We will be starting soon!

Thanks for joining us

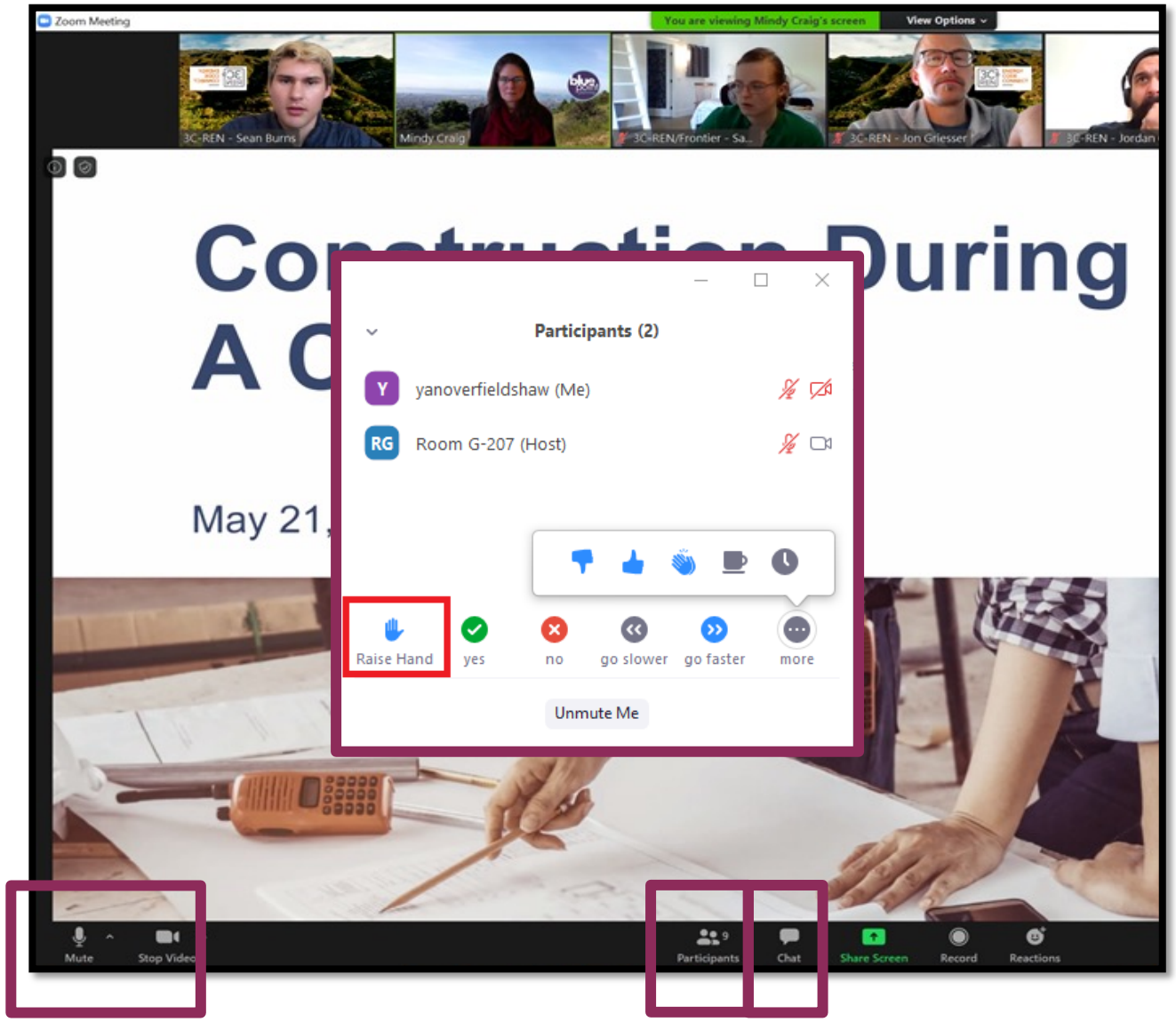
The Role of Building Science in High Performance Building

Peter Yost, Building - Wright

May 17th & 19th

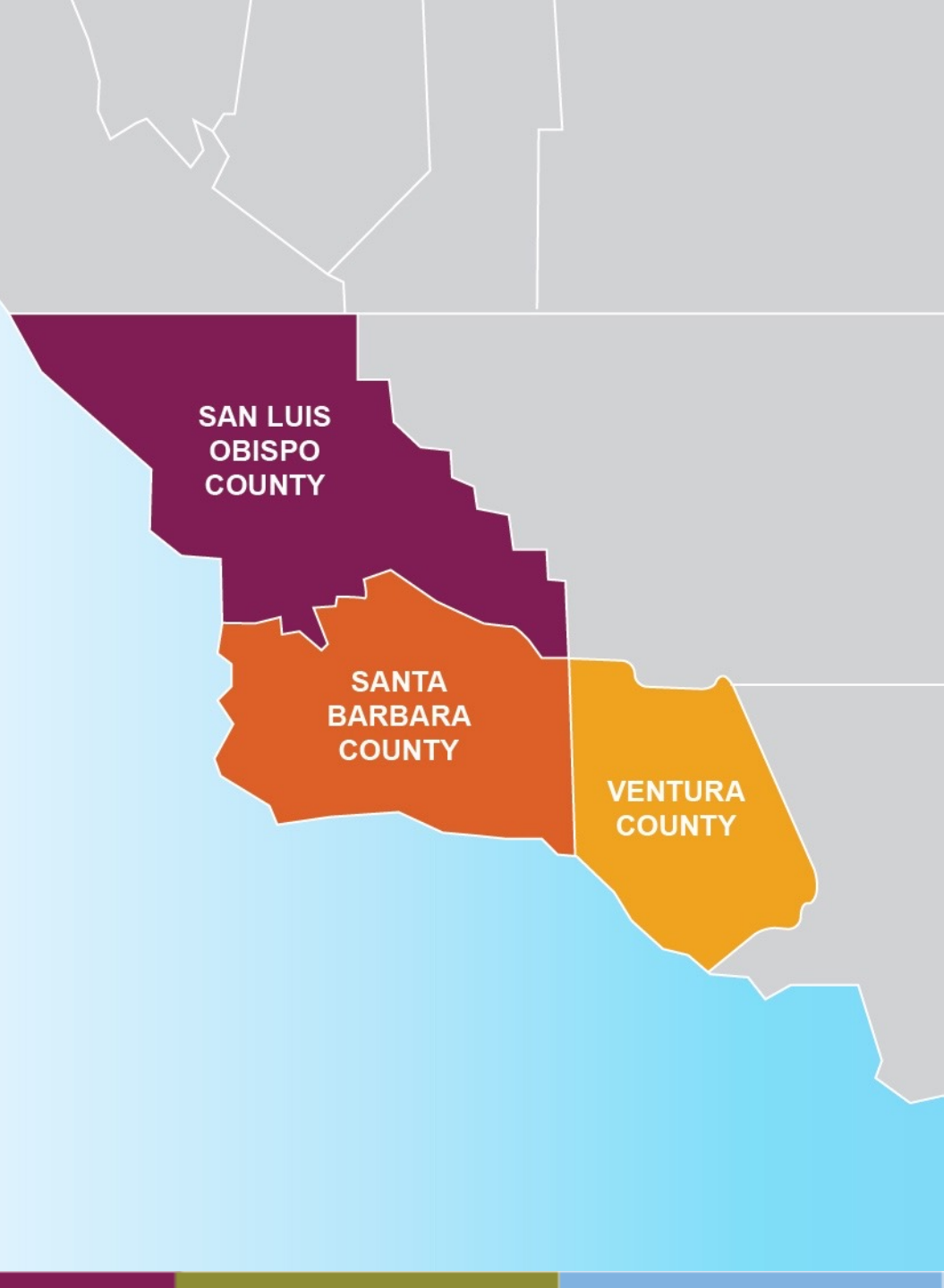
Zoom Orientation

- 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.

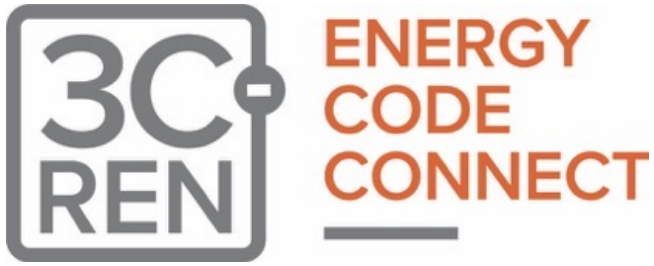


3C-REN: Tri-County Regional Energy Network

- 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:

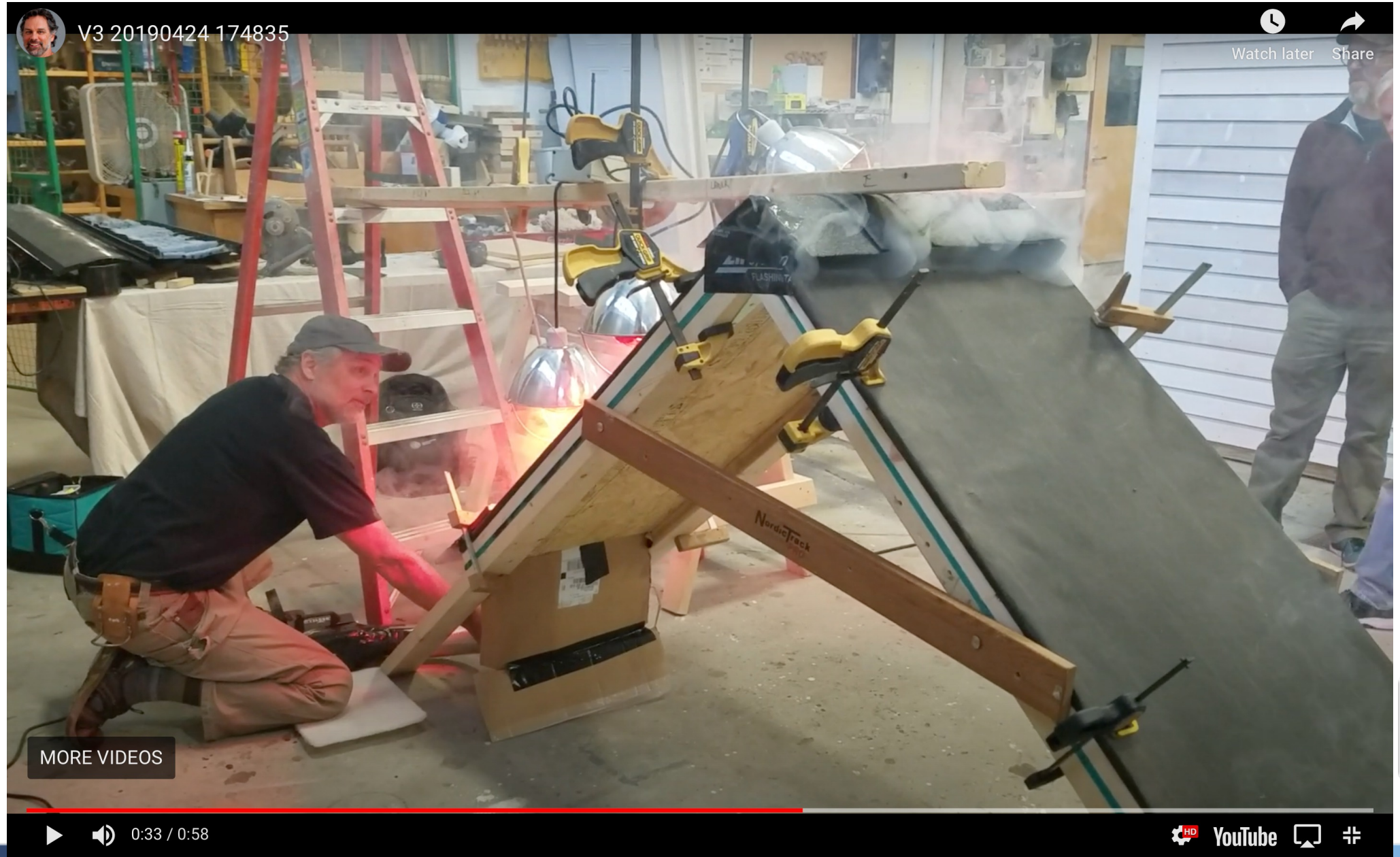
- Formal certificate of completion
- Field-based, hands-on classes to complement initial series of lecture classes
- Mentorship and/or peer learning activities to support participants' learning process

How Buildings Work
Part I

SCIENCE **AND** BUILDINGS

PETER YOST
BUILDING - WRIGHT

Your Instructor...



Your Instructor...

Course Structure

- Two 1.5-hour sessions
  - Part I: Science AND Buildings
  - Part II: Science IN Buildings
- Homework
- Discussion

What Makes Some Homes Work Better?

18820 Barnhart Ave Cupertino CA

18870 Barnhart Ave Cupertino CA

What does “better” mean?

- Efficient
  - **Energy**
  - Water
  - Materials
- Safe
  - **Indoor air quality**
  - Fire
- Durable
  - **Built to last**
  - Built to serve over time
  - Resilient
- Easy on...
  - **Occupants**
  - **Community**
  - **Planet**

} **(the “electric slide”)**

18870 Barnhart Ave Cupertino CA

Science & buildings: just three things...

- It’s a bit of physical science
- It’s a bit of chemistry
- It’s a bit of biology

Science & buildings: physics example
Wind and pressure...

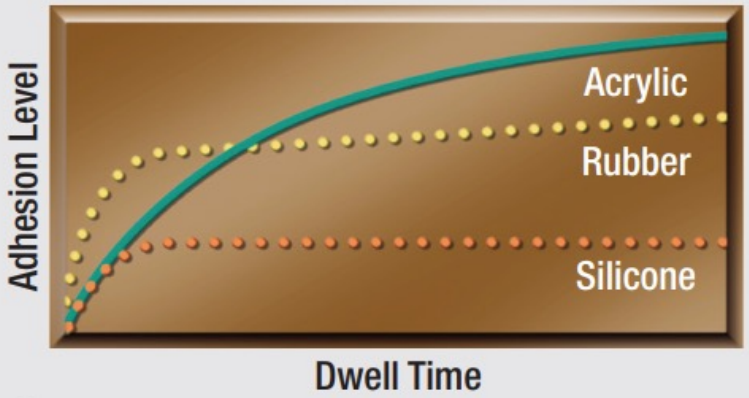
- 20 mph – 50 Pascals
- 25 mph – 75 Pa
- 100 mph – 1300 Pa
- 232 mph – 6400 Pa

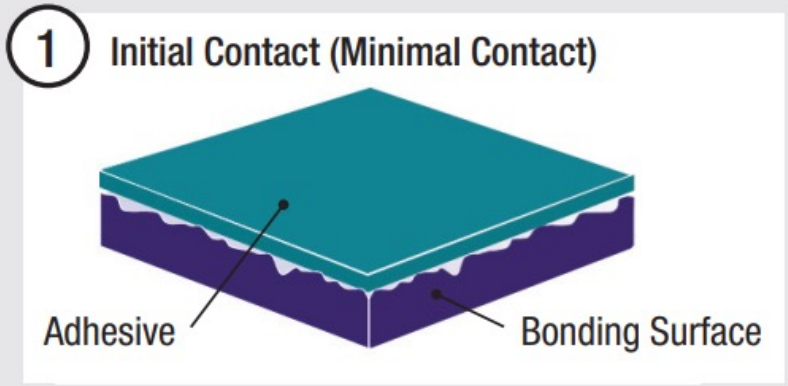
Institute for Business & Home Safety

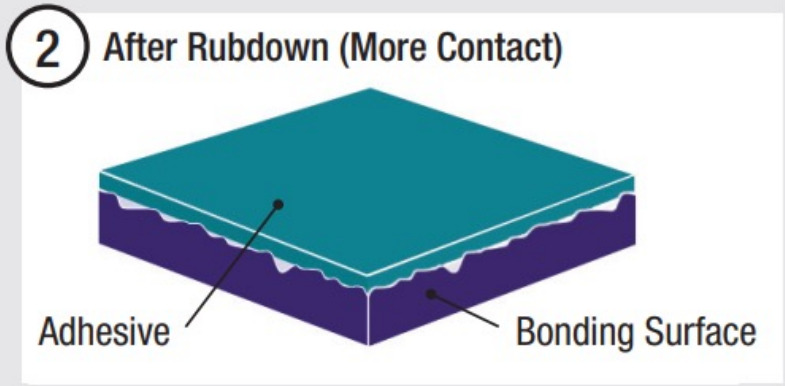
Science & buildings: Chemistry example
Pressure-sensitive adhesive (PSA) tapes

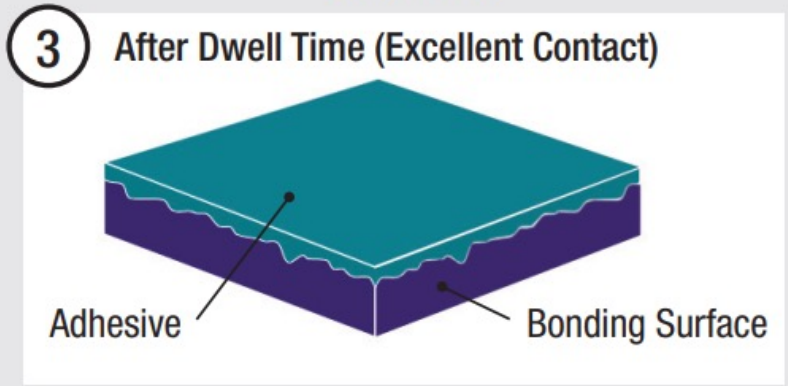
Adhesive Surface Contact

Applying firm pressure to the bond increases adhesive flow and contact for more secure bonding. Time and temperature will typically further increase contact and adhesion values.









Science & buildings: Biology example
Mold

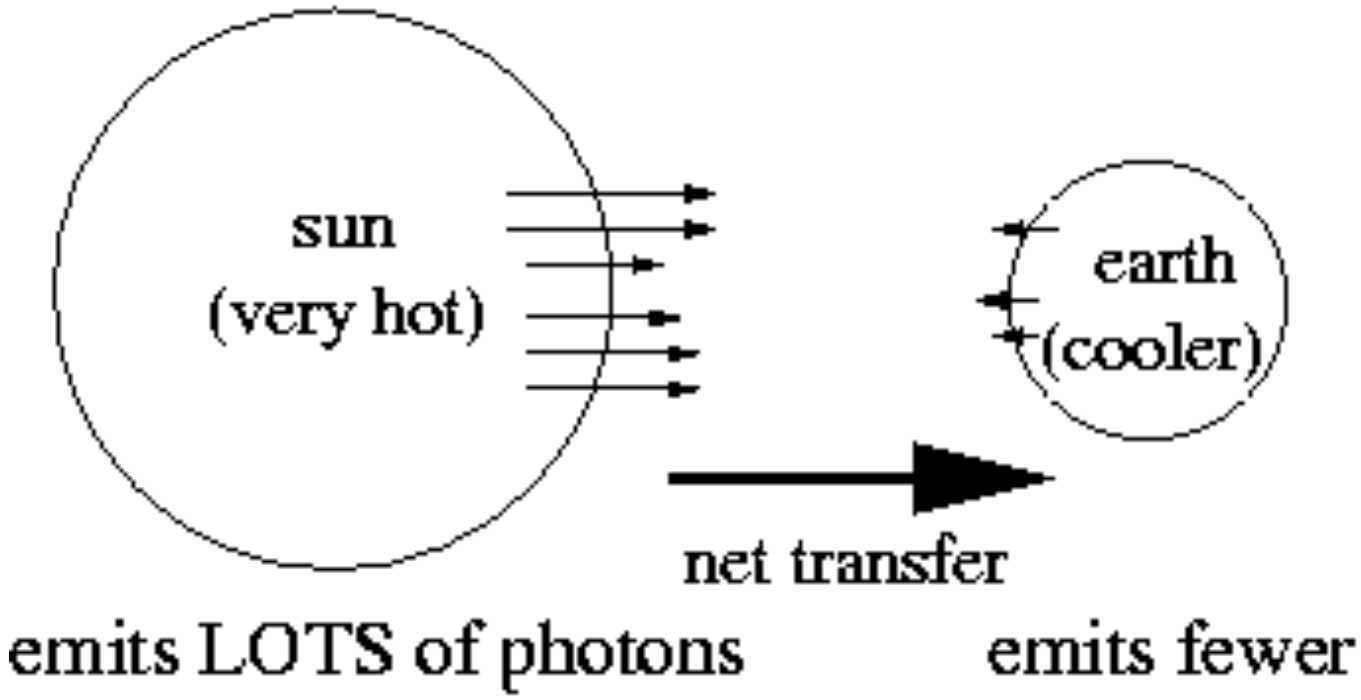
Science & buildings: just three things...

- How does heat get around?
- How does water get around?
- How are the two related?

Just Three Things

- How does heat get around?

Radiant heat transfer – driven by surface temperature difference

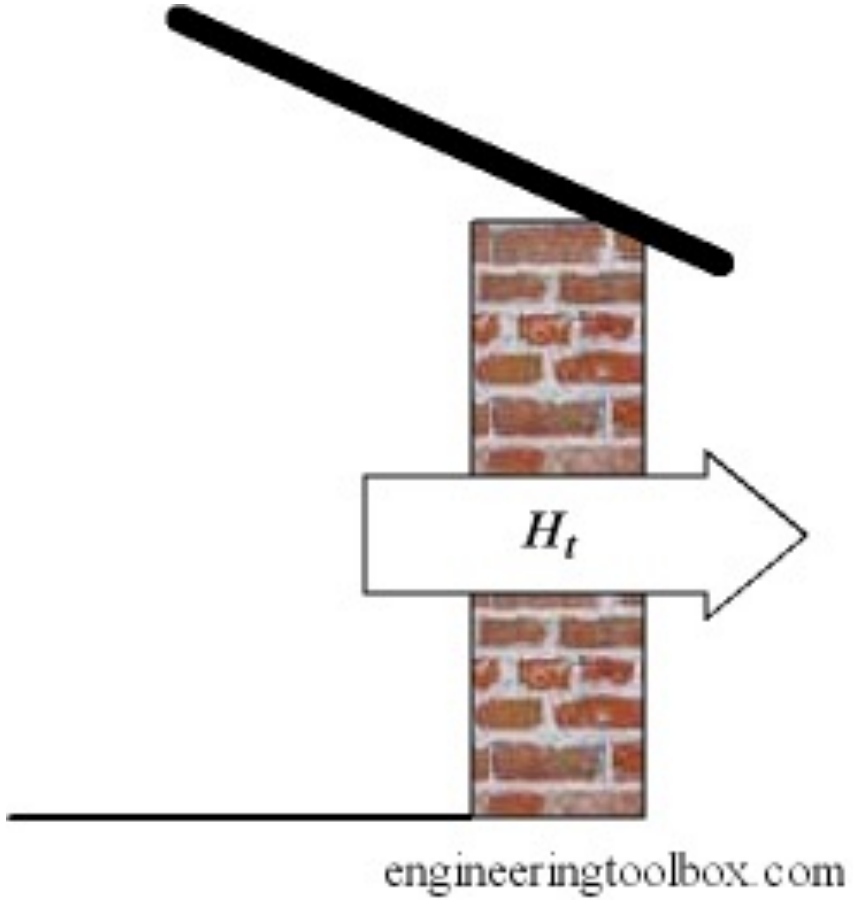


radiation

Electromagnetic waves—from high to low through empty space

Once this energy strikes an object, the energy can be transmitted, reflected or absorbed.

Conductive heat transfer – driven by temperature differences



conduction

Direct transfer of kinetic (vibrational) energy; from high to low in solids

Convective heat transfer – driven by temperature gradients in fluids

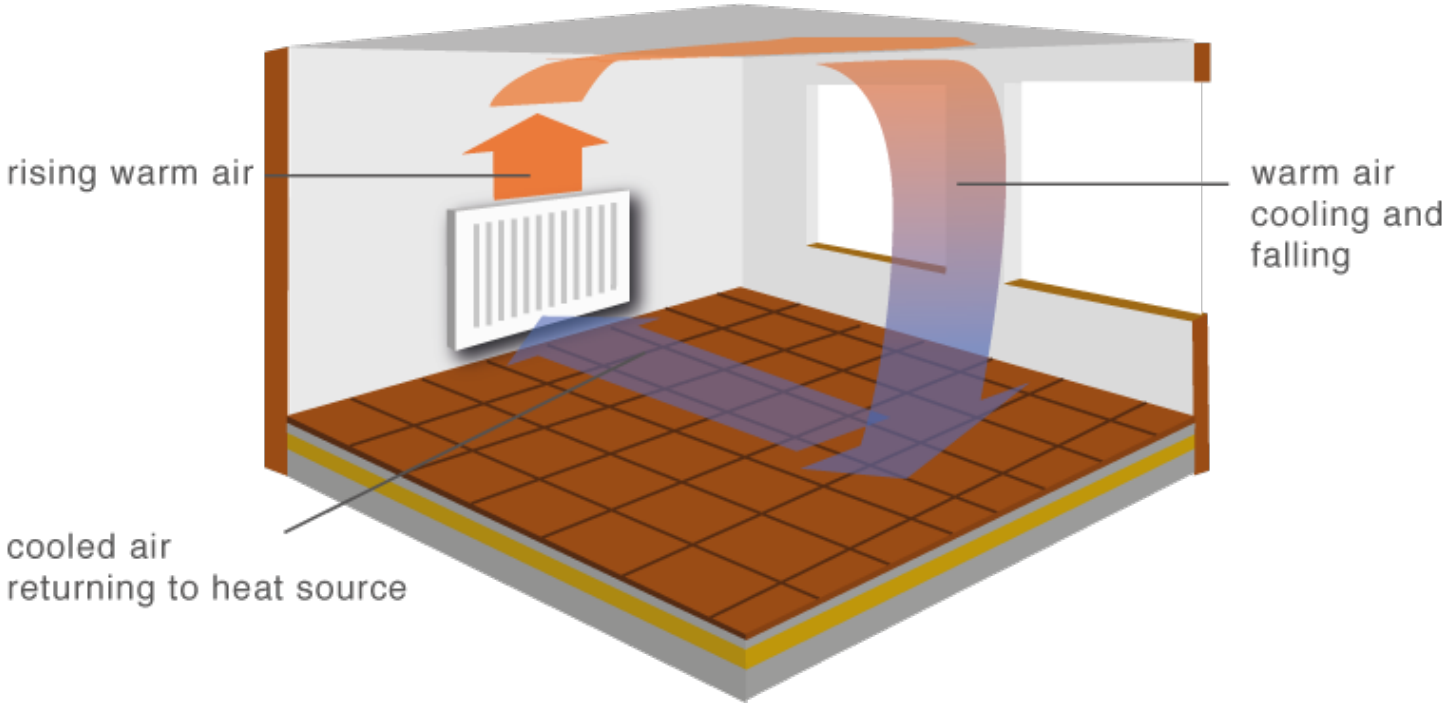


Image credit: greenspec.co.uk

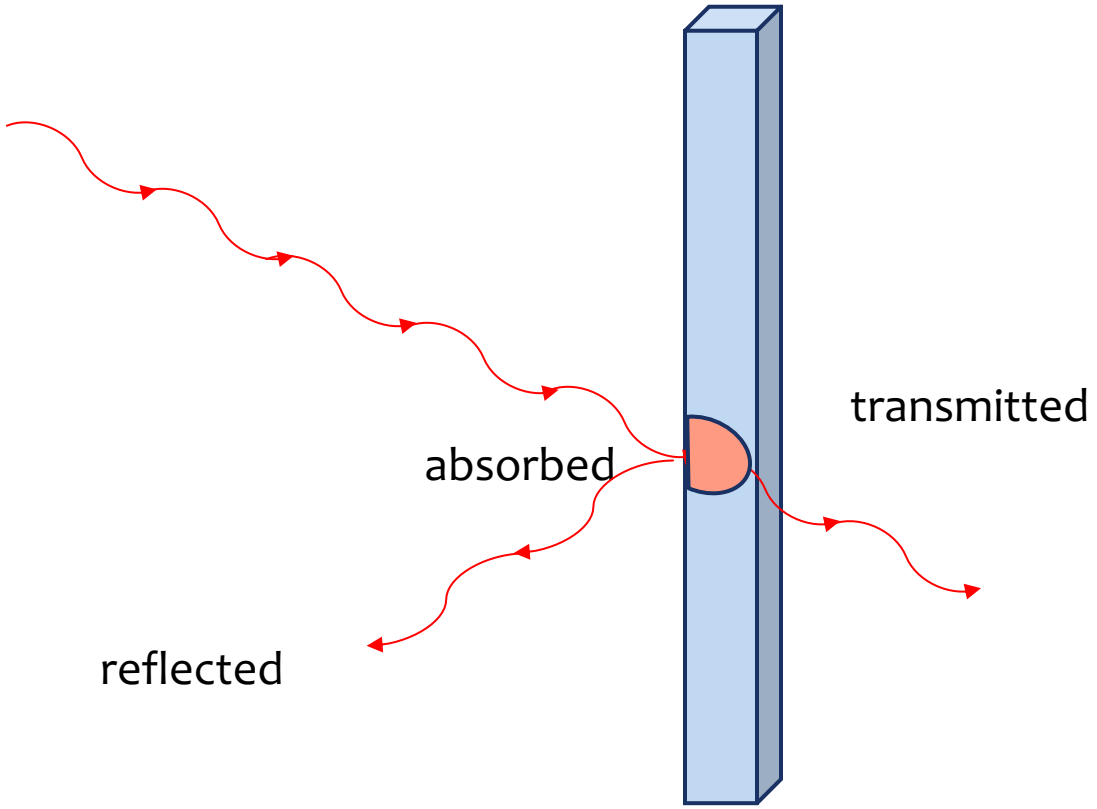
convection

Transfer of thermal energy by a medium—typically fluids like air and water

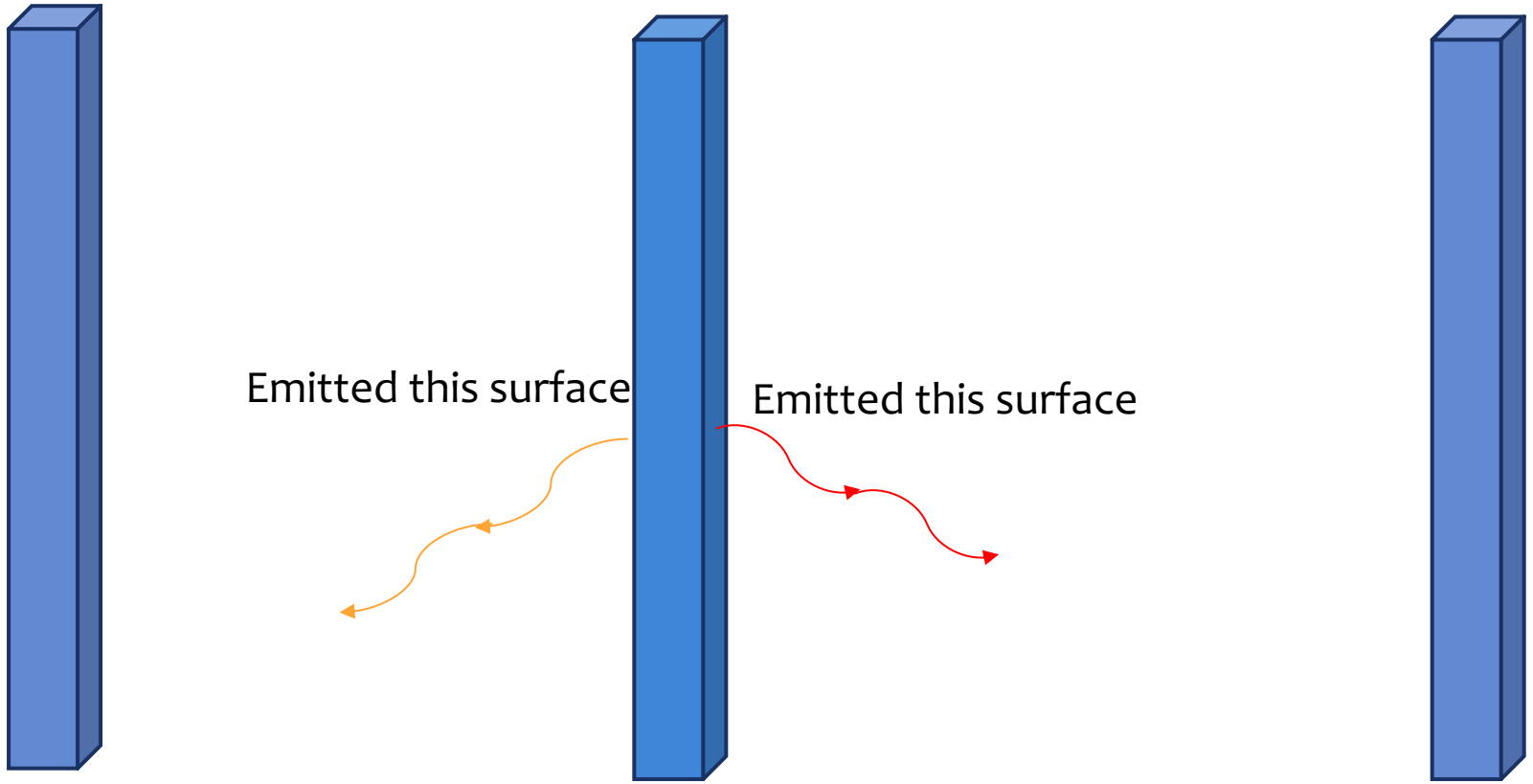
(By the way: heat does not rise, hot air does)

Heat transfer and wood stoves

Radiation: 3 outcomes upon striking a surface



Subsequent action: emission of infra-red radiation - emissivity



Emissivity—just plain weird...

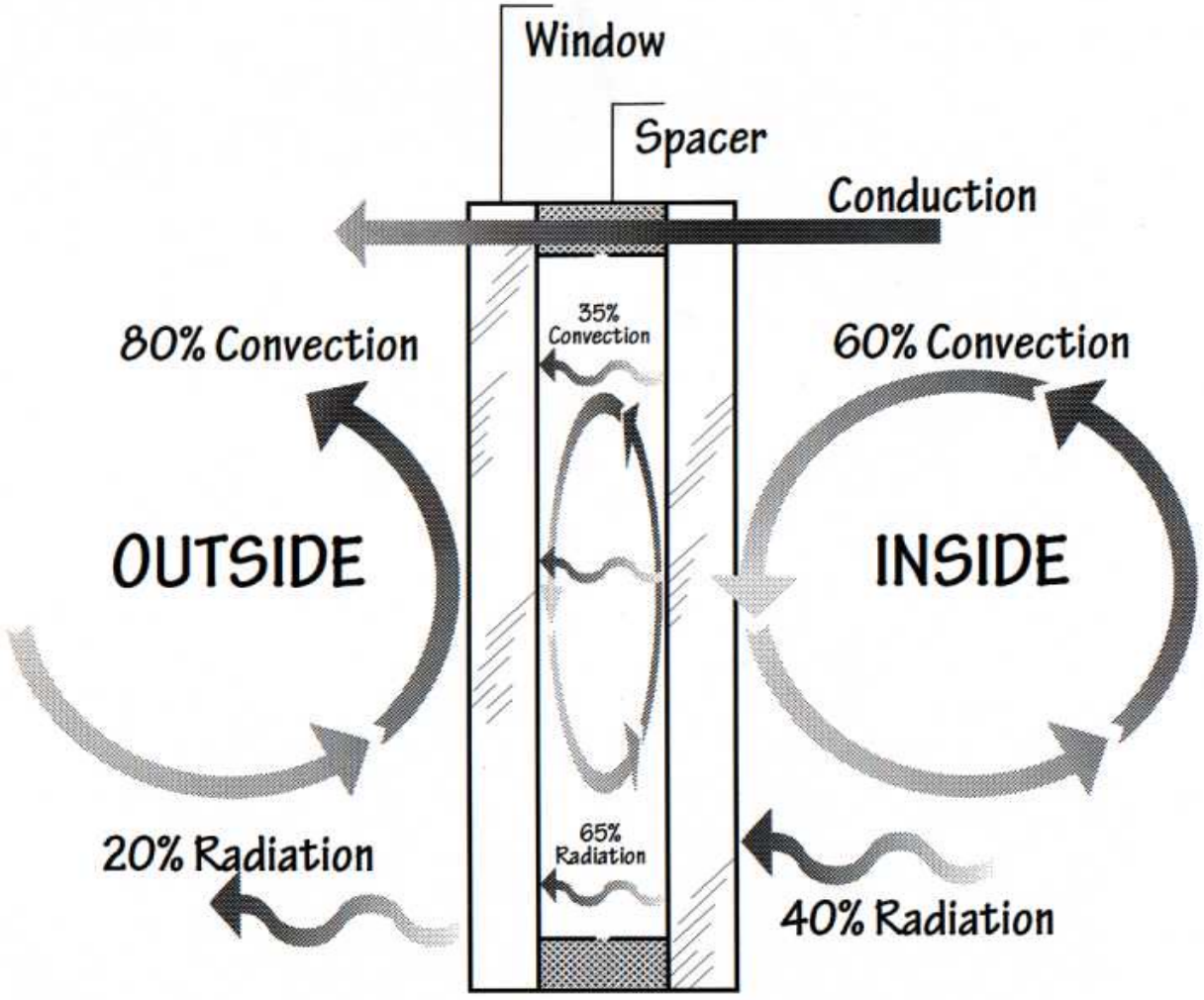
- Once energy is absorbed, how readily that energy is emitted as radiation from the surface of the material
- Shiny polished materials are poor emitters while dull rough surfaces are good emitters
- Assessed from 0.0 to 1.00 with 0 a perfect no-emission and 1 as a perfect complete emission
- It’s really just magic...or very complex atomic-level physics

Absorptance/Emittance Common Building Materials

Material	Solar Absorptance	Thermal Emittance
Red Brick	0.60 – 0.80	0.90
Stucco (white)	0.30 – 0.45	0.90
Polished aluminum	0.10 – 0.30	0.03 – 0.04
Window glass	0.04 – 0.40	.05 (low-e) – 0.8 (non low-e)
Stainless steel	0.40	0.11
Concrete	0.65 – 0.68	0.90

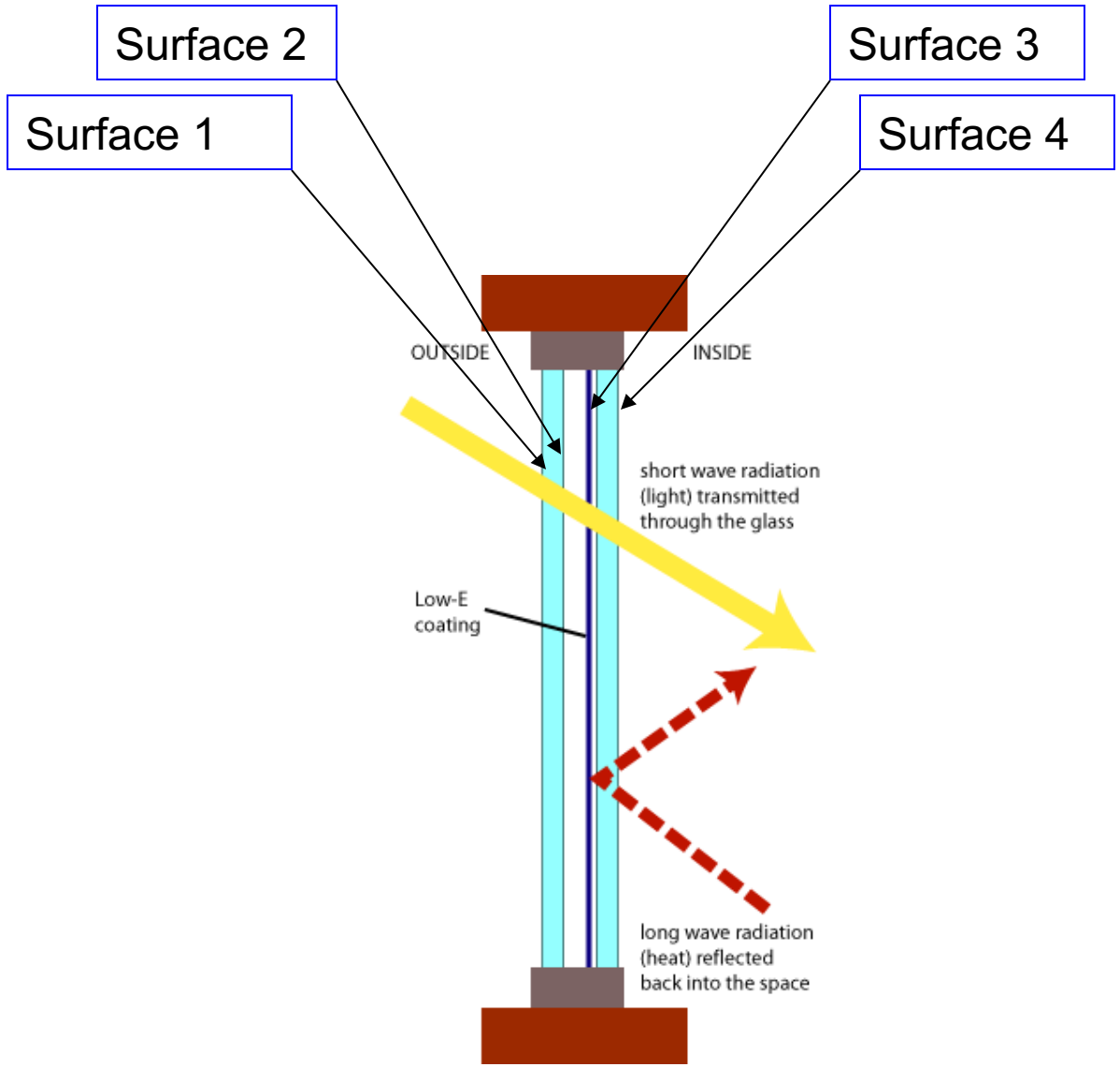
Heat transfer and wood stoves

Practical application - window

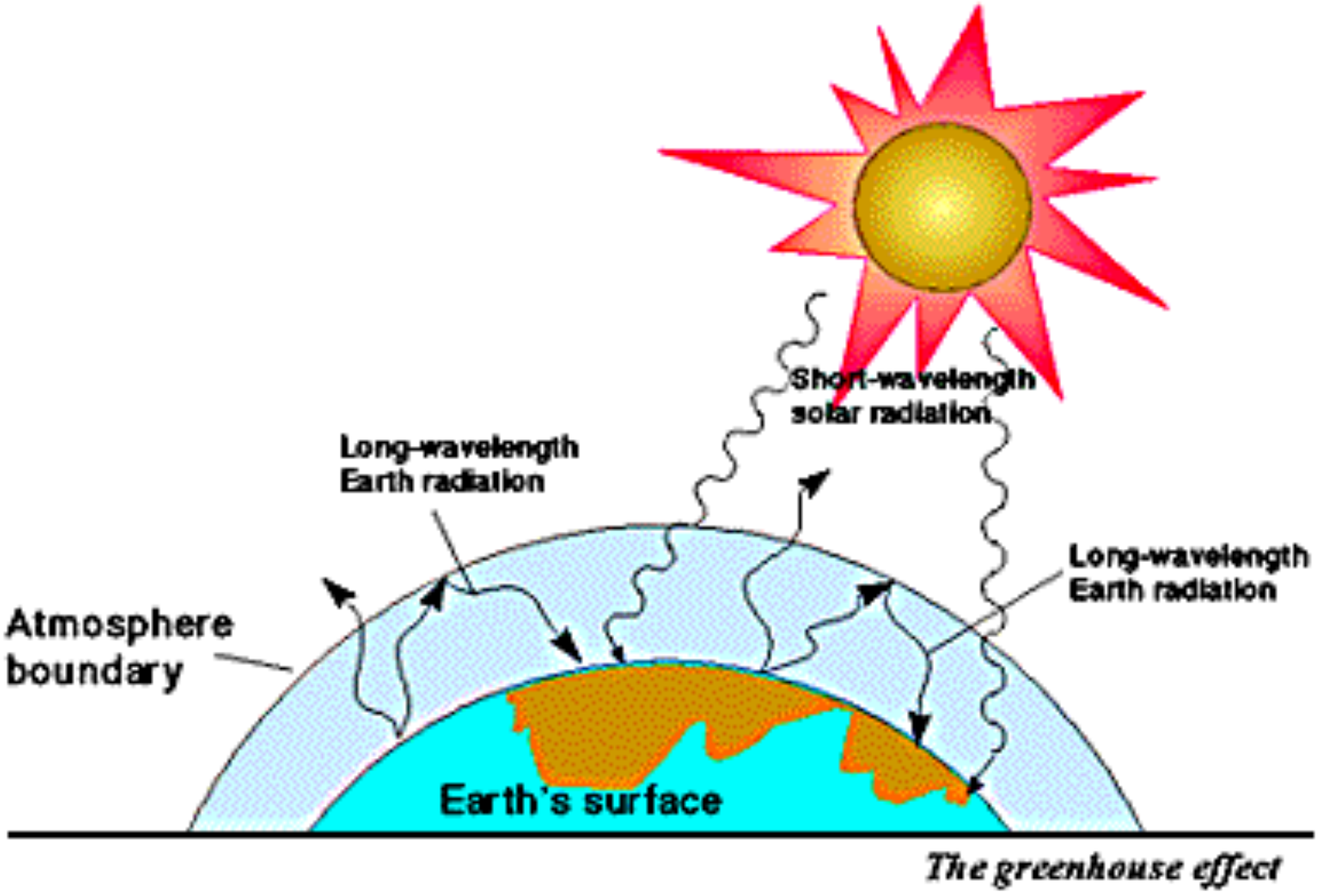


1. Always high to low
2. Always a mix of transfers
3. Different rates of transfer an be important

How low-e windows work (e for emissivity)



Greenhouse Effect – why we are all here...



https://ei.lehigh.edu

How do we measure heat transfer?

- Quite a bit oddly, we use British Thermal Units—BTUs
- BTU = the amount of energy it takes to raise the temperature of 1 pound of water 1 degree Farenheit
- A BTU is really small...
- Radiation? Direct sunlight is about 500 Btus per square foot
- Conduction? 1-inch thick fiberglass insulation allows 0.3 Btus per square foot per hour at a 1 degree F temperature difference
- Convection? Air “carries” about 1/50 Btu per cubic foot per 1 degree Fahrenheit

How do we measure heat transfer?

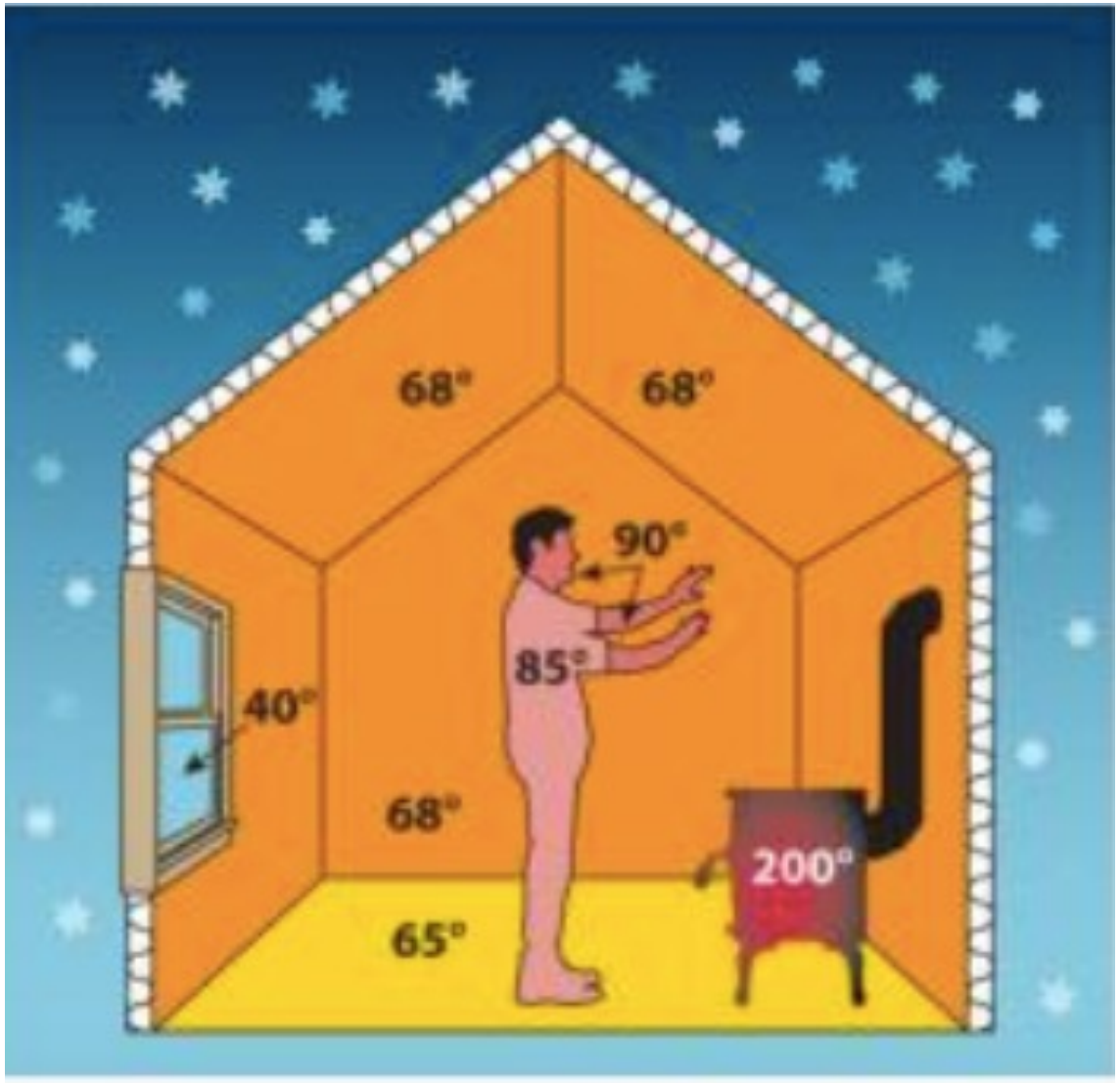
- Radiation: btu/ft^2
- Conduction: $btu/ft^2/hr/°F$
- Convection: $btu/ft^3/°F$

One more perspective on heat transfer: Thermal Comfort

- Made up of 4 environmental factors
  - Mean radiant temperature
  - Air temperature
  - Air speed
  - Relative humidity
- And 2 personal factors
  - Metabolic activity
  - Clothing ensemble
- But dominated by a phenomenon called operative temperature

NY Times August 4 2015

Mean radiant temperature



Operative temperature (T_{op})

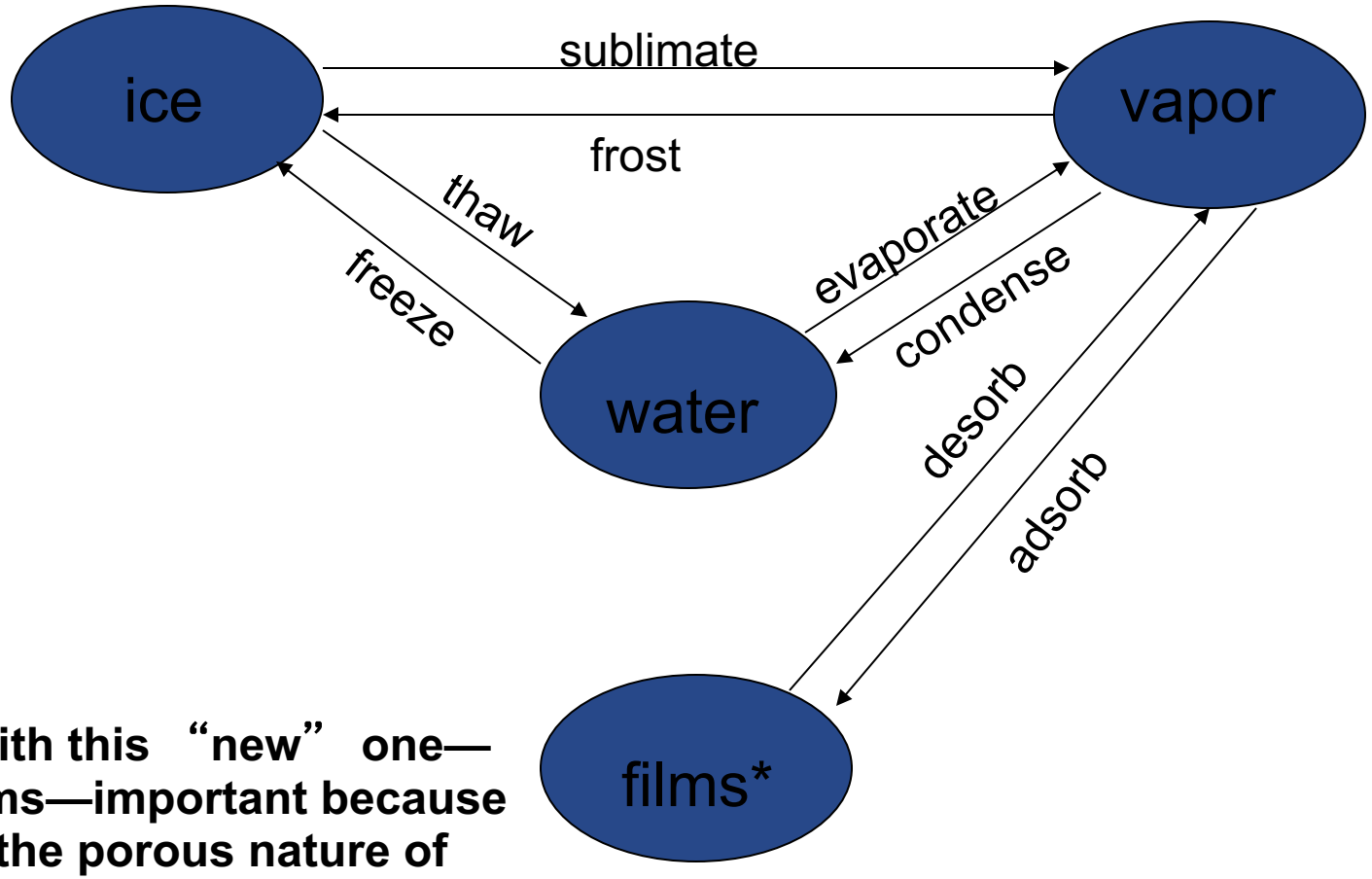
[Mean radiant temp (MRT) + Air temp (AT)] ÷ 2

$= T_{op}$

Just Three Things

- How does water get around?

Moisture Movement – 4? ways

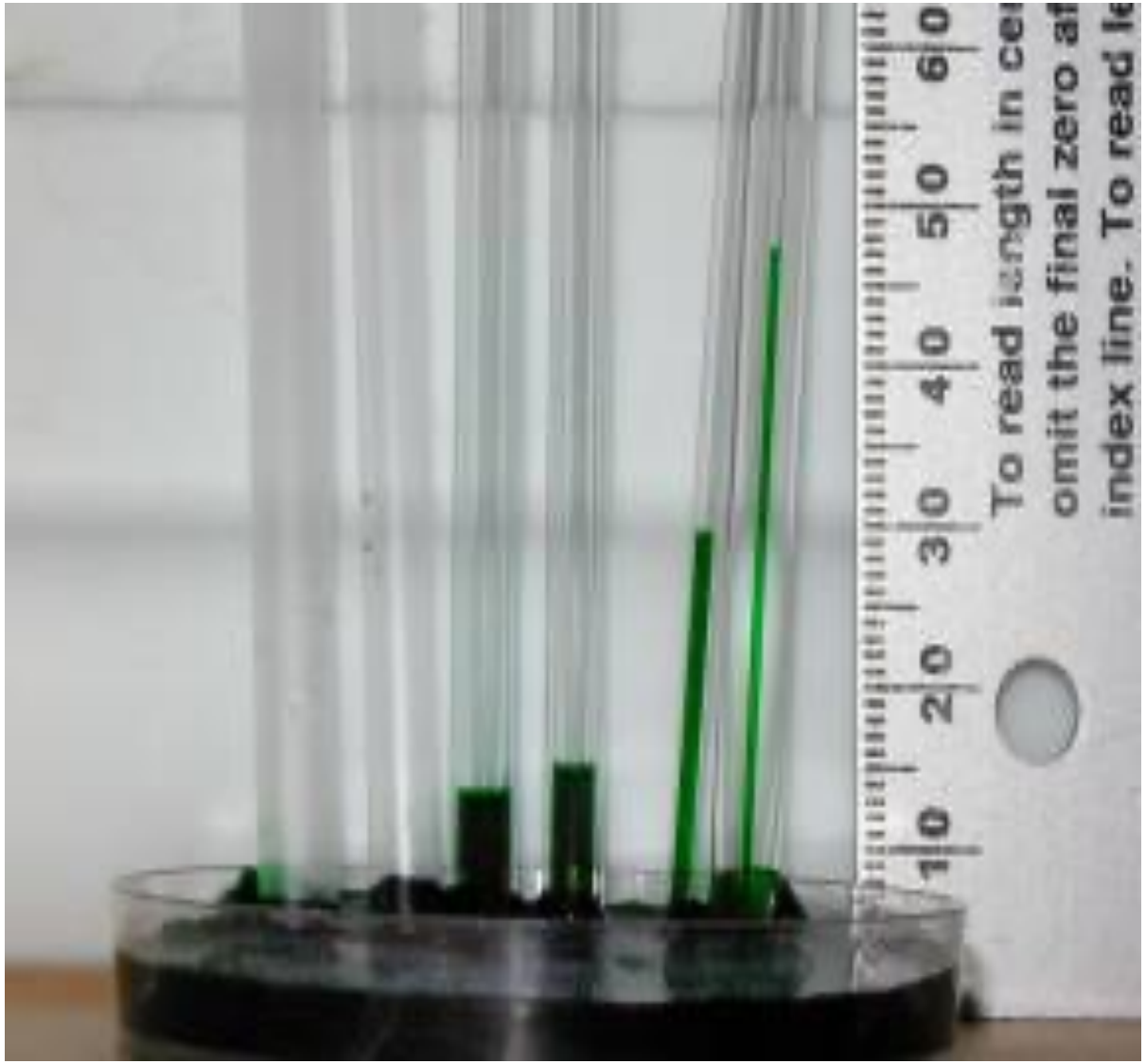


***with this "new" one—films—important because of the porous nature of many materials**

Moisture transfer: bulk water (1)

(Liquid water)

Moisture transfer: wicking (2)



Moisture transfer: capillary – wicking (2)

(Liquid water)

Which of these building materials are porous?

Brick & mortar

Cellulose & fiberglass

Drywall & wood

Concrete and ???

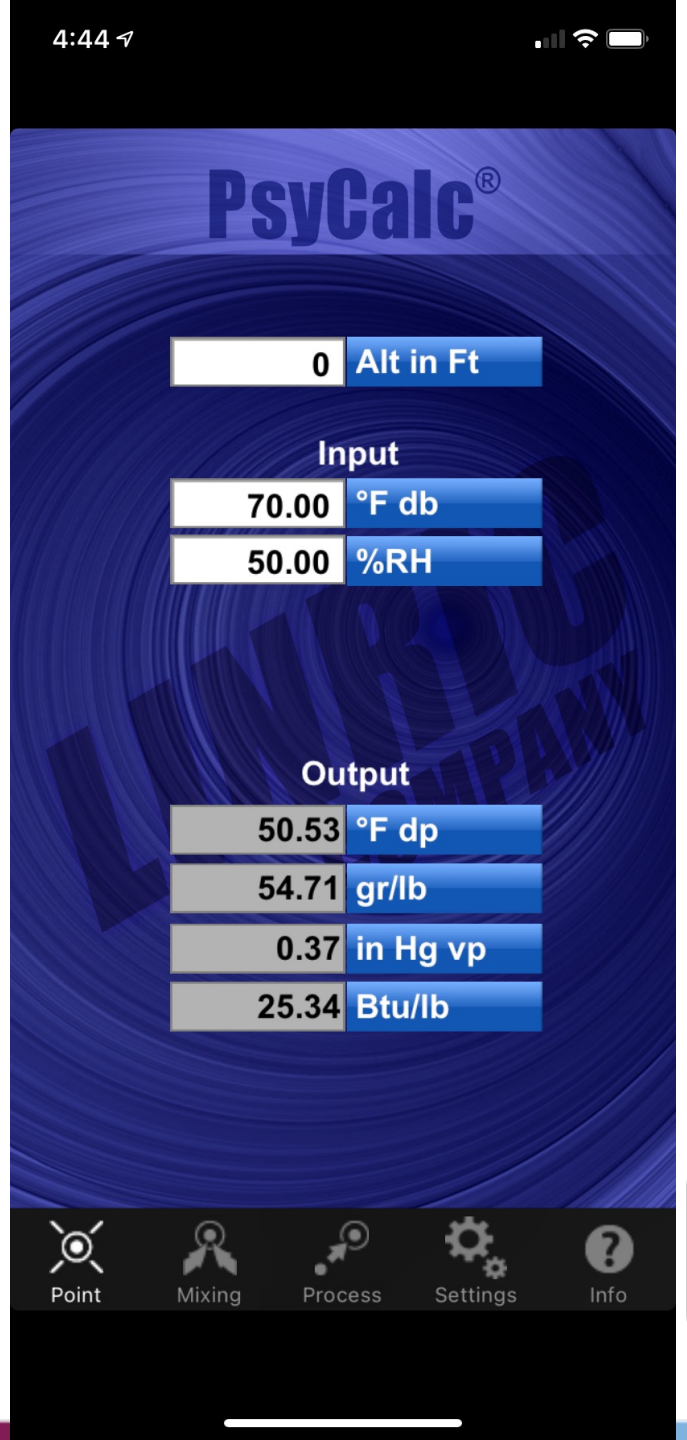
Moisture transfer: leaking air (3)

(Water vapor)

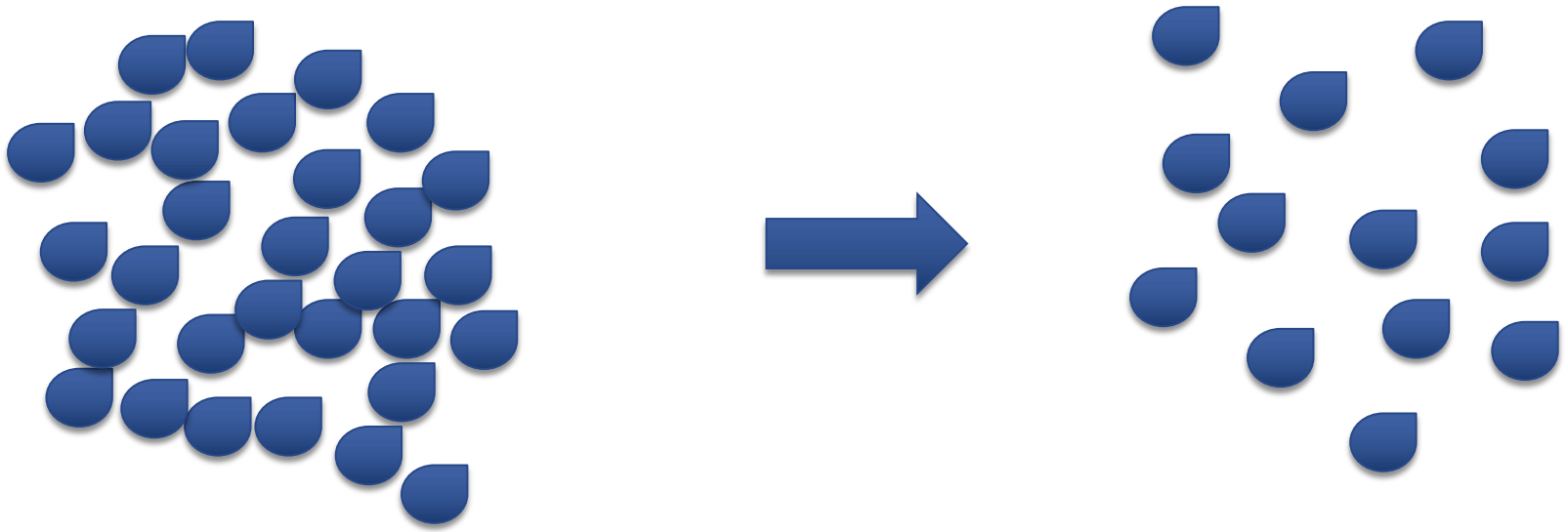
Moisture transfer: leaking air (3)

(Vapor)

Android or iPhone phone app



Moisture transfer: diffusion (4)



Higher concentration

Higher vapor pressure

Lower concentration

Lower vapor pressure

(Water vapor)

Measuring vapor flow…the “perm…”

- 1 perm =
  1 grain of water
  moving thru 1 sf
  in 1 hour
  at 1 inch of Hg pressure
- 7,000 grains of water = 1 lb H2O or…
- 1 drop of water is about 1 grain of water
- 1 inch Hg is (about) vapor pressure between inside/outside of fridge and a greenhouse

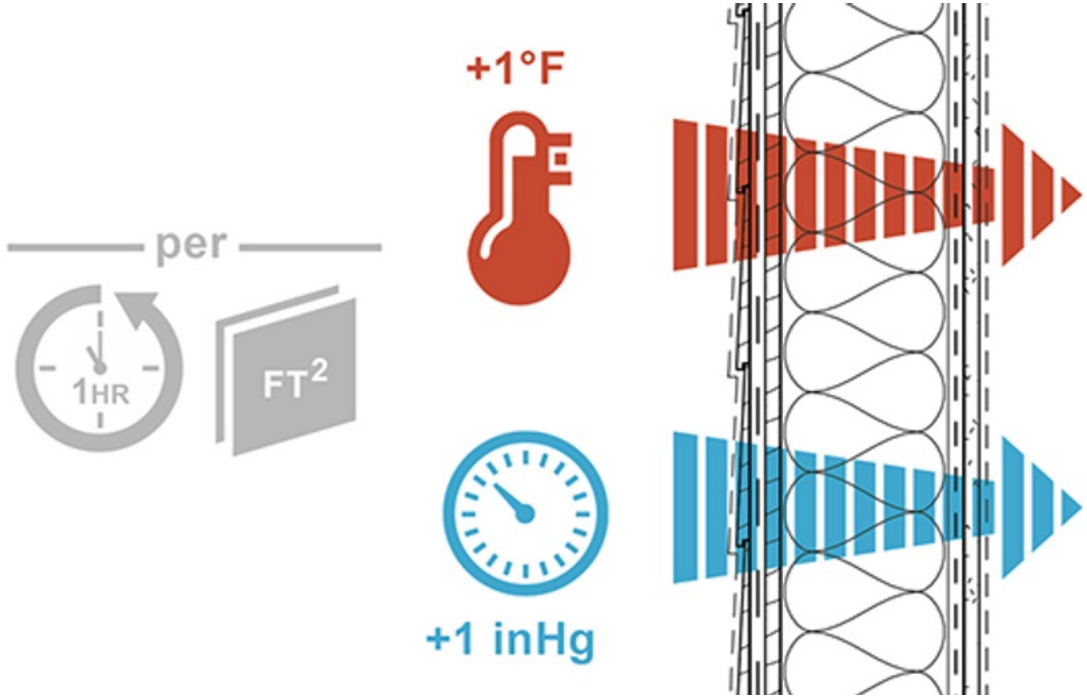


Image credit: Daniel Overbey

Measuring vapor flow…the “perm…”

- What does this mean? It’s a very small amount of moisture moving slowly through a building material or
- Even more slowly through the many layers of a building assembly

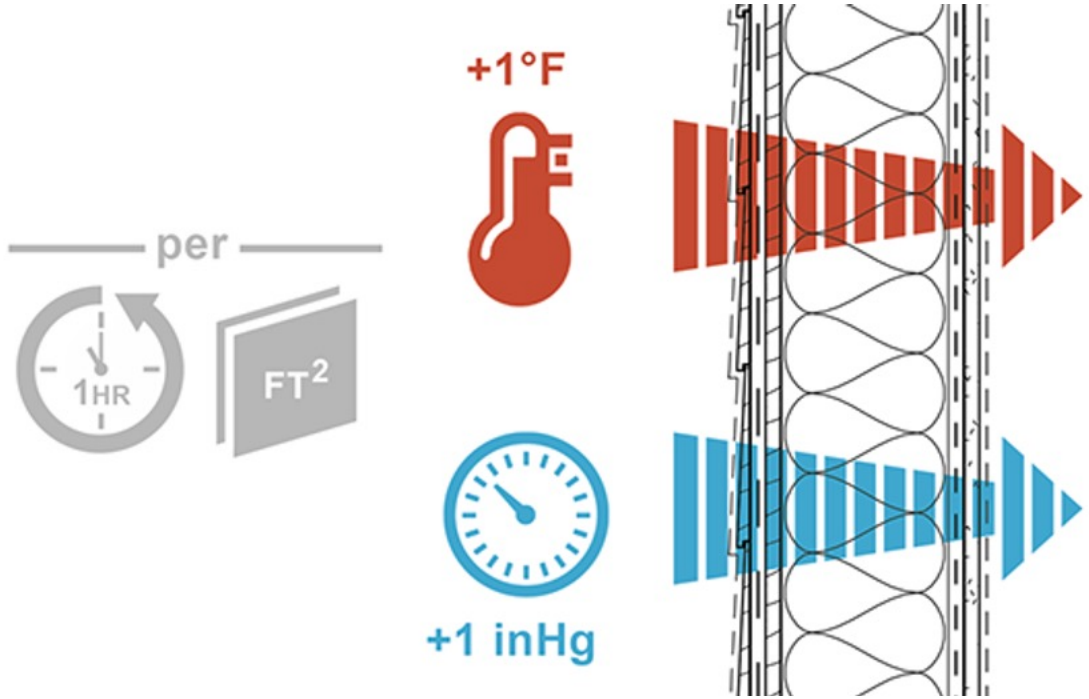


Image credit: Daniel Overbey

The perm…it works both ways…

- Getting assemblies wet by diffusion is usually slow and not a big problem
- But once an assembly gets wet, how does it dry?
  - Can I drain it (bulk water)?
  - Can I wick it (capillary water)?
  - Can I air-dry it? (convective drying)?
- I can usually only get water out by vapor diffusion, which is usually slow and moves small amounts…

Some example perm ratings for building materials

- Drywall: 40 perms
- Cellulose insulation: 75 perms
- Latex paint (two coats w/ latex primer): 3 – 5
- Plywood: 2 – 15 perms (“dry” to “wet”)
- 1-inch rigid insulation (“blue board): 1 – 2
- Kraft paper facing: 1 – 10 (“dry” to “wet”)
- Plastic sheet: .06

Remember, perms are about VAPOR, not liquid water…

Those pesky occupants...

Sources - Household Moisture

Source	Quantity (pints)
Showering	???
Clothes drying	4 - 6/load
Cooking (dinner)	1.2 (+1.5 gas)
5 house plants	1/day
1 cord “green” wood	600 - 800/season
4 people	.5/hour
Building materials	???
Ground moisture	0 - 100/day

Source: Minnesota Extension Service (also, see GBA blog…)

Sources - Household Moisture

Source	Quantity (pints)
Showering	**.5 (5 - min shower)**
Clothes drying	4 - 6/load
Cooking (dinner)	1.2 (+1.5 gas)
5 house plants	1/day
1 cord “green” wood	600 - 800/season
4 people	.5/hour
Building materials	**6 - 17/day**
Ground moisture	0 - 100/day

Source: Minnesota Extension Service (also, see GBA blog…)

Heat/Moisture transfer summary

- Heat transfer happens three ways:
  - Radiation
  - Conduction
  - Convection
- Moisture moves in four ways:
  - Bulk water (by gravity and sometimes wind)
  - Capillary water (by wicking in porous materials)
  - Air-transported moisture (by air leakage)
  - Vapor by diffusion
- BOTH always move high to low, warm to cold
- The list above is by priority and often amounts
- BOTH are very dynamic, always changing in proportions

Just Three Things

- How are the two related?

Homework #1

- Come back to class 2 with one of the following for class discussion/ instructor review. Supporting info such as image or report or quick hand drawing is definitively encouraged.
  - A physical, chemical, or biological example or expression of building performance you do NOT understand.
  - A design, materials, or construction process element that you do NOT understand.

OR...

Homework #2

- Come back to class with a a description of a situation that requires a custom, site-specific or climate-specific, science-based building performance solution

Till next time…

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

3C REN

TRI-COUNTY REGIONAL ENERGY NETWORK

SAN LUIS OBISPO • SANTA BARBARA • VENTURA