METROPOLITAN Community College

Residential Energy Code – Session 3

Building Science and Moisture Management, Part 2

Instructor: Matt Belcher

February 9, 2021: 6:30-8:30pm

Today’s Agenda

- Session 2 review
- Define key building science principles
- Explain how building science principles impact structures differently in various climate zones
- Describe the whole house approach
- Foundational concepts
- Integrated perspective for building design and construction

Today's Objectives

- ► Updated energy codes require a whole house approach
- ► Building science has a key role
- ► Today's homes are built to higher efficiency standards based on building science principles that improve building performance
  - – Even homes built where codes have not advanced often exceed minimum requirements
- ► Lack of knowledge or attention to detail ~~could~~ <u>*WILL*</u> yield unintended consequences impacting operation, indoor environment, or durability

SESSION 2 - REVIEW

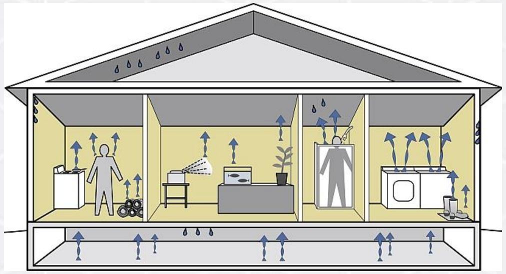
Session 2 Review

- Building science is the collection of scientific knowledge that focuses on physical phenomena affecting buildings.

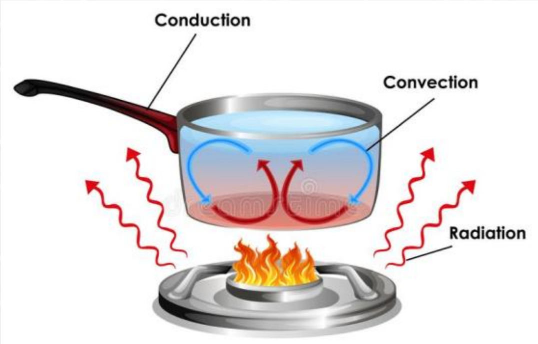
- In other words – Building Performance!
  - Building Envelope
  - Mechanical Systems
  - Lighting Systems
  - Occupant Health and Comfort

Session 2 Review

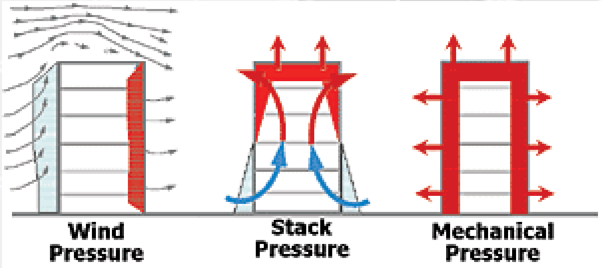
► Moisture Movement



► Heat Transfer



► Air Pressure



Moisture Movement

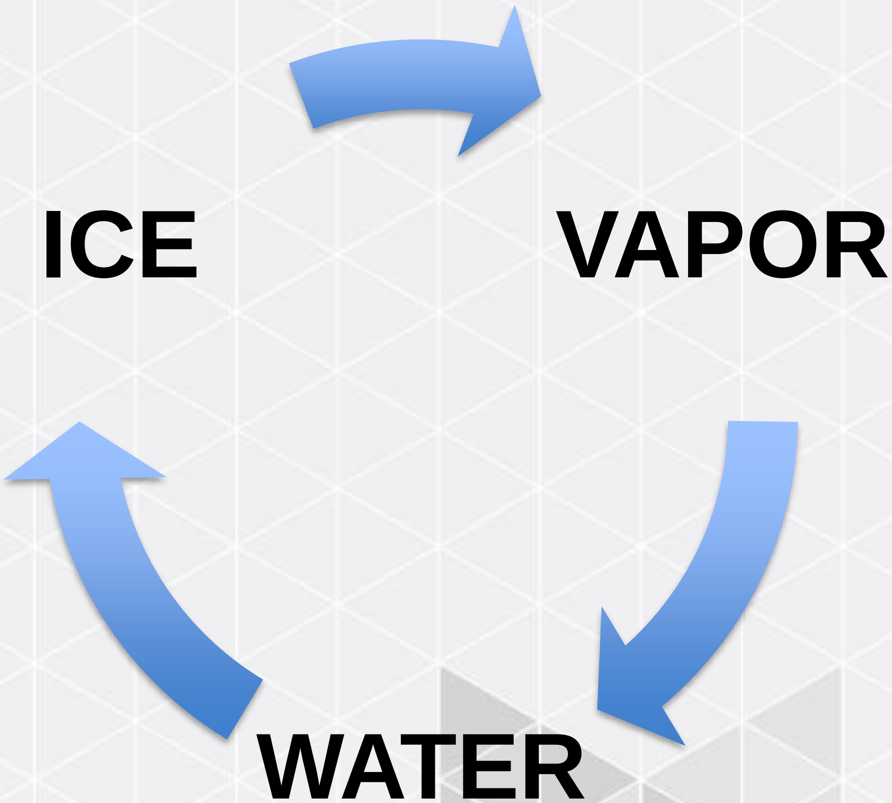
#1 – Bulk Water

#2 – Capillary Water

#3 – Air-transported Water

#4 – Diffusive Moisture Management

Let's discuss examples of each.



Bulk Moisture

- Good building practices focus on preventing bulk moisture from entering building cavities and living spaces.
- Bulk moisture movement occurs by:
  - **Gravity**
  - **Capillary action**
  - **Air pressure**
  - **Wind**

Bulk Moisture – Gravity

- Gravity is the primary driver of bulk moisture.
  - But water doesn't always flow straight down
- Multiple forces at work can add to the potential problems associated with bulk moisture intrusion.
- Correct construction provides for the moisture to drain down and then out.

Image: buildingconservation.com

Capillary Action

- ► Capillary action:
  - – It is the ability of bulk moisture to move upward within and between solid objects.
  - – The smaller the space, the higher water can climb.

Image: greenbuidingadvisor.com

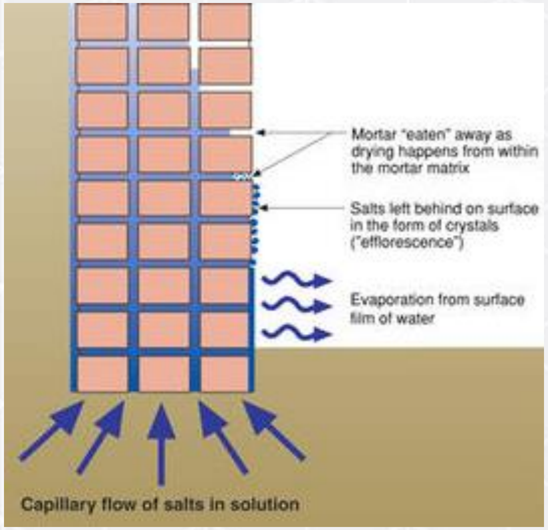


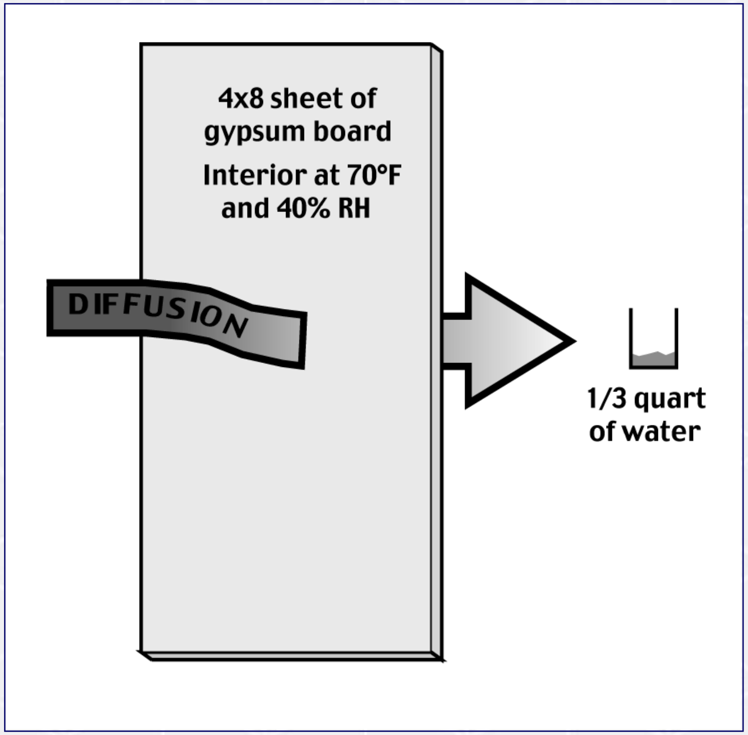
Image: buildingscience.com

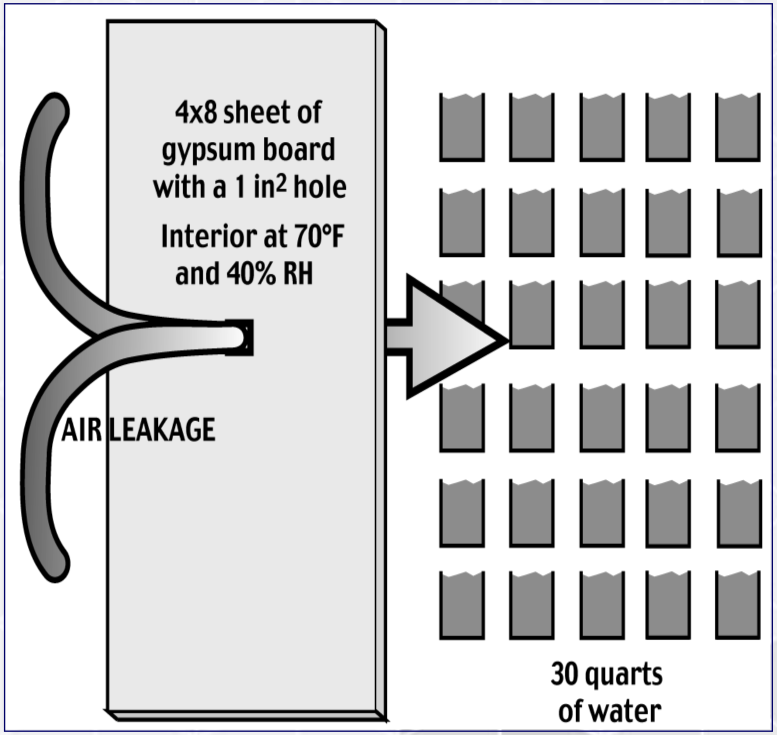
Air Movement and Diffusion

- Two mechanisms of movement:
  - Air movement
  - Diffusion
- Two characteristics:
  - Higher → Lower Humidity level
  - Warmer → Cooler Temperatures
- At the right balance of temperature and humidity, the vapor will condense at dew point.

Image: theguardian.com

Air Movement





Moisture movement via air movement has much more potential than diffusion (up to 90x!).

Diffusion

- It is the movement of moisture through solid material.
- Every material is given a perm rating:
  - It is a gauge of how much vapor passes through.
  - The lower the perm rating, the less moisture a material allows to pass through.
- The amount of moisture that passes through a material is also a function of the vapor pressure that is present on either side of it.

Permeance of Common Building Materials

Material	Permeance (perms)	Classification
Aluminum Foil, 1 mil	0.00	Vapor Impermeable
Polyethylene, 6 mil	0.06	Vapor Impermeable
Exterior Plywood, ¼ in	0.70	Vapor Semi-Impermeable
Brick, 4 in	0.80	Vapor Semi-Impermeable
Polystyrene, 1 in	1.20	Vapor Semi-Permeable
Plaster on metal lath, ¾ in	15.00	Vapor Permeable
Gypsum Wallboard, ½ in	50.00	Vapor Permeable

Source: ASTM E36, Standard Test Method for Water Vapor Transmission of Materials

Managing Moisture

- Exterior bulk moisture sources and solutions:
  - Incorporate continuous drainage plane regardless of climate and exterior finish.
- Interior moisture sources and solutions:
  - Pay attention to the permeability of the assembly materials and their placement in the assembly.
- Interior moisture sources and solutions:
  - Allow cavity to dry itself out (via diffusion) in both directions away from the material with the lowest permeability.

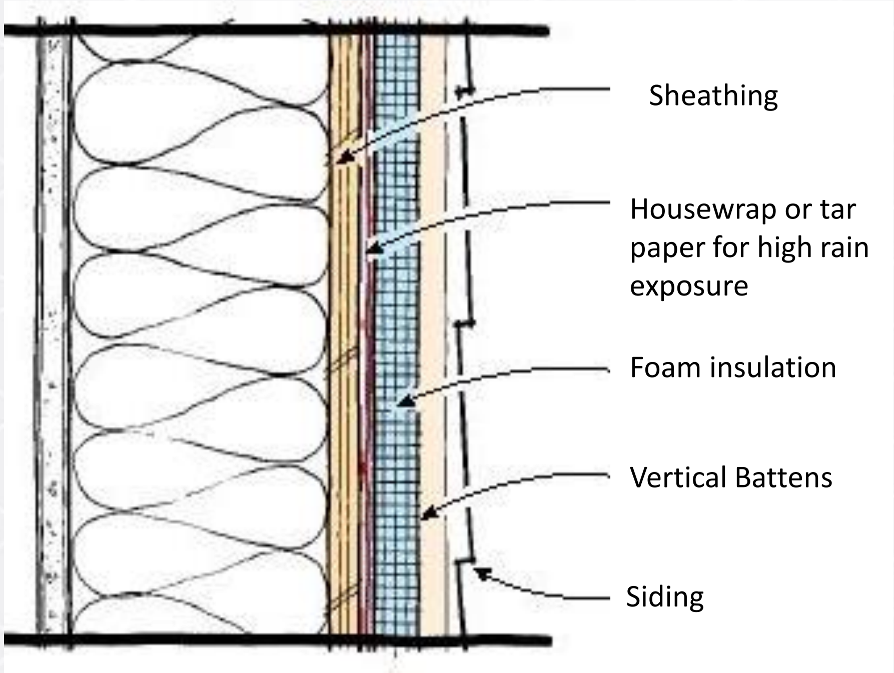
Heat Transfer

- Three types:
  - Conduction
  - Convection
  - Radiation

- All three types of heat transfer can occur in homes and they most often occur collectively.

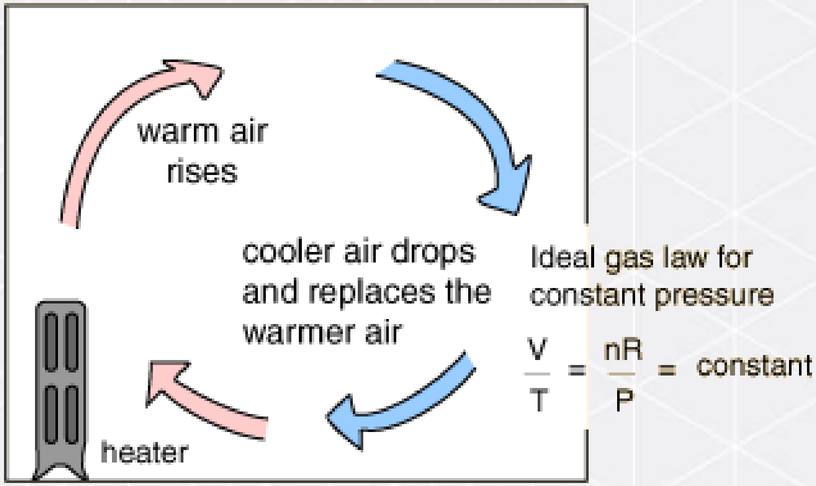
Conduction

- When objects that are in direct contact transfer heat from the warmer object to the colder one
- Thermal resistance of building materials refers to **conductivity** of materials
- Example: Thermal bridging
  - Wood studs have greater heat conductivity than the insulation.
  - Studs provide an easy path for heat to bridge the wall.



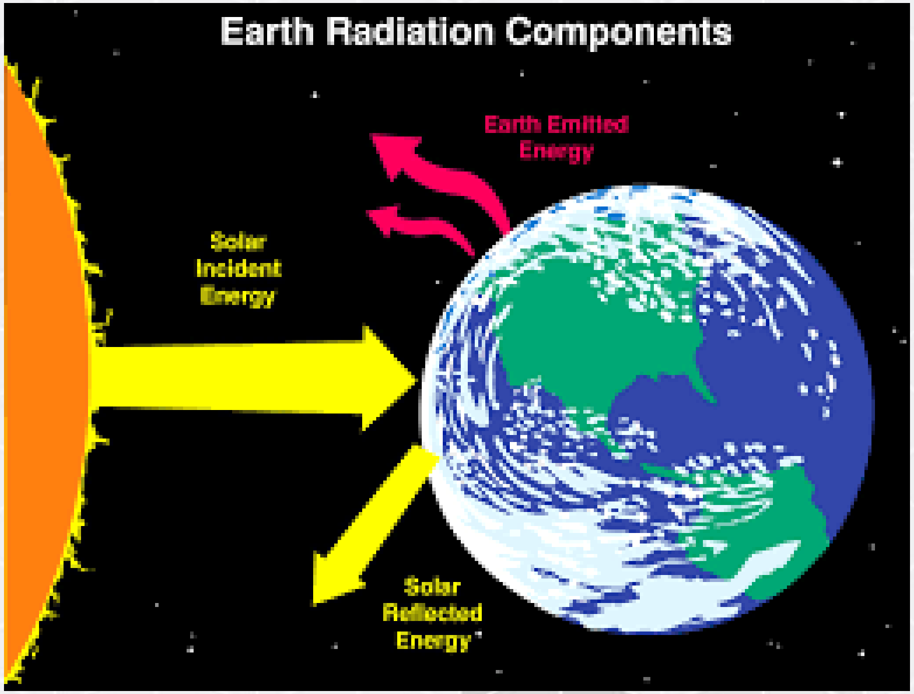
Convection

- Transfer of thermal energy by circulation in a medium—typically fluids like air and water.
- Heat does not rise – hot air does
- Example: Soffit vents and ridge vents combine to create a natural updraft through the house.



Radiation

- Heat transfer through space from a warmer object to a colder object
- Electromagnetic waves—from high to low through empty space
- Once this energy strikes an object, the energy can be transmitted, reflected or absorbed.

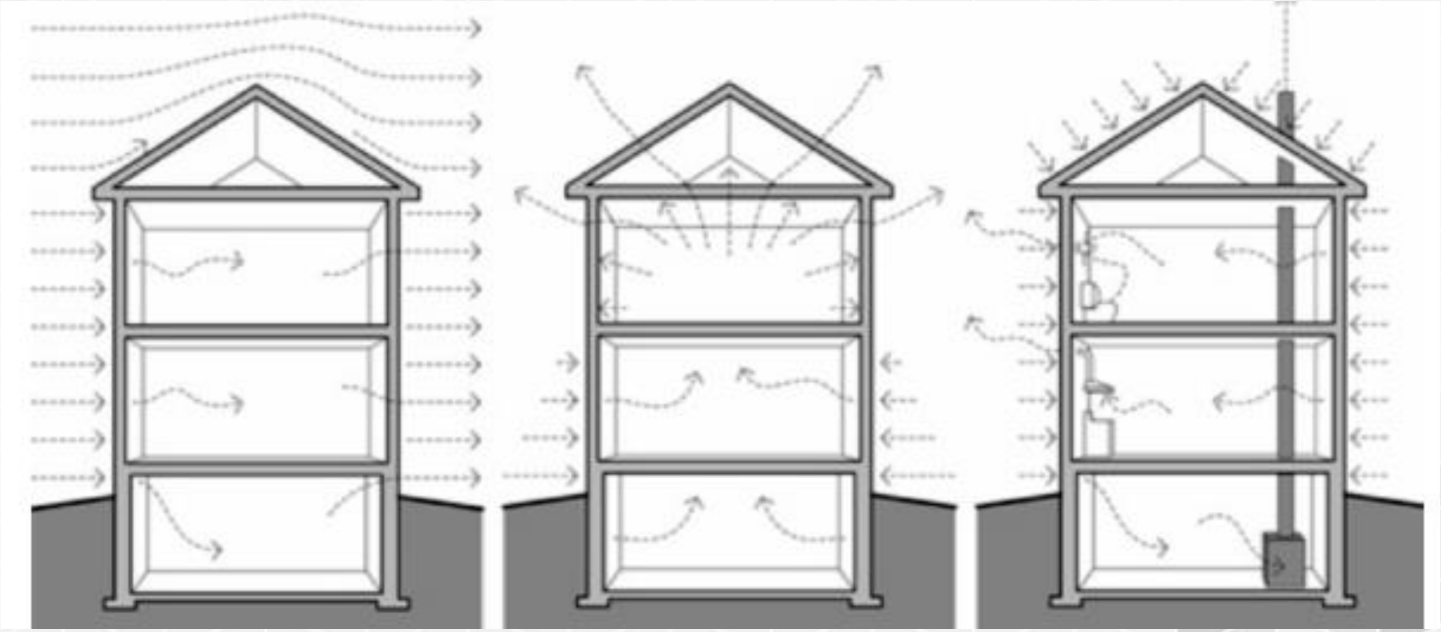


Discussion Question

- If you stand near a window in the middle of winter on a cold day, with the sun shining on you, what forms of heat transfer will you likely experience?

Air Pressure

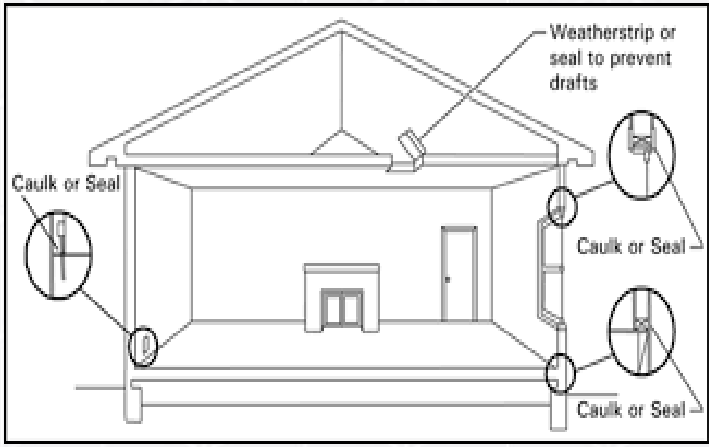
- ►Two factors that influence air pressure:
  - – A hole, crack or gap in the building's envelope
  - – A driving force



Wind Pressure **Stack Effect** **Mechanical Pressure**

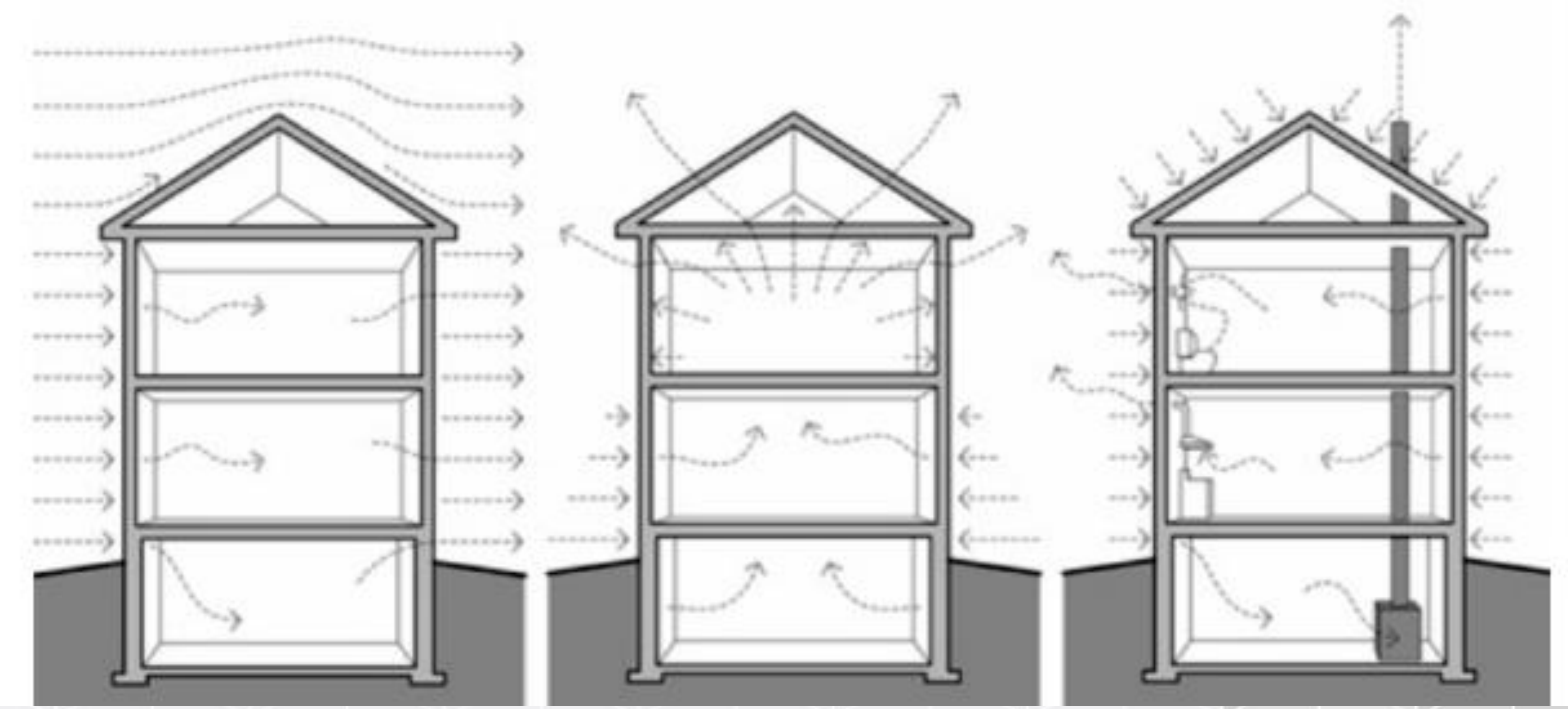
Holes, Cracks and Gaps

- Holes that allow air into or out of a home have a negative impact on the home and its occupants.
- Energy Efficient homes have a low leakage rate.
- Minimizing envelope air leakage with proper ventilation must be the goal in the home.
  - "Build tight, Ventilate Right!"
- The health of the occupants must then also be addressed through controlled ventilation.



Driving Force

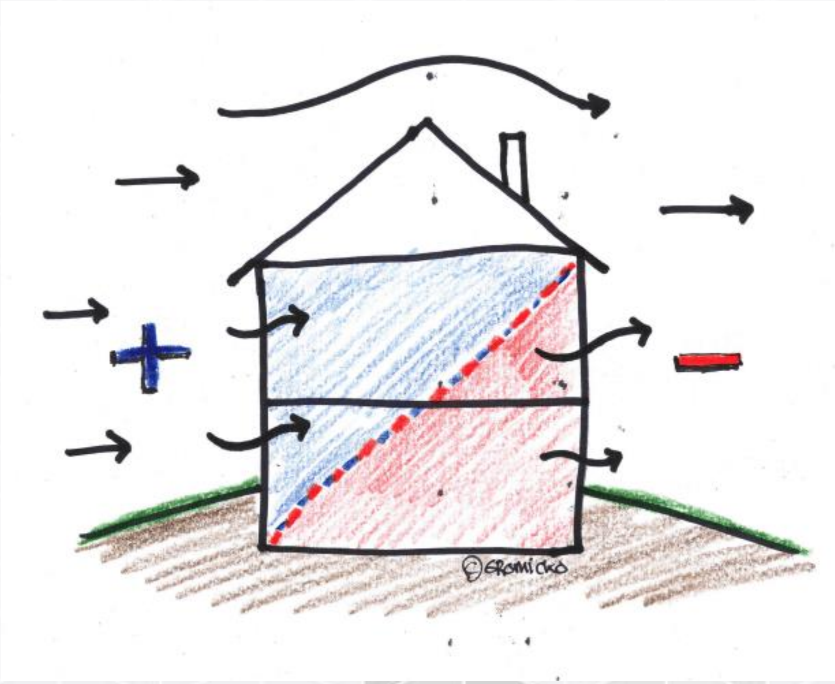
- Three types:



Wind Pressure **Stack Effect** **Mechanical Pressure**

Wind Pressure

- Wind hitting one side of a house creates positive pressure.
- Lack of pressure against the opposite (lee side) of the home creates negative air pressure.
- Air moves from the positive side to the negative side, creating airflow within the structure.



Stack Effect

- Cold air sinks and warm air rises, causing flow and pressure.
- Warm air expands and rises and pushes household air out.
- Air leaving creates negative pressure in the cooler or lower levels of a home drawing air in through cracks.

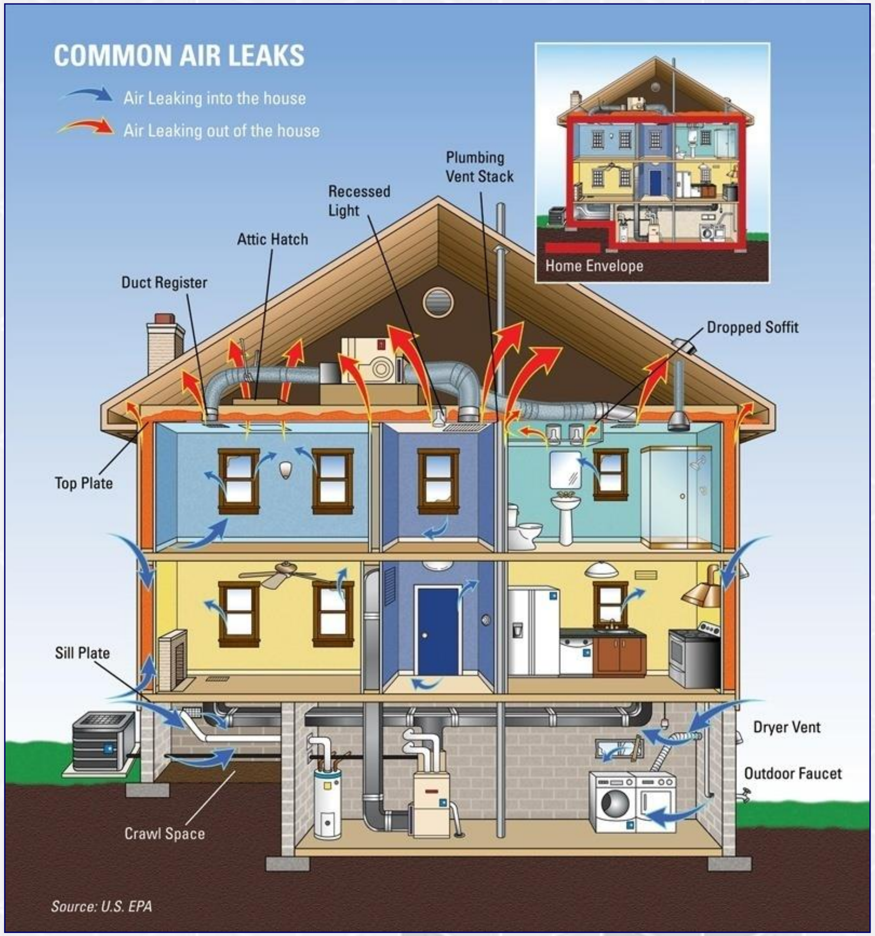


Image: of U.S. Environmental Protection Agency

Mechanical Pressures

- Air handlers and ventilation systems create both desirable and undesirable pressures.
- Air handling equipment or ventilation systems partially inside and partially outside the thermal envelope can create problems.
- The goal is:
  - Balanced ventilation within the thermal envelope
  - Controlled air exchange with outside air

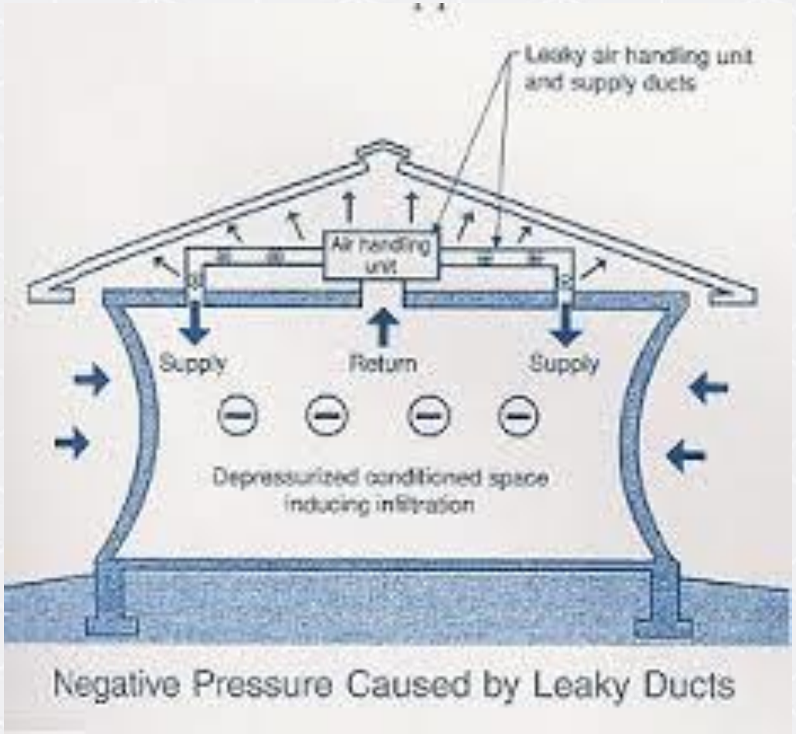


Image: home-energy.extension.org

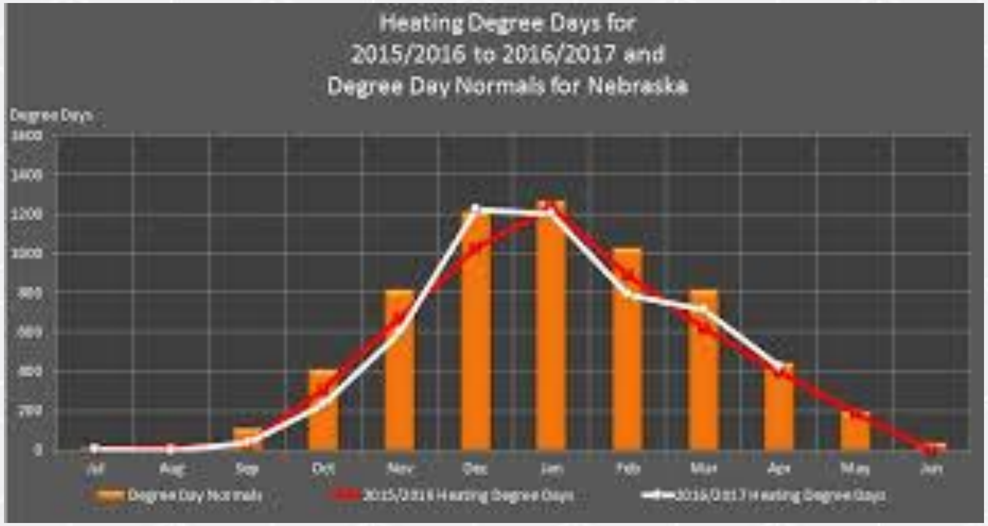
CLIMATE ZONES AND THEIR IMPACT

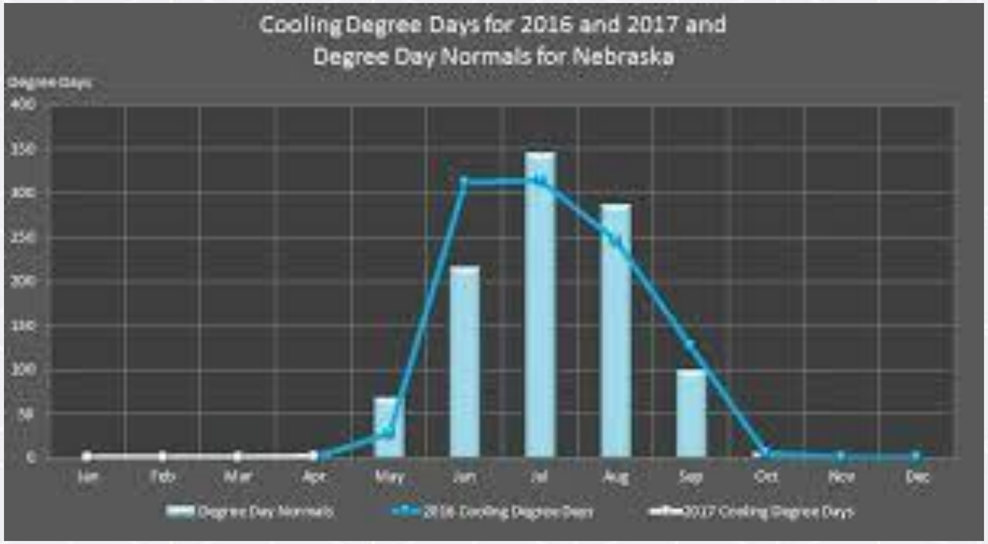
Climate Zones and Their Impact

- The principles of building science are constant, yet their impact is different in each climate zone.
- A primary consideration for builders and designers must be their region’s climate, wind, soils, and ground water
  - All have significant impacts on homes from the viewpoint of building science.
- Practices and techniques utilized in one region of the country can have disastrous results in other climate zones.

Climate Zones and Their Impact

- Distinguishing elements for specific zones include:
  - Monthly temperature variation and annual precipitation
  - Heating and cooling degree-days





Climate Regions vs Climate Zones

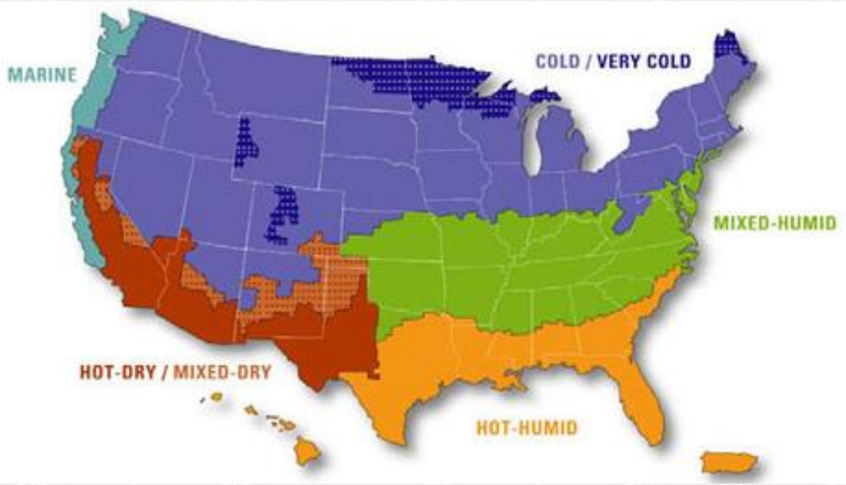


Image: U.S. Department of Energy

Climate Regions

- Hot-humid, mixed-humid, hot-dry, mixed-dry, cold and very cold, marine

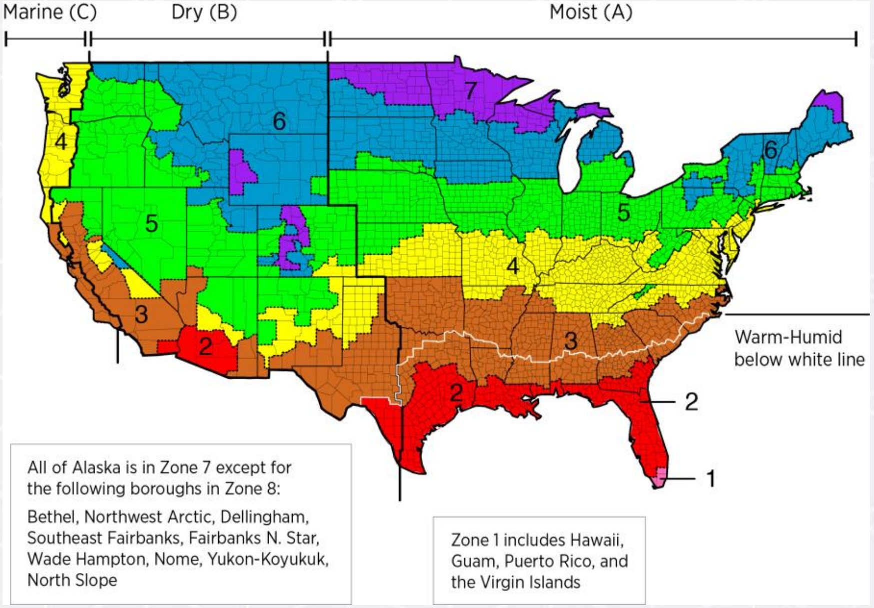


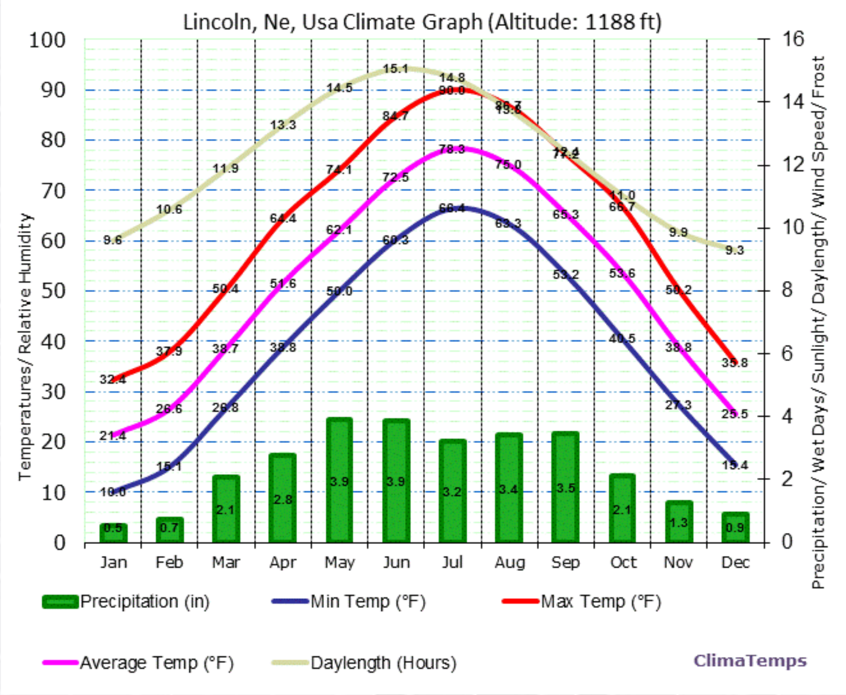
Image: pnnl.gov

Climate Zones

- Zones 1 (hot) through 7 (very cold)
- Designations adjusted for humid and marine zones
- **NE - Climate Zone 5**

Temperature and Precipitation

- Monthly temperature variation can be considerable between zones and seasons
  - Average December high is ~10 degrees colder in St. Paul
- The amount and type of precipitation are important because bulk water management is a key determinant in durability
- The home should be designed to perform best in the climate of the region



Heating and Cooling Degree Days

- These quantify the energy demand needed to heat and cool buildings in a particular location.
- They are calculated based on variance of the actual daily mean temperature to the stated mean temperature for the area.
- For example:
  - December 20th mean daily temperature: 35 F
  - Stated mean temperature: 70 F
  - 35 heating degree-days for December 20th

Climate Zones and Heat Transfer Quiz

Based on your understand of heat transfer, in what direction would heat move in the following climate zone conditions?

1. South/cold night
    a. Exterior to the interior
    b. Interior to the exterior

Climate Zones and Heat Transfer Quiz

Based on your understand of heat transfer, in what direction would heat move in the following climate zone conditions?

1. South/cold night
2. **North/hot summer day**
   a. Exterior to the interior
   b. Interior to the exterior

Climate Zones and Heat Transfer Quiz

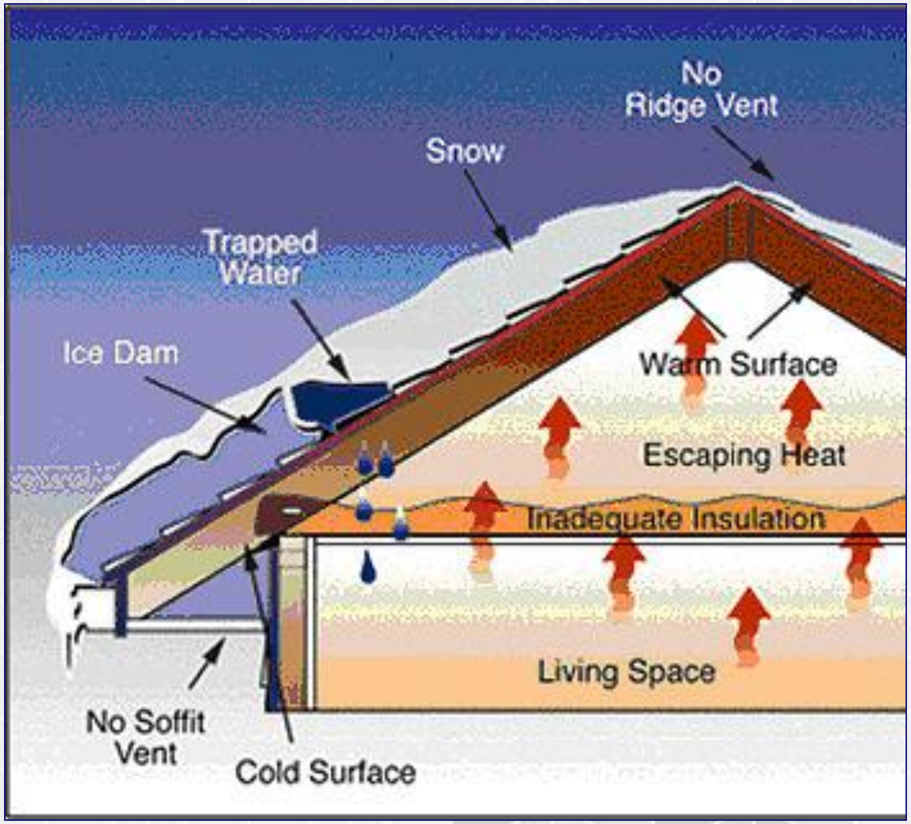
Based on your understand of heat transfer, in what direction would heat move in the following climate zone conditions?

1. South/cold night
2. North/hot summer day
3. **North/30-degree day and sun is shining on the south wall**
    a. Exterior to the interior
    b. Interior to the exterior

BUILDING SCIENCE IN ACTION

Building Science in Action

- A properly built home must address all three of the building science principles.
  - Heat Transfer
  - Moisture Movement
  - Air Pressure



Courtesy of National Weather Service

Building Science in Action

- Purpose: To check your understanding of the building science principles
- Read the scenario.
- Discuss the questions:
  - What building science principle is in action?
  - What could be done to improve the situation?

Building Science in Action – Scenario 1

- Your customer, whose home is in a cold climate, complains of a drafty window. The window does not appear to have any noticeable air leaks around the frame or sashes and the weather strip is in good condition.

Image: medium.com

- What building science principle is in action?
- What could be done to improve the situation?

Building Science in Action – Scenario 2

- A homeowner complains that regardless of how long the air conditioning unit runs, his house is still too humid in the summertime. The home is in a mixed-humid climate region. In addition, he says that the home is too dry in the wintertime.

- What building science principle is in action?
- What could be done to improve the situation?

Building Science in Action – Scenario 3

- A homeowner complains that his home feels very drafty. You inspect the home, a two-story structure built in 1971 in a cold climate region, and feel the draft especially around receptacles, certain doorways, the fireplace and base boards.

- What building science principle is in action?
- What could be done to improve the situation?

WHOLE HOUSE APPROACH

Whole House Approach

- In building science, components ***work together*** to achieve the end result — a home that:
  - Uses less energy, water and natural resources
  - Creates less waste
  - Healthier for the people living inside
- It is important to consider how changes to one component may affect the whole house.
- Decisions must be based on the best practices that can be implemented in the most cost-effective manner across all systems.

Image: ase.org

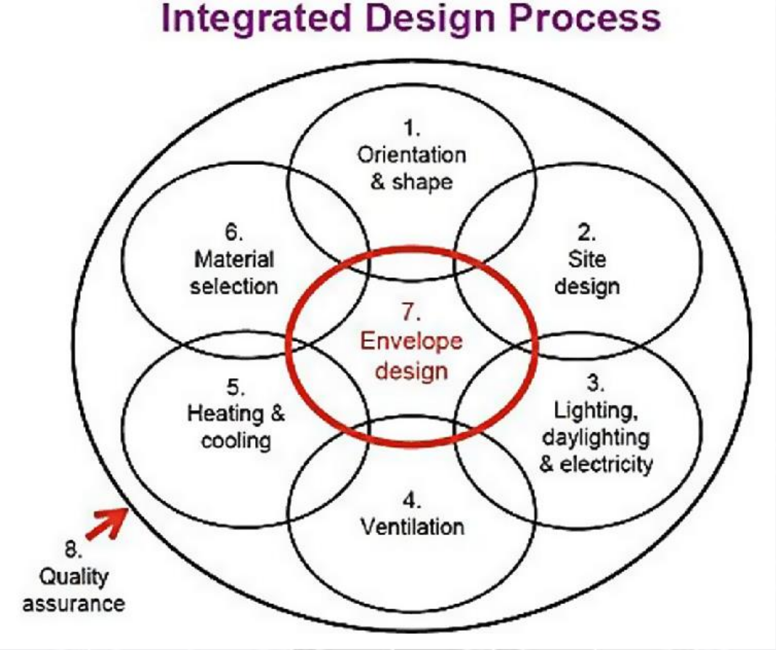
Whole House Approach

- Building science provides the basic concepts:
  - Provides better understanding of the material and component relationships
  - Enables the appropriate decisions
- Three concepts for engaging the whole house approach:
  - Integrated design
  - Building science and the related climate zone
  - Knowledgeable team

Image: wbdg.org

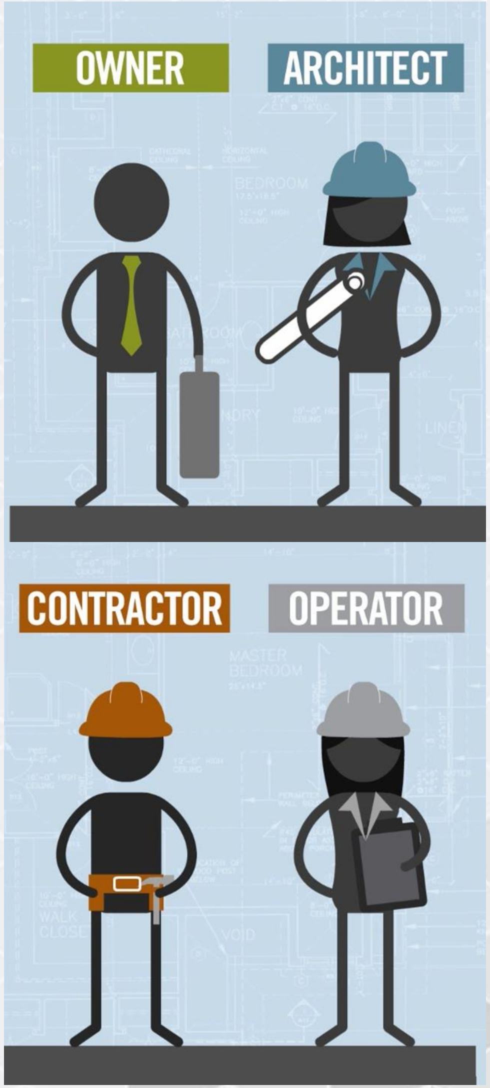
Integrated Approach

- Home performance is highly dependent on good teamwork:
  - Clear communication and feedback process
  - Supportive mission statements, policies and procedures
  - Complete detailed drawings and specifications
  - Well defined scopes of work for all team members
  - Proper monitoring and verification



Integrated Design

- It sets forth certain requirements for the design stage and design team.
- Design team:
  - Close partnership among designer, builder and owner (or marketing team if speculative project)
  - Designers strike a balance among owner needs, green goals and budget
  - Builder and each sub contribute a unique perspective
  - Third party verifier provides an understanding and advice about certifications (HERS, NGBS, Passive House, etc.)

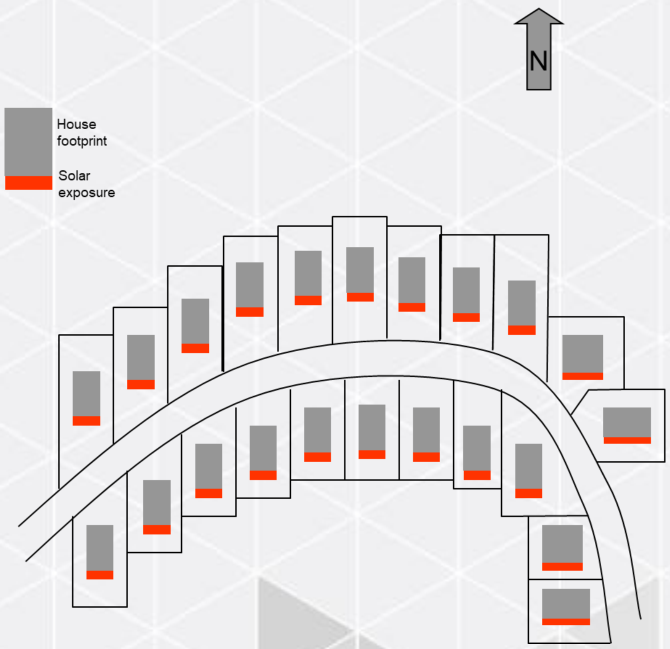


Education of the Whole Team

- The whole house approach changes the way you approach projects and asks your team to do the same.
- Educating your team can avoid costly problems during the construction process:
  - Changes could result in not attaining the targeted level of performance.
  - Simple substitutions may disqualify a related practice.
- Knowledge fosters more receptivity to changes because everyone understands the reasons behind them.

Lot Design and Construction

- Home orientation on a site optimizes the heating and cooling effects of the sun.
- Lot design utilizes the existing site resources.
- Proper planning and protection minimizes water runoff, erosion and silting.
- Careful planning and design drains water away from the building and keeps moisture intrusion at bay.
- Solar Power Roof area Ordinances



Lot Design and Construction

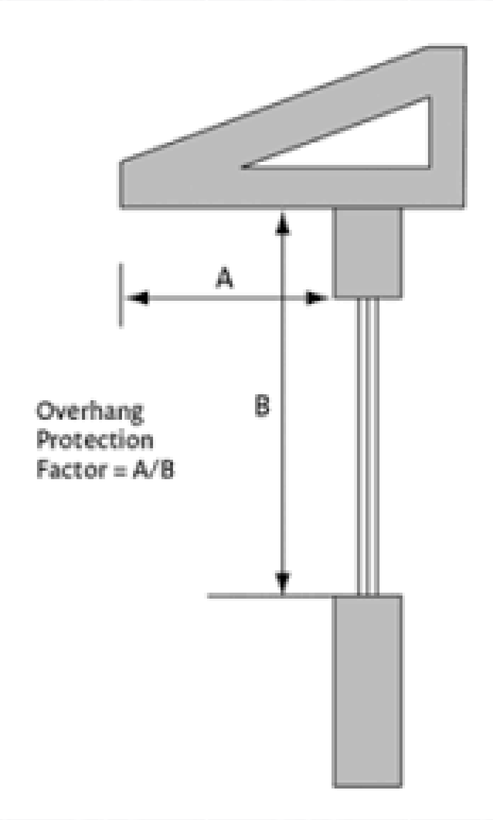


Image: up.codes

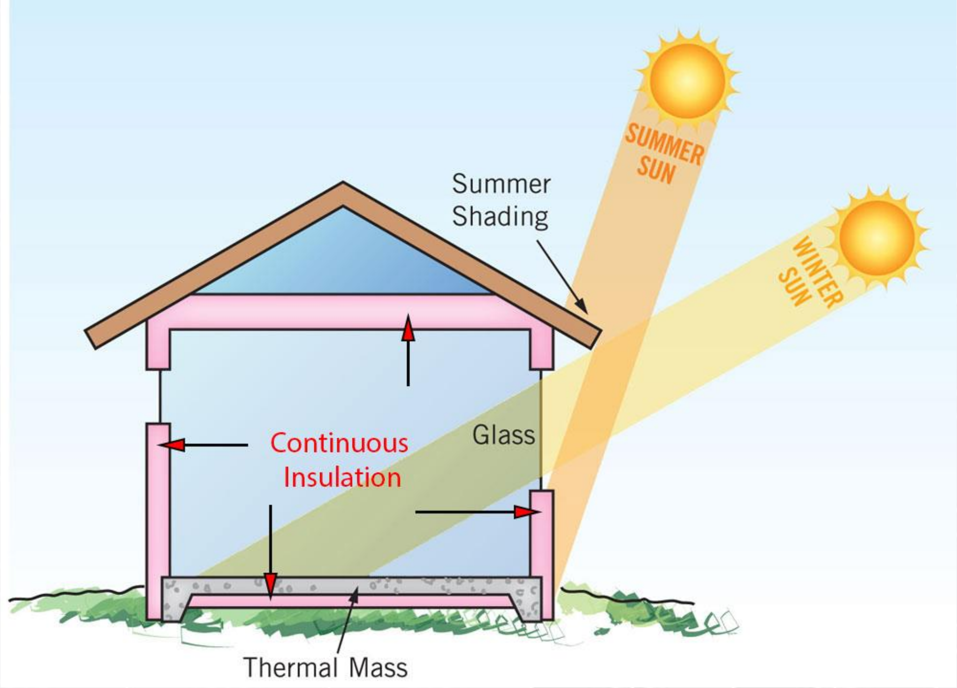


Image: ecodesignadvisor.org.nz

Projection Factor

Solar Angle

Building Envelope

- The building envelope must serve four functions.
  - Contain heat.
  - Handle moisture as vapor.
  - Keep bulk moisture out.
  - Contain air movement.

- How would you prioritize the four damage functions?
  1. Keep bulk moisture out.
  2. Handle moisture as vapor.
  3. Contain air movement.
  4. Contain heat.

Building Envelope

- All of the elements of the envelope and the assembly methods determine how well the building envelope performs
- The building envelope must be an unbroken boundary surrounding the structure
- Whole house strategies focus on moisture management:
  - Deflect
  - Drain
  - Dry
  - Durability
  - Doability

Image: U.S. Environmental Protection Agency

Activity: Whole House Design

- Purpose: To explore current practices within the assemblies and mechanical systems, and identify improvements based on building science and the whole house approach

- Questions to explore: (Take notes!)
  1. What is the current code mandated practice?
  2. How can you improve on current practice?
  3. Given cost considerations and climate zone considerations, what is the best approach you can take to the assembly?

Foundation

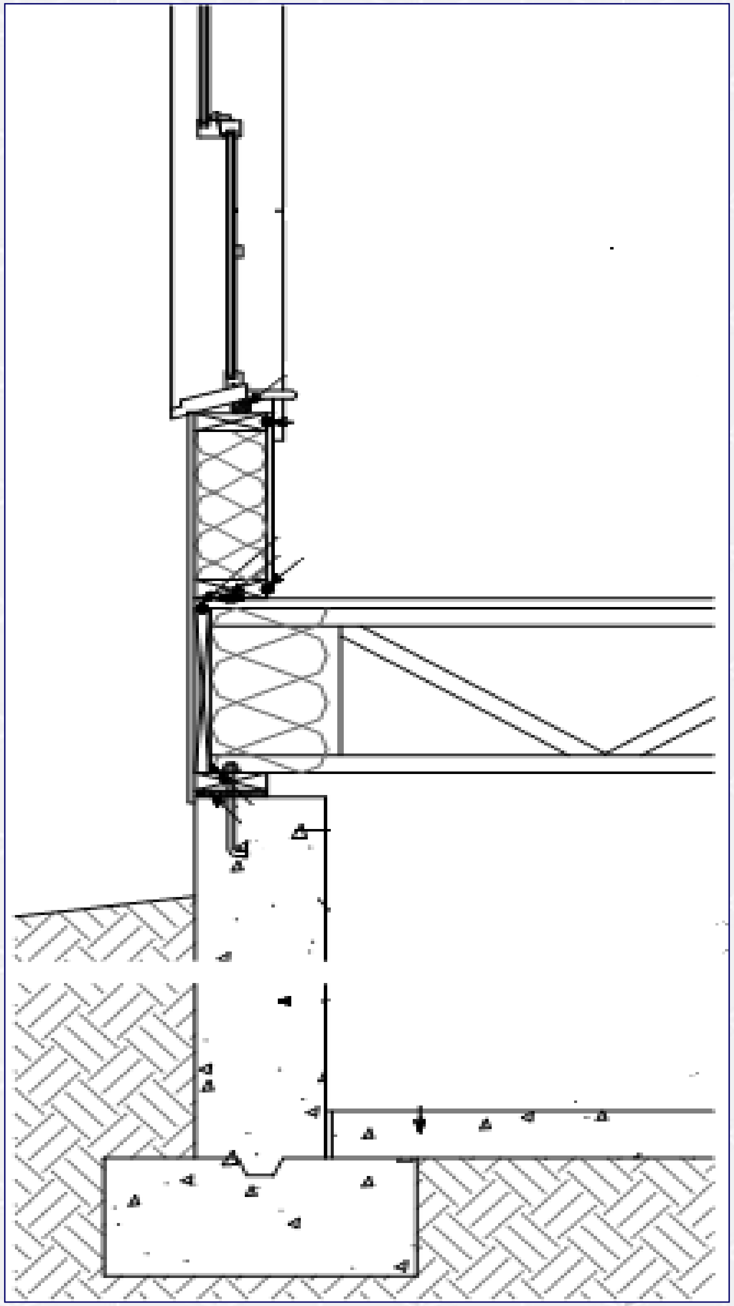


Image: Green Building Advisor

Foundation

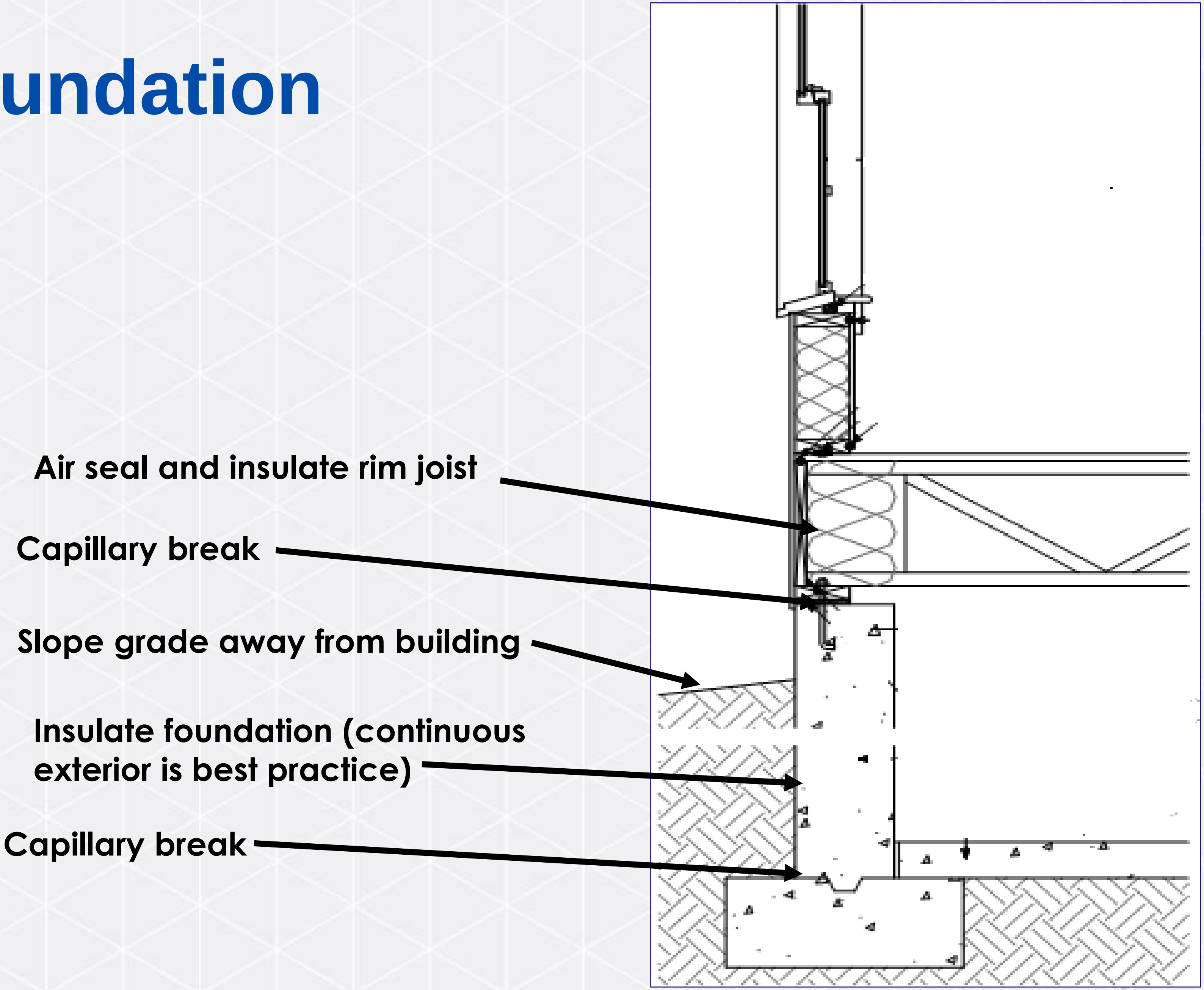


Image: Green Building Advisor

Wall

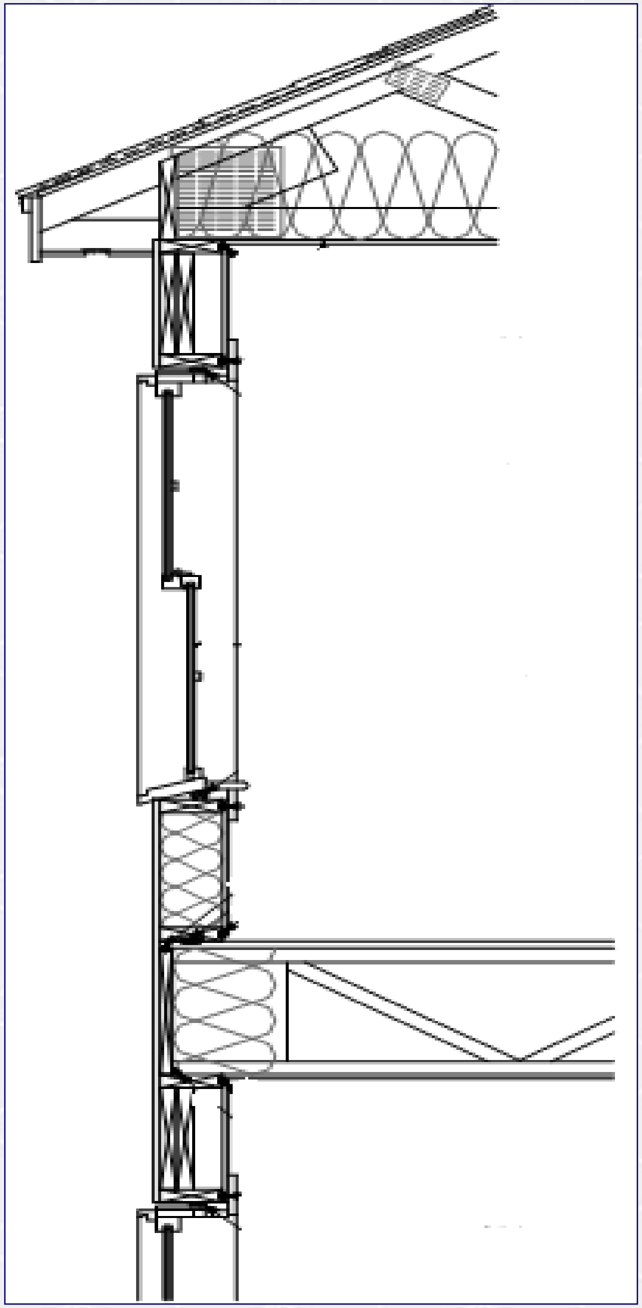


Image: Green Building Advisor

Wall

Insulate header

Head flashing

Insulating glass
- U-factor
- SHGC
- Low-E?
- Argon filled?
- Tinted?

Pan flashing

Seal bottom plate

Air seal and insulate rim joist

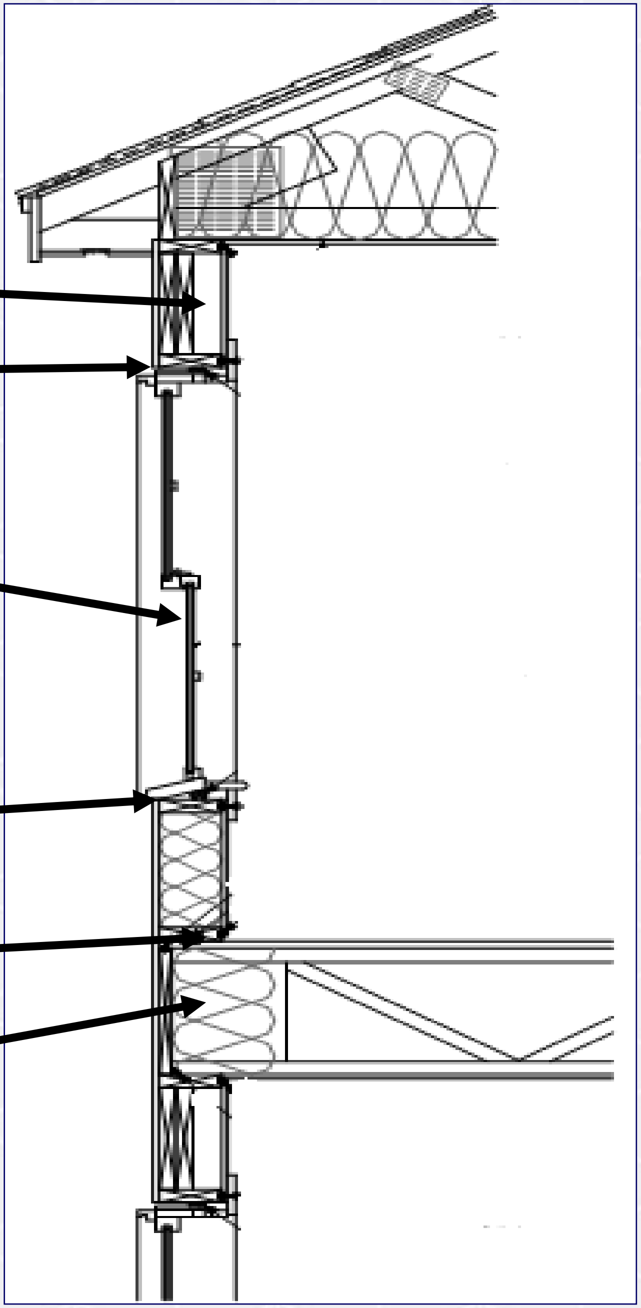


Image: Green Building Advisor

Ceiling/Roof

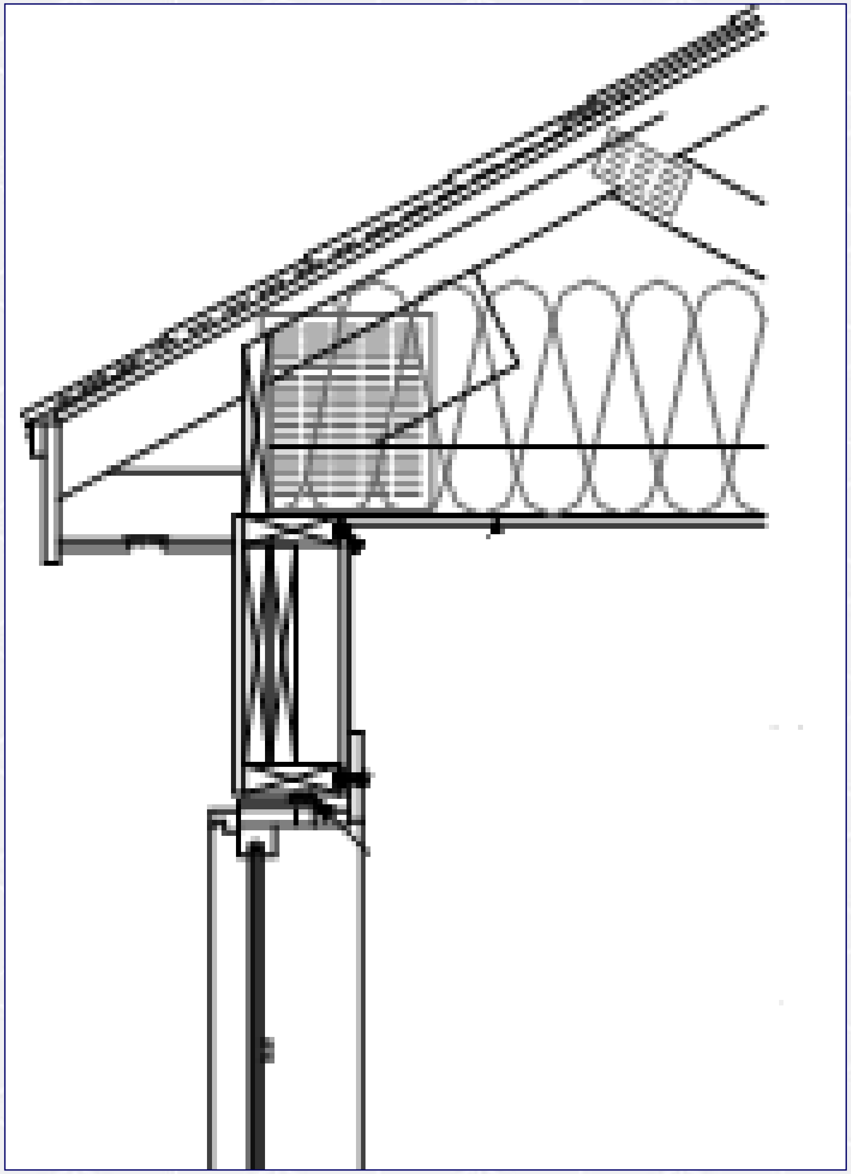


Image: Green Building Advisor

Ceiling/Roof

Ridge vent (balance with eave vents)

Insulation baffle

Use raised heal truss for full depth insulation coverage

Ceiling insulation

Eave vent (balance with ridge vent)

Air seal and insulate header

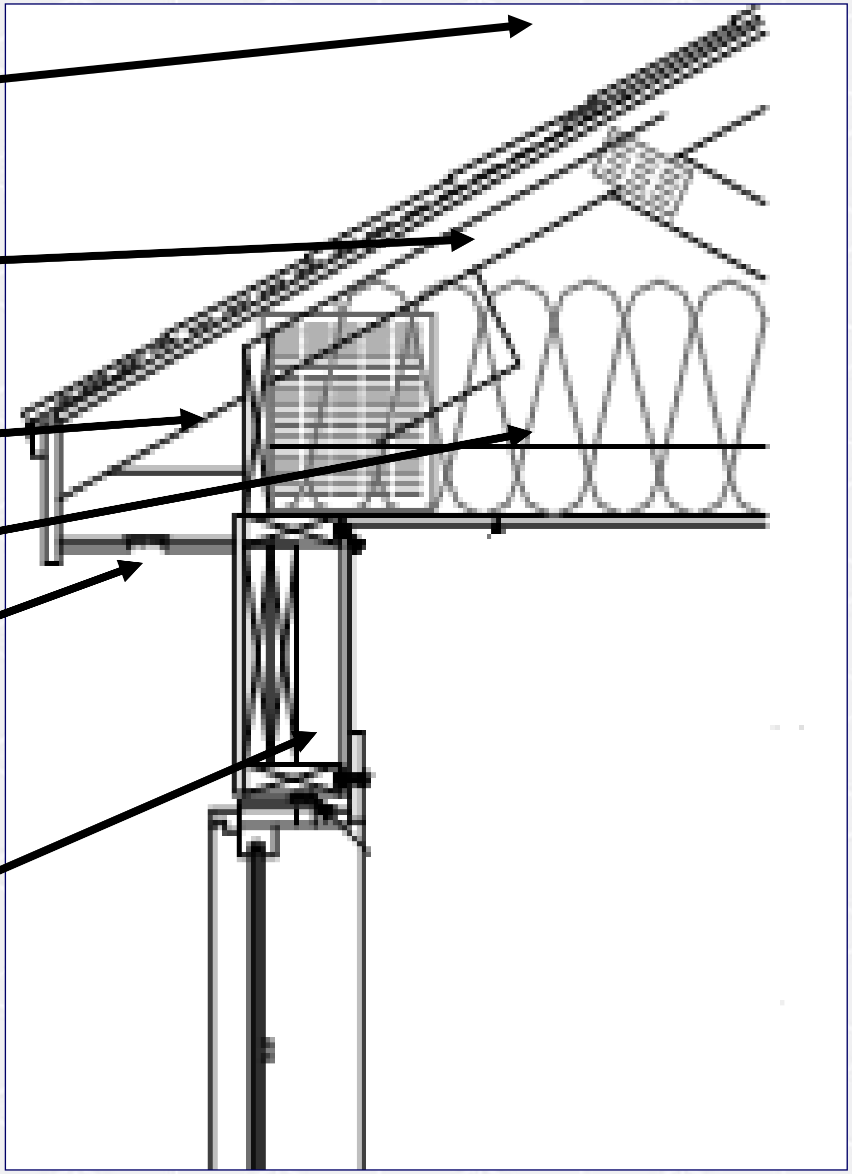


Image: Green Building Advisor

Key Takeaways

- The “Major Damage Functions” – Moisture, Heat, Air Pressure, and Radiation (UV degradation) – can have a significant and long-term impact on a home
- Addressing these challenges in a “wholistic” systems approach leads to a better functioning and more livable building
- Understanding the Climate and Climate Zone of the home profoundly affects design and construction
  - What works in one place can be detrimental elsewhere!

Questions?

- Submit a question in the chat or unmute yourself to ask a question

Review Questions – Session 3

What are two factors in a structure that can influence air pressure?

A. Height and Weight
B. A Hole, Crack or Gap and a driving force.
C. Airspeed, Direction and Furniture
D. Improper sealing, bad insulation, and time of construction

Review Questions – Session 3

How do the distinguishing elements of climate zones have significance for building practices and techniques?

A. Influences design, components, and best practices.
B. Makes energy code more important in Colder climate zones.
C. Makes vacation decisions easier.
D. Helps decide when to pour concrete.

Review Questions – Session 3

In Climate Zone 5 you should be concerned with:

A. Cold/dry Air moving out year-round.
B. Hot/moist air moving in year-round.
C. Hot/moist air moving in during winter and out during Summer.
D. Warm/moist air moving out in winter and in during Summer.

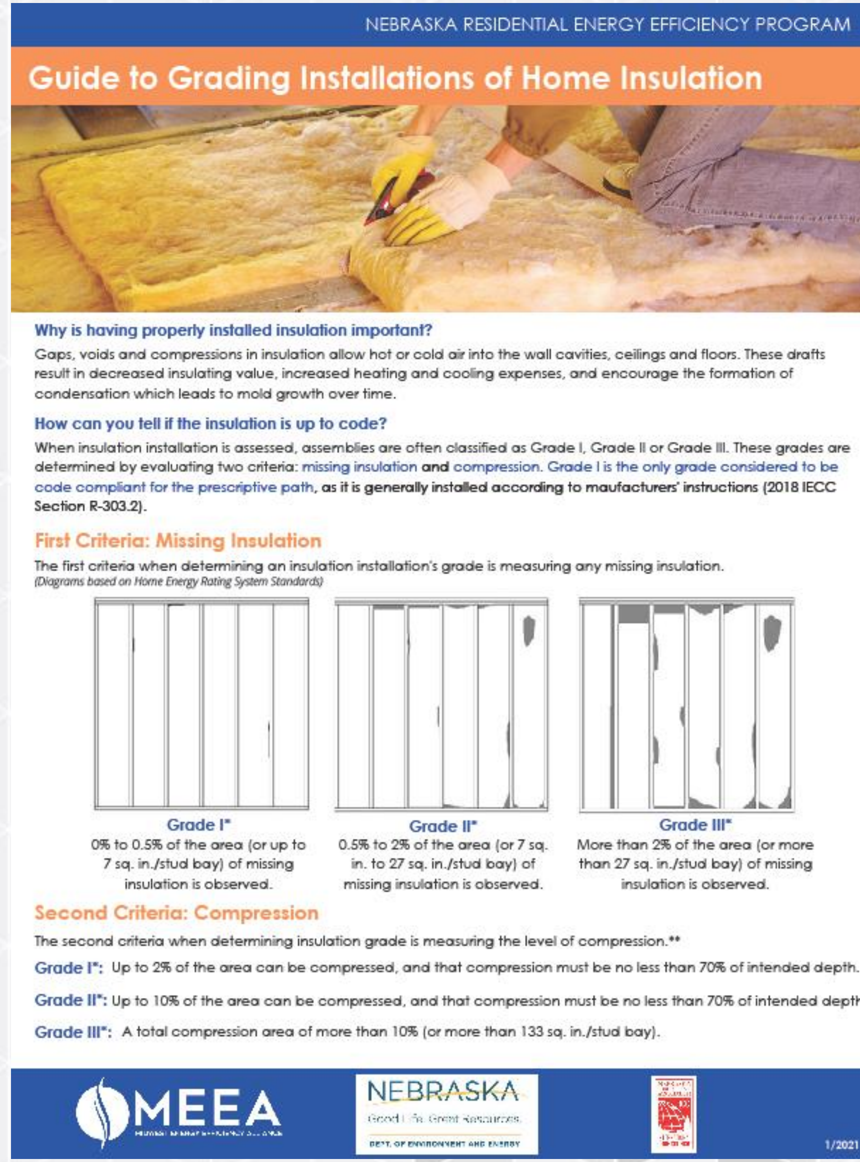
Review Questions – Session 3

What are the three concepts that form an important foundation for engaging the whole house approach?

A. Uses less energy, water and natural resources. Creates less waste. Healthier for occupants.
B. Built to withstand strong winds. Able to heat and cool without electricity. Feels good to live there.
C. Uses advanced technology. Costs more but feels better. Uses granite counter tops.
D. Same concept as whole foods; Costs a little more but all natural.

Resources

- Handouts on specific topics
  - Insulation installation
  - HVAC Right Sizing
  - Others coming soon
- Made to share with Trades/Subs, etc.
- Visit: https://www.mwalliance.org/metropolitan-community-college-energy-code-course



NEBRASKA RESIDENTIAL ENERGY EFFICIENCY PROGRAM

Guide to Grading Installations of Home Insulation

Why is having properly installed insulation important?

Gaps, voids and compressions in insulation allow hot or cold air into the wall cavities, ceilings and floors. These drafts result in decreased insulating value, increased heating and cooling expenses, and encourage the formation of condensation which leads to mold growth over time.

How can you tell if the insulation is up to code?

When insulation installation is assessed, assemblies are often classified as Grade I, Grade II or Grade III. These grades are determined by evaluating two criteria: missing insulation and compression. Grade I is the only grade considered to be code compliant for the prescriptive path, as it is generally installed according to maufacturers' instructions (2018 IECC Section R-303.2).

First Criteria: Missing Insulation

The first criteria when determining an insulation installation's grade is measuring any missing insulation.
(Diagrams based on Home Energy Rating System Standards)

Grade I*	Grade II*	Grade III*
0% to 0.5% of the area (or up to 7 sq. in./stud bay) of missing insulation is observed.	0.5% to 2% of the area (or 7 sq. in. to 27 sq. in./stud bay) of missing insulation is observed.	More than 2% of the area (or more than 27 sq. in./stud bay) of missing insulation is observed.

Second Criteria: Compression

The second criteria when determining insulation grade is measuring the level of compression.**

Grade I*: Up to 2% of the area can be compressed, and that compression must be no less than 70% of intended depth.

Grade II*: Up to 10% of the area can be compressed, and that compression must be no less than 70% of intended depth.

Grade III*: A total compression area of more than 10% (or more than 133 sq. in./stud bay).

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1/2021

Continuing Education Credits

- Participants of this session are eligible for continuing education credits from the International Code Council

- Course ID: **27057**
- CEUs: **0.20**

- If you would like a certificate of completion for this session, email Nicole at nwestfall@mwalliance.org

Next Week

- February 16, 2021, 6:30-8:30pm
- Topic: Residential Energy Code Basics
- Contact Matt with Questions: matt@verda-solutions.com

SEE YOU NEXT WEEK!