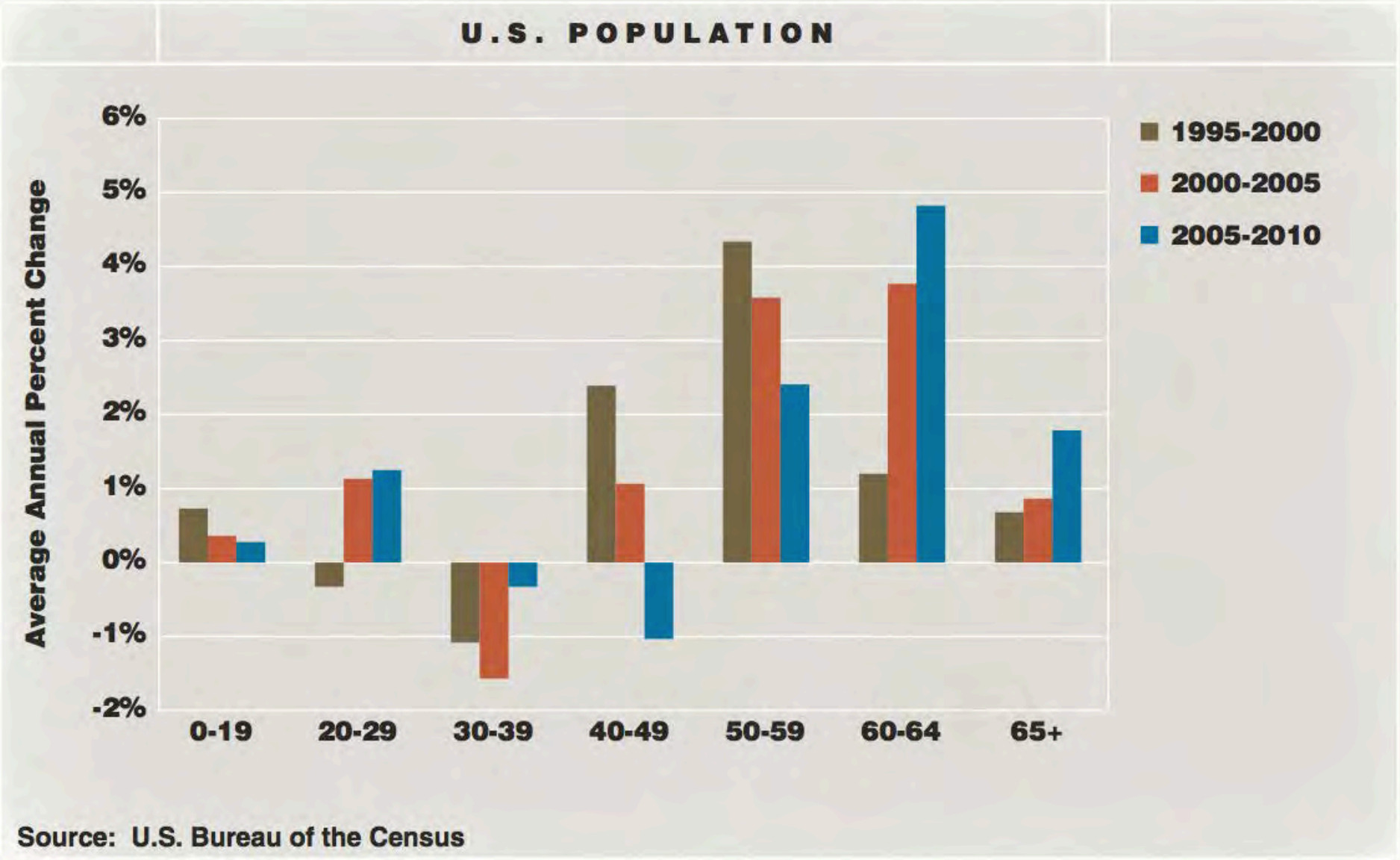




Conclusions

- Great potential to improve durability, comfort and energy efficiency of housing
  - New and existing
  - Science is available to guide best decisions
  - Critical that design is correct
  - Good workmanship/operation of course is also needed


LIVE BIRTHS
Thousands
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1913
1918
1923
1928
1933
1938
1943
1948
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
Source: U.S. Bureau of the Census


U.S. POPULATION
Average Annual Percent Change
6%
5%
4%
3%
2%
1%
0%
-1%
-2%
0-19
20-29
30-39
40-49
50-59
60-64
65+
1995-2000
2000-2005
2005-2010
Source: U.S. Bureau of the Census

NO
TRESPASSING

Tyvek
HomeWrap
S-65
4943