We will be starting soon!

Thanks for joining us

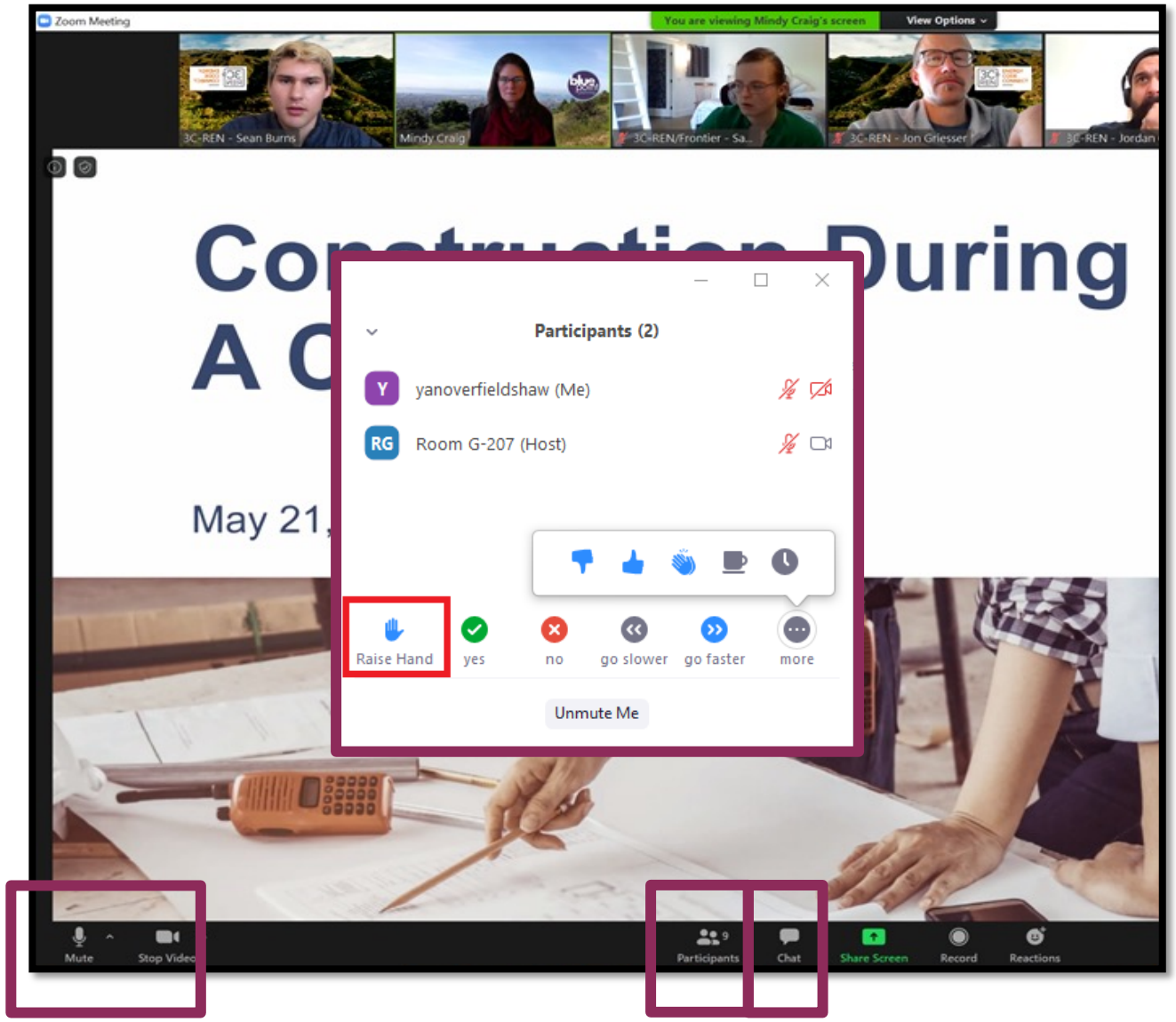
The Role of Building Science in High Performance Building

Peter Yost, Building - Wright

May 17th & 19th

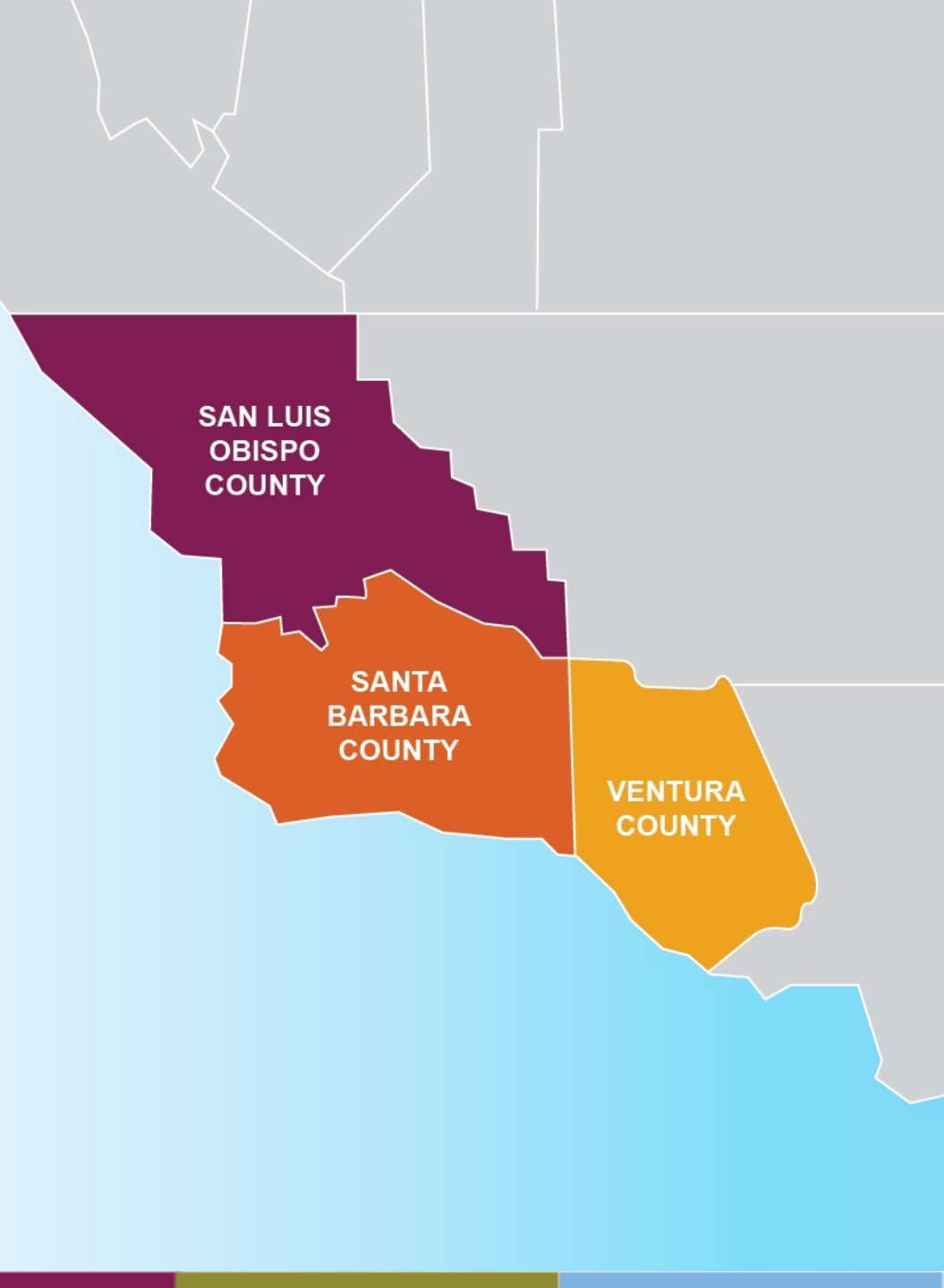
Zoom Orientation

- Please be sure your full name is displayed
- Please mute upon joining
- Use "Chat“ box to share questions or comments
- Under "Participant" select "Raise Hand" to share a question or comment verbally
- The session may be recorded and posted to 3C-REN's on-demand page. Feel free to ask questions via the chat and keep video off if you want to remain anonymous in the recording.

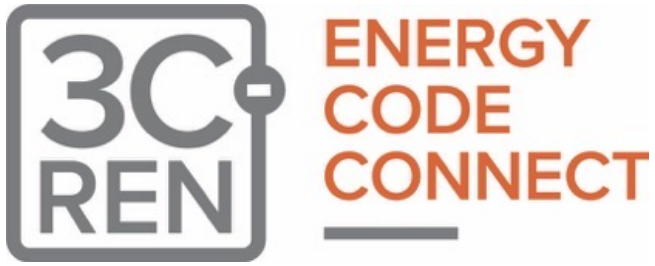


3C-REN: Tri-County Regional Energy Network

- Three counties working together to improve energy efficiency in the region
- Services for –
  - **Building Professionals:** industry events, training, and energy code compliance support
  - **Households:** free and discounted home upgrades
- Funded by ratepayer dollars that 3C-REN returns to the region



3C-REN
Staff Online


3C
REN
ENERGY
CODE
CONNECT


3C
REN
HOME
ENERGY
SAVINGS


3C
REN
BUILDING
PERFORMANCE
TRAINING


3C
REN

3C REN ENERGY CODE CONNECT

- Serves all building professionals
- Three services –
  - **Energy Code Coach**
  - **Training and Support**
  - **Regional Forums**
- Makes the Energy Code easy to follow

Energy Code Coach:
3c-ren.org/codes
805.220.9991

Event Registration:
3c-ren.org/events

HOME ENERGY SAVINGS

Multifamily (5+ units)

- No cost technical assistance
- Rebates up to $750/apartment plus additional rebates for specialty measures like heat pumps

Single Family (up to 4 units)

- Sign up to participate!
- Get paid for the metered energy savings of your customers

3C-REN.org/home

BUILDING PERFORMANCE TRAINING

- Serves current and prospective building professionals
- Expert instruction:
  - **Technical skills**
  - **Soft skills**
- Helps workers to thrive in an evolving industry

Event Registration:
3c-ren.org/events

Introducing 3C-REN's new High-Performance Fundamentals (HPF) Program

Context

- “High performance” refers to buildings that are designed, built, and commissioned to achieve above-code, optimized performance.
- Specialized companies offering high-performance design and construction services in many parts of the State experience high demand, ongoing backlogs, and difficulty finding qualified new hires.

Goals

- Prepare aspiring building practitioners to for competitive job opportunities.
- For those in the industry, provide a refresher or supplement prior building science knowledge

Content

- Developed in consultation with dozens of national experts in high-performance building businesses
- Based on the foundational knowledge they are looking for in new hires
- Rooted in the fundamentals of building science and the design, construction, and business practices that distinguish high-performance practitioners from their conventionally-trained competitors

Classes

1. High-Performance Buildings and Careers: June 21
2. The Role of Building Science in High-Performance Buildings: May 17 & 19
3. Enclosure Best Practices: Air Sealing, Insulation, Testing & Metrics: July 12
4. Heat Pump Fundamentals: Space Conditioning and Water Heating: ***Coming in September***
5. Water Heating Distribution Best Practices: ***Coming in October***
6. How To Assess a Home for Electrification: ***Coming in November***

Other HPF Program Elements

3C-REN's plans for further program development include:

- Formal certificate of completion
- Field-based, hands-on classes to complement initial series of lecture classes
- Mentorship and/or peer learning activities to support participants' learning process

How Buildings Work Part II

SCIENCE **IN** BUILDINGS

PETER YOST
BUILDING - WRIGHT

Science IN Buildings

- Some perspectives on buildings
  - Architect
  - Engineer
  - Philosopher
  - Your Instructor
- Managing water
- Managing air
- Managing vapor
- Managing heat
- Buildings as systems
- Integrating enclosures & mechanicals
- The importance of windows/glazing
- Climate-tuning
- High performance building case studies
- Resources

Homework...

How/ why is foil faced OSB considered a radiant barrier when the foil is attached to the OSB?

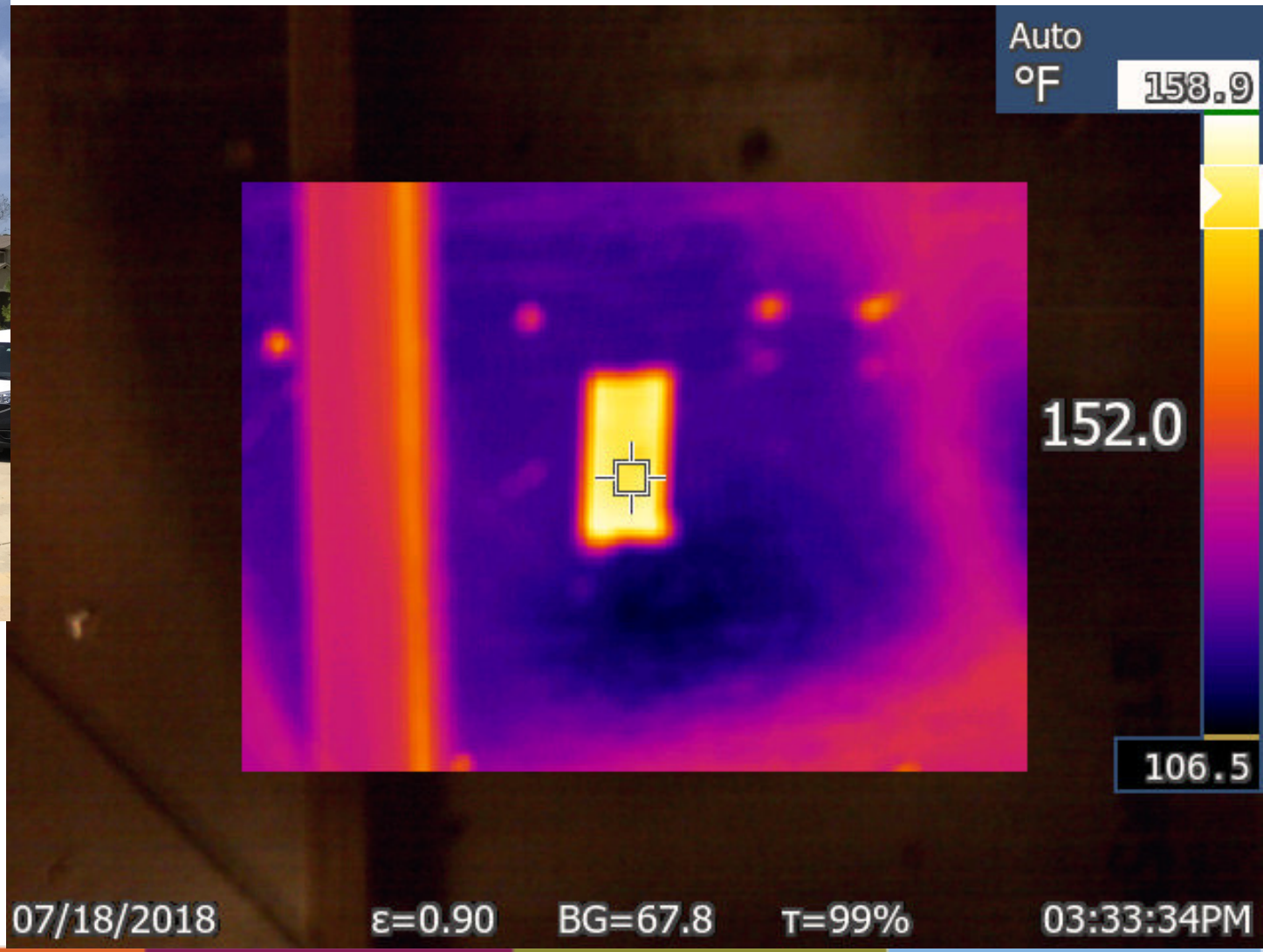
There is no air space on one side of the foil. Although foil has low emittance doesn't it have very high conductance?

So if it is touching anything it will be conducting heat readily?

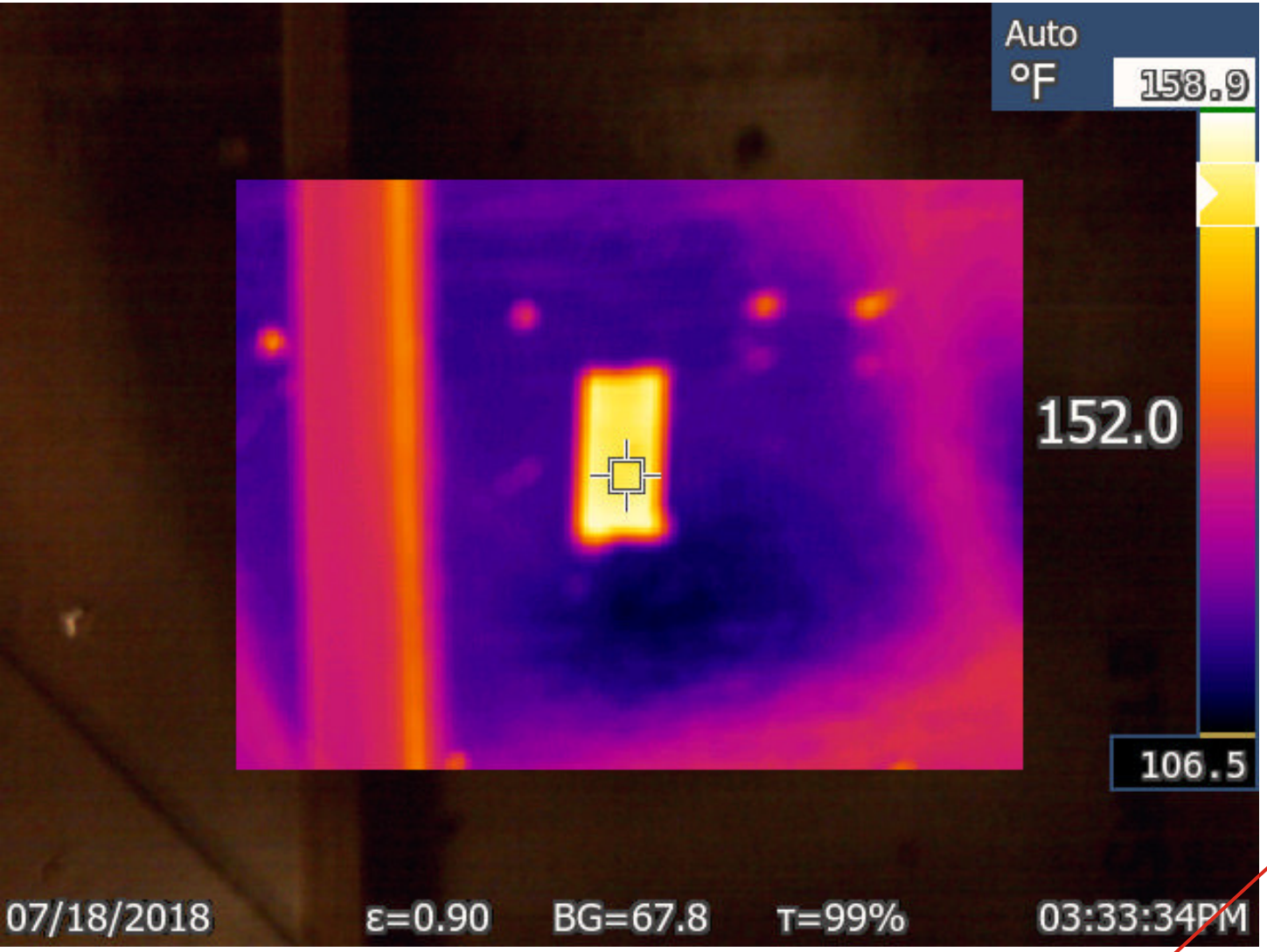
Is this just a misuse of the term radiant barrier?

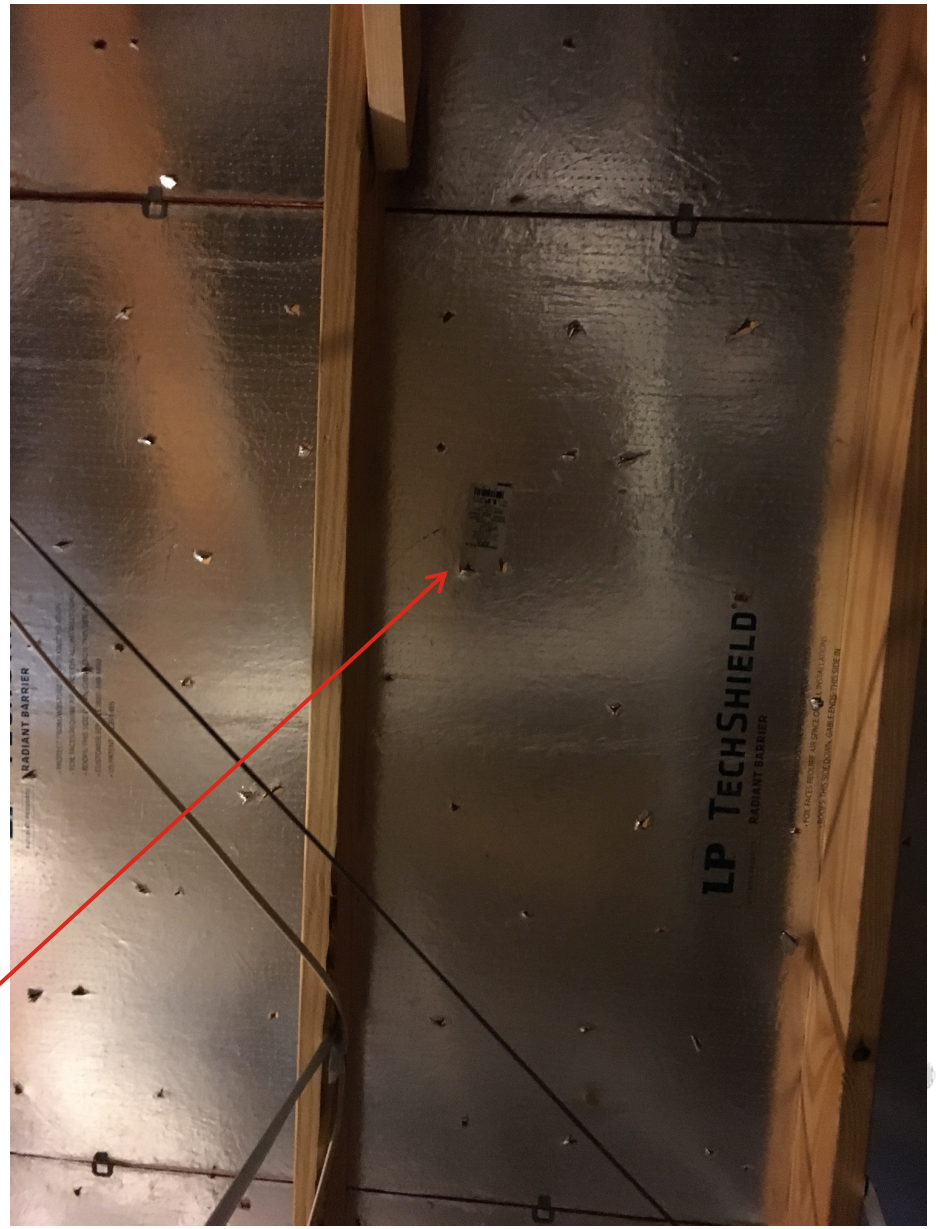
Attics, climate, and radiant barrier sheathing

Vented attic Houston TX 3:30 pm July 2018

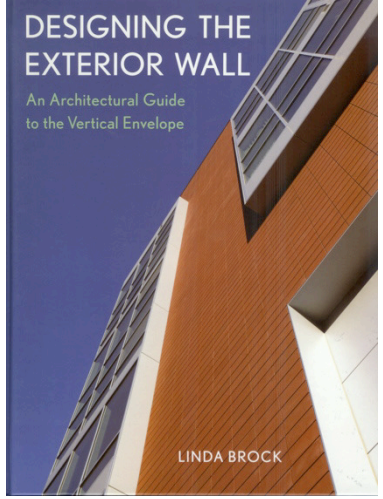


Vented attic Houston TX 3:30 pm July 2018





Building supply bar code sticker



Linda Brock (architect):

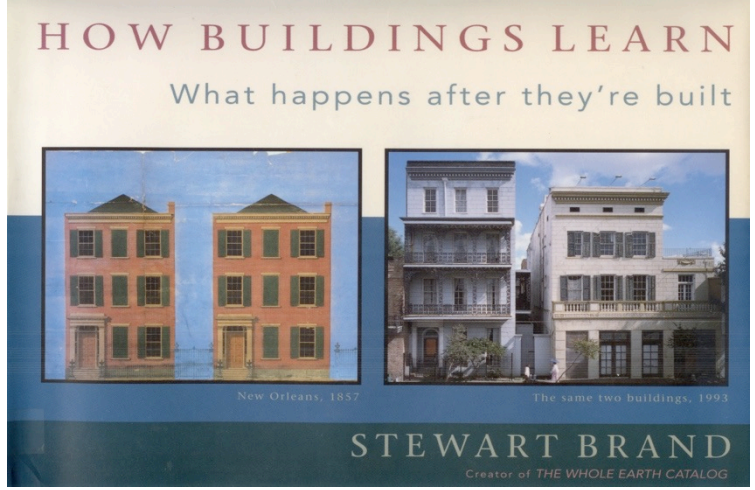
The exterior wall is a complex system that includes –

- the cladding and the structure
- windows and doors
- a series of barriers and retarders that mediate the environment.
  - These must be evaluated in terms of function, durability, appearance and cost.”

Modern buildings can be divided into four parts:

1. the form-giving structure
2. the equipment and systems that help control the interior environment and deliver services
3. the partitions and finishes defining interior function
4. the building envelope...(enclosure)

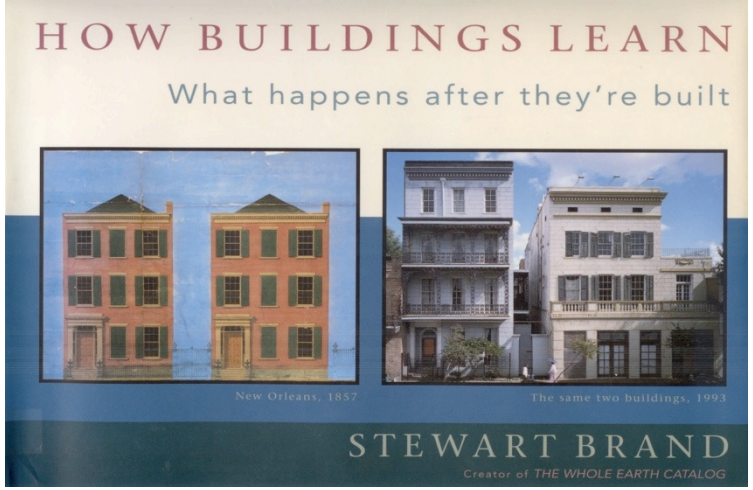
Stewart Brand (philosopher)

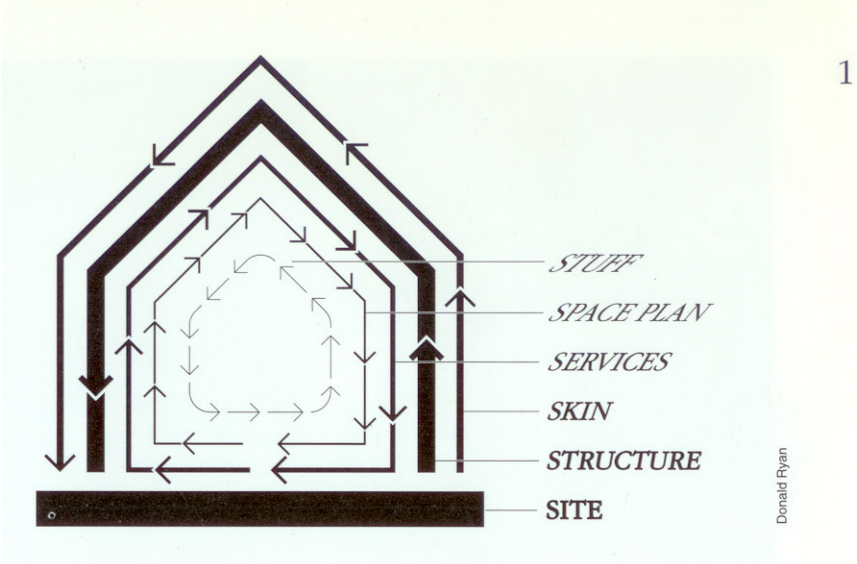


- "The whole idea of architecture is permanence…architecture means unchanging deep structure."
- "My approach is to examine buildings as a whole—not just whole in space, but whole in time."
- "And they [buildings] are wonderful to study. All dressed up in dissimulation, buildings are so naked."

Brand (philosopher)

- An expansion on Frank Duffy's perspective
- For Brand, building enclosure = Skin?
- It's not just about change, but rates of change.

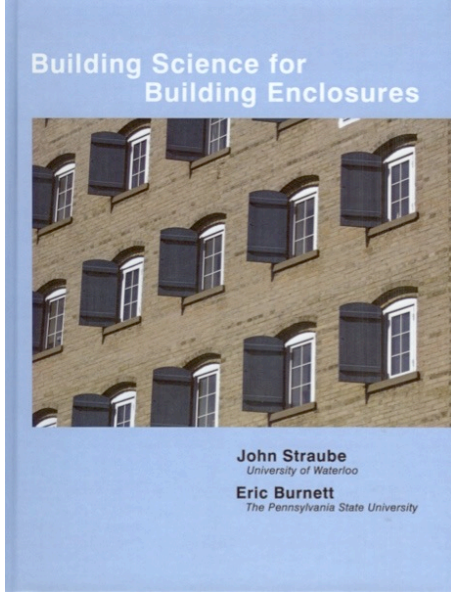




SHEARING LAYERS OF CHANGE. Because of the different rates of change of its components, a building is always tearing itself apart.

From Brand's *How Buildings Learn*, Chapter 2, pg 13

John Straube (Engineer)



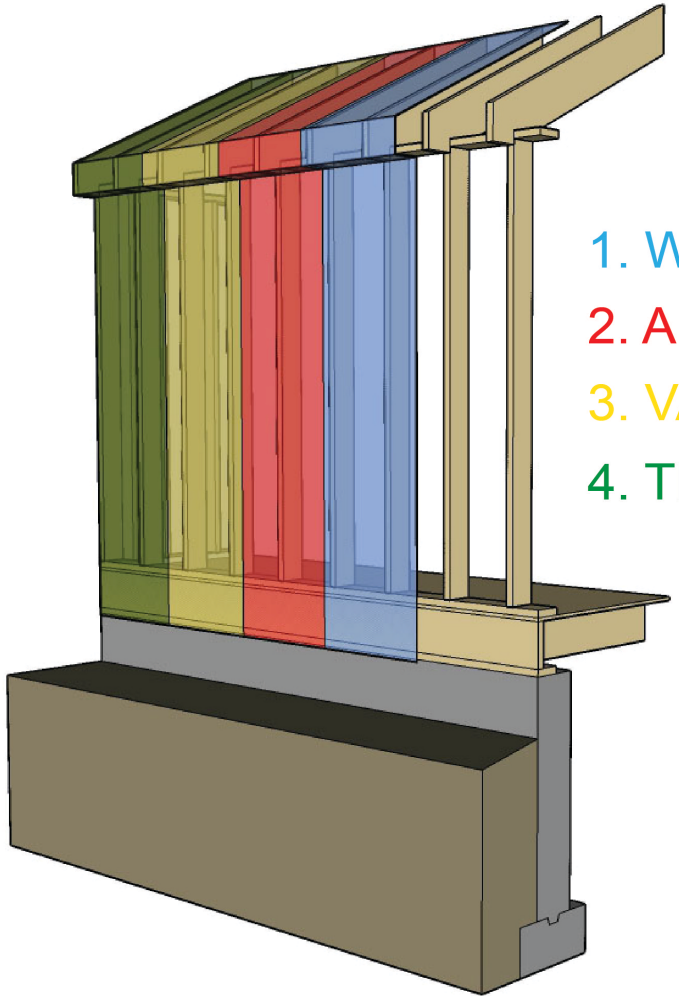
- [Enclosure] “That part of any building, above or below grade, that physically separates the outside or exterior environment from the interior environment(s). Environmental separator is another term used.”
- Four parts: “superstructure, enclosure, service systems, fabric”
- “…each enclosure component is a 3-D, multi-layer, multi-material assembly…”

Just Three Things (My Perspective): How are the two—heat & moisture–related?

- Heat flow through building enclosures dries them out.
- Energy efficiency measure reduce heat flow through building enclosures.
- Energy efficiency measures can and often do reduce drying potential.
- If you reduce drying potential you probably need to reduce wetting.

THEREFORE: Manage energy and moisture with equal intensity.

My Perspective: manage energy & moisture with continuous control layers

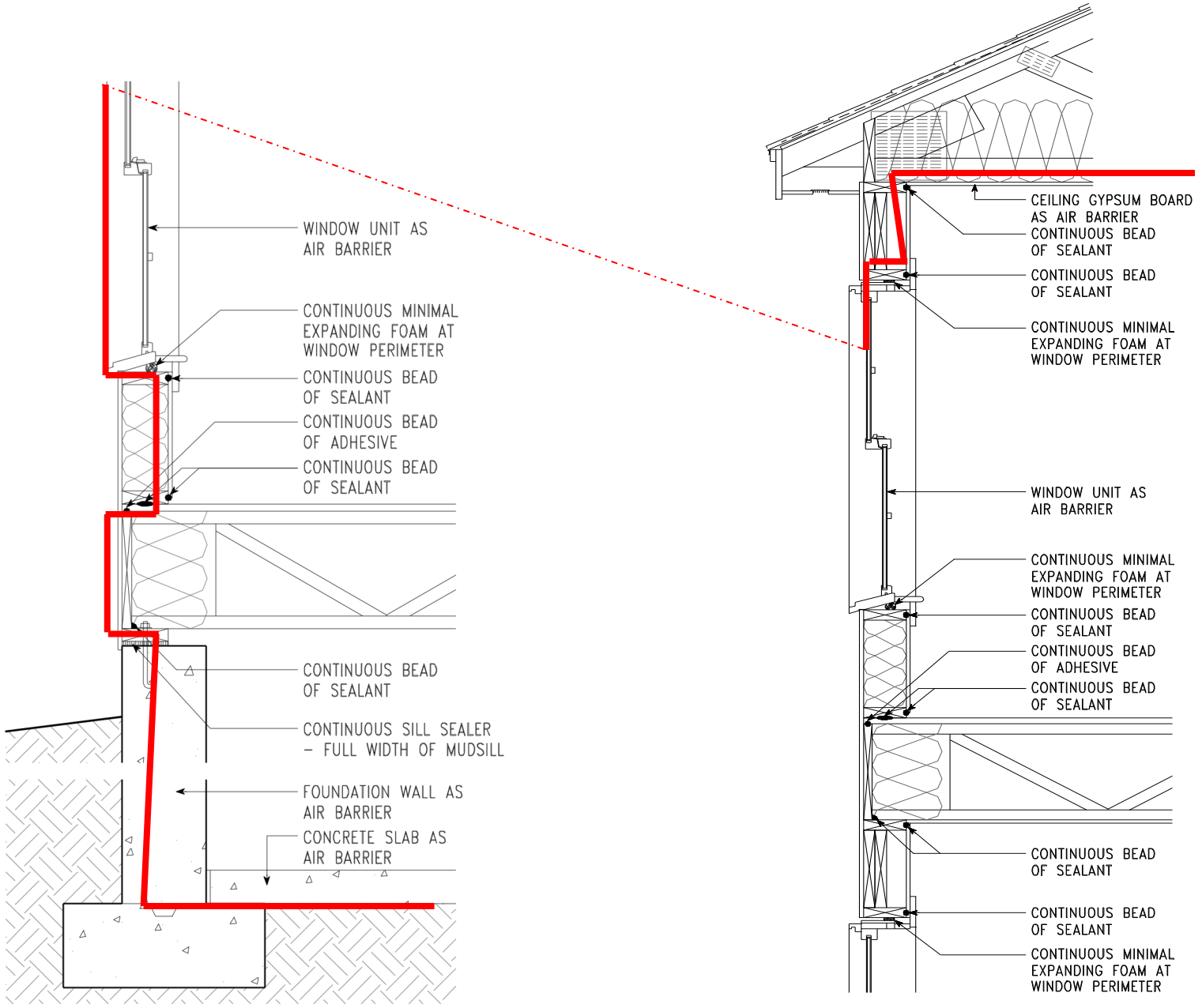


1. WATER
2. AIR
3. VAPOR
4. THERMAL

STEVEN BACZEK
architect

Image credit: Weichert Realty

The “Pen” Test


WINDOW UNIT AS AIR BARRIER
CONTINUOUS MINIMAL EXPANDING FOAM AT WINDOW PERIMETER
CONTINUOUS BEAD OF SEALANT
CONTINUOUS BEAD OF ADHESIVE
CONTINUOUS BEAD OF SEALANT
CONTINUOUS BEAD OF SEALANT
CONTINUOUS SILL SEALER – FULL WIDTH OF MUDSILL
FOUNDATION WALL AS AIR BARRIER
CONCRETE SLAB AS AIR BARRIER
CEILING GYPSUM BOARD AS AIR BARRIER
CONTINUOUS BEAD OF SEALANT
CONTINUOUS BEAD OF SEALANT
CONTINUOUS MINIMAL EXPANDING FOAM AT WINDOW PERIMETER
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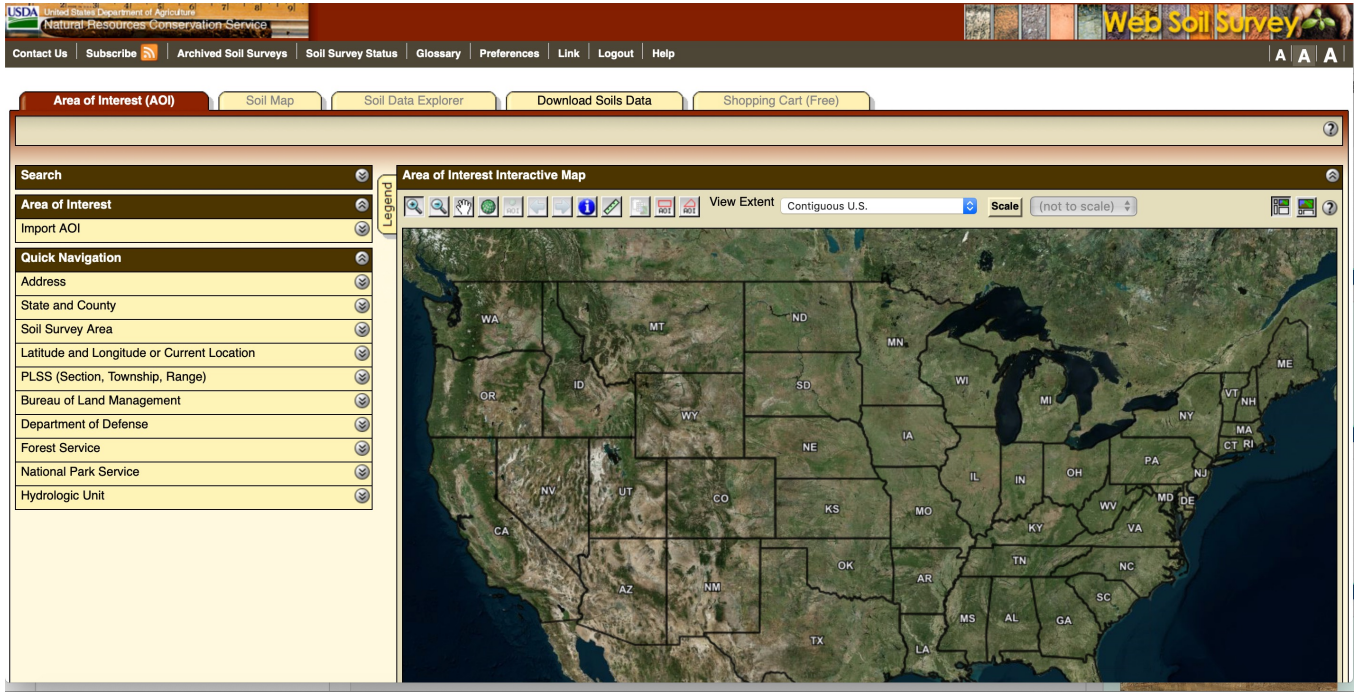
CONTINUOUS BEAD OF SEALANT
CONTINUOUS BEAD OF SEALANT
CONTINUOUS MINIMAL EXPANDING FOAM AT WINDOW PERIMETER

1 – manage water

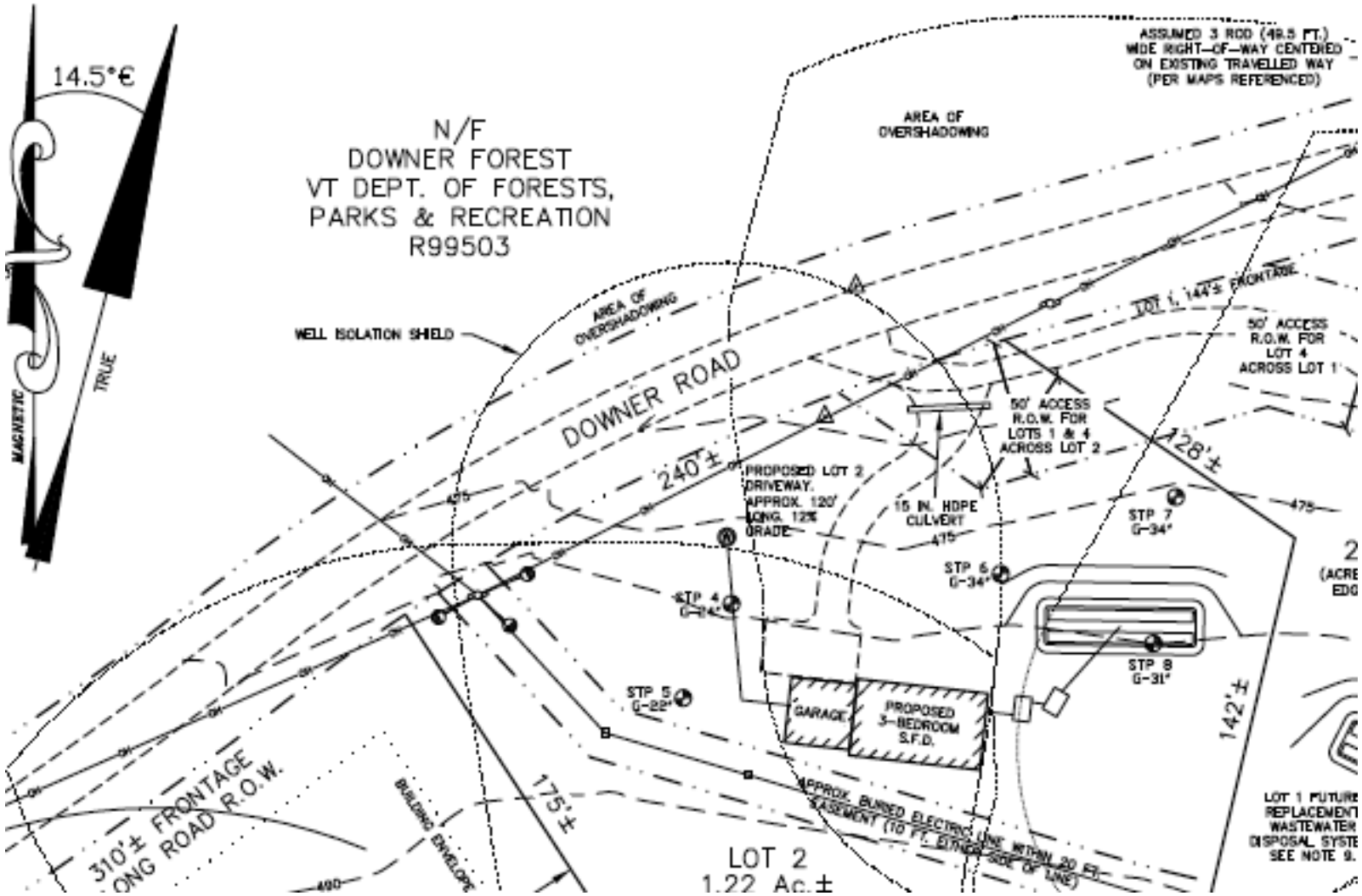
- Ground water
- Surface water
- Building water

Ground water

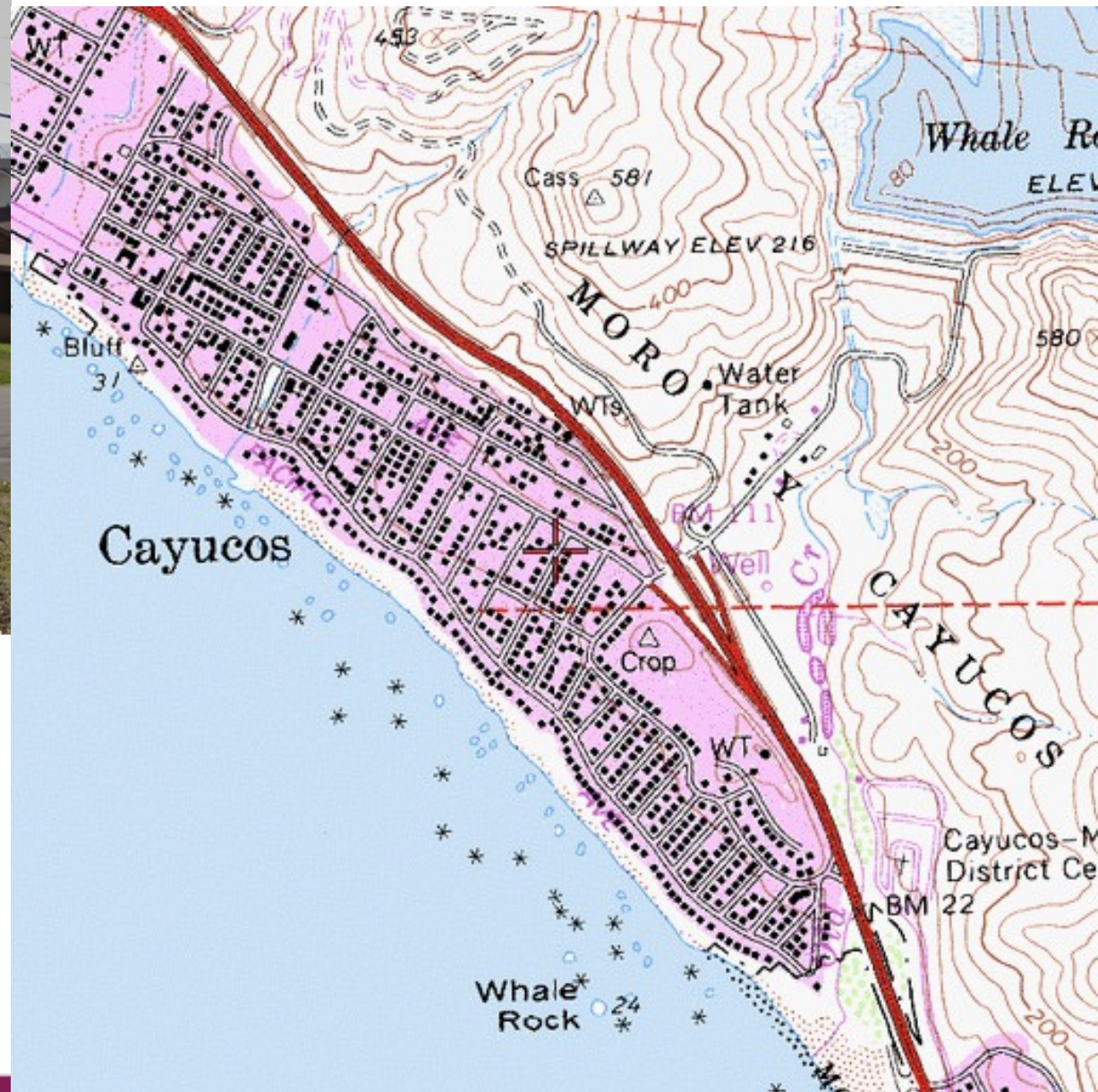
https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm



Site surface water

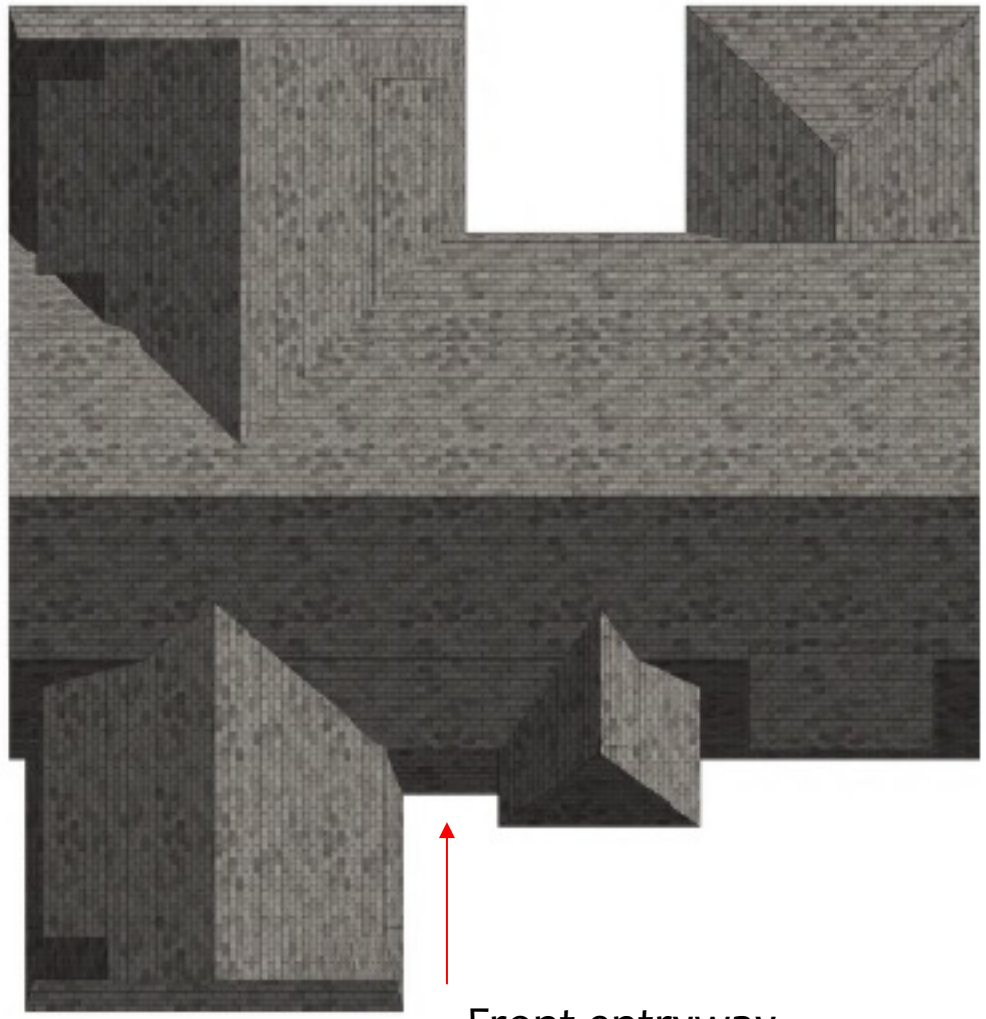


Site surface water – 1802 Cass Ave Cayucos



Building water

Front entryway



Front entryway

Building water

Flashing a house to the ground …

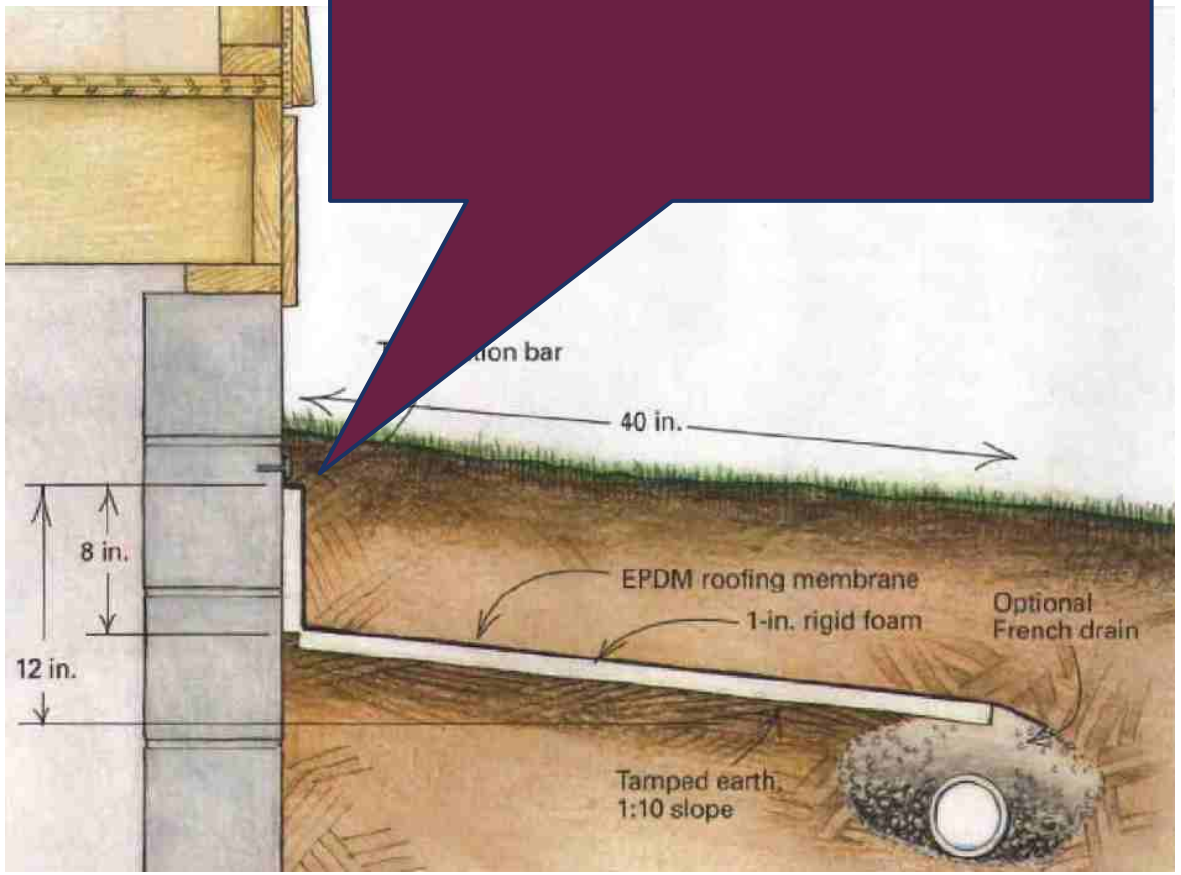
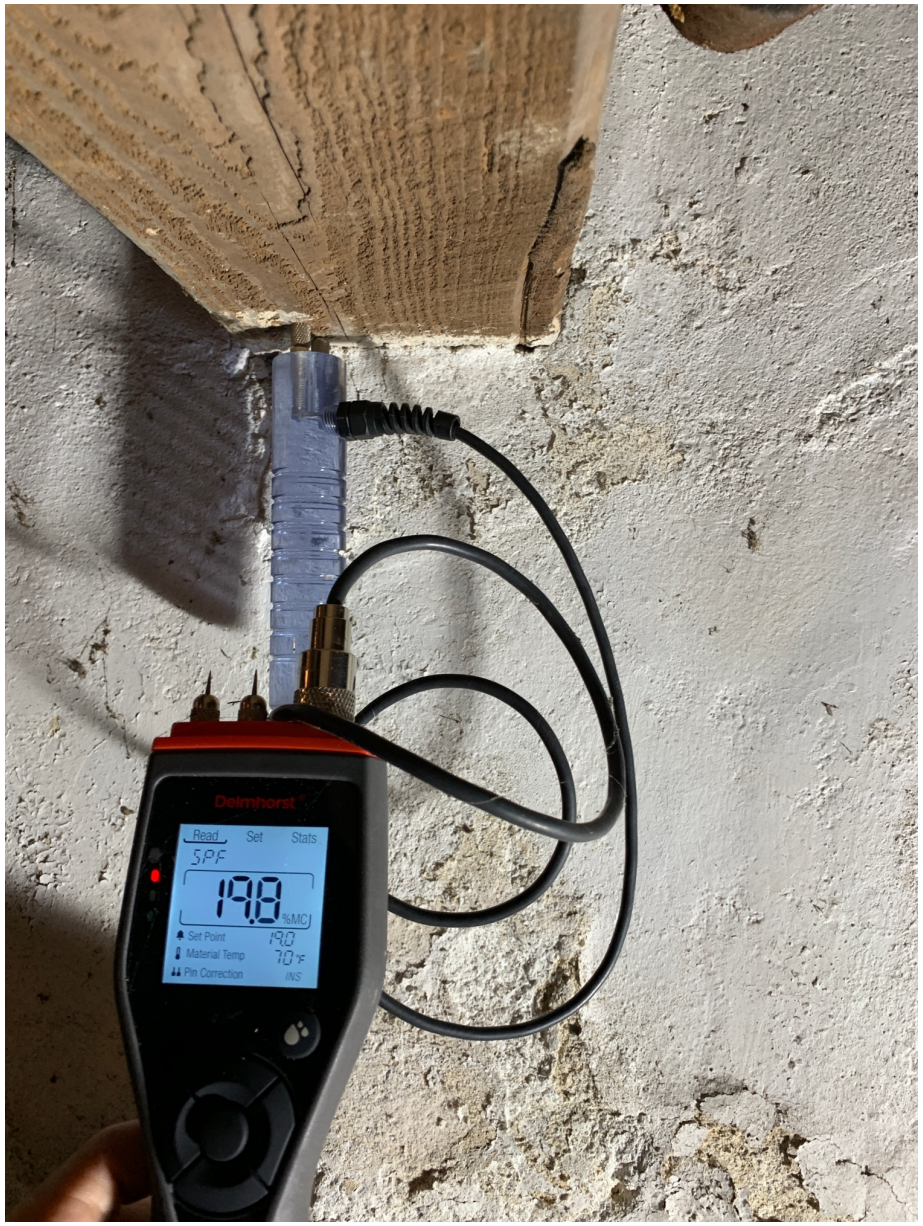


Image Credit: Fine Homebuilding

What about wicking?



Capillary breaks...
free-draining space & non-porous materials

Energocell

Building America Solutions Center

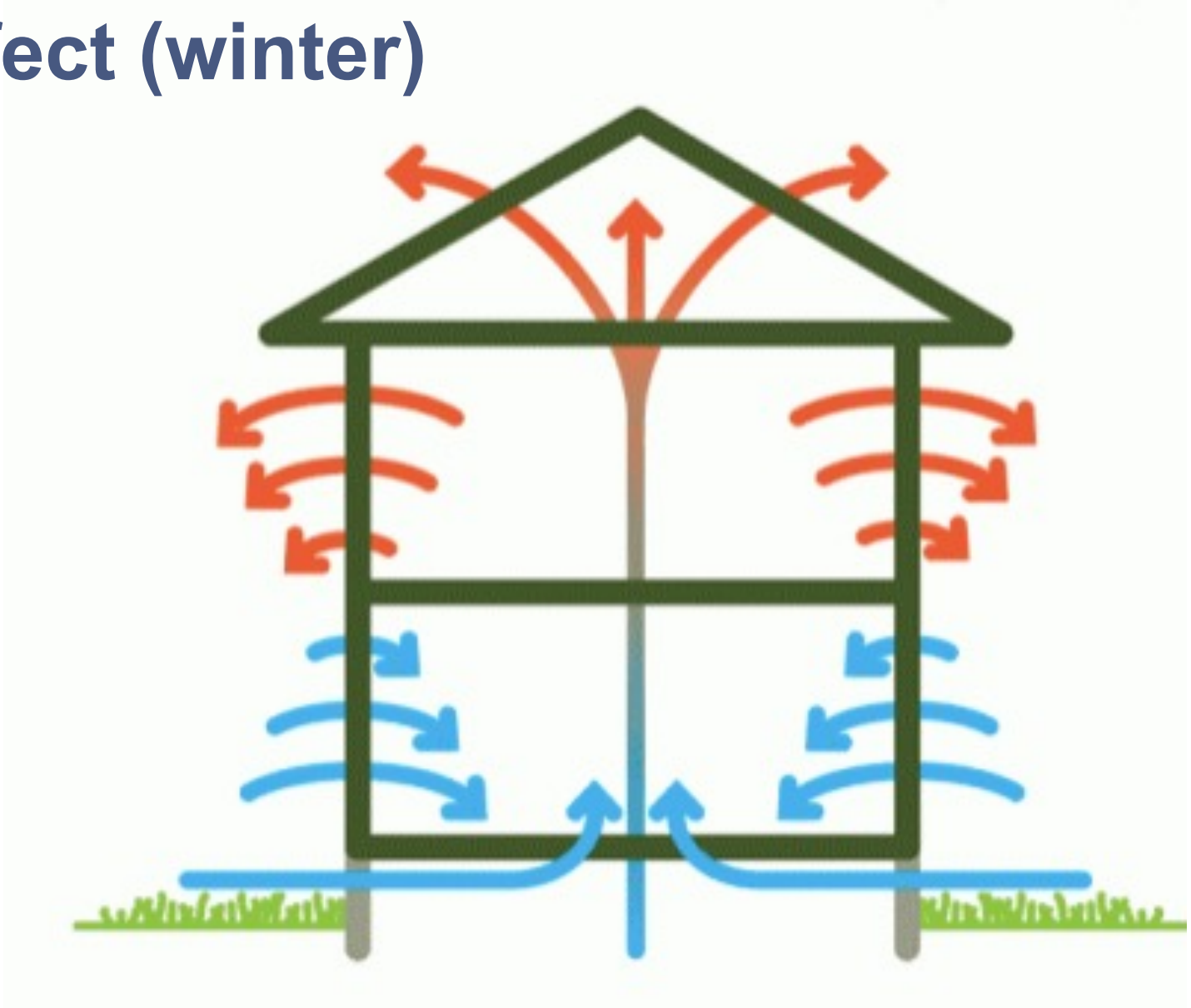
CONFOUND IT!

Do we want to make things in buildings continuous or with breaks?

2 – Manage air

- Stack effect
- Wind
- Mechanical (fans)

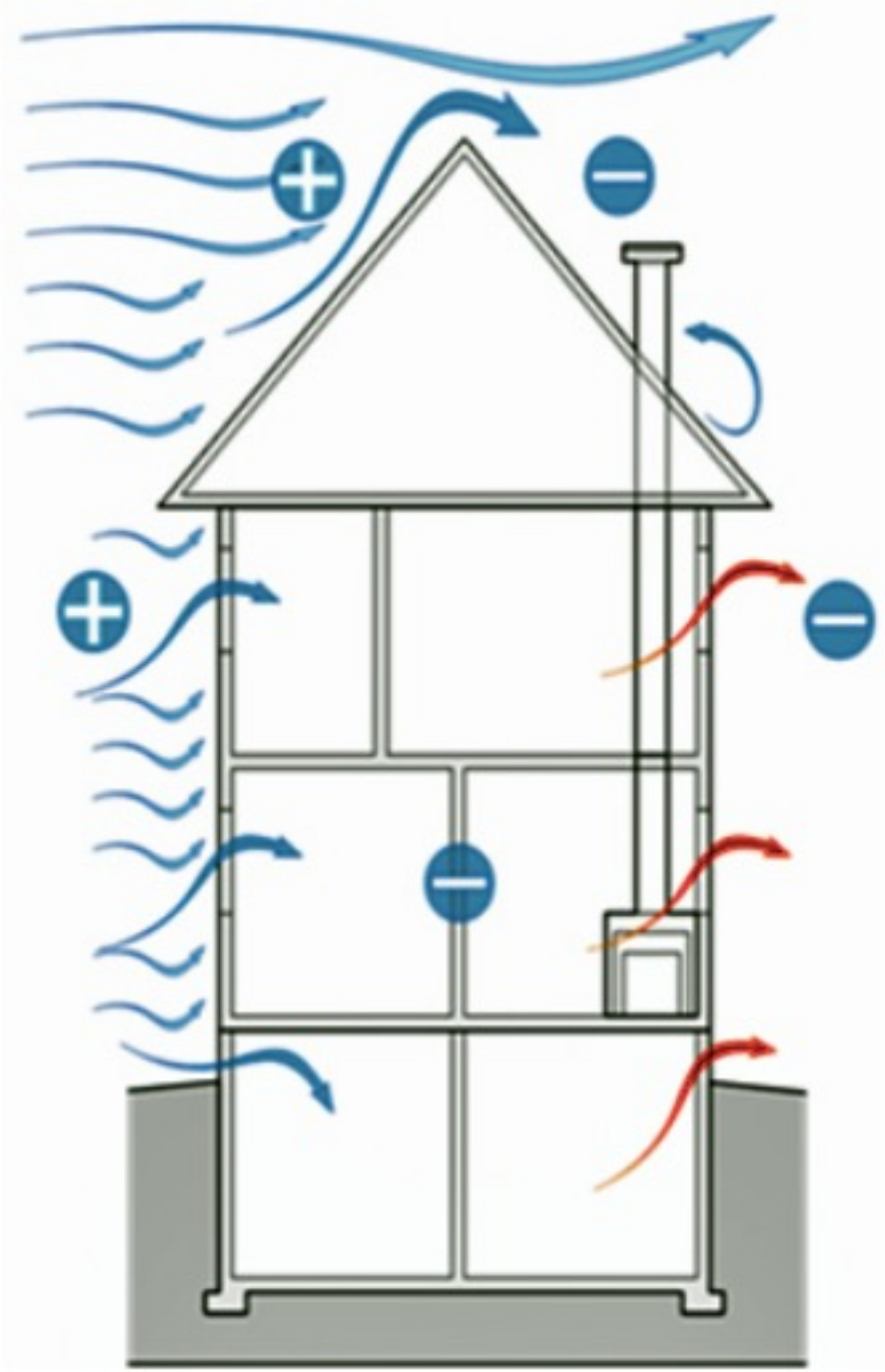
Stack Effect (winter)



(Cold dry air is more dense than warm moist air…)

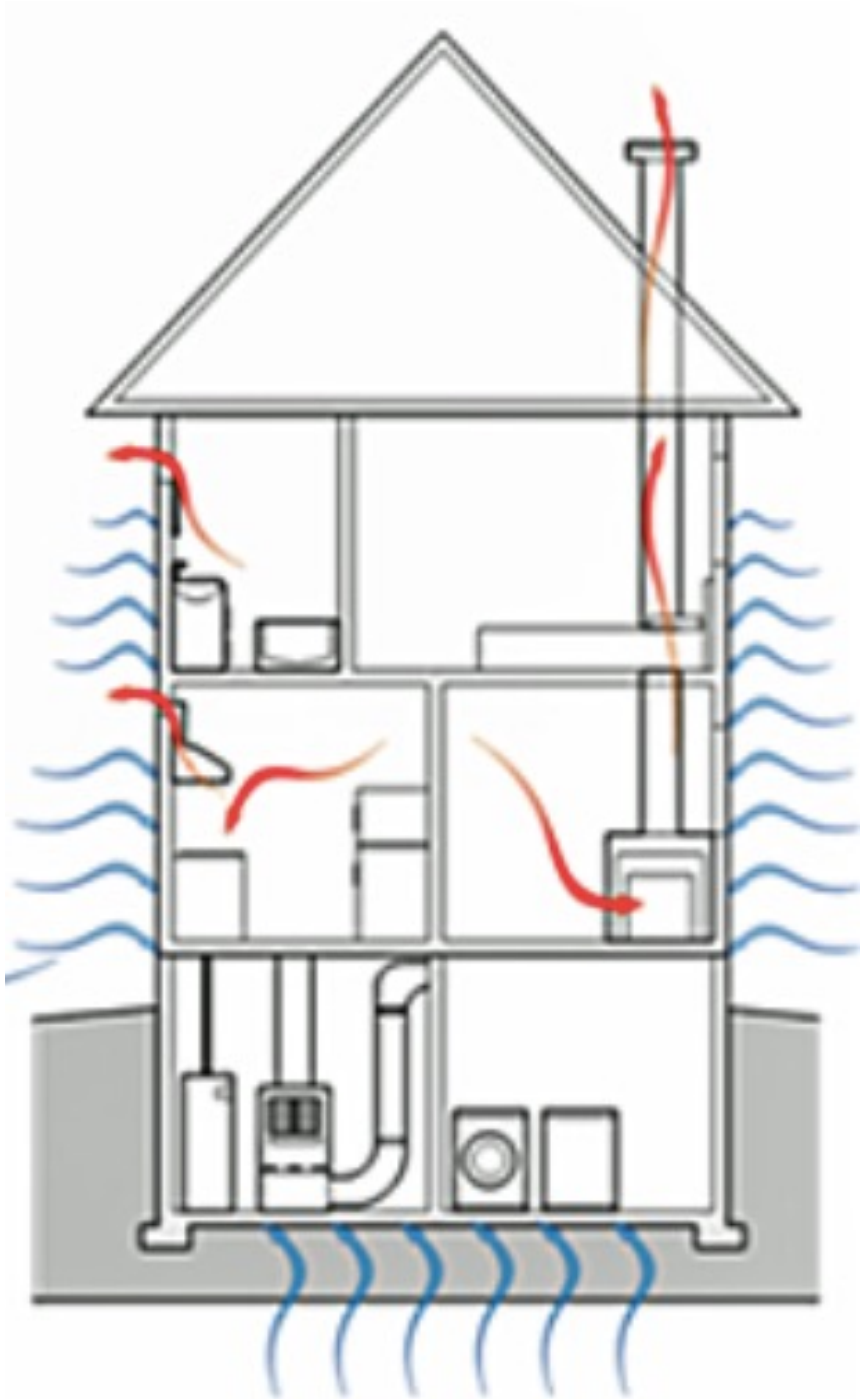
Stack Effect in Winter

Wind Effect

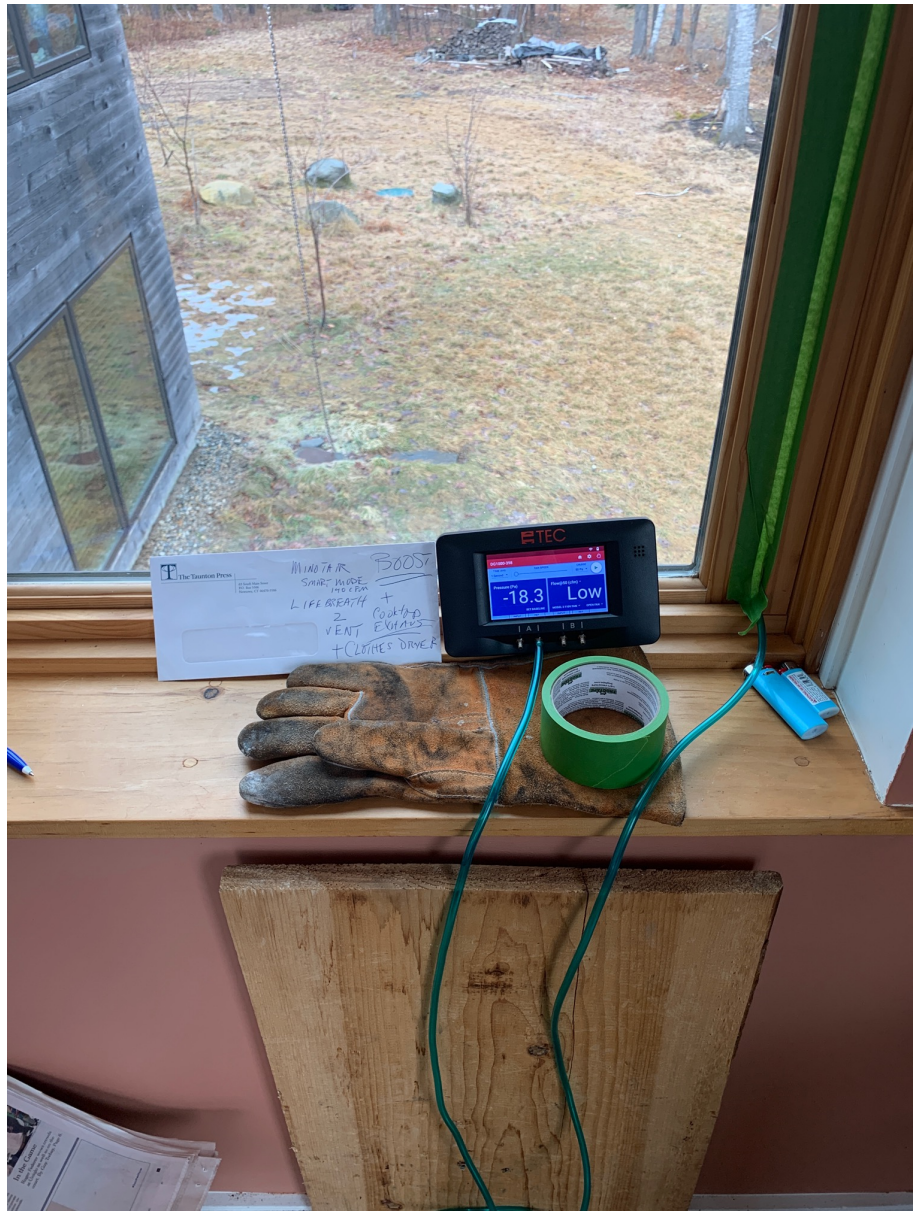


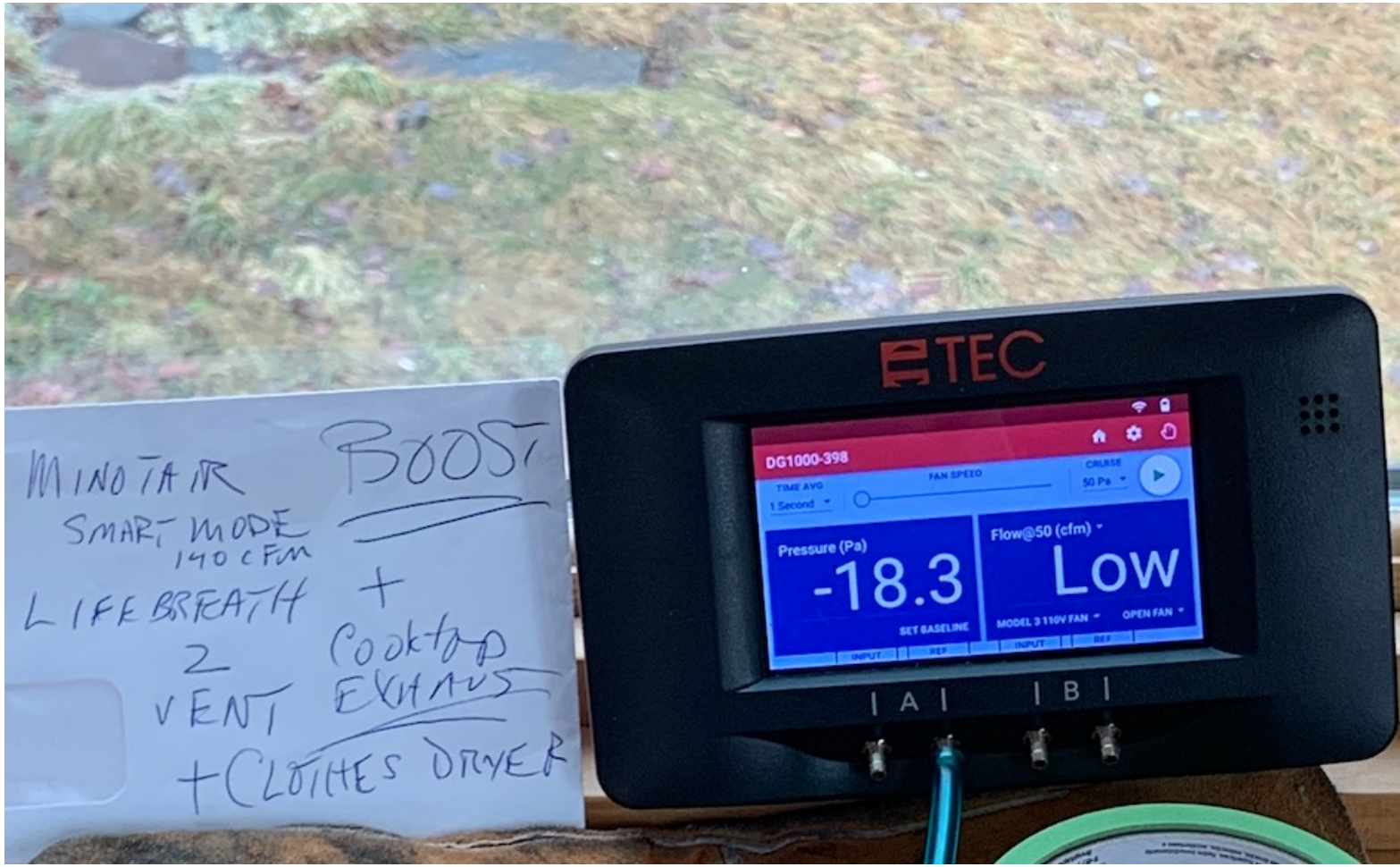
Mechanical Effect (Fans…)

- Bath exhaust
- Kitchen range hood
- Gas/fuel oil boiler/furnace
- Gas water heater
- Clothes dryer
- (Fireplace/woodstove)



Bunch of fans exhausting...who cares?





Spiders and air leakage...

Measuring building airtightness: blower door

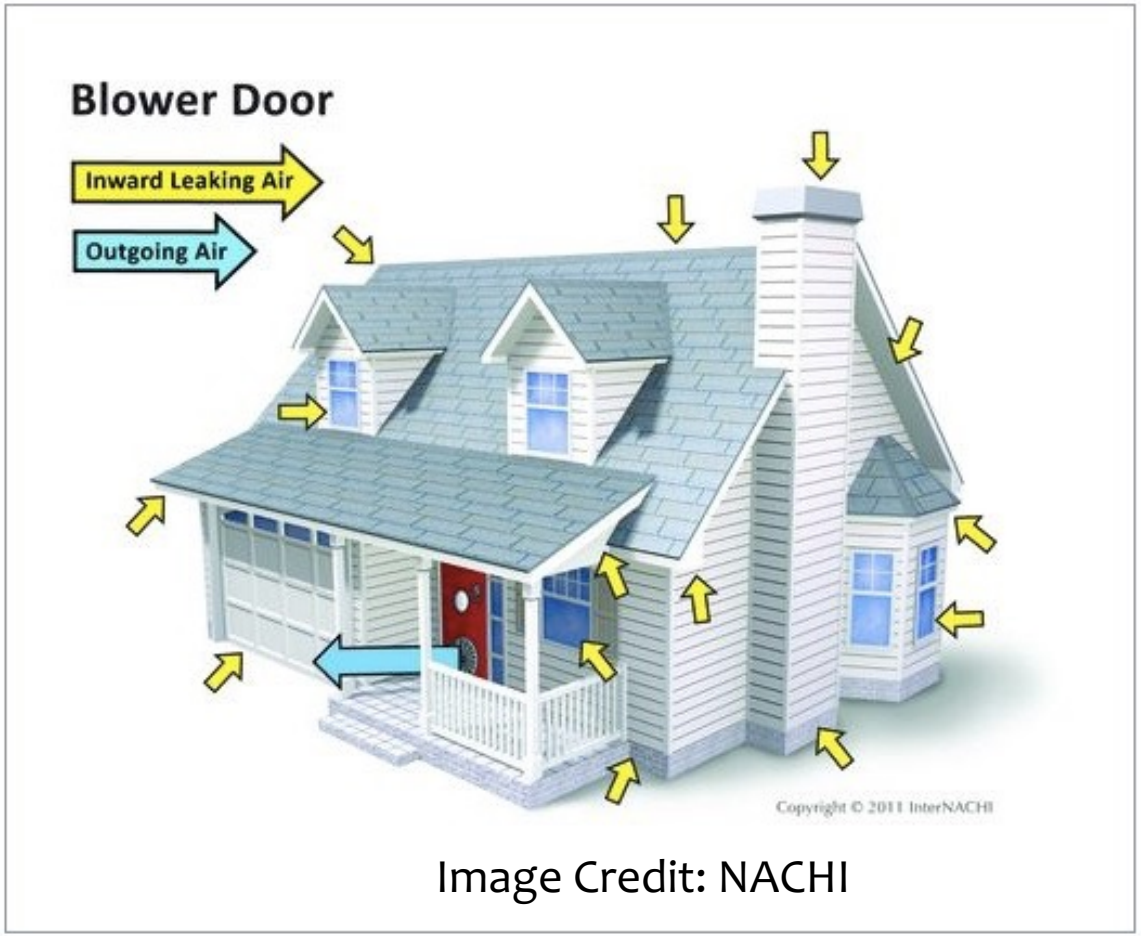
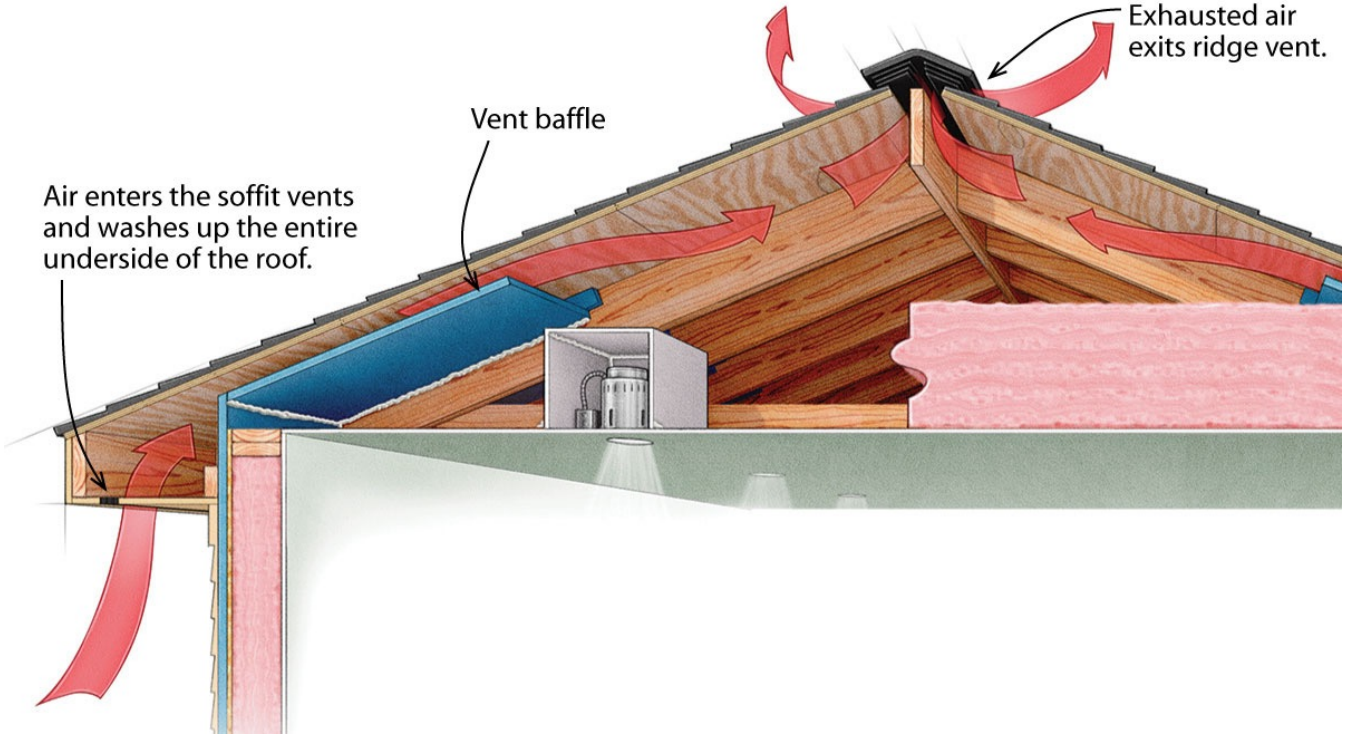


Image Credit: NACHI

Relates pressure and air flow at 50 Pascals (20 mph wind) and is a true performance test...

Wait...isn’t venting INTENTIONAL air flow?

CONFOUND IT!
Does moving (or leaking) air get things wet or dry them out?



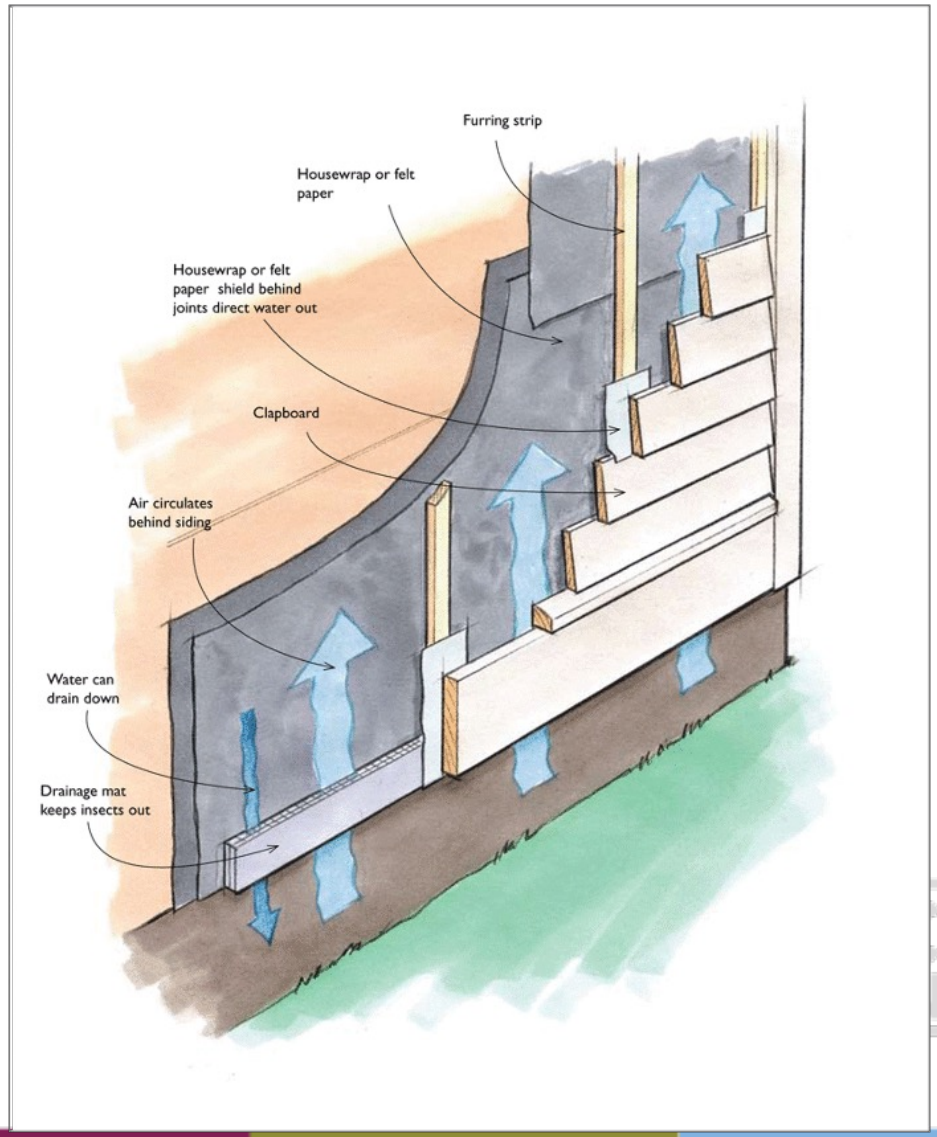
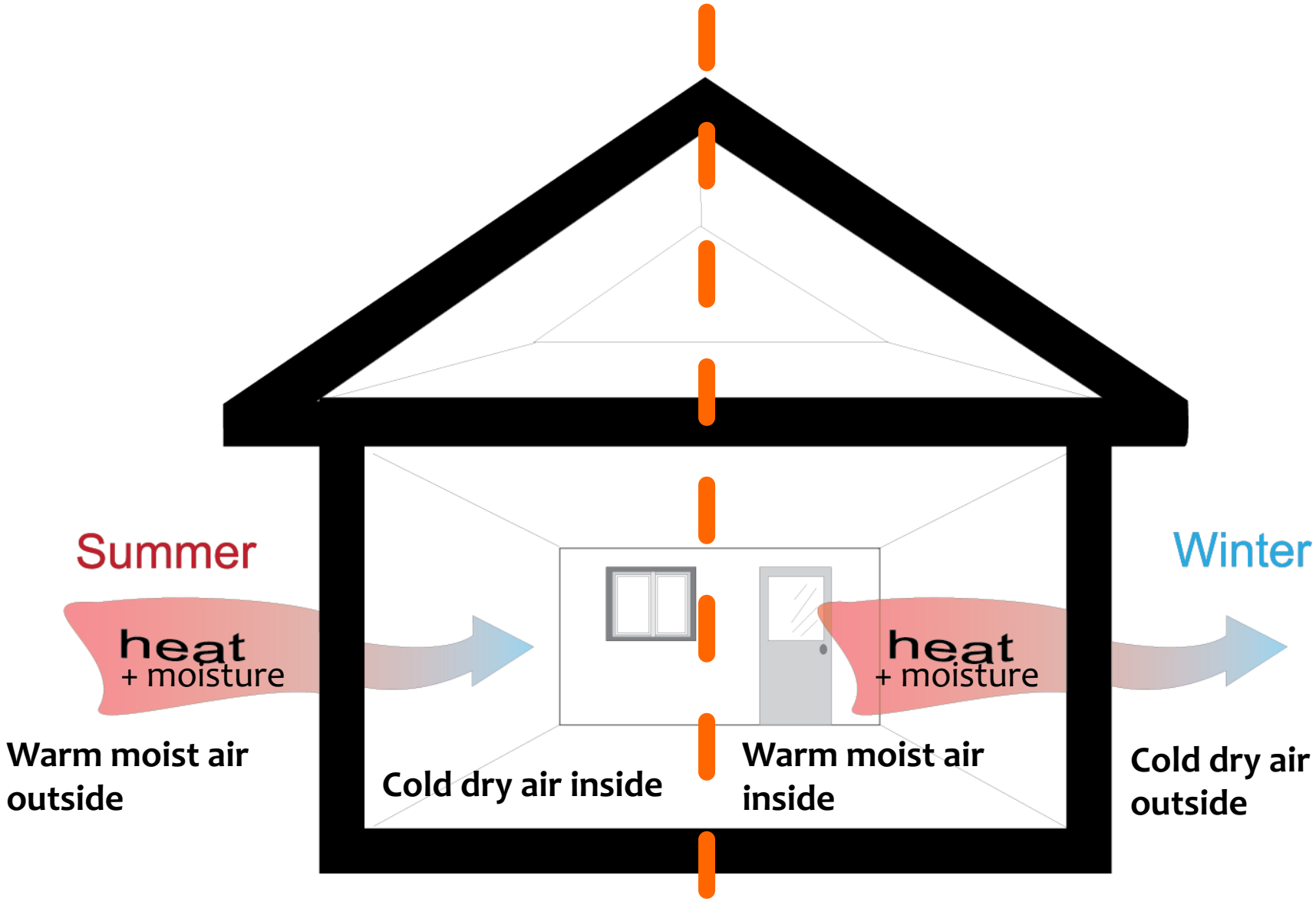


Image Credit: Fine Homebuilding

3 – Manage vapor

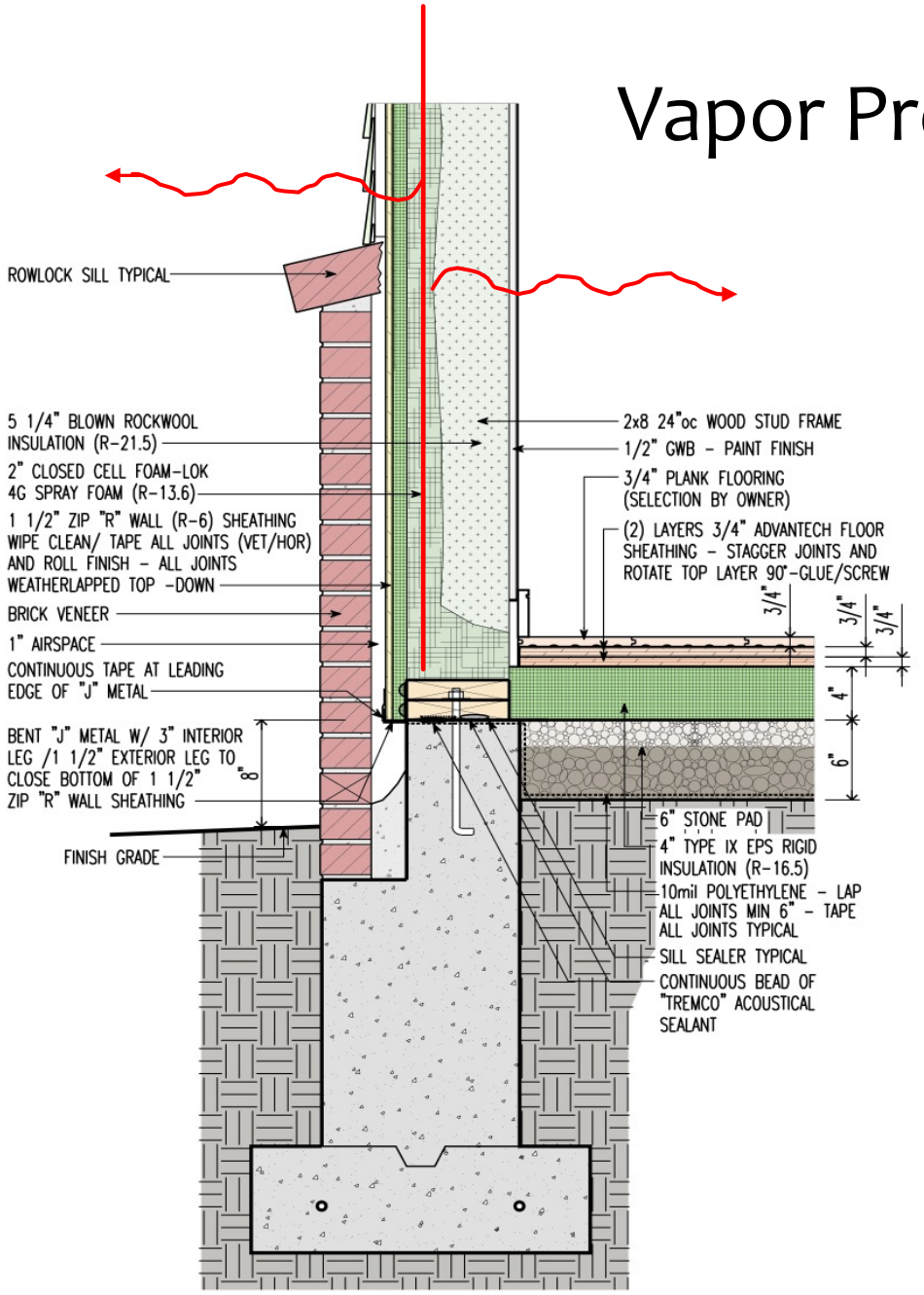
- Vapor moving through air (straight diffusion)
- Vapor moving through materials (vapor permeability)
- Vapor retarders?

Vapor diffusion in buildings



CONFOUND IT! Does vapor diffusion get things wet or dry them out?

Vapor Profile



Alexandra Baczek

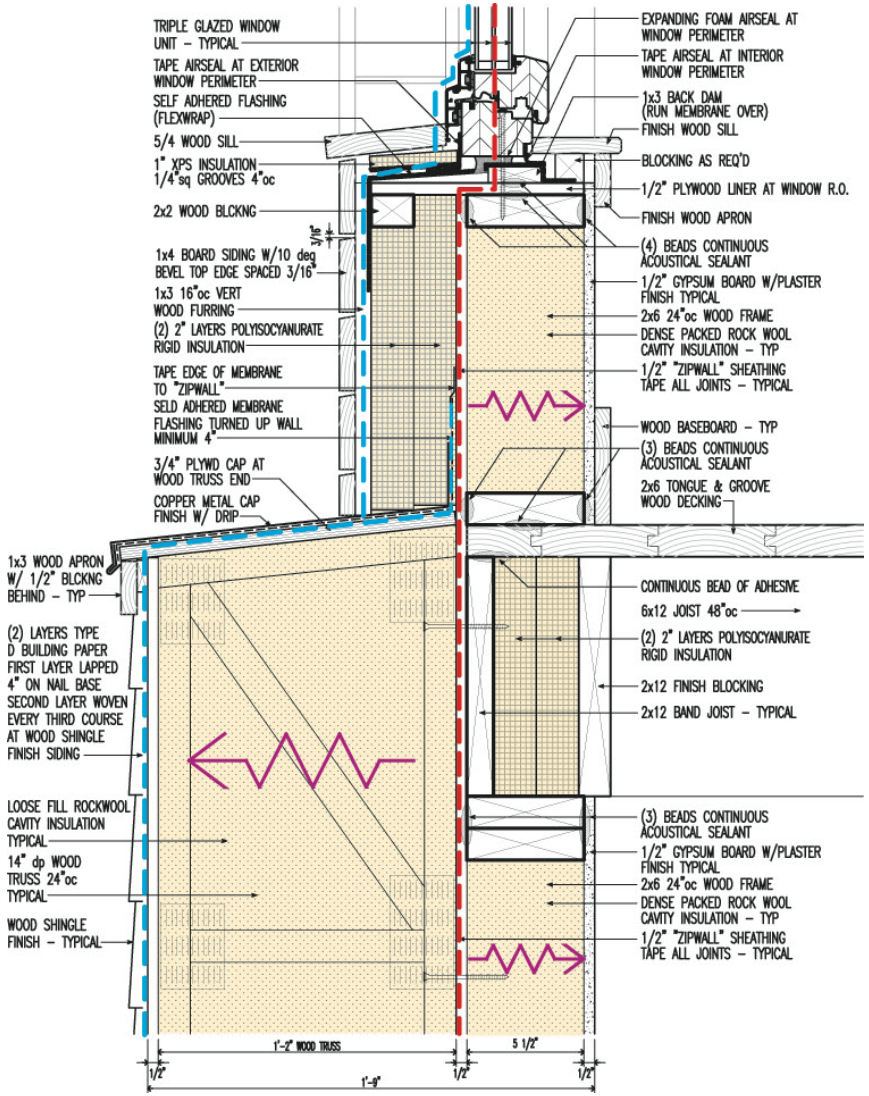
4 – Manage heat

- Thermal bridges - thermal breaks
- Insulation: continuous exterior - cavity
- Straight economic vs resilience approach to how much insulation?

Insulation – thermal bridges and breaks


Tyvek

Insulation – exterior continuous & cavity



STEVEN BACZEK
architect

CONFOUND IT!
How the heck do we determine how much insulation to use; what R-value should we aim for?

- Straight economics and payback – energy modeling (such as BEopt)
- Thermal comfort – ASHRAE Standard 55 & Center for the Built Environment (CBE) Thermal Comfort Tool
- Resilience – How long can any home maintain livable conditions without power?

Buildings as systems:
Integrating building enclosures & mechanical systems

Issues of “Cost”

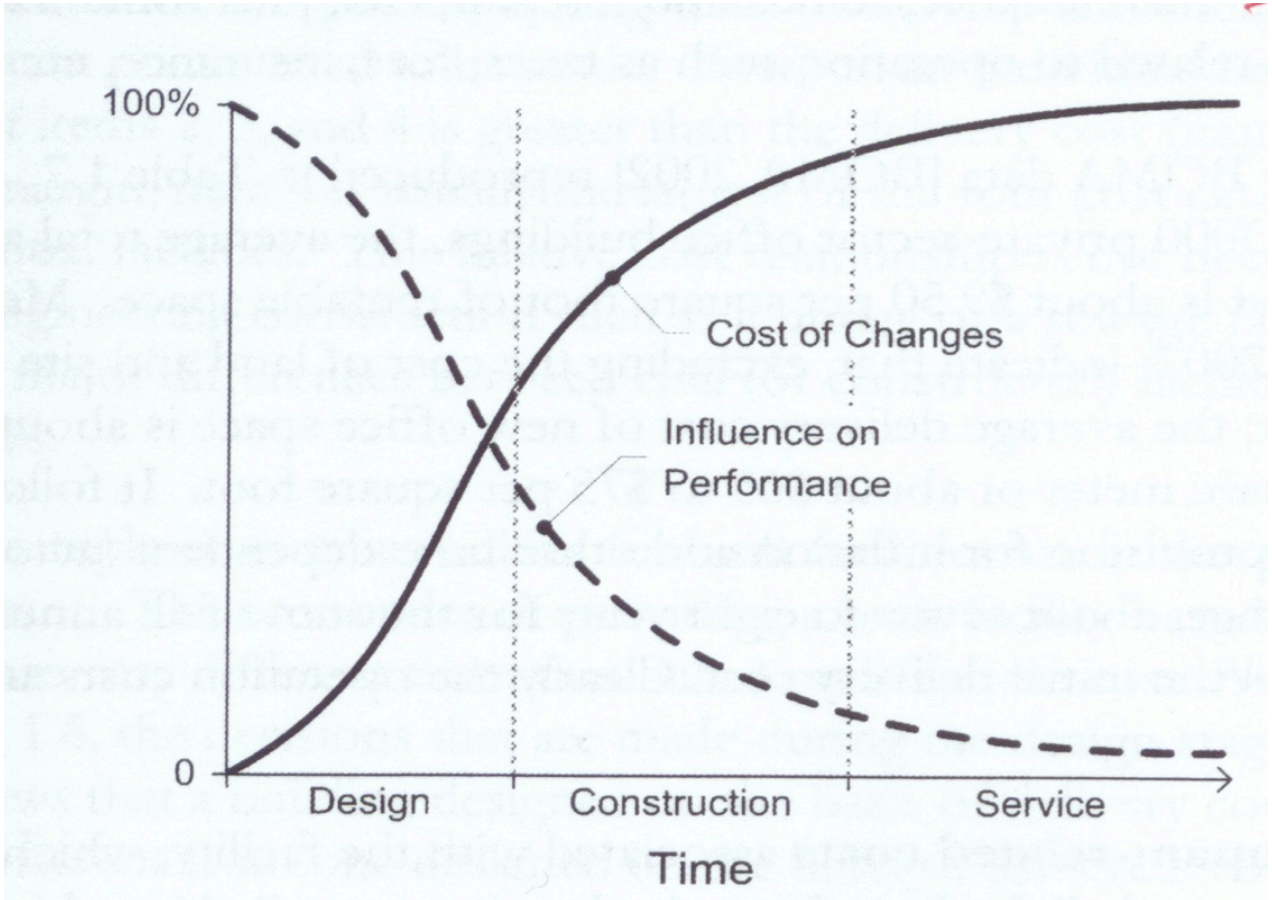


Figure 1.6: Opportunity to influence building performance

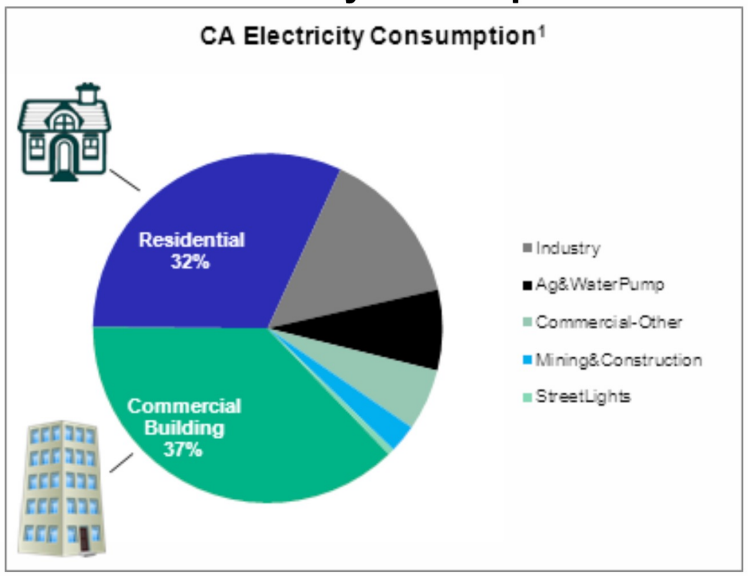
From Straube’s *Building Science for Building Enclosures*, Chapter 1, pg 21

Building “loads”

California Energy Commission

Building Energy Use

Buildings are responsible for nearly 70 percent of California’s electricity consumption

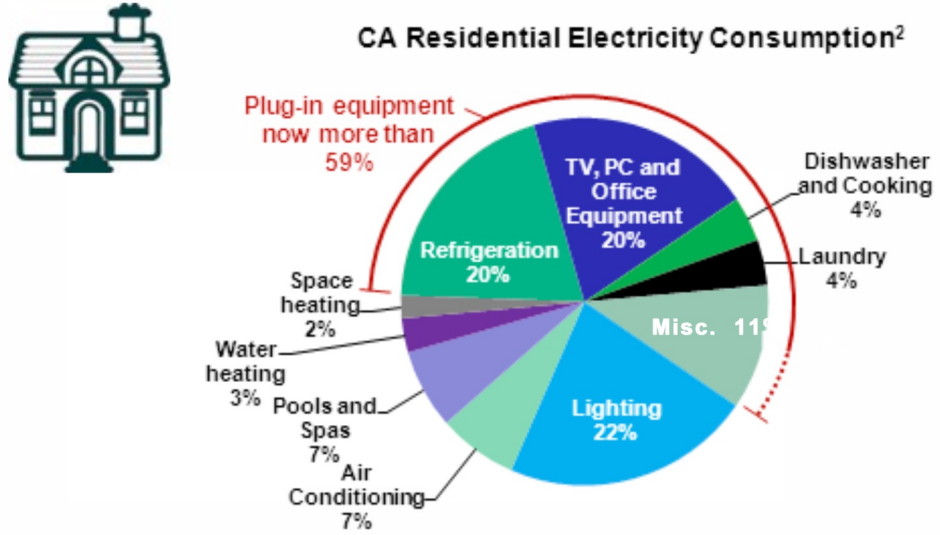


(1) CA Energy Consumption Data Management System
http://ecdms.energy.ca.gov/

California Energy Commission

Residential Loads

Plug-in equipment now contributes the majority of electricity consumption



(2) CA Residential Appliance Saturation Survey (RASS) 2010.
EIA Annual Energy Outlook 2013 also shows a majority for all of US.

Building “loads”

Enclosure-dominated performance

- Space heating
- Space cooling
- Humidification
- Dehumidification
- Ventilation

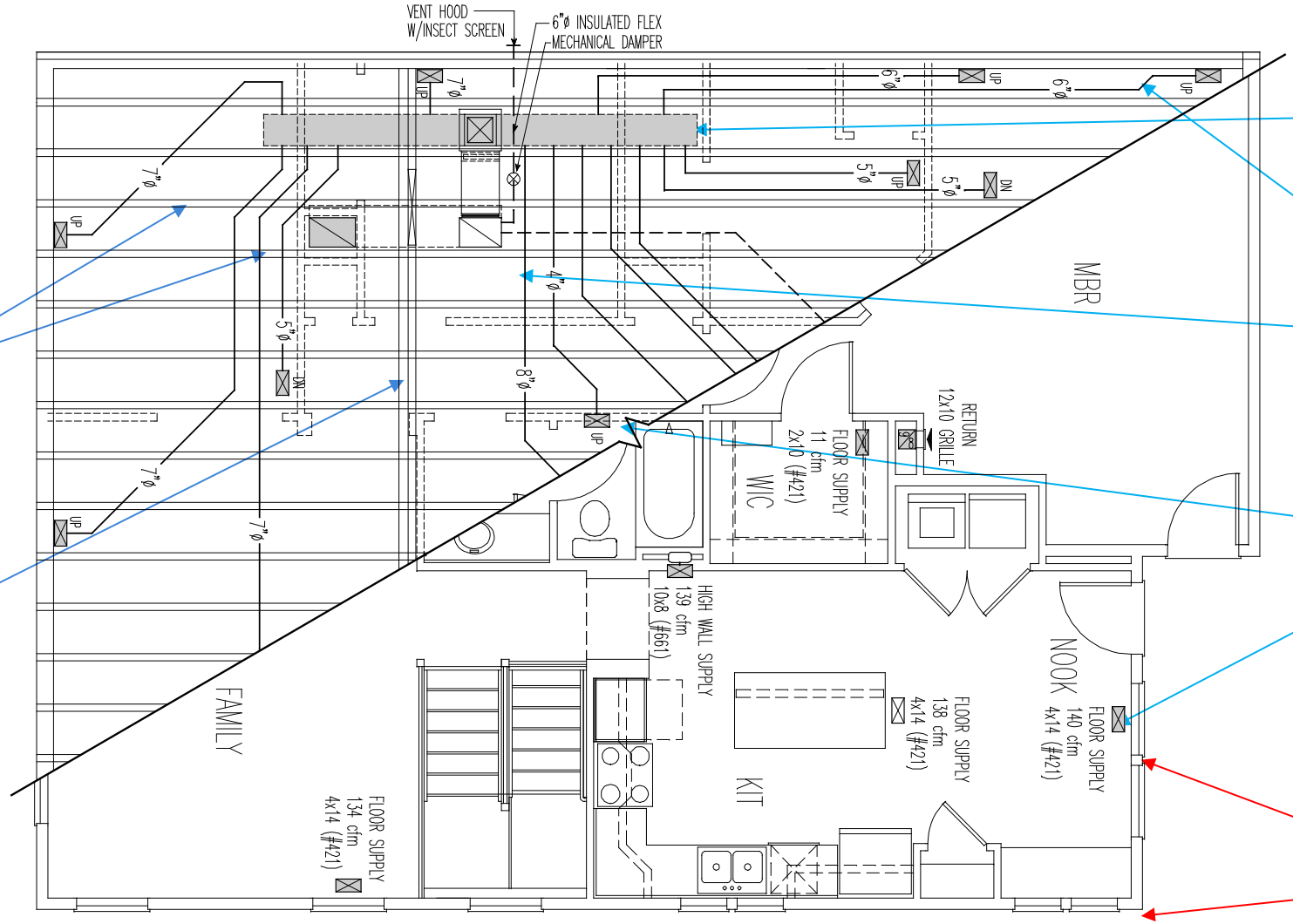
Occupant-dominated performance

- Domestic hot water (DHW)
- Appliances
- Lighting
- Plug load

CONFOUND IT!
Why make a home so airtight that then we need to introduce mechanical ventilation?

- It's about control or management, not by happenstance
- The right amount
- From the right place
- At the right time

Designing for high performance integrating HVAC and building enclosure: architect



FRAMING:
Floor joists

FRAMING:
Carrying beam

HVAC:
Forced air supply trunk

HVAC:
FA supply ducts

HVAC:
FA supply registers

ENCLOSURE:
Windows

Designing for high performance: Integrating HVAC and building enclosure

Branch Duct Runs

Room [Add locations as needed]	Design Airflow (cfm)	Branch Duct Size (in)	Register Type/ Hart & Cooley Model #	Size	Transfer Grille or Jump Duct: Jump Duct Dia (in)	Transfer Grille or Jump Duct: Transfer Grille Size #650
Basement (Front)	67	5	Ceiling #661	8x4		
Basement (Rear)	67	5	Ceiling #661	8x4		
Kitchen (Front)	139	8	Wall #661	10x8		
Kitchen (Island)	138	8	Floor #421	4x14		
Nook	140	8	Floor #421	4x14		
Family Rm (Right)	134	7	Floor #421	4x14		
Family Rm (Front)	134	7	Floor #421	4x14		
MBR (Rear)	85	6	Floor #421	4x8		
MBR (Front)	85	6	Floor #421	4x8		
MBath	61	5	Floor #421	2x12		
WIkIn	11	4	Floor #421	2x10		
BR2	113	7	Floor #421	4x12		14x8
Study/BR3	128	7	Floor #421	4x14		14x8
Bath 2	20	4	Wall #661	6x4		
Front Hall Return Grille	1,080		Wall #650	18x24		
MBR Return Grille	242		Wall #650	12x10		
Air Cycler Ventilation Syst.	73	6				

Supply Trunks

Trunk Name	Rooms	Airflow (cfm)	Depth (in)	Width (in)
Rear Supply Trunk	Kit, MBR, Mbath, etc.	858	12	17
Front Supply Trunk	Fam Rm, Study	464	10	11

Return Trunks

					Flex Duct Dia (in)
Main Return	All	1,285	18	21	---
Front Hall Return	All but MBR Suite	1,080	14	22	---
MBR Return	MBR, MBath, WIkIn	242	8	9	10

Round - Oval Equivalent Sizes

Round Duct (in)	Oval Riser Size (in)
6	4 x 9
7	5 x 10
8	5 x 11
9	5 x 14

HVAC Duct Size Documentation

CONFOUND IT!
Seriously: you mean the architect and engineer need to cooperate/speak each other's language?

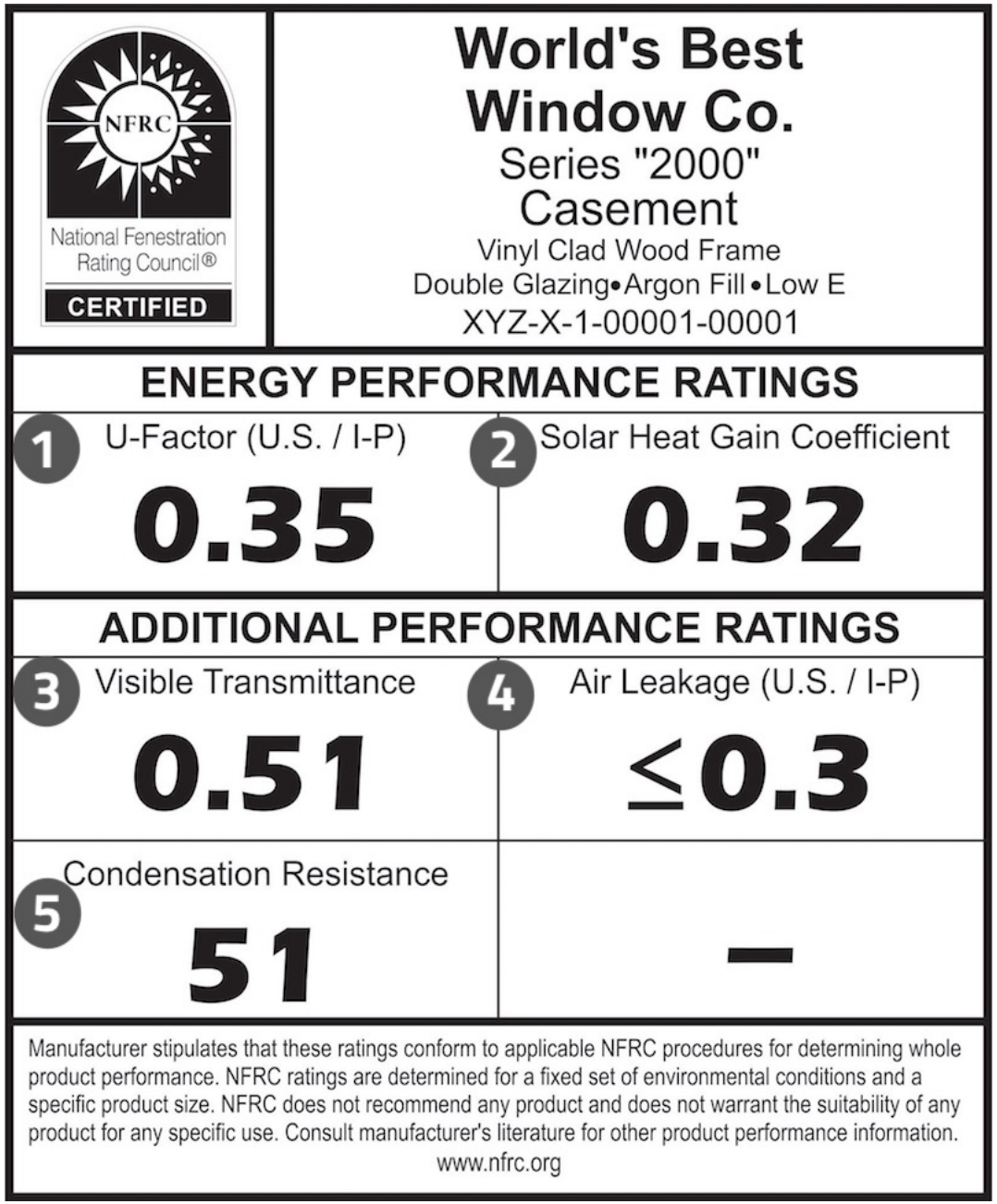
CONFOUND IT!
What are our priorities In 3C-REN climate zones?

CA CZ COMPARISON

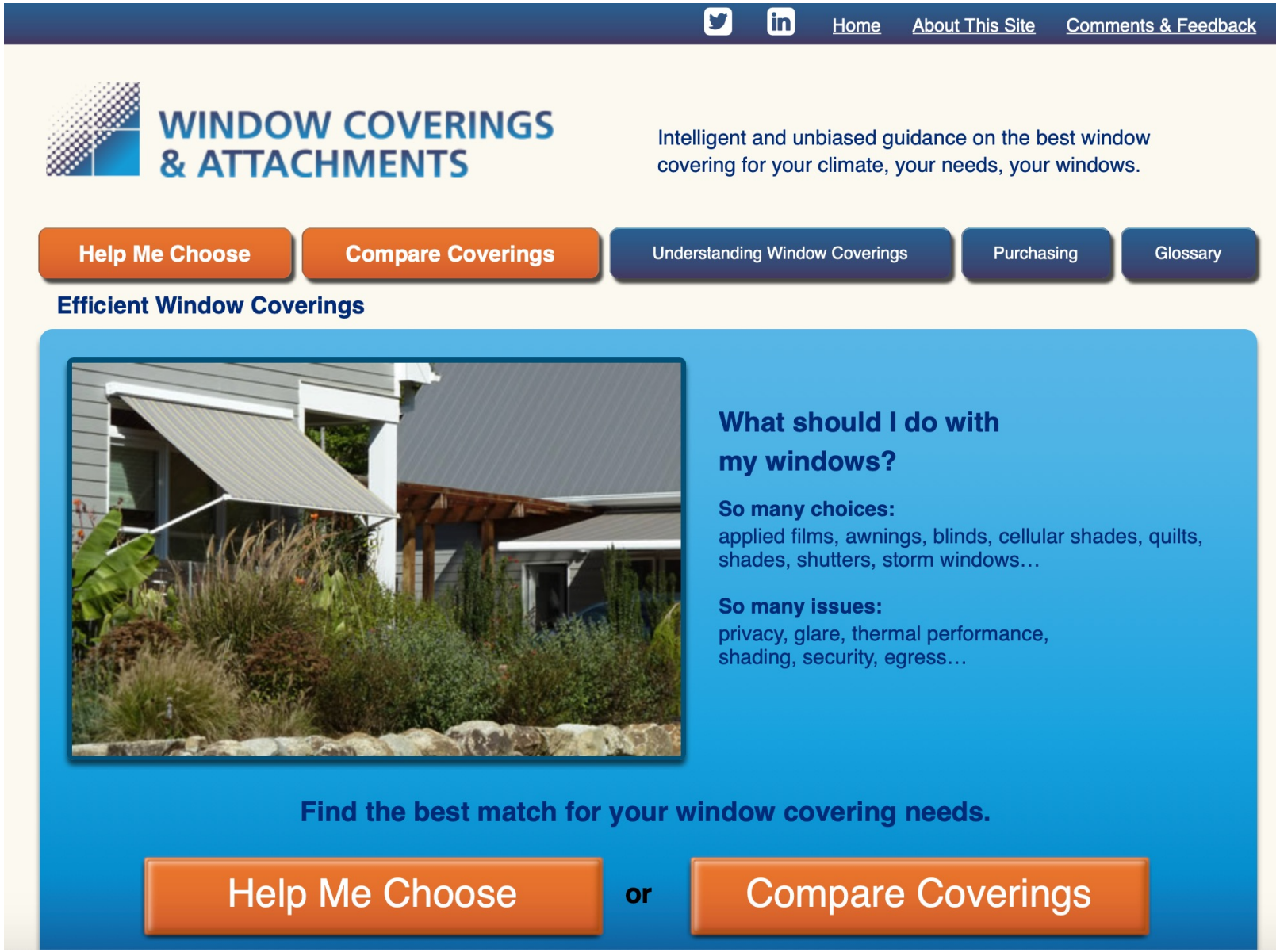
ZONE	Ref City	Climate Conditions			Design Day (97.5%)		Climate Priorities			Title 24 Reqs			
		Summer Temp R	Record High	Record Low	Winter	Summer	Winter	Summer		Ceiling	Walls	Glazing U	Max Area (%)
4	San Jose	23	109	19	36	81	Insulate	Shade	C	R38	R25	0.38	14
							Reduce Infiltration	Nat ventilation	D	R30	R13	0.67	20
							Passive Solar	Evap cooling					
5	Santa Maria	22	108	20	33	76	Insulate	Shade	C	R38	R25	0.42	16
							Red Infil	Nat vent	D	R30	R13	0.67	20
							Passive Solar	Distr Therm Mass					
6	LA (LAX)	15	110	27	43	80	Insulate	Shade	C	R38	R21	0.42	14
							Reduce Infiltration	Nat vent	D	R30	R13	0.67	20
							Passive Solar	Distr Therm Mass					
9	LA (Civic Ctr)	19	110	28	40	89	Insulate	Shade	C	R38	R21	0.38	14
							Reduce Infiltration	Nat vent	D	R30	R13	0.67	20
							Passive Solar	Distr Therm Mass					
16	Bishop	34	109	-7	15	100	Insulate	Shade	C	R49	R29	0.42	14
							Reduce Infiltration	Evap Cool	D	R38	R21	0.55	20
							Passive Solar	High T Mass w Night vent					

The importance of windows, glazing, shading

https://efficientwindows.org


NFRC
National Fenestration Rating Council®
CERTIFIED
World's Best Window Co.
Series "2000"
Casement
Vinyl Clad Wood Frame
Double Glazing•Argon Fill•Low E
XYZ-X-1-00001-00001
ENERGY PERFORMANCE RATINGS
1 U-Factor (U.S. / I-P)
0.35
2 Solar Heat Gain Coefficient
0.32
ADDITIONAL PERFORMANCE RATINGS
3 Visible Transmittance
0.51
4 Air Leakage (U.S. / I-P)
≤0.3
5 Condensation Resistance
51
–
Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information.
www.nfrc.org

The importance of windows, glazing, shading



https://efficientwindowcoverings.org

HP Case Study: 18870 Barnhart Ave. Cupertino

The Energy+ Household:

a consumer's perspective on sustainable energy

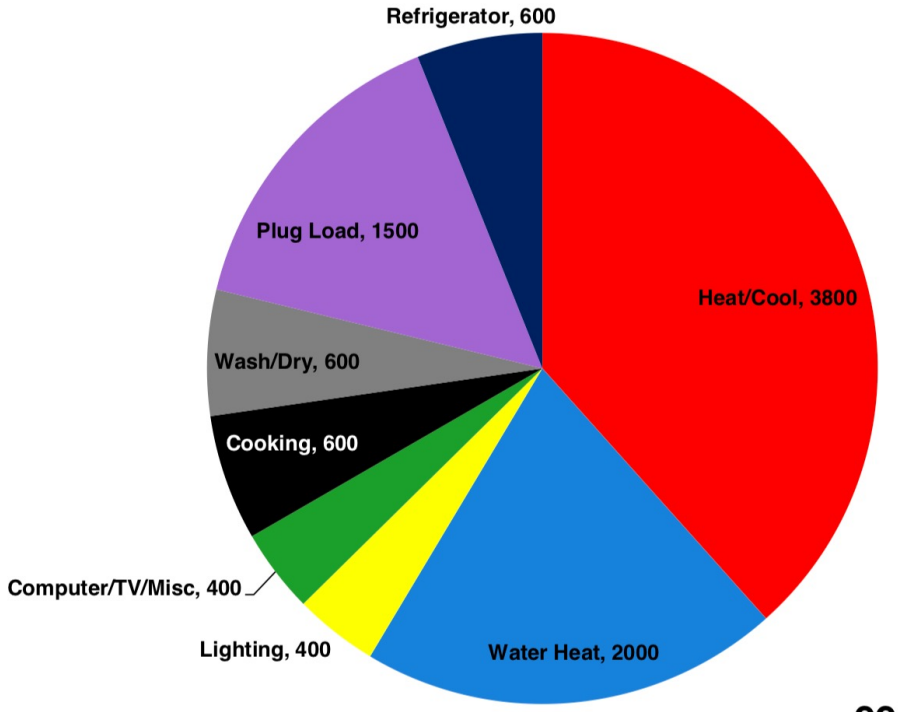
Indradeep Ghosh, PhD
Cupertino, CA, USA

Energy Use Intensity (EUI) – kBtu/sf/yr

(1 kWh = 3,412 Btu)

4.5 kWh/sf/yr = 15.36 kBtu/sf/yr

Total for the Year



9900 kWh

(50% of US Average)
(All electric home)

4.5 kWh/sq ft per year

High Performance Case Study: 9 Eastlake, Pacifica

Green Building Advisor

9 Eastlake, Pacifica

Energy Use Intensity (EUI) – kBtu/sf/yr

35,635 kBtu/yr ÷ 1,745 ft = 20.4 kBtu/sf/yr

Pacific Gas and Electric Company

PACIFIC GAS AND ELECTRIC COMPANY
NET ENERGY METERING ELECTRIC STATEMENT
THIS IS NOT A BILL
Service Dates: January 13,2010 to February 12,2010
Includes True-up period from Mar 2009 to Feb 2010

[redacted]

Rate Schedule: E6TB/NEMS

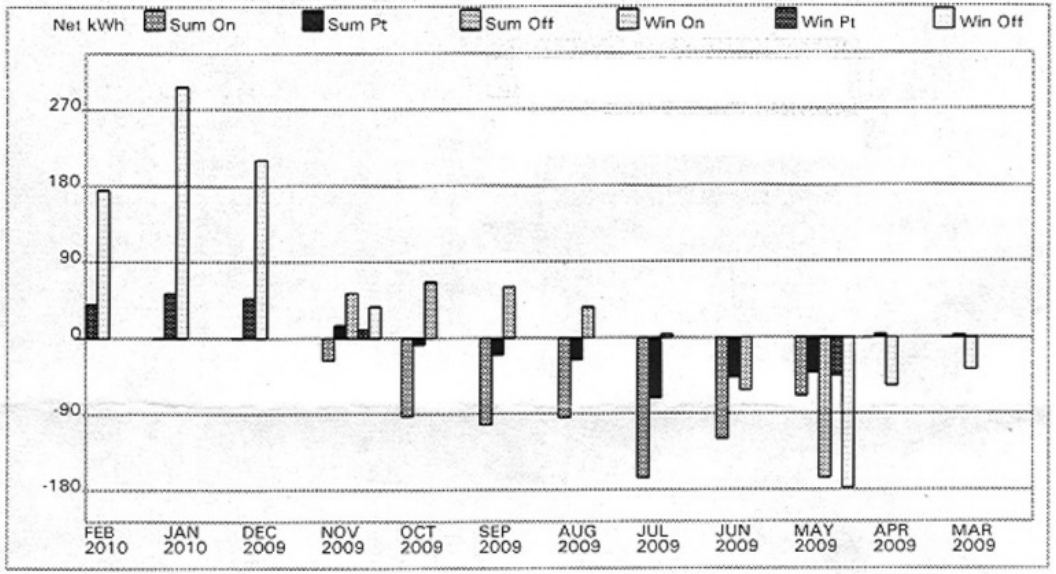
PAGE 3

ENERGY TRUE-UP HISTORY:

BILLING MONTH	BILL TO DATE	SUMMER ON	SUMMER PART	SUMMER OFF	WINTER PART	WINTER OFF	TOTAL ENERGY	ENERGY CHARGES /CREDITS
FEB 2010	02/12/10				40	175	215	$20.13
JAN 2010	01/13/10				53	297	350	$32.97
DEC 2009	12/14/09				47	210	257	$23.35
NOV 2009	11/12/09	-26	15	53	10	37	89	$3.32
OCT 2009	10/14/09	-93	-8	66			-35	$-22.81
SEP 2009	09/14/09	-103	-20	60			-63	$-27.97
AUG 2009	08/14/09	-95	-26	36			-85	$-28.53
JUL 2009	07/16/09	-166	-72	4			-234	$-58.68
JUN 2009	06/16/09	-120	-47	-62			-229	$-47.19
MAY 2009	05/15/09	-69	-42	-166	-45	-178	-500	$-88.24
APR 2009	04/16/09				4	-57	-53	$-4.65
MAR 2009	03/17/09				3	-38	-35	$-3.07
TOTALS							-323	$-201.37

**Energy Charges/Credits (-) include all energy related amounts and taxes. Any negative amounts shown in the "TOTALS" row will not be applied to your next true-up period. This is because the net metering program was designed by the legislature for systems sized to customer usage on an annual basis. Currently approved tariffs and legislation provide that any financial credit associated with this program be used to offset current year bills, but neither result in a negative annual bill, nor be carried forward from one year to the next.

KWH



Bye for now—take home resources

- Building America Solutions Center: https://basc.pnnl.gov
- Building Science Corporation: https://www.buildingscience.com
- Building-Wright:
  - Assessment form – https://building-wright.com/2019/02/24/hygrothermal-building-assessment-available-as-a-pdf/
  - YouTube series on assessments – https://www.youtube.com/playlist?list=PL2pL2KVsx9SCcqQBdEjbiYfI3AouC1CoL
- GreenBuildingAdvisor: https://www.greenbuildingadvisor.com

3C REN

PETER YOST
BUILDING - WRIGHT

Closing

- Continuing Education Units Available
  - Contact ian.logan@ventura.org for AIA HSW|LUs
- Coming to Your Inbox Soon!
  - Slides, Recording, & Survey – Please Take It and Help Us Out!
- **Upcoming HPF Courses:**
  - **The Role of Building Science in High Performance Buildings: Session 2 (5/19) ***ZOOM LINK GOOD FOR BOTH DAYS**
  - **Introduction to High Performance Buildings & Careers (6/21)**
  - **Crafting High-Performance Enclosures: Roofs, Walls, and Floors (7/12)**
- Regularly Scheduled Programming:
  - Home Performance: Tools of the Trade (5/24)
  - All Electric Construction: Part 2 HPWH's (6/7
  - Healthy Homes for Healthier Living – A Webinar for Households (6/8)

Thank you!

For more info:
3c-ren.org

For questions:
info@3c-ren.org

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TRI-COUNTY REGIONAL ENERGY NETWORK

SAN LUIS OBISPO • SANTA BARBARA • VENTURA