HES & HES-IE Lead Technician Insulation Boot Camp Training

www.centerforecotechnology.org

Course Goal

This course is intended to build upon your existing knowledge, to familiarize you with the current standards of the Energize CT program, and to minimize call-backs by meeting and exceeding customer expectations.

Instructor Introduction

CET CENTER FOR ECOTECHNOLOGY

Robert Williams

- 2007-2017 Insulation Contractor
- 2015-2021 Army National Guard (Paralegal)
- 2017-2021 Home Inspector
- Jan 2022-Present, CET, Senior Residential Energy Assessor
- Building Performance Institute (BPI) Certifications (EP, BA, IDL)

Instructor Introduction

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Edison Dika

- Bachelors in Building and Construction Technology UMASS
- 2011 Weatherization crew member
- 2012-2018 Mass Save Energy Auditor
- 2017-2018 Residential New Construction HERS Rater
- 2018-2021 Multifamily Energy Auditor
- 2021-Present CET, Senior Energy Assessor
- Building Performance Institute (BPI) Certifications (BA, MFBA)

Center for EcoTechnology

- We help people and businesses save energy and reduce waste.
- Formed in 1976
- Non-profit 501(c)(3)

Participant Introductions

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- Name
- Company
- Experience
- Location
- Hobby or Interest

Overview

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7:30	Breakfast
8:00	Course Introduction
8:30	Lesson 1: Building Science
9:30	Lesson 2: Air-Sealing
11:00	Lesson 3: Insulation
12:00	Lunch
12:30	Props
2:30	Lesson 4: Health & Safety
3:00	Lesson 5: Customer Relations
4:00	Class Ends

Classroom Courtesy

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- Please silence your phones
- No texting in class
- Discussion is encouraged
- Help each other learn!

Questions

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???

Building Science

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Lesson 1: Basic Building Science

Building Science

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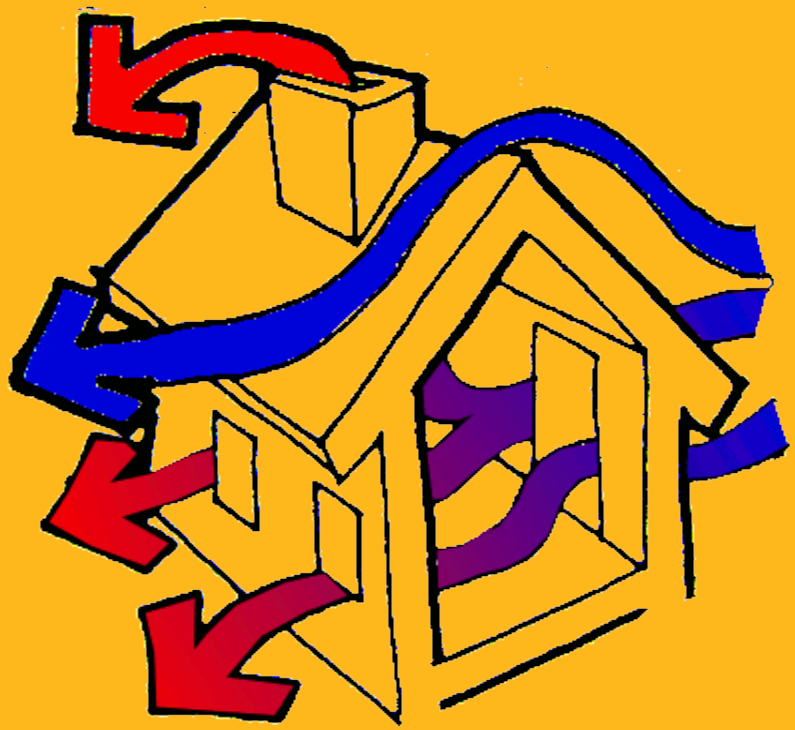
What we will cover:

- The house as a system
- Heat, air, and moisture
- Locating the thermal and air barrier
- Communicating with the homeowner



Definitions

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Building Envelope:

- The building envelope, which includes the walls, windows, roof, and foundation, forms the primary barrier between the interior and exterior environments.

Definitions

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Thermal Boundary:

- The thermal boundary forms the primary barrier with which to prevent conductive heat flow.

Definitions

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Pressure Boundary:

- The pressure boundary (or air barrier) forms the primary barrier with which to prevent convective heat flow and should be in alignment with the thermal boundary.

House as a System

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A house is a system of interdependent parts.

- The operation of one part affects many others.
- When they all work together, the house is comfortable, safe, efficient, and durable.

A house will experience problems when its parts don't work together properly.

- Some obvious, some invisible.
- Some now, some years down the road

House as a System

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A poorly insulated attic...

House as a System

... causes the heating system to work harder.

House as a System

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Air leaks around chimney chases...

House as a System

…increase heat loss or gain and can lead to issues such as ice dams.

House as a System

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An unvented or improperly vented bathroom exhaust fan…

House as a System

…can lead to moisture issues such as mold growth.

House as a System Discussion

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How do building occupants contribute to the “house as a system” approach?

House as a System Discussion

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How do building occupants contribute to the "house as a system" approach?

- Number of occupants
- Bath/shower frequency and length
- Leaving windows open
- Watering plants
- Pets (heat lamps, water)
- Temperature settings
- Home electronics
- Cooking

House as a System Discussion

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How does weatherizing a building positively impact the structure?

House as a System Discussion

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How does weatherizing a building positively impact the house as a system?

- Increases occupant comfort (and happiness)
- Reduces the energy use of the home
- May reduce the monthly utility costs of the home
- A properly vented and insulated attic prevents ice dams
- Reduces the likeliness of frozen pipes

House as a System Discussion

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How can weatherizing a building negatively impact the structure?

House as a System Discussion

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How can weatherizing a building negatively impact the house as a system?

- Uneven room temperatures if areas are poorly or not insulated
- Potential for moisture intrusion if exterior siding is poorly re-installed
- Fire risk if insulation is installed over K&T or non-IC recessed lights
- Can lead to frozen pipes if thermal barrier is relocated

What is Heat?

- Heat is a form of energy
- When heat moves from one area to another, it is referred to as “heat transfer”
- There are three types of heat transfer

Heat Types: Conduction

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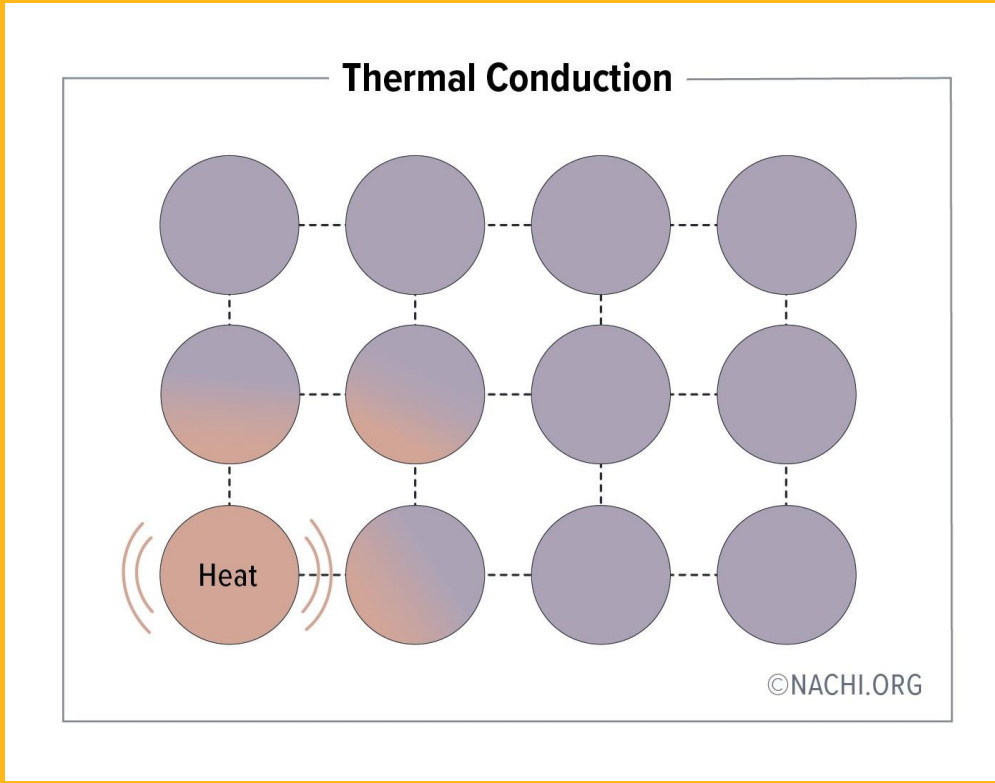
- Conduction occurs when energy is transferred from one atom or object to another
- Conduction can occur in liquid, gas, or solid objects
- What are some examples of conduction?



Heat Types: Conduction

Conduction occurs more readily in solids and liquids, where the particles are closer together than in gases, where particles are further apart. The rate of energy transfer by conduction is higher where there is a large temperature difference between the substances that are in contact.

Heat Types: Convection

- Convection is the flow of heat within a fluid, with warmer fluids rising and colder fluids falling
- In homes, this fluid is air
- Warm air is less dense, therefore lighter, than cold air
- What are some examples of convection?

Heat Types: Convection

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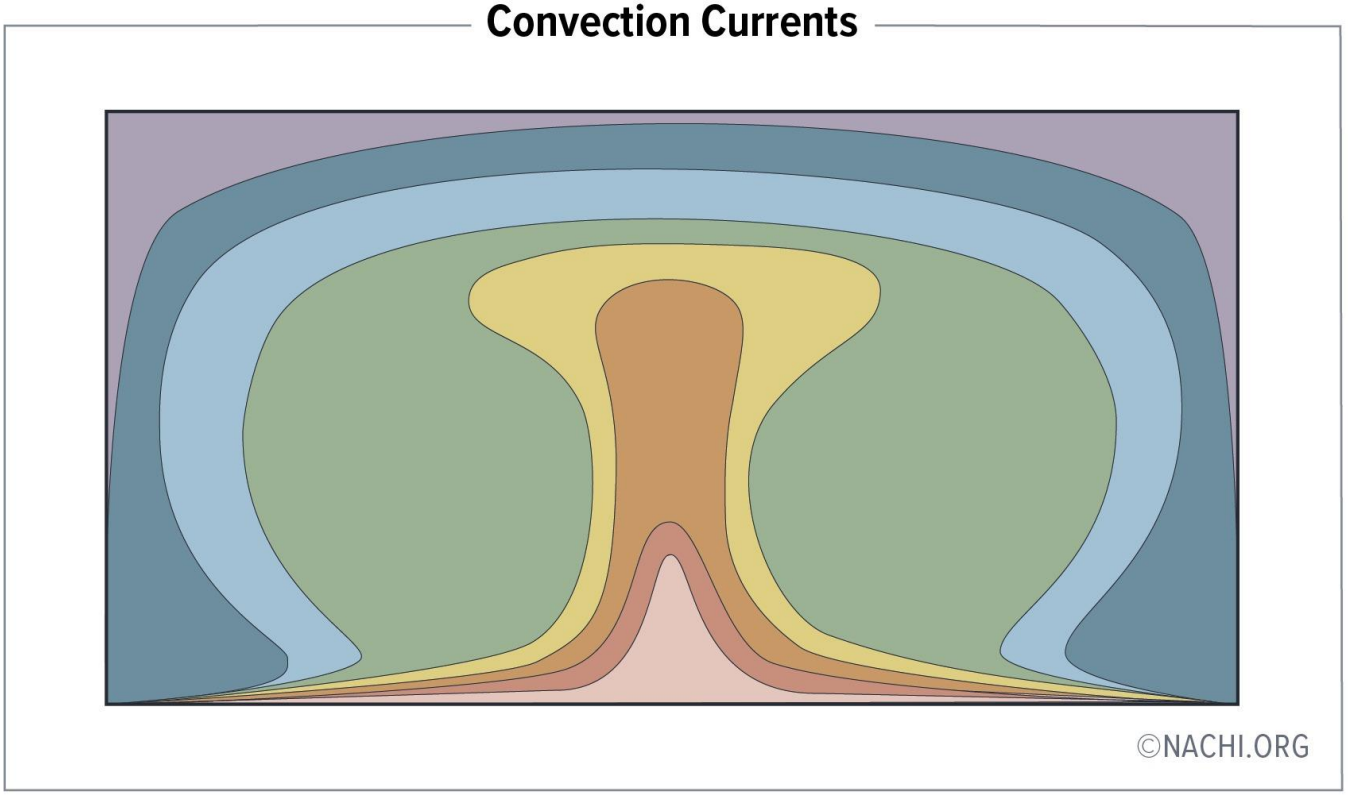

Heat Types: Convection

Hot air balloons function with this convective air principle. They float due to the difference in air density between the hot air inside the balloon and the surrounding air. When the burner heats the air inside the balloon, it expands and becomes less dense than the surrounding air, creating an upward force that lifts the balloon.

Heat Types: Radiation

- Radiant heat is the mode of transfer of heat from one place to another in the form of waves called electromagnetic waves.
- Radiation does not require a “medium” to carry the heat
- The objects must be in sight of one another
- What are some examples of radiation?

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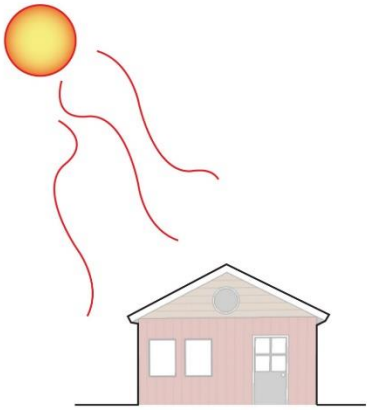
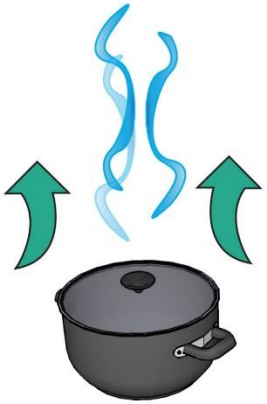
HEAT TRANSFER METHODS



RADIATION

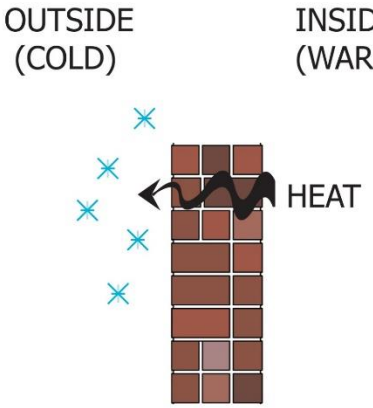
HEAT TRANSFERRED THROUGH ELECTROMAGNETIC WAVES

AIR ABOVE THE POT WARMS UP AND RISES, DRAWING MORE COOL AIR FROM THE SIDES TO HEAT UP



CONVECTION

HEAT TRANSFER WITHIN A GAS OR LIQUID



CONDUCTION

HEAT TRANSFERRED THROUGH A SOLID MATERIAL

How is Heat Measured?

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1 British Thermal Unit (BTU) = amount of thermal energy required to increase the temperature of 1 lb. of water 1˚F

1 wooden match ≈ 1 BTU

Heating Fuel

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Heating Fuel	Unit	BTUs per Unit
#2 Heating Oil	Gallon	138,500
Natural Gas	Therm	100,000
Propane	Gallon	91,452
Electricity	Kilowatt -hour	3,412
Wood	Cord	20,000,000

Delta T (ΔT)

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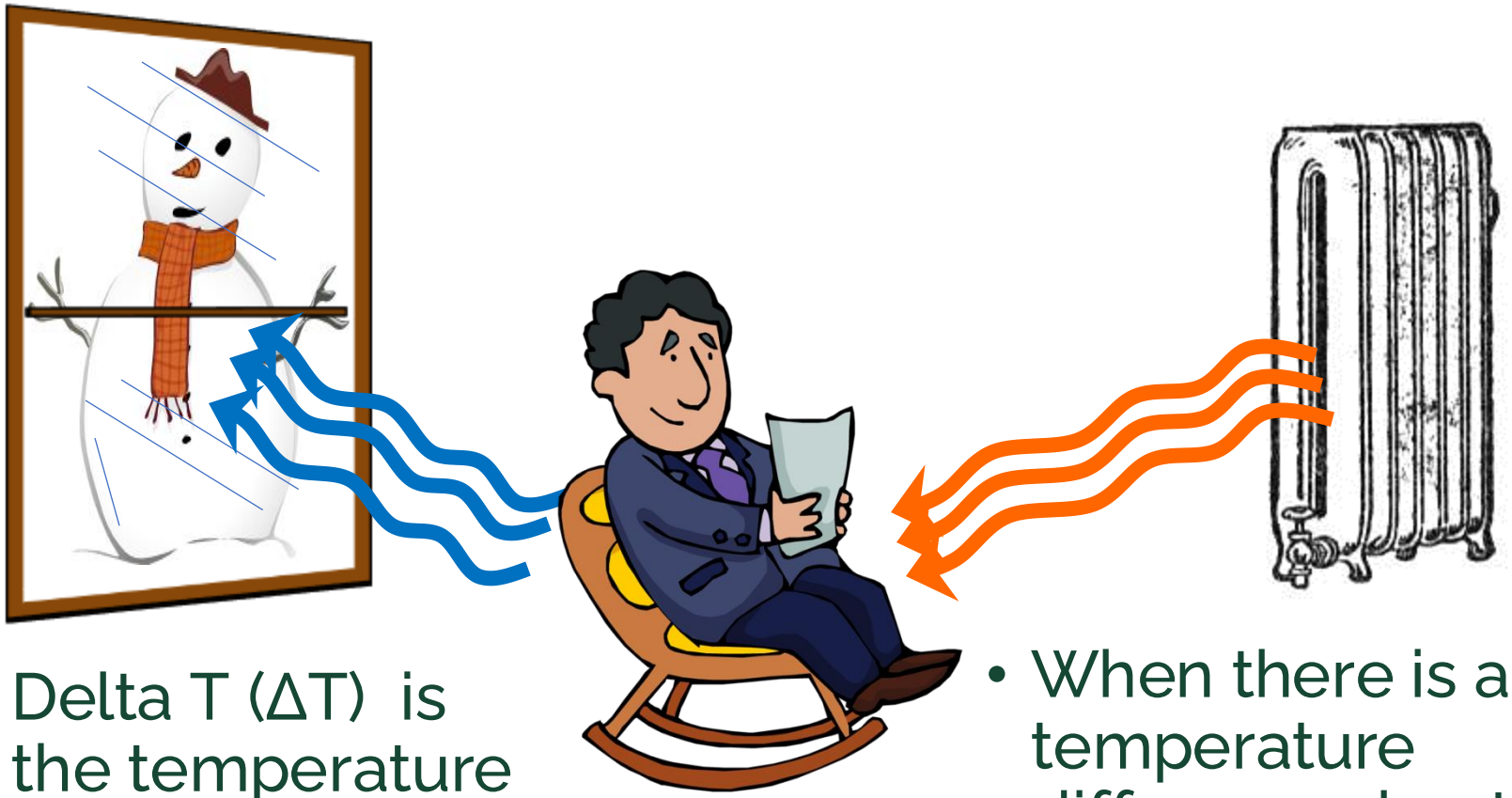

- Delta T (ΔT) is the temperature difference between two measuring points
- When there is a temperature difference, heat transfer will occur

What is the Delta T (ΔT)?

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- During the winter, the indoor temperature of a home is 68 degrees while the outside is 23 degrees. What is the Delta T (ΔT)?

- During the summer, the indoor temperature of a home is 72 degrees while the outside is 88 degrees. What is the Delta T (ΔT)?

2nd Law of Thermodynamics

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Energy flows naturally from high concentrations to low concentrations

For example:

- Heat Transfer: Heat moves to cold
- Moisture Transfer: Wet moves to dry
- Air movement: High air pressure moves to low air pressure

Heat Moves from Hot to Cold

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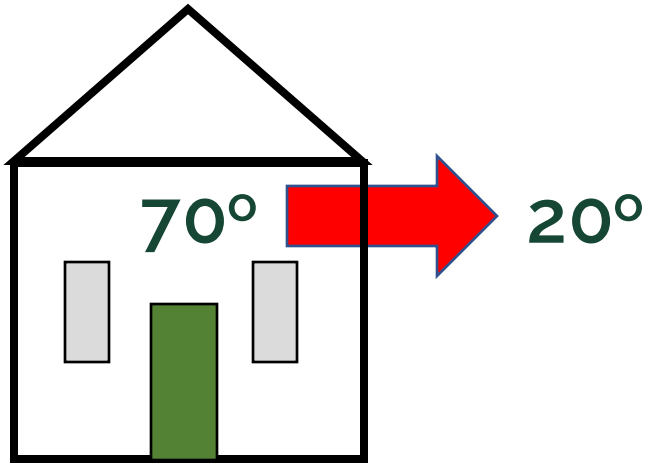
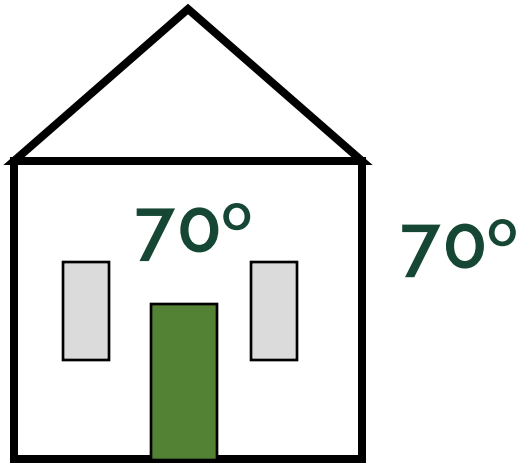
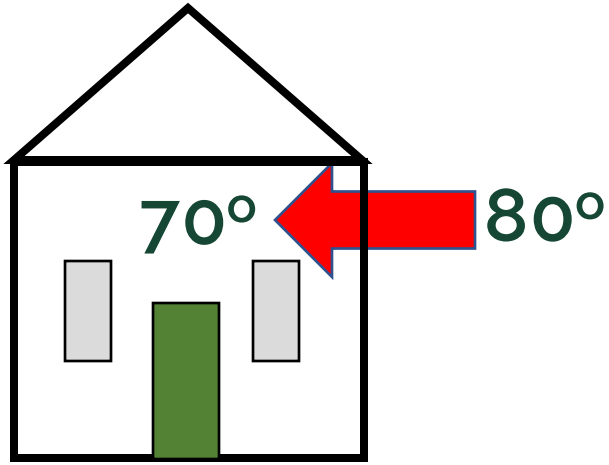


Heat flows out of the house during winter



No heat flow



Heat flows into the house during summer

Heat Loss in BTU's

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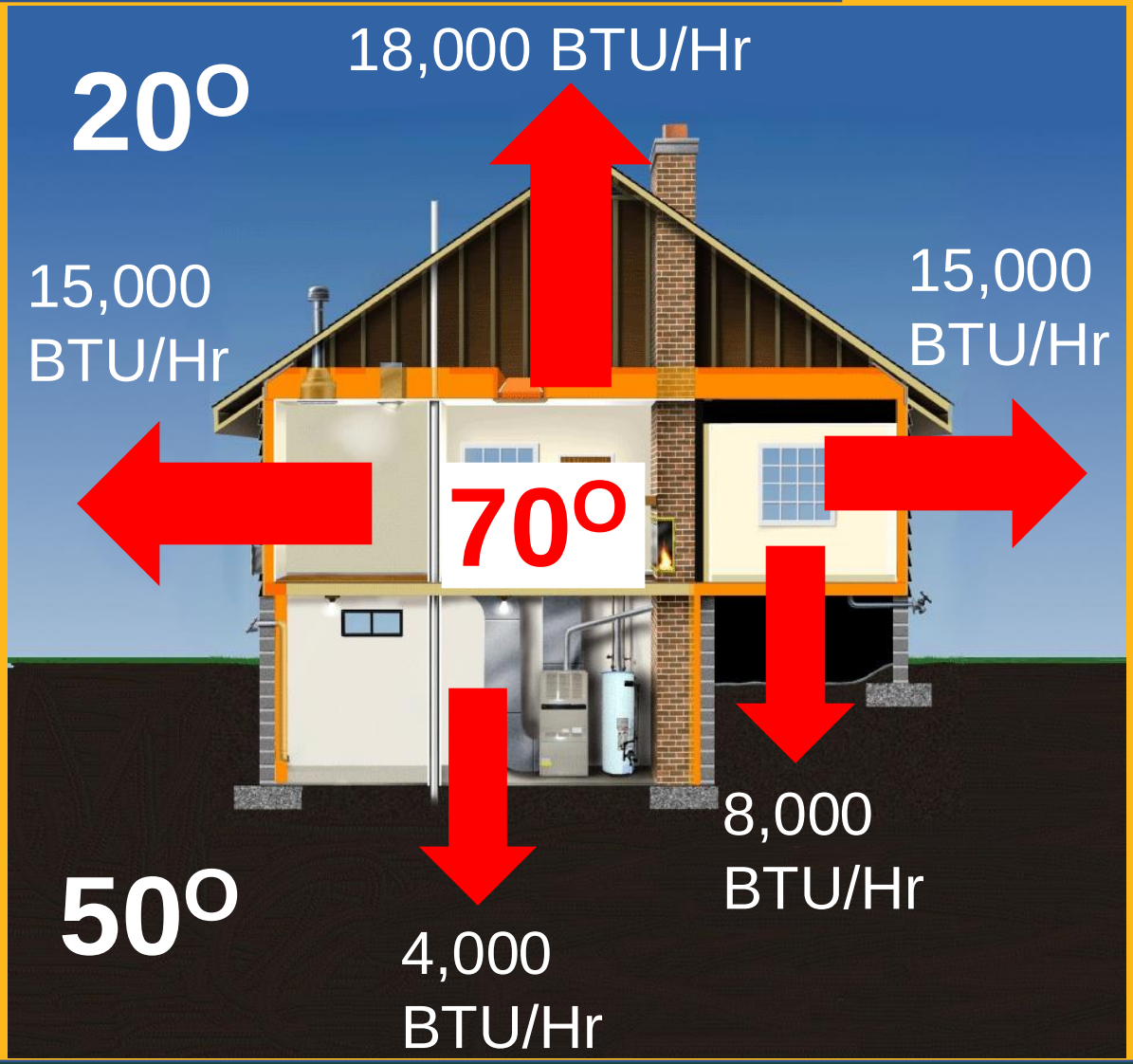

Air Movement

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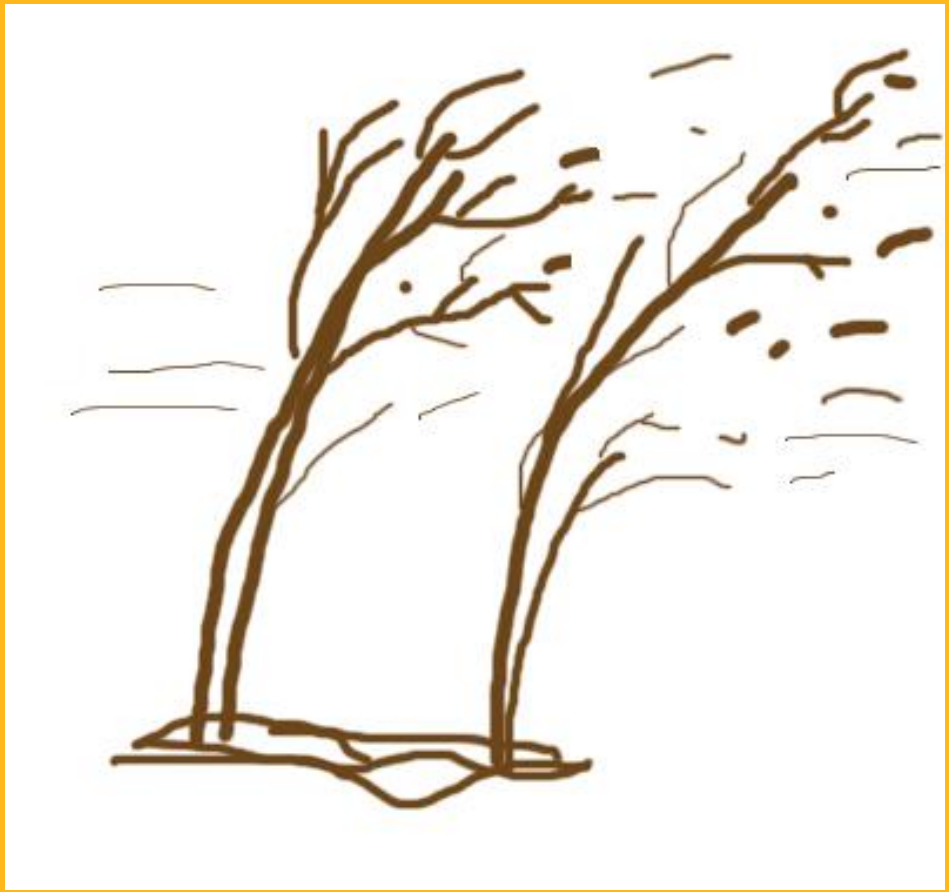
How does air move?



Why Air Leakage Is Important

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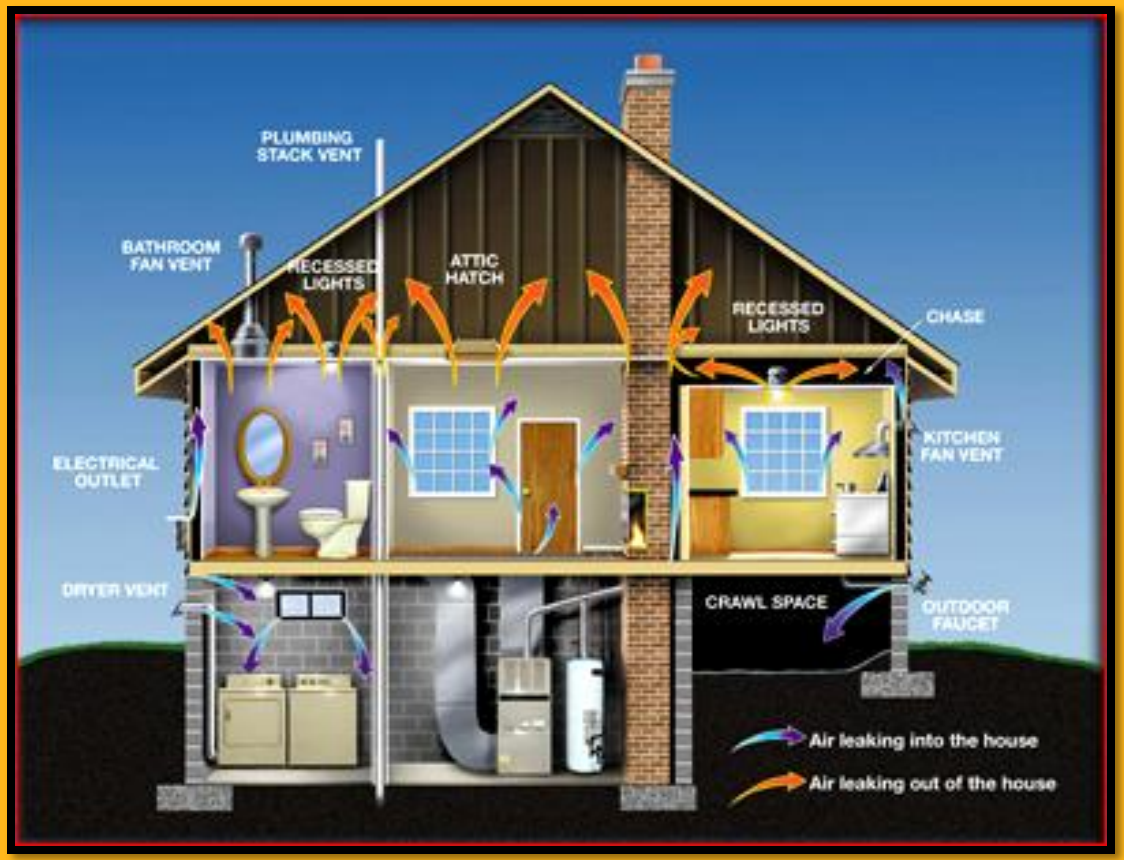

Air Leaks = Heat Loss = Wasted Money

For every cubic foot of air entering the home, one cubic foot is leaving.

Types of Air Movement

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Air in a house can move via:

1. Pressure differences
2. Active air movement
3. Stack effect

Wherever a pressure difference and pathway (hole) are present, air leakage will occur

Active Air Movement

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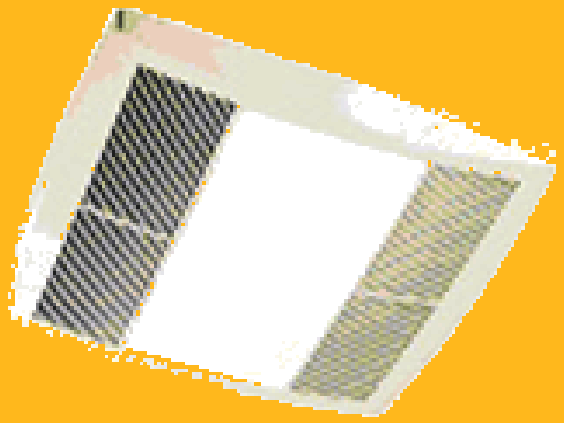
Furnace blowers



Bath and kitchen fans

Whole house fans

Air Duct Leakage

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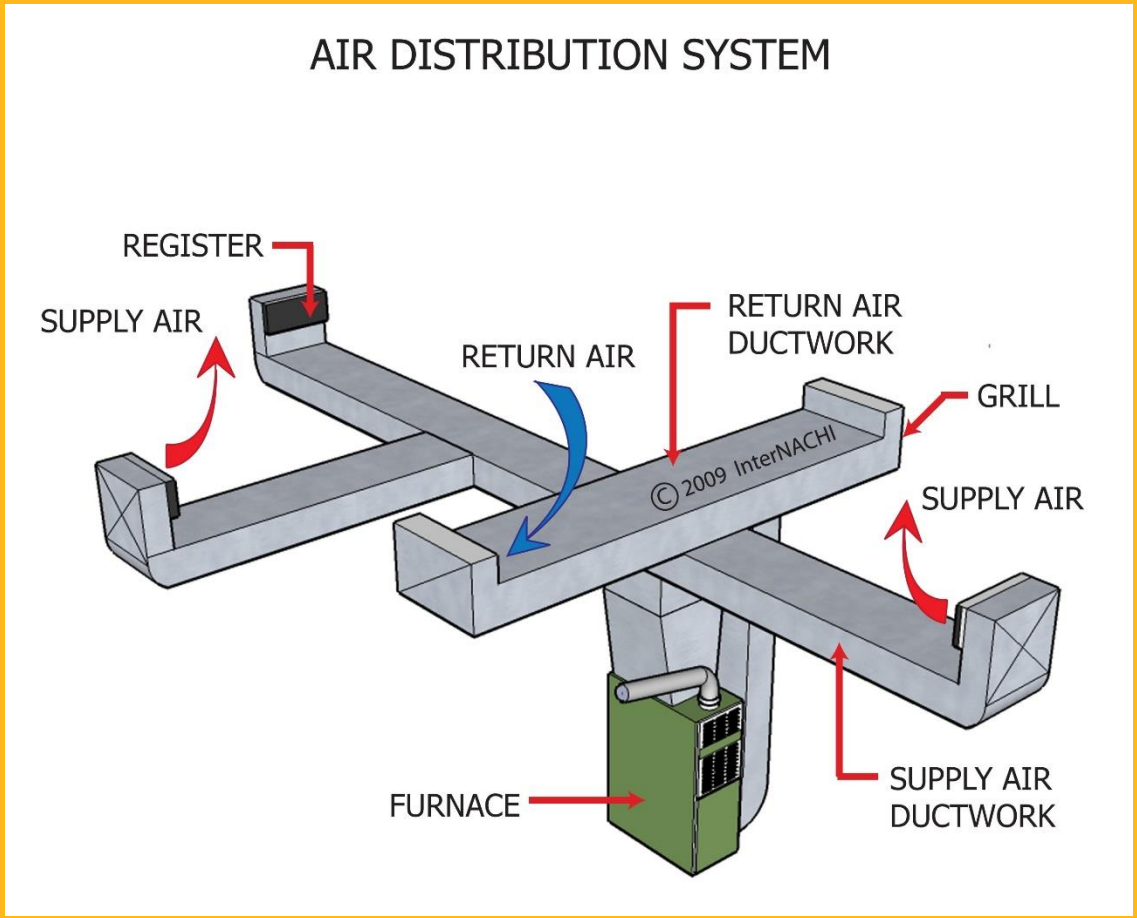

Definition

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Stack Effect:

- The stack effect or chimney effect is the movement of air into and out of buildings through unsealed openings, chimneys, flue-gas stacks, or other containers, resulting from air buoyancy. Buoyancy occurs due to a difference in indoor-to-outdoor air density resulting from temperature differences.

Definition

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Stack Effect:

- In the winter, the warm air in a heated building is lighter (less dense) than the cold air outside the building; that warm bubble of air wants to rise up and out. The flow of air leaving the top of the building draws cold air into cracks at the bottom.

Stack Effect Defined

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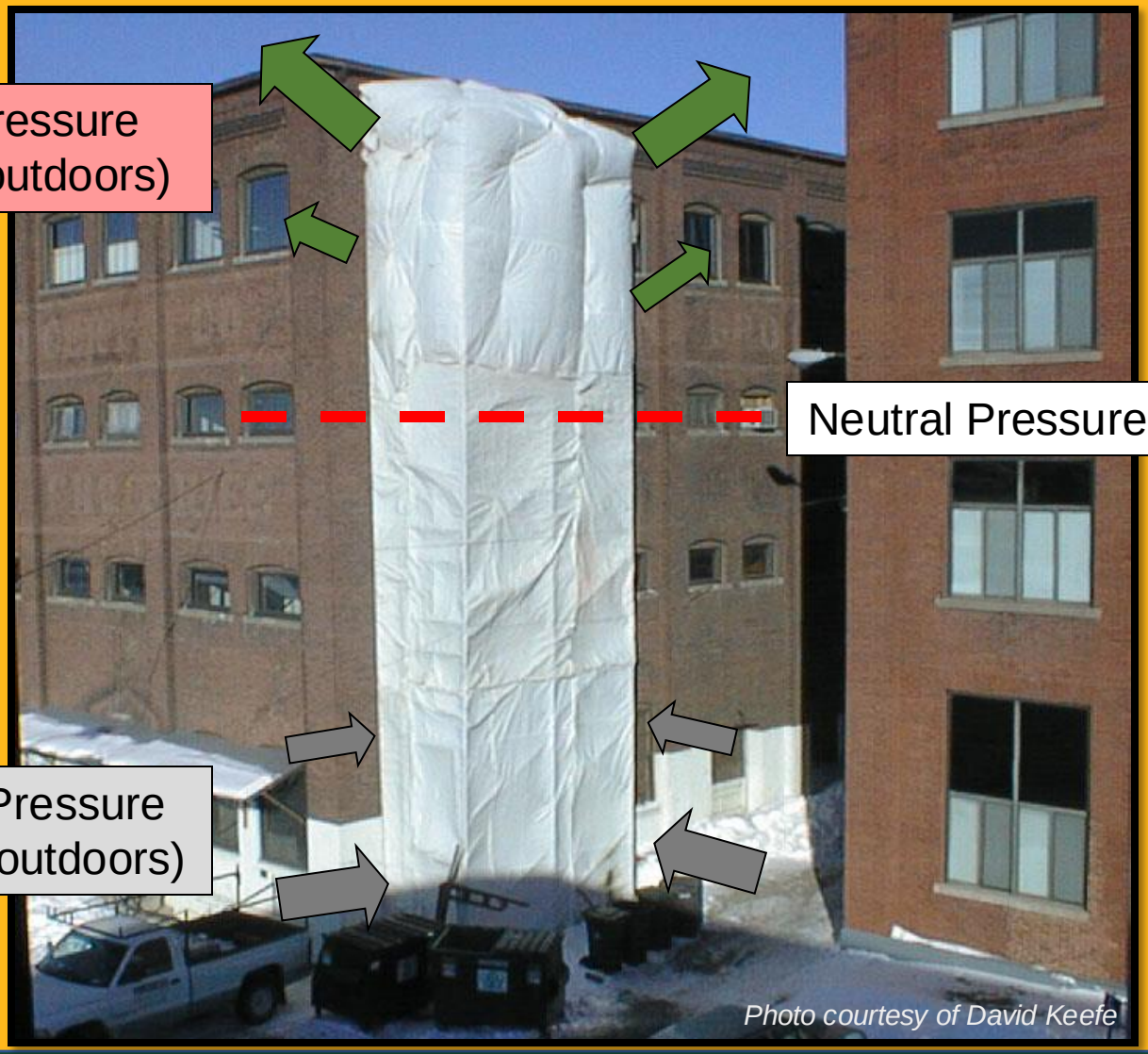

Greatest Leakage

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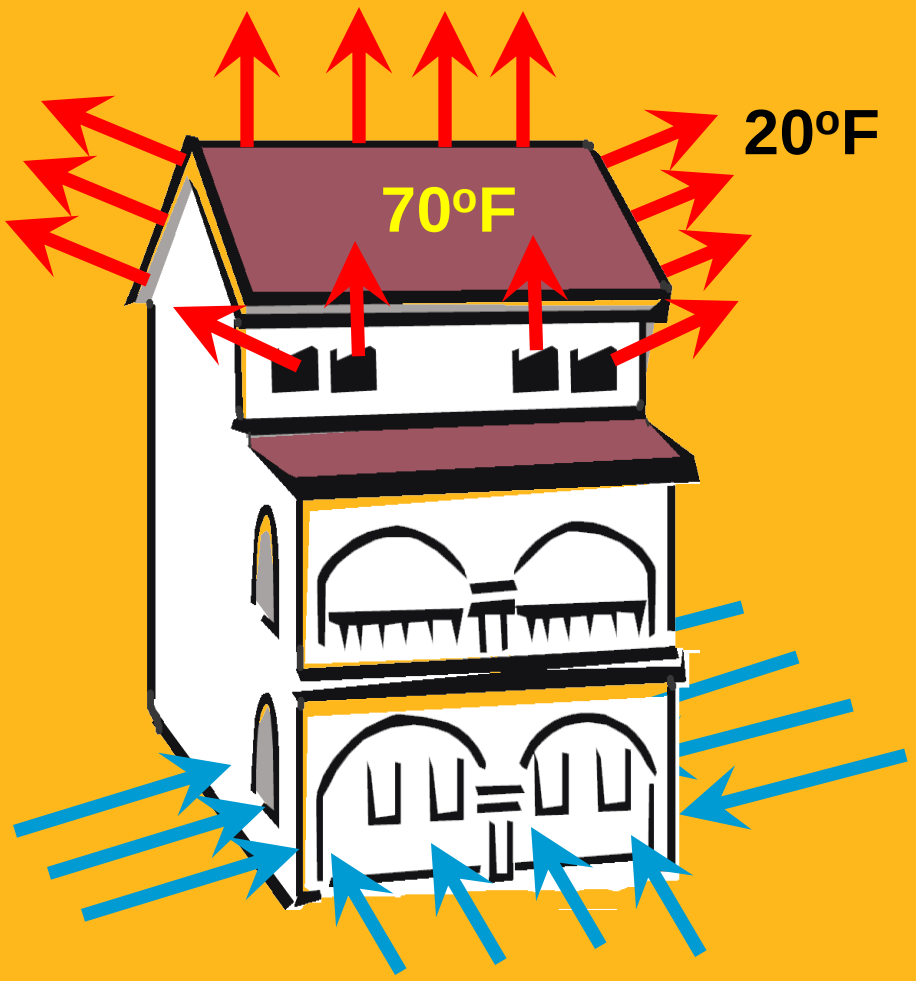
The stack effect creates the greatest leakage at the top and bottom of the building.



Stack Effect & Temperature

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Larger Temperature Difference = Greater Stack Effect

Stack Effect & Height

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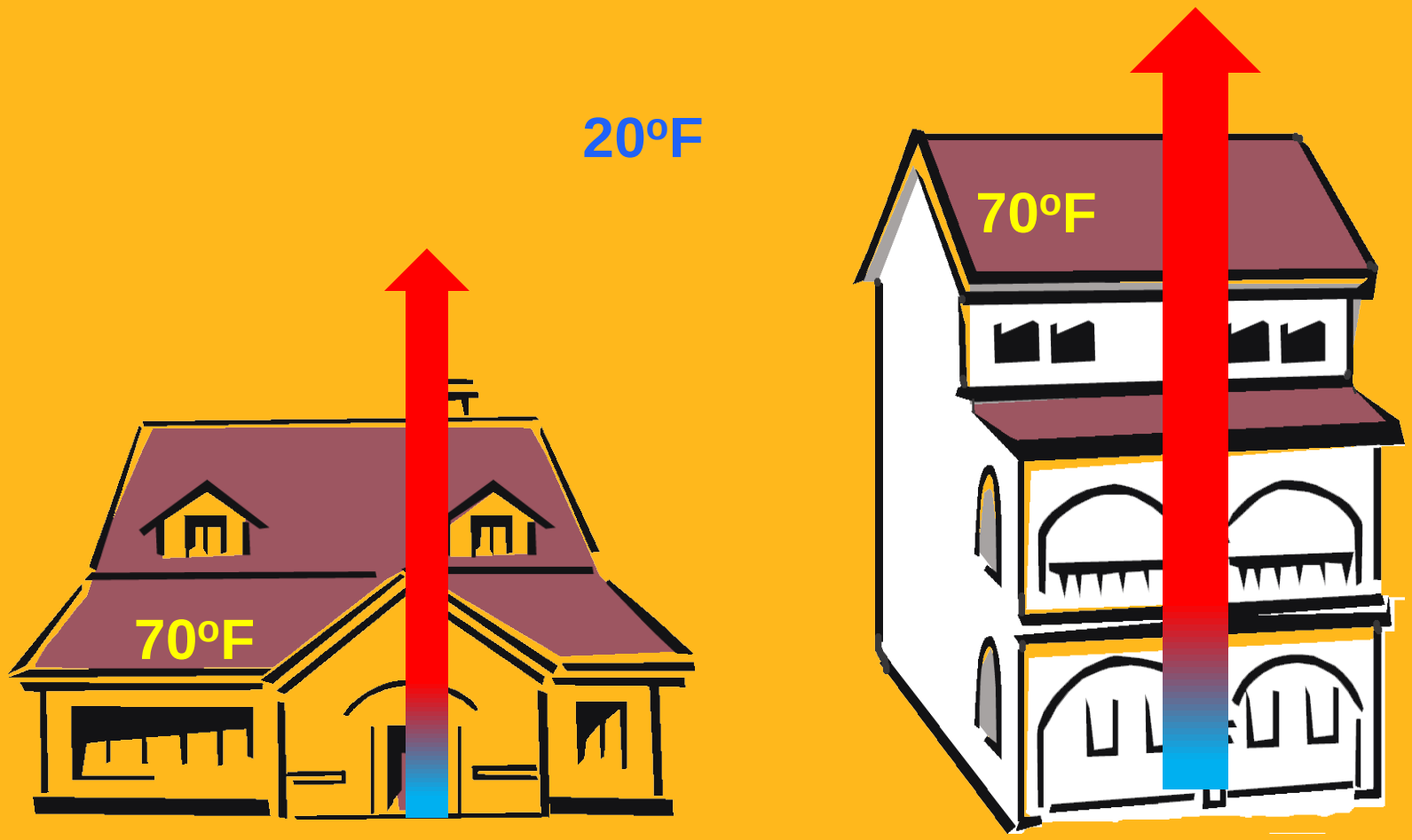

Taller House = Greater Stack Effect

Air Barrier

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How do you stop air movement caused by the stack effect?

By sealing leakage points to create a complete air barrier

Air Barrier Defined

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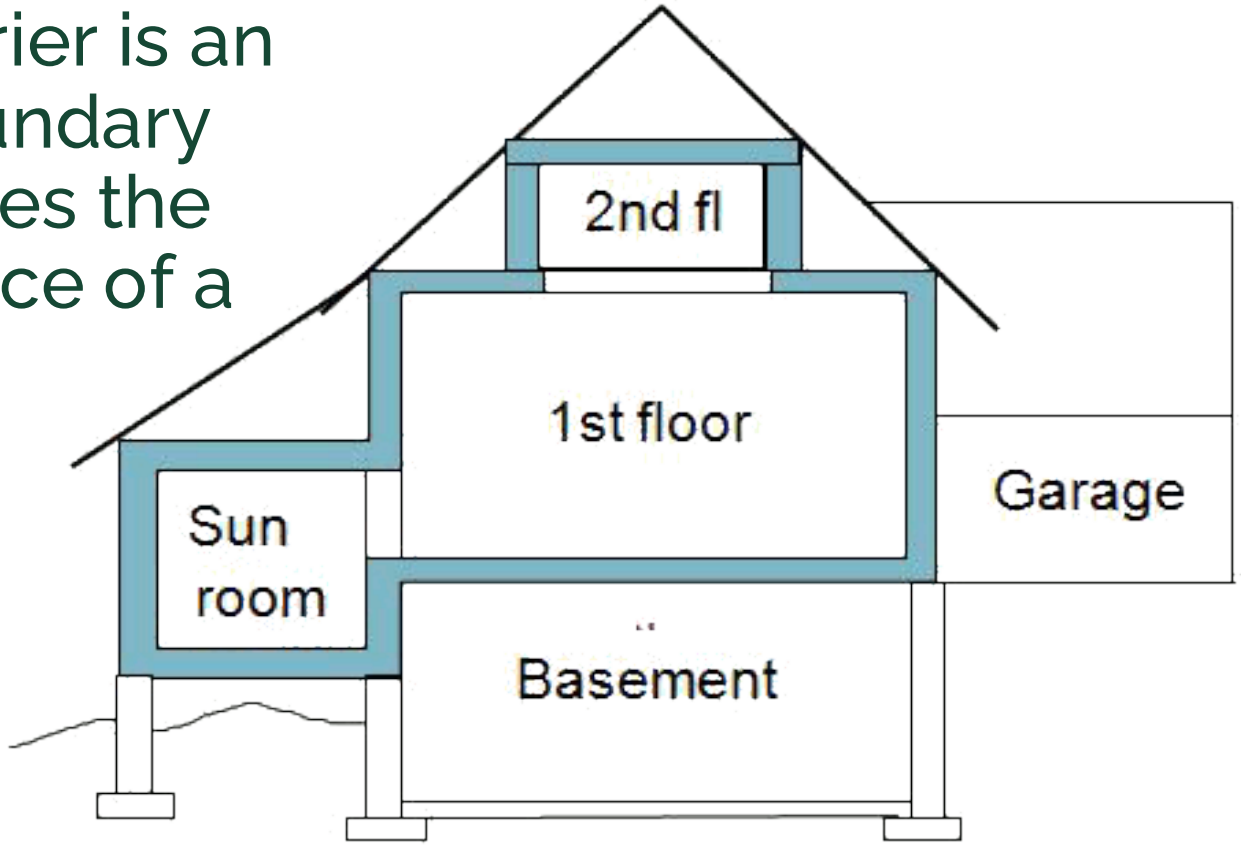
What is an air barrier?

- The air barrier is an airtight boundary that encloses the heated space of a building.



Air Barrier

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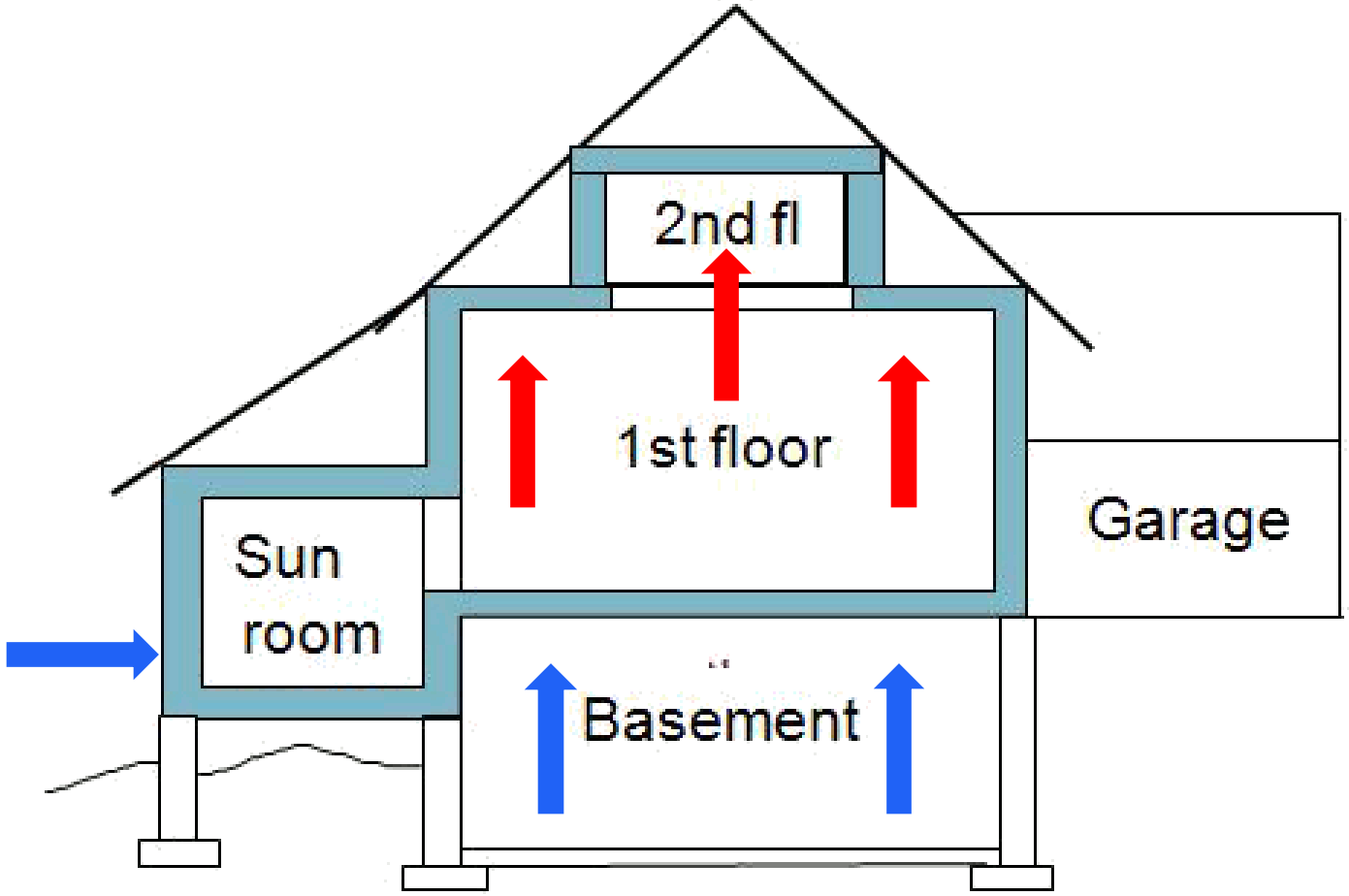
The air barrier blocks air infiltration and exfiltration.



Highest Priorities

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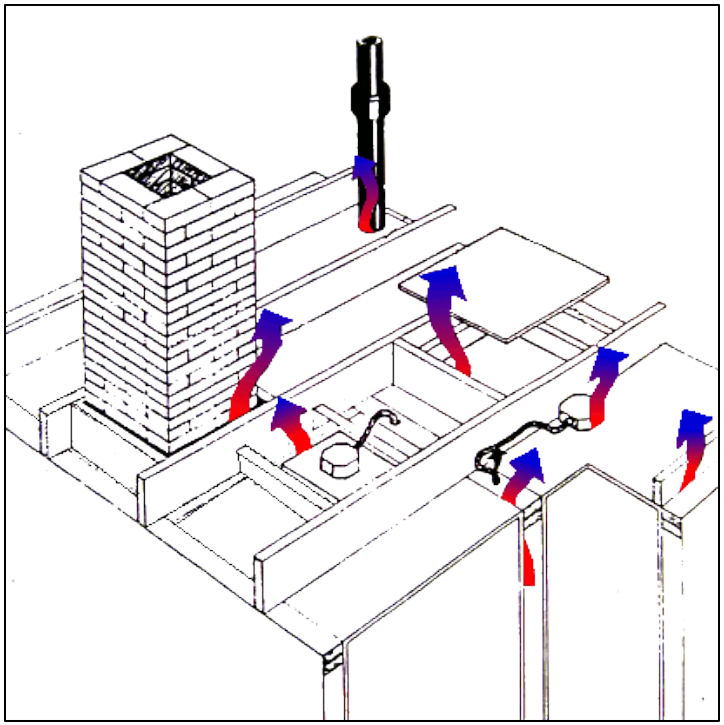
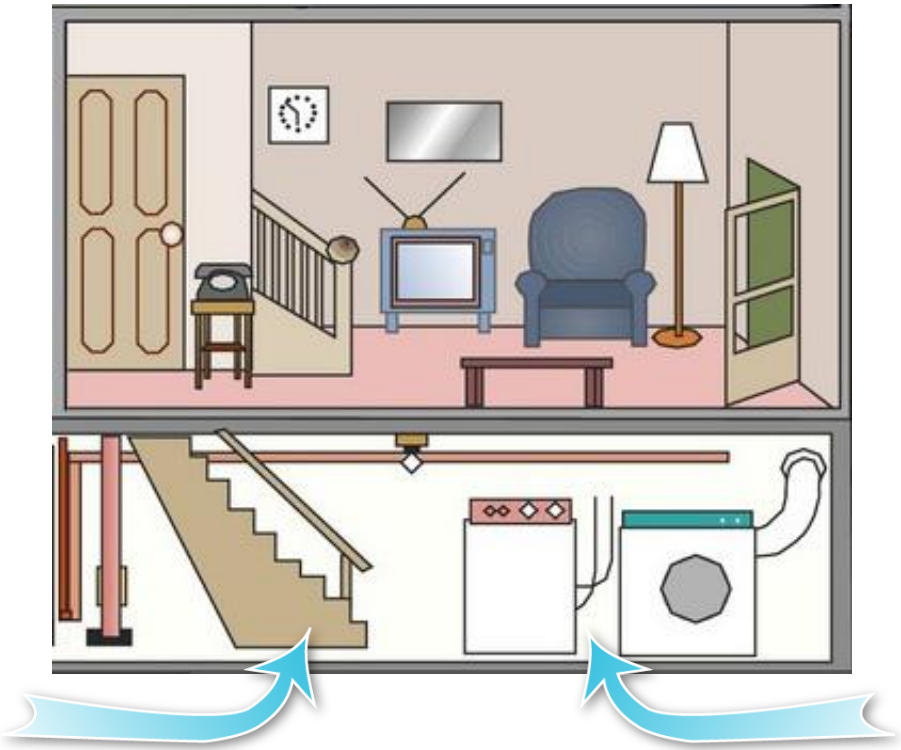
Attic



Basement



What are some major areas of air leakage in an attic?

Typical Leakage Points

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Question

What is the leading cause of all building failures?

Building Science: Moisture in Homes

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Moisture is associated with 90% of all building failures.

— American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

Question

What are the three forms of moisture?

Forms & Sources of Moisture

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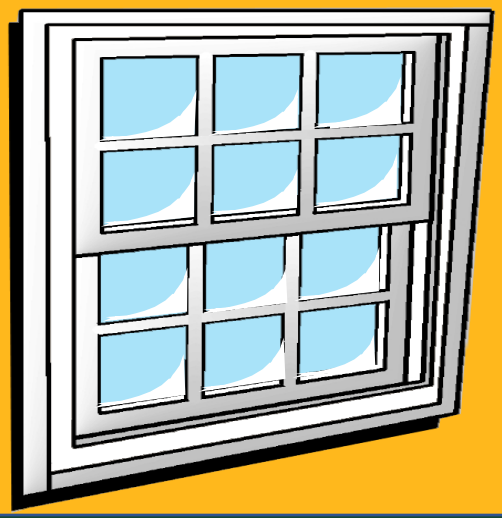
Bulk (liquid) moisture

Water vapor

Condensate



Moisture Movement: Bulk

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What are some examples of bulk moisture?

Moisture Movement: Vapor

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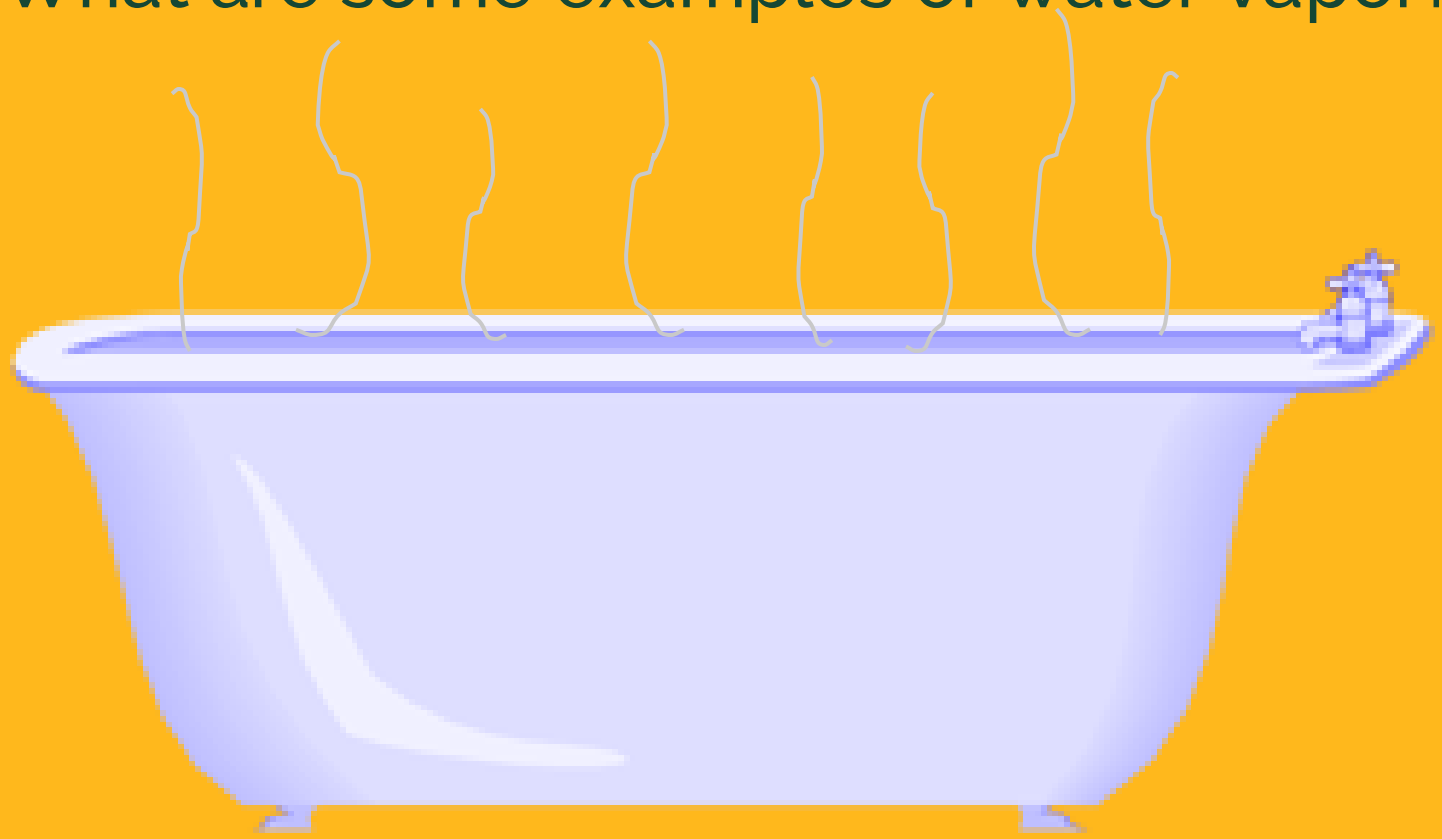
What are some examples of water vapor?



Moisture Movement: Condensate

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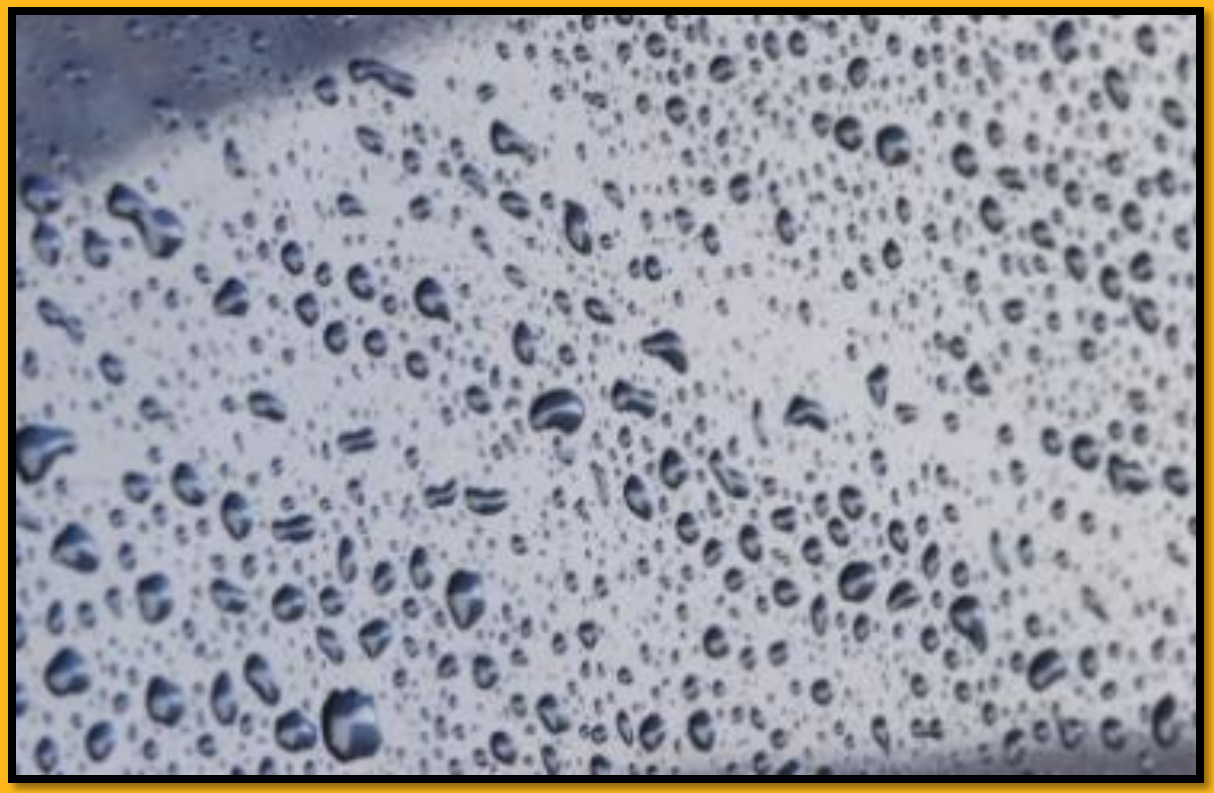
What are some examples of condensate?



Condensate is water vapor that condenses (changes back to water).

Moisture Accumulation

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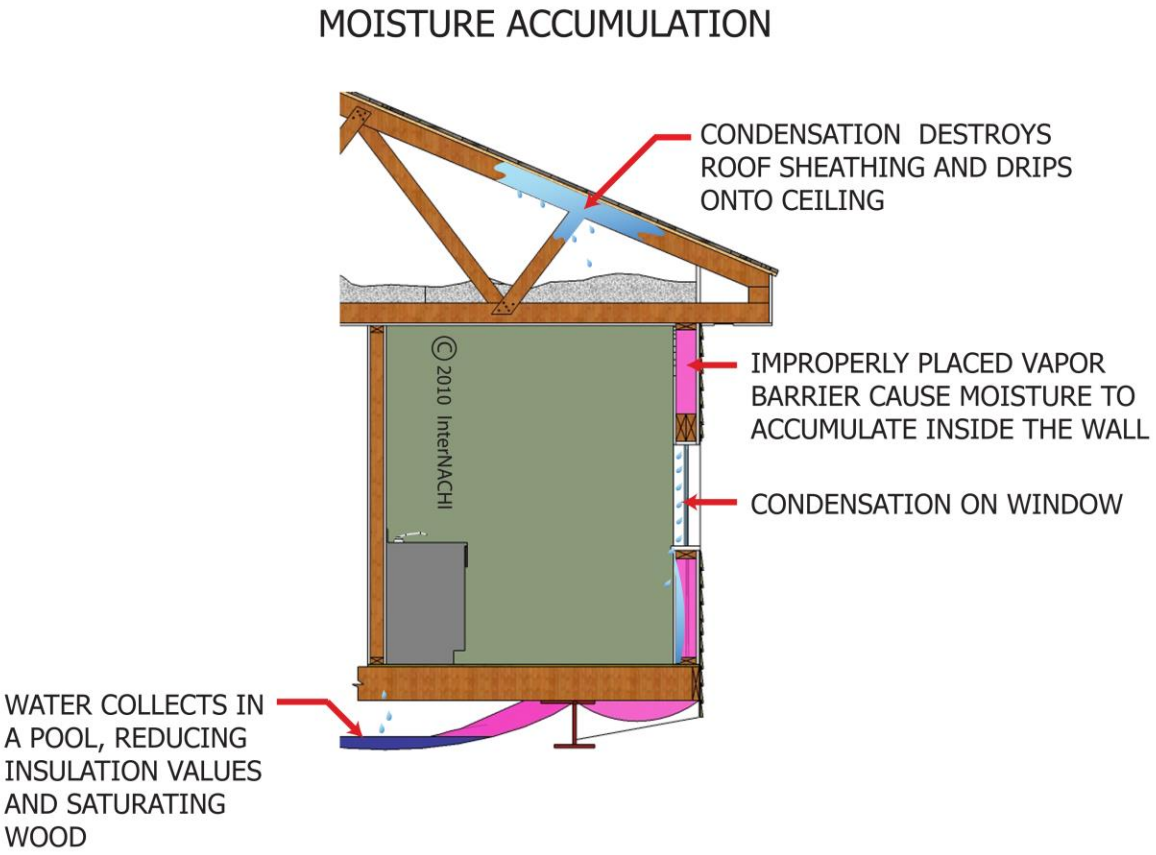

Moisture From Domestic Activities

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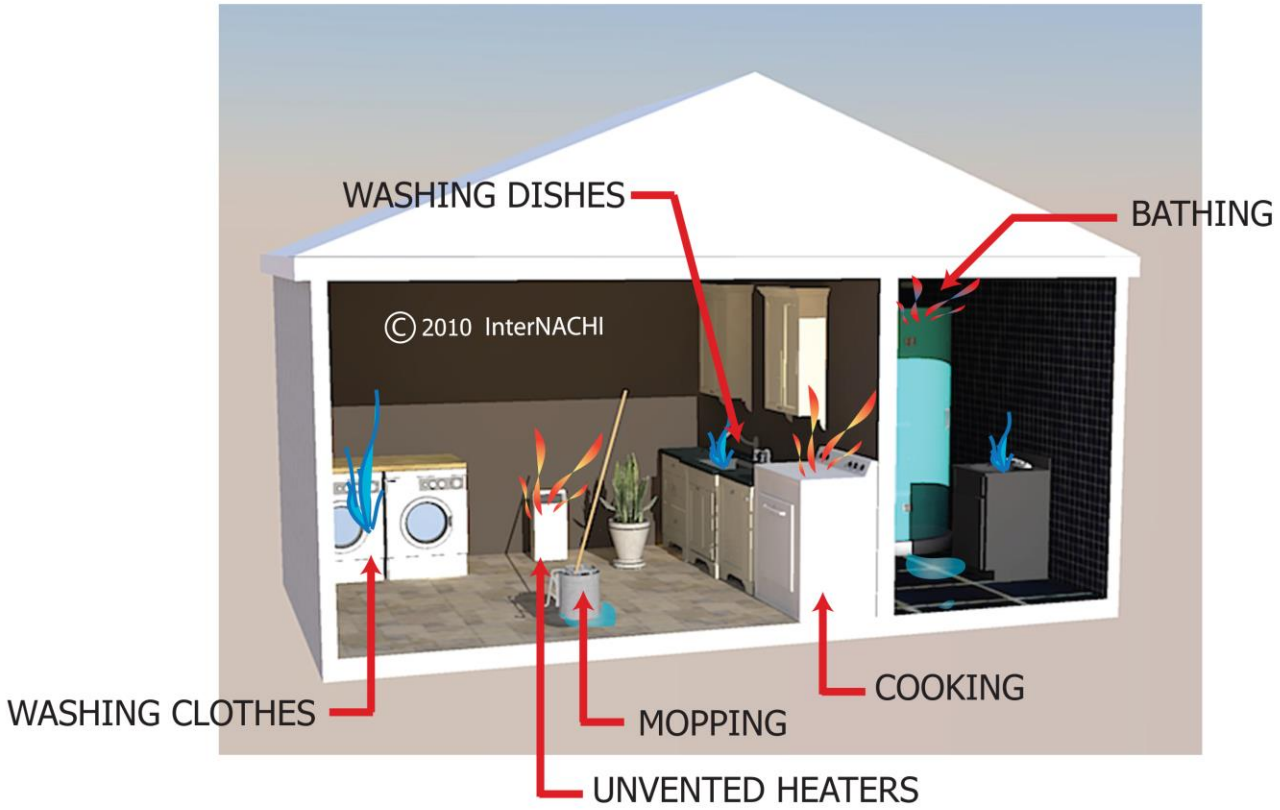
MOISTURE PRODUCTION FROM DOMESTIC ACTIVITIES



Relative Humidity & Condensation

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Water vapor can enter your home via air movement.

How many cups of water can enter through a half inch hole in one year?

Water Vapor Movement

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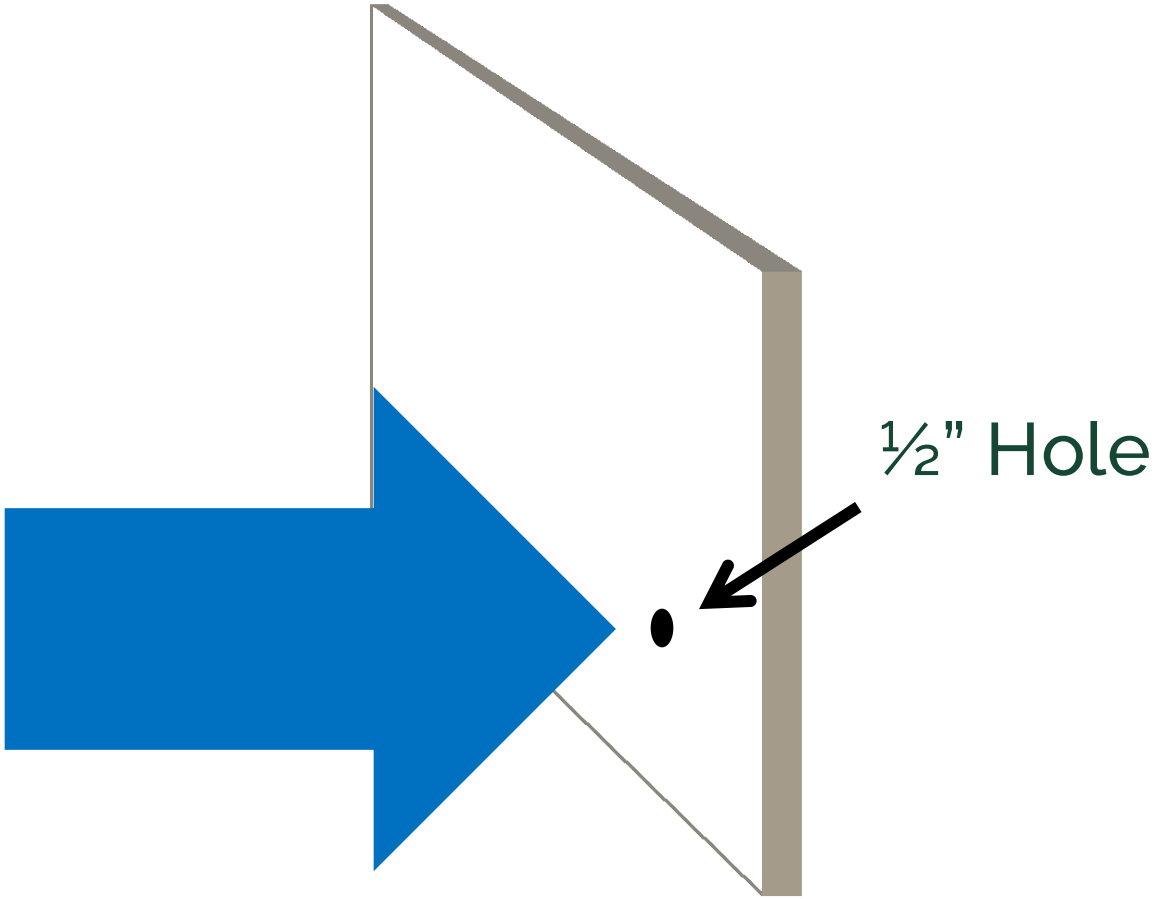
Air movement:
50 cups of water



Relative Humidity & Condensation

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Relative Humidity: a measurement of the amount of moisture in a sample of air, compared to the total amount of moisture the air could hold at a given temperature, expressed as a percentage. Air that is 100% RH is said to be "saturated"

Dew Point: the temperature to which air must be cooled to become saturated with water vapor. When air is cooled below the dew point, its moisture capacity is reduced, and airborne water vapor will condense to form liquid water known as dew. When this occurs through the air's contact with a colder surface, dew will form on that surface.

Relative Humidity & Condensation

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- Warm air can hold more moisture than colder air
- Relative humidity depends on the temperature of the air sample

RH Example

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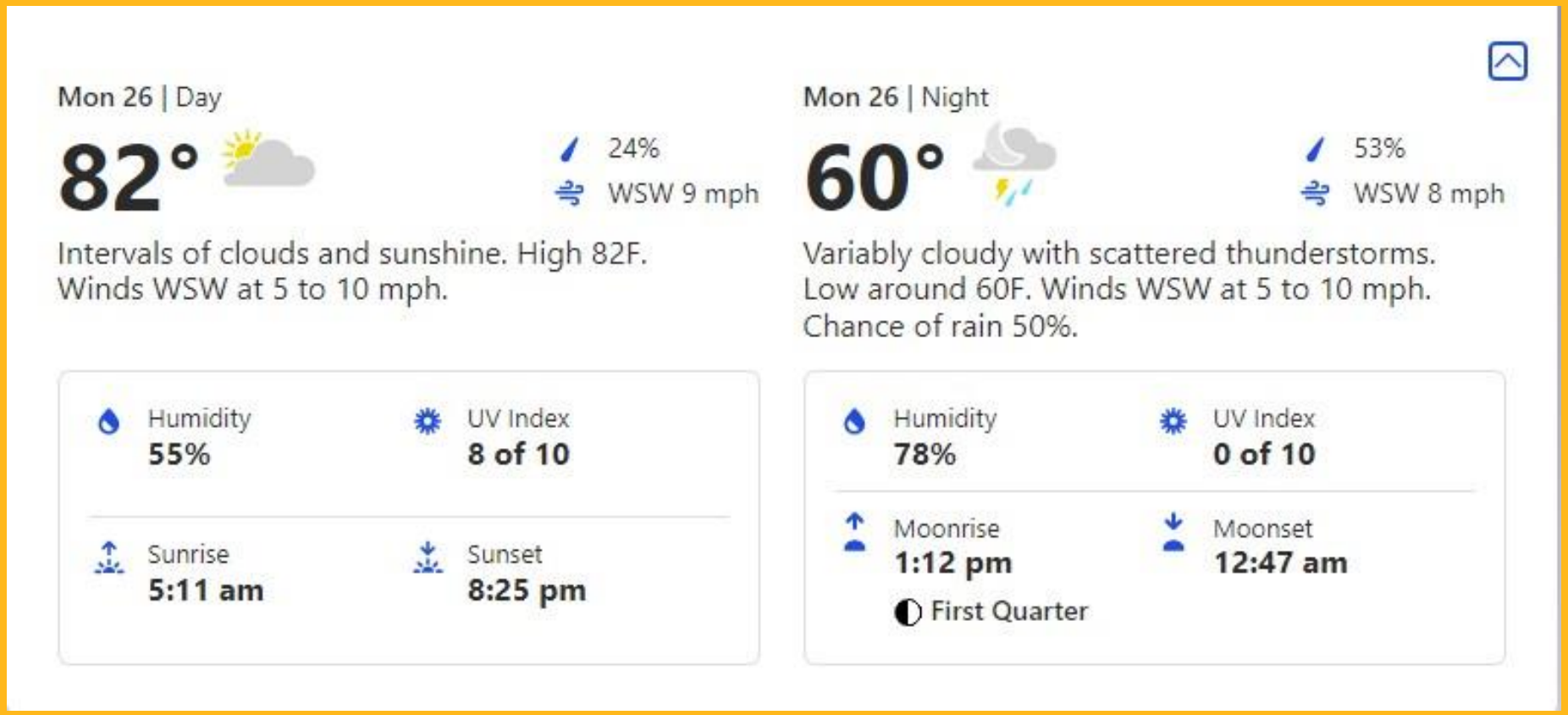

Dew Point Example

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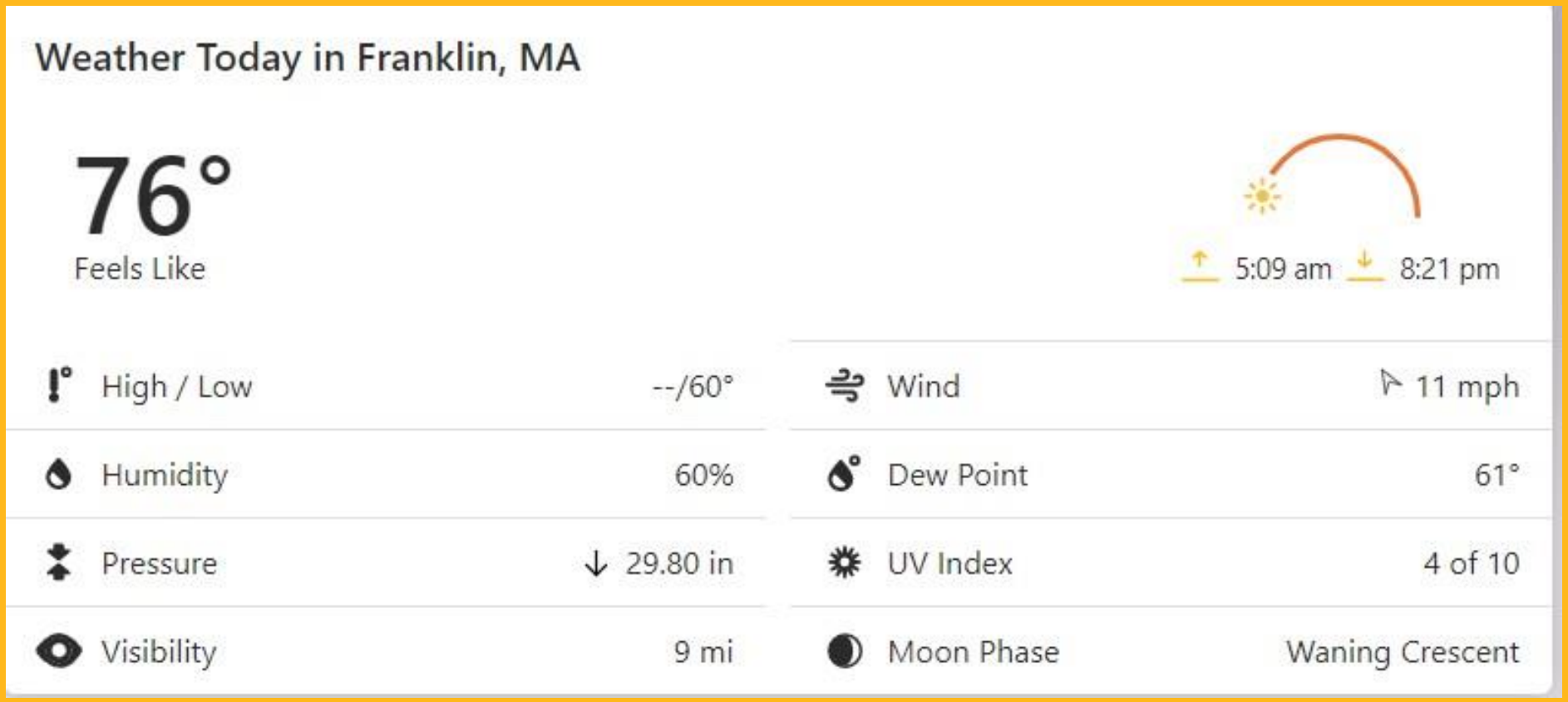

Relative Humidity & Condensation

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As the air temperature drops, so does its capacity to hold water vapor

Absolute Humidity	Air Temperature	Relative Humidity
	95° F	55%
	90° F	65%
	85° F	76%
	80° F	87%
	75° F	99%
	70° F	Condensation

Moisture in Basements

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Excessive moisture is common in basements

- Causes of moisture include:
  - High water table
  - Poor drainage
  - Missing/poorly designed gutters & downspouts
  - Dirt floors
  - Open windows and vents
  - Unvented/poorly vented dryer
  - Unvented/poorly vented combustion equipment

Discussion: Moisture

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- What are some conditions caused by moisture that you may find in crawlspaces and basements?
- What conditions might insulating the crawlspace and basement ceilings create?
- What is one important way to reduce potential moisture problems from exposed earth floors?

Indications of Moisture Issues

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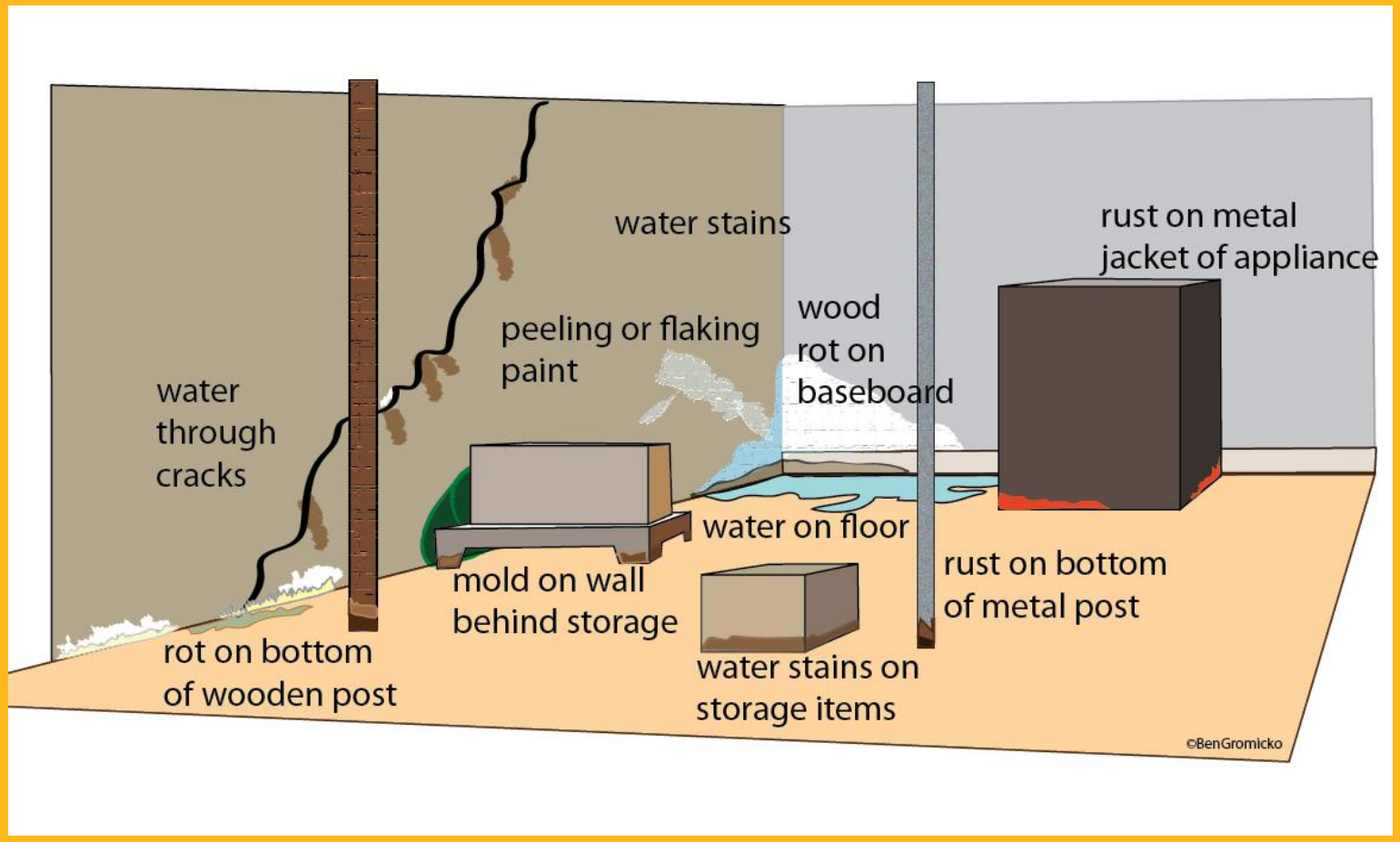

Efflorescence

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Efflorescence is the dissolved salts deposited on the surface of a porous material (such as concrete or brick) that are visible after the evaporation of the water in which it was transported. The moisture that creates efflorescence often comes from groundwater, but rainwater can also be the source.

Efflorescence alone does not pose a major problem, but it can be an indication of moisture intrusion, which may compromise the structural material.

Water Entry

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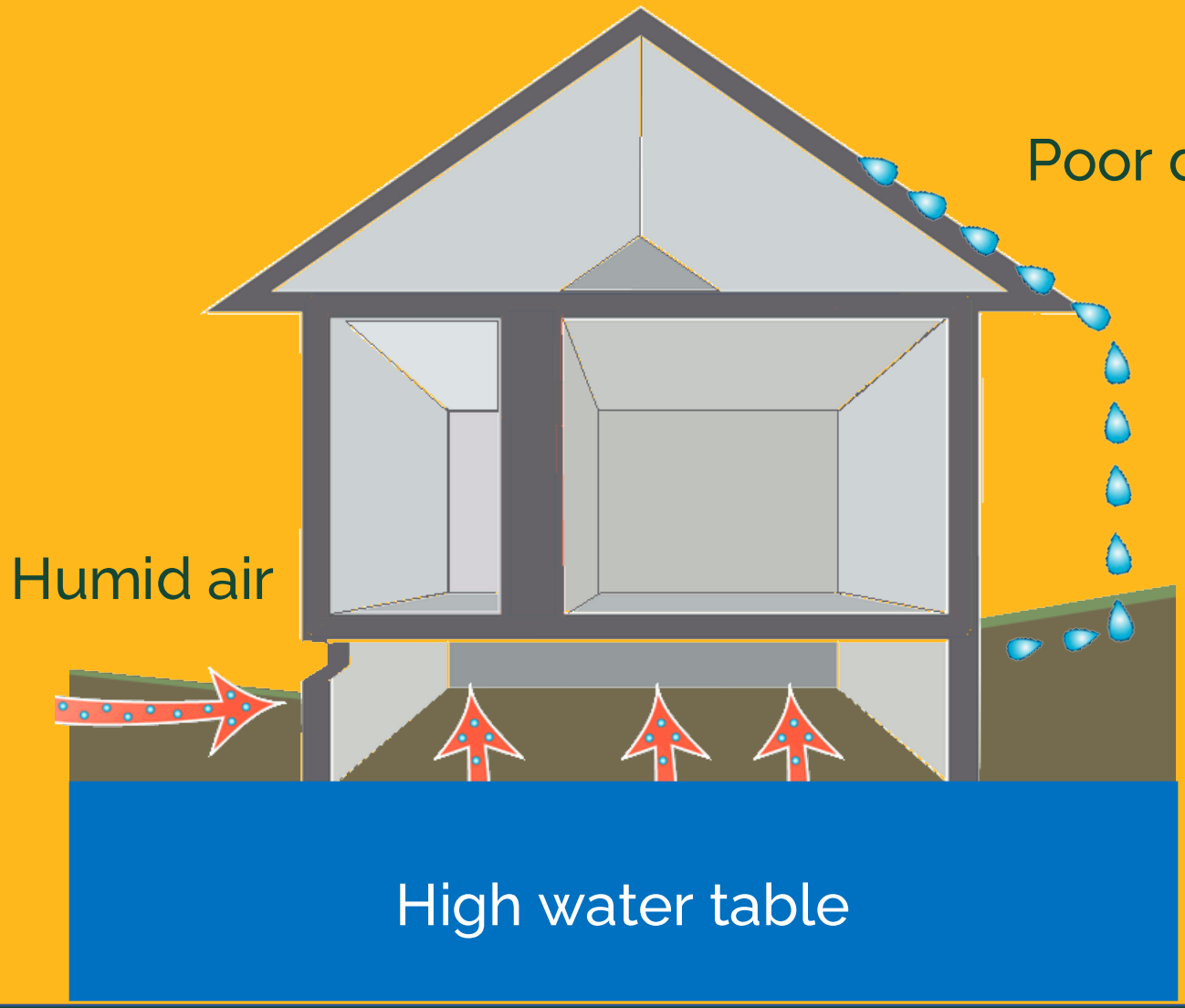

Example 1: Before & After

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Example 2: Encapsulated Crawlspace

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Proper Crawlspace Vapor Barrier

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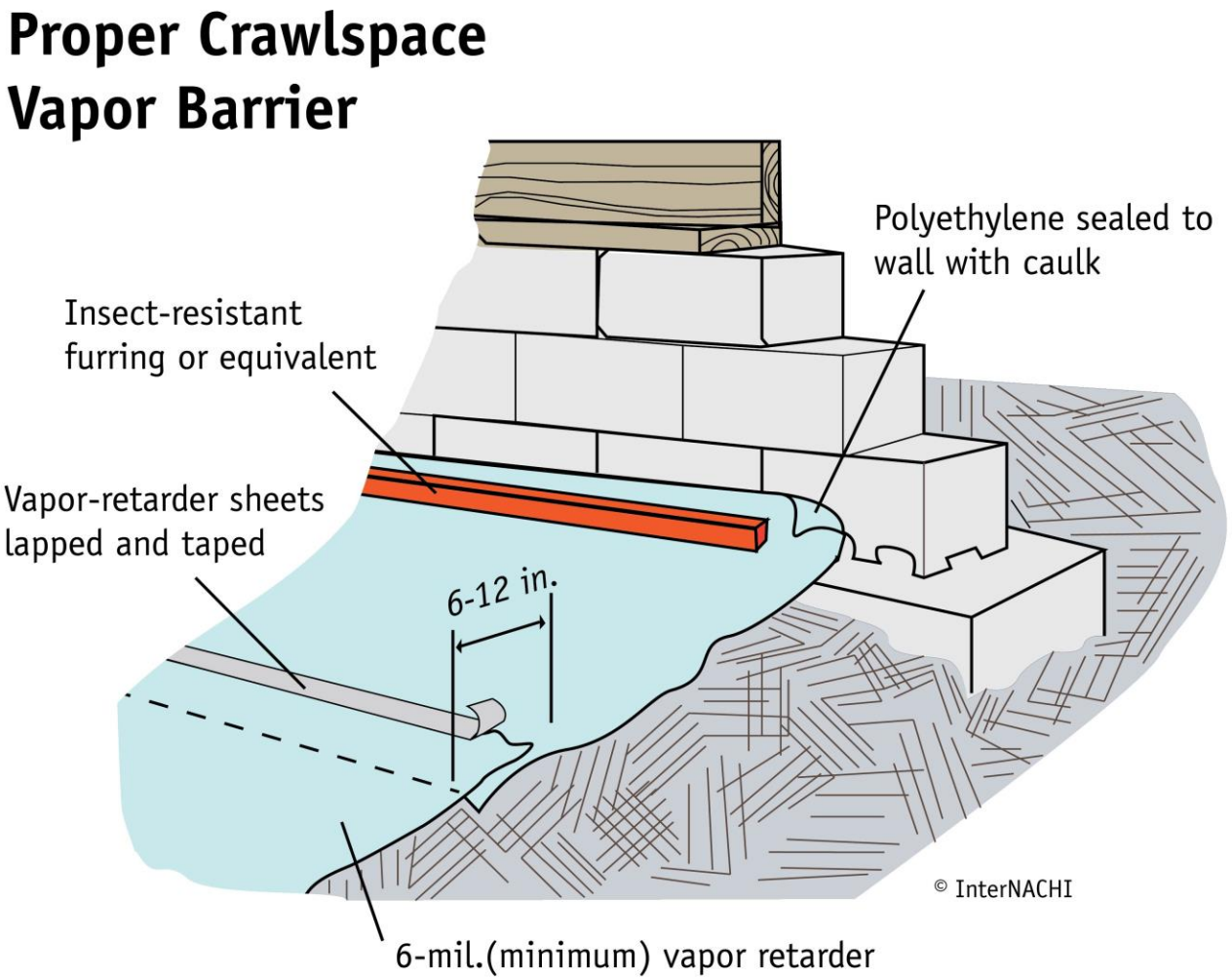

Locating the Thermal Boundary

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Accurately locating and defining the thermal boundary is crucial – a poorly defined thermal boundary will lead to occupant discomfort, wasted energy, and higher utility bills

Locating the Thermal Boundary

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- What is best for the house?
- What are the homeowners' wishes?
- What are the program guidelines?

Sometimes the three answers will align, other times they will conflict with one another.

Thermal Boundary

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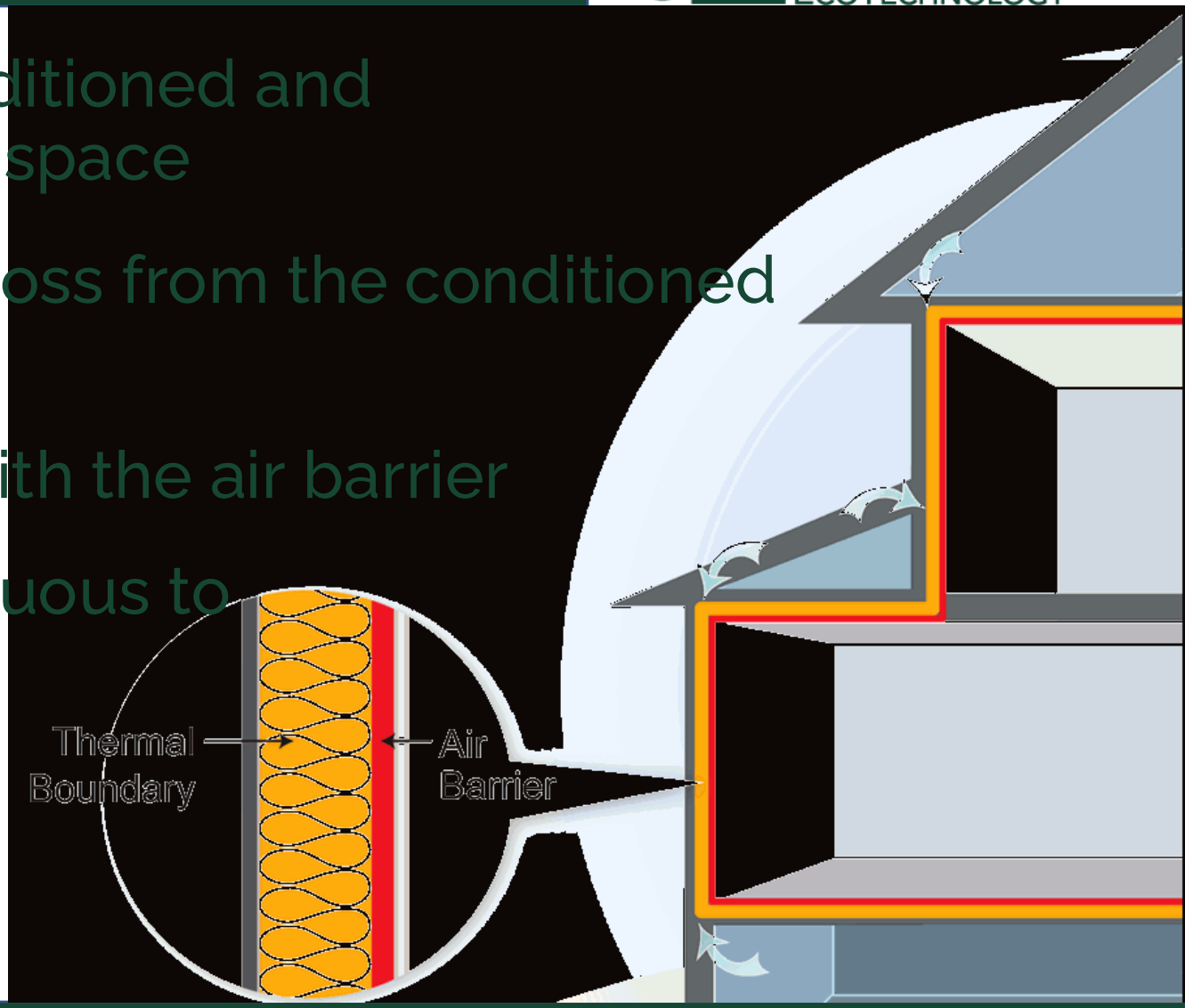
- Separates conditioned and unconditioned space
- Reduces heat loss from the conditioned area
- Should align with the air barrier
- Must be continuous to work properly



Exercise 1: Thermal Boundary

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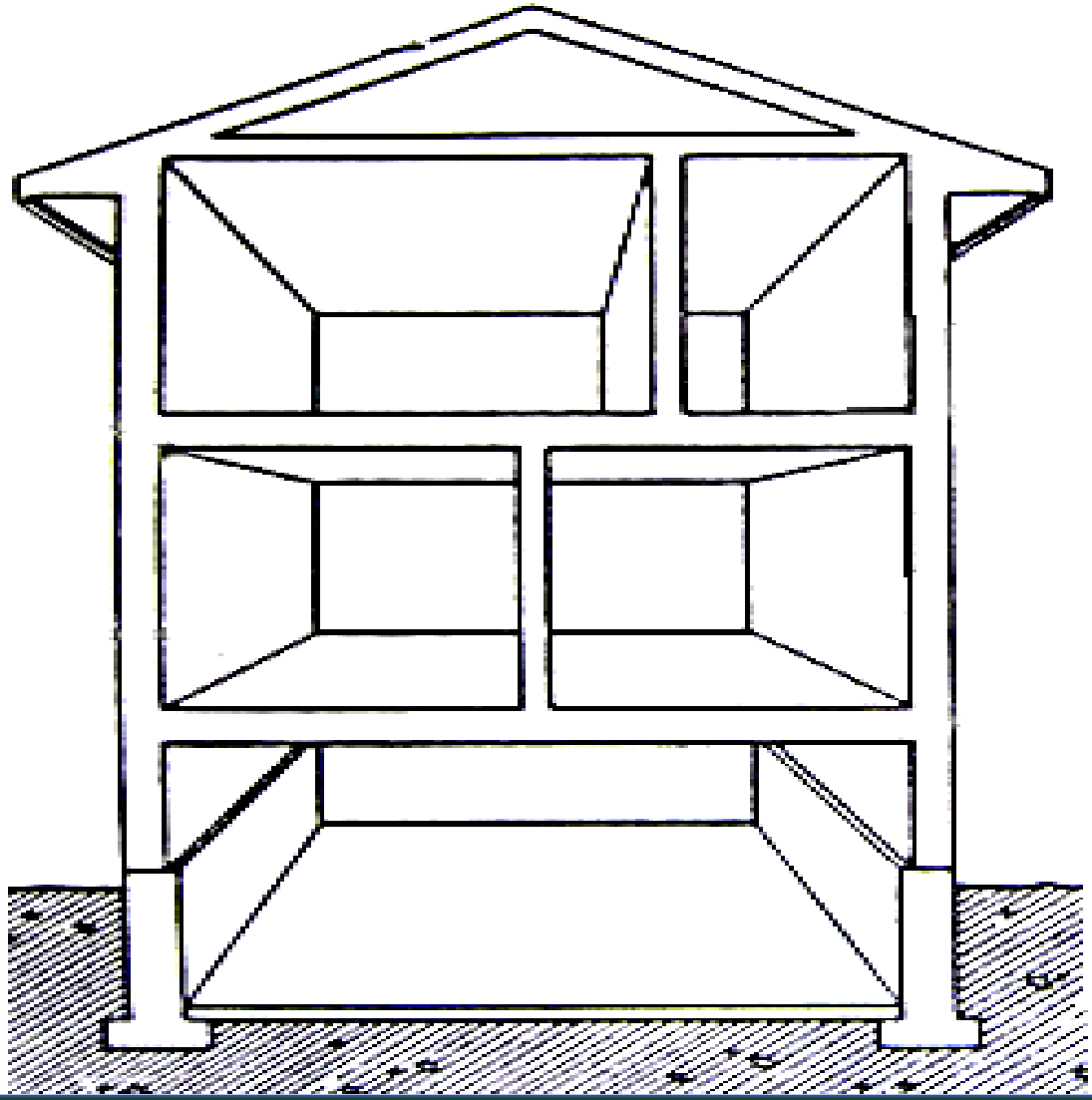
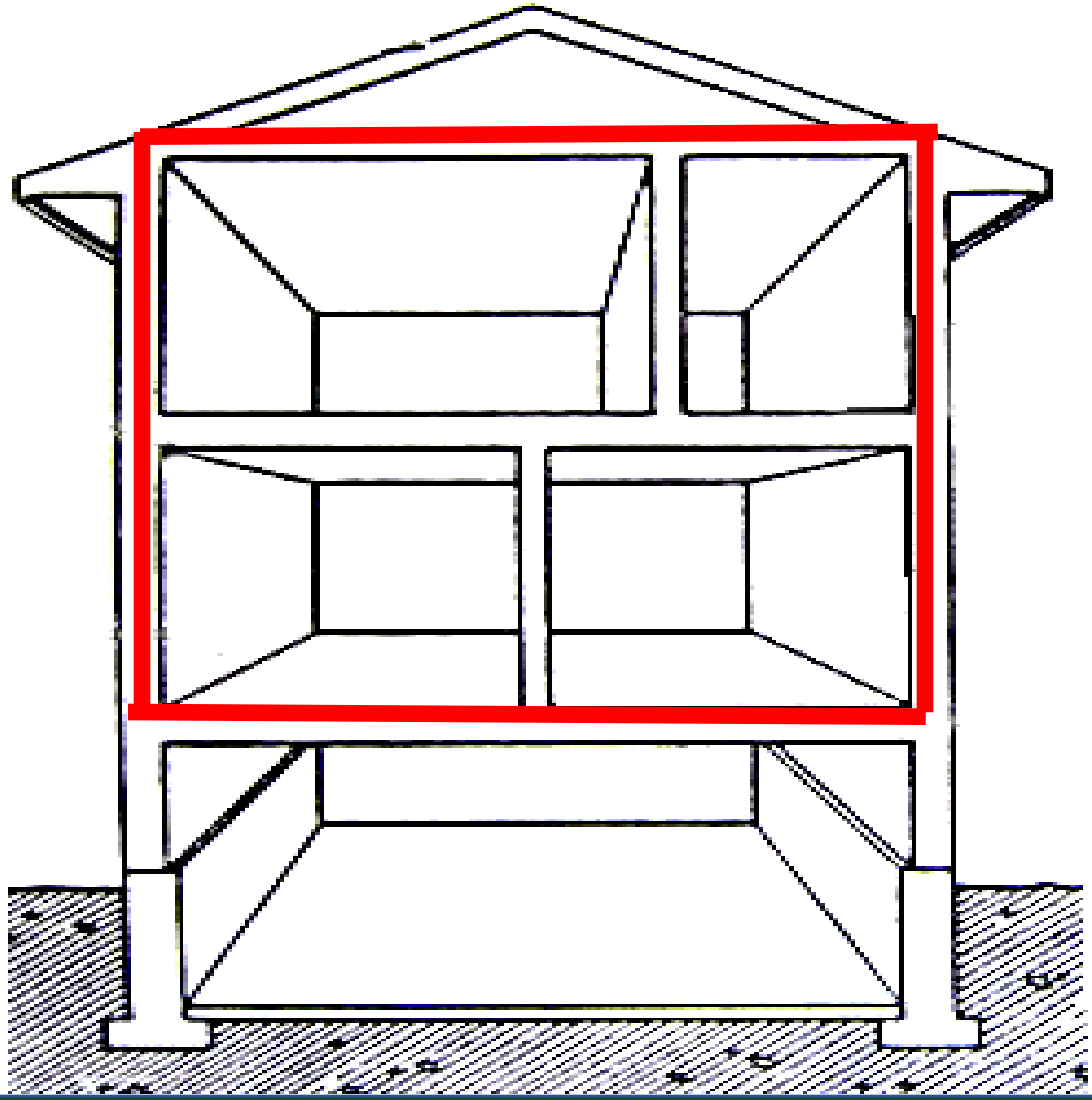


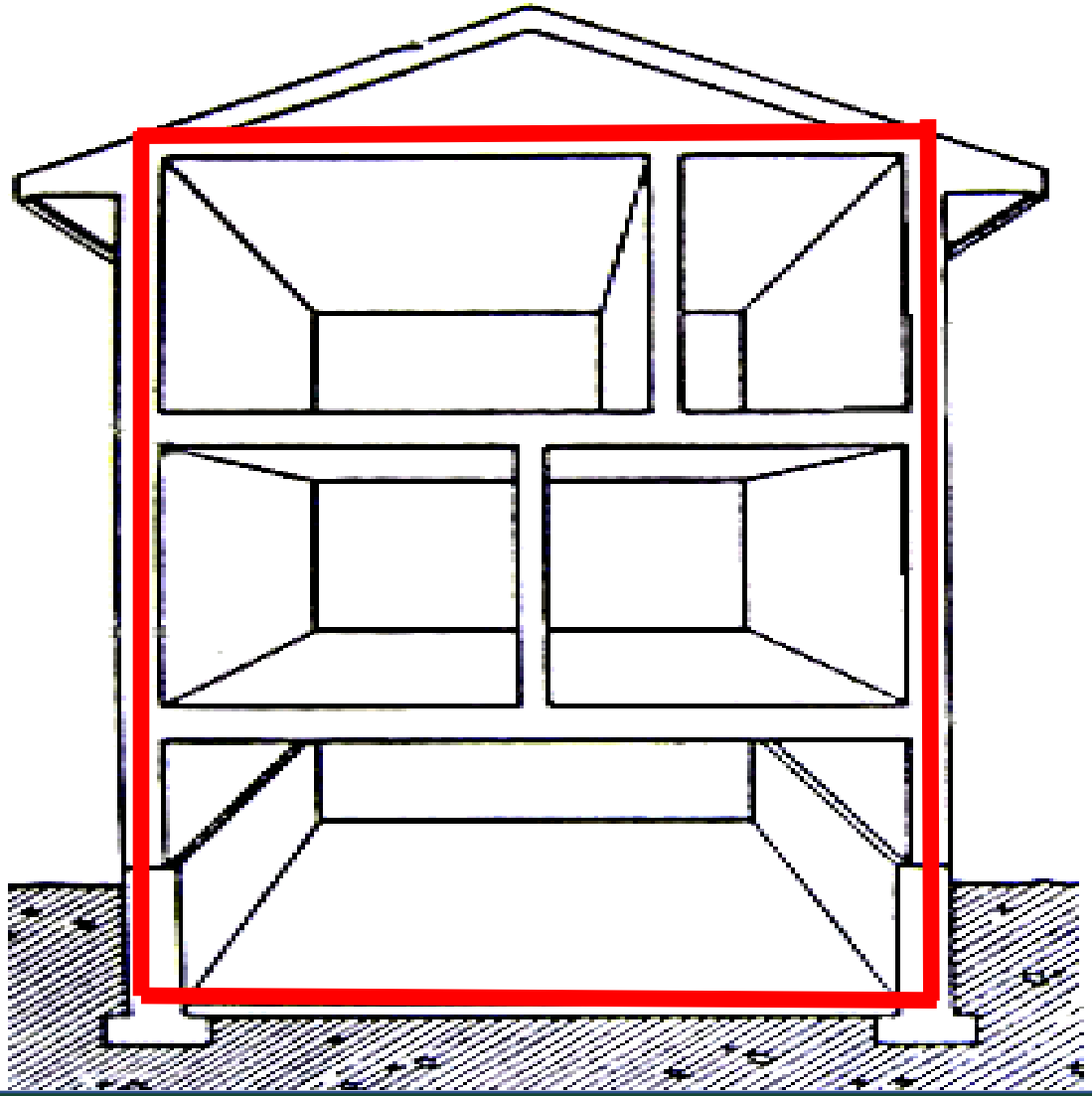
Exercise 1: Thermal Boundary

CET CENTER FOR ECOTECHNOLOGY



Exercise 1: Thermal Boundary

CET CENTER FOR ECOTECHNOLOGY



Exercise: Thermal Boundary

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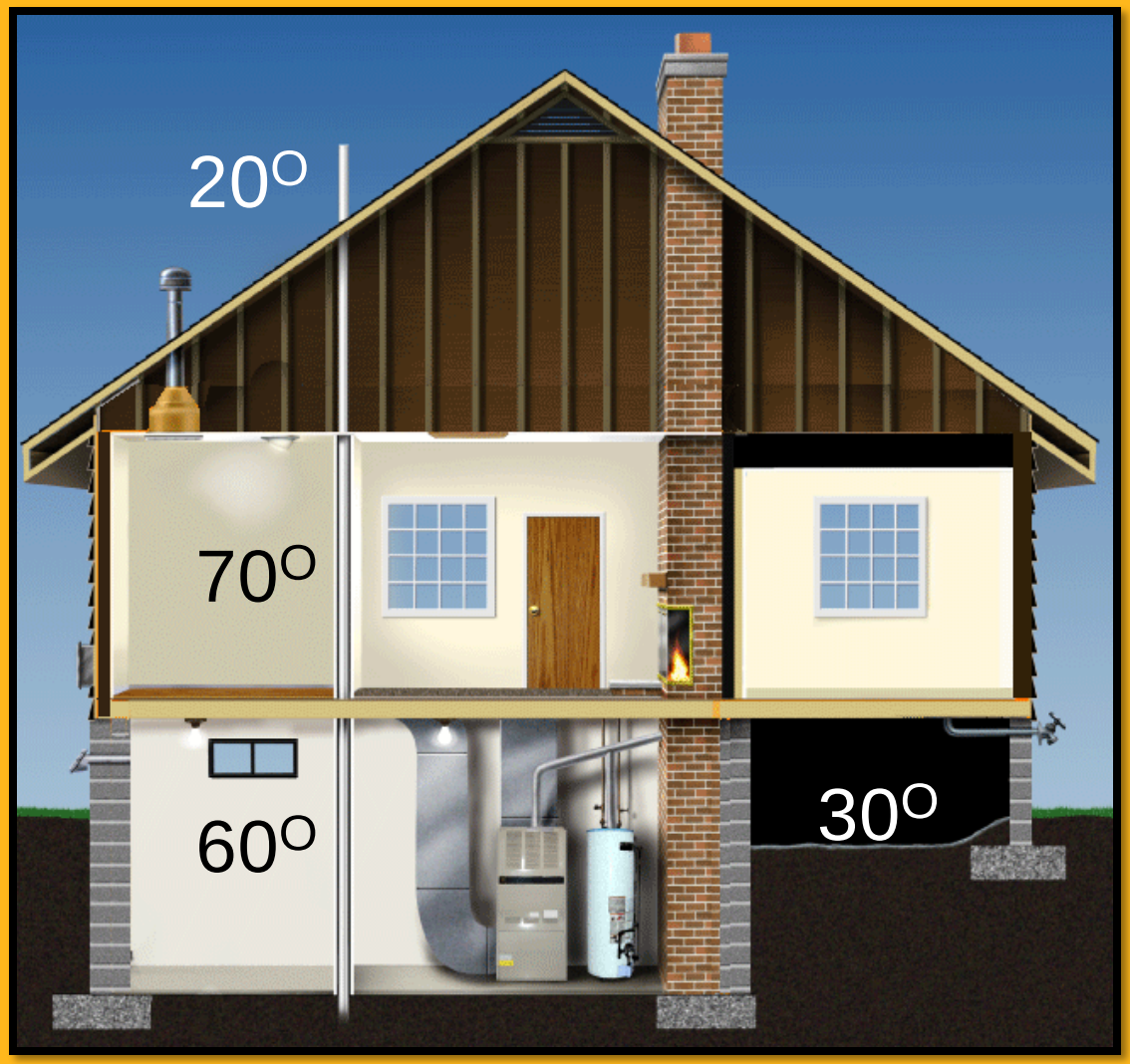

Answer: Thermal Boundary

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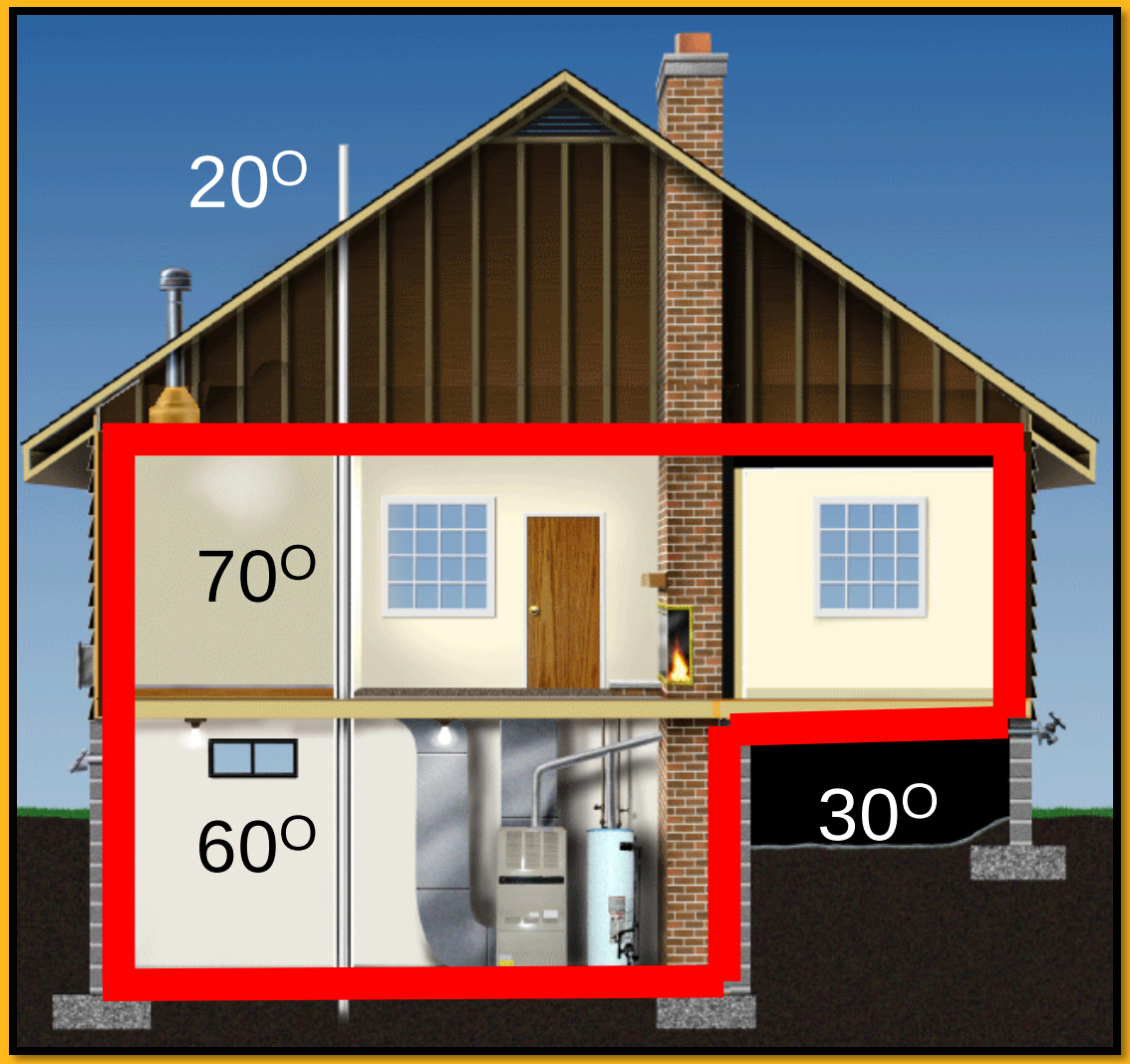

Gaps

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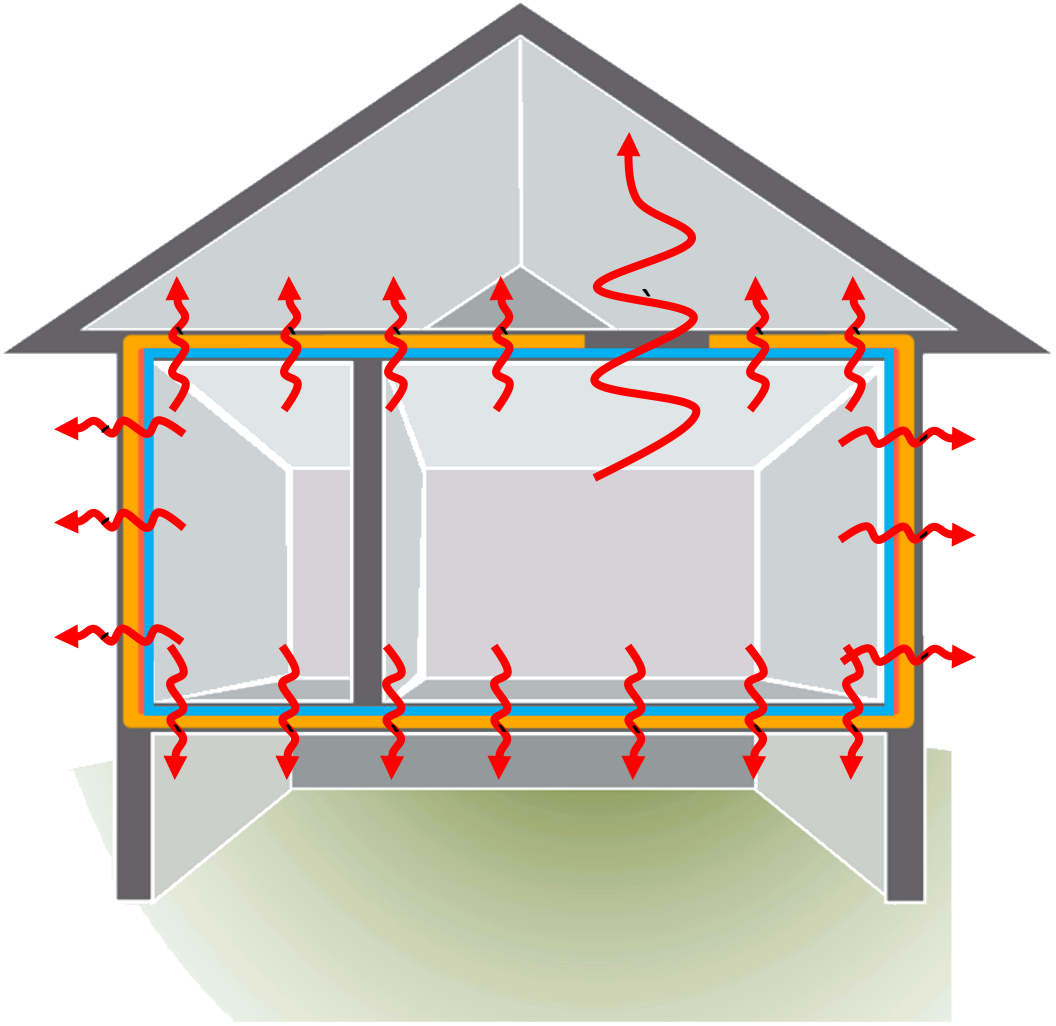
Air Barrier

Thermal Boundary



Uninsulated Attic Hatch

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Incorrect Thermal Boundary

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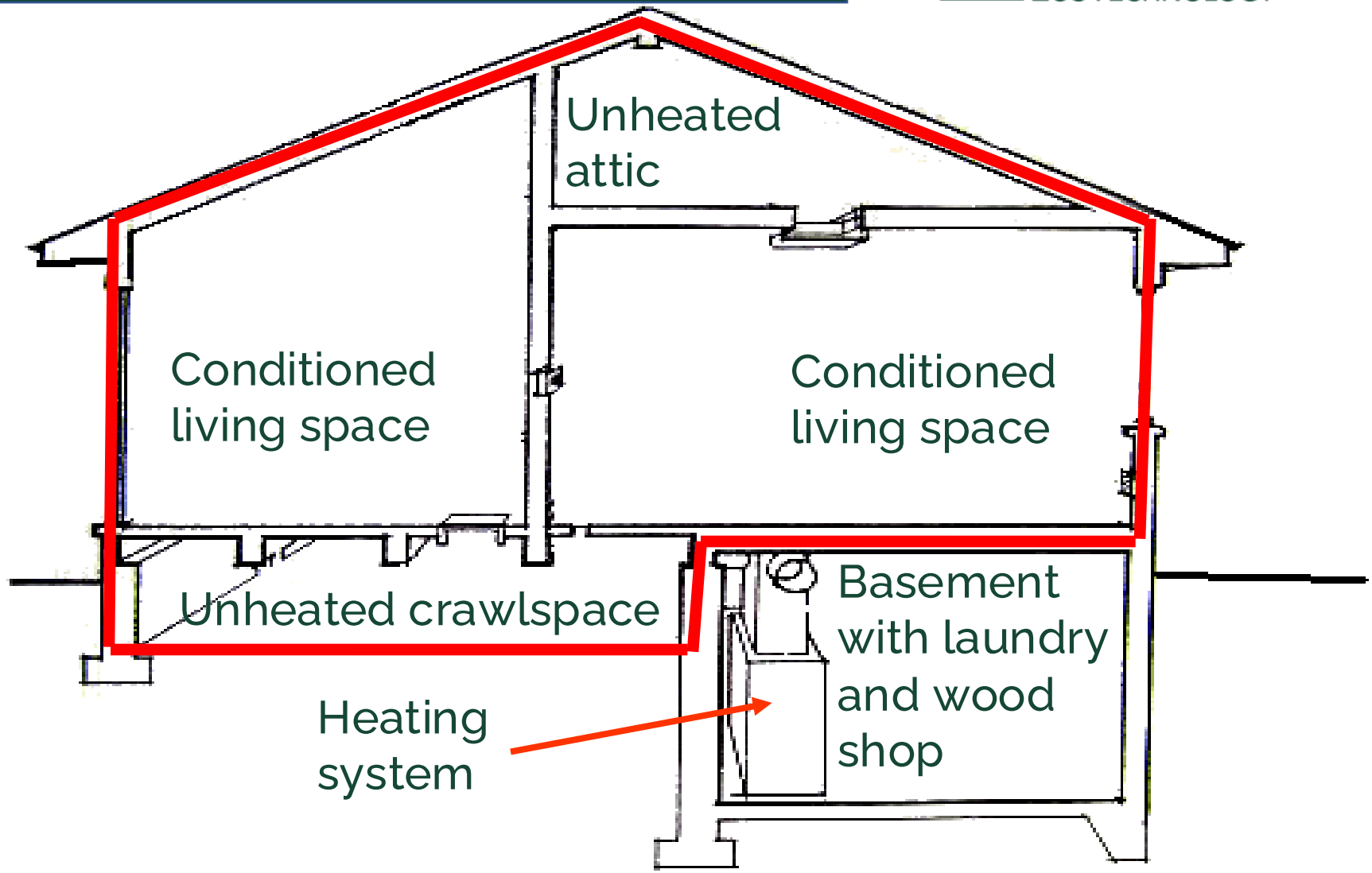
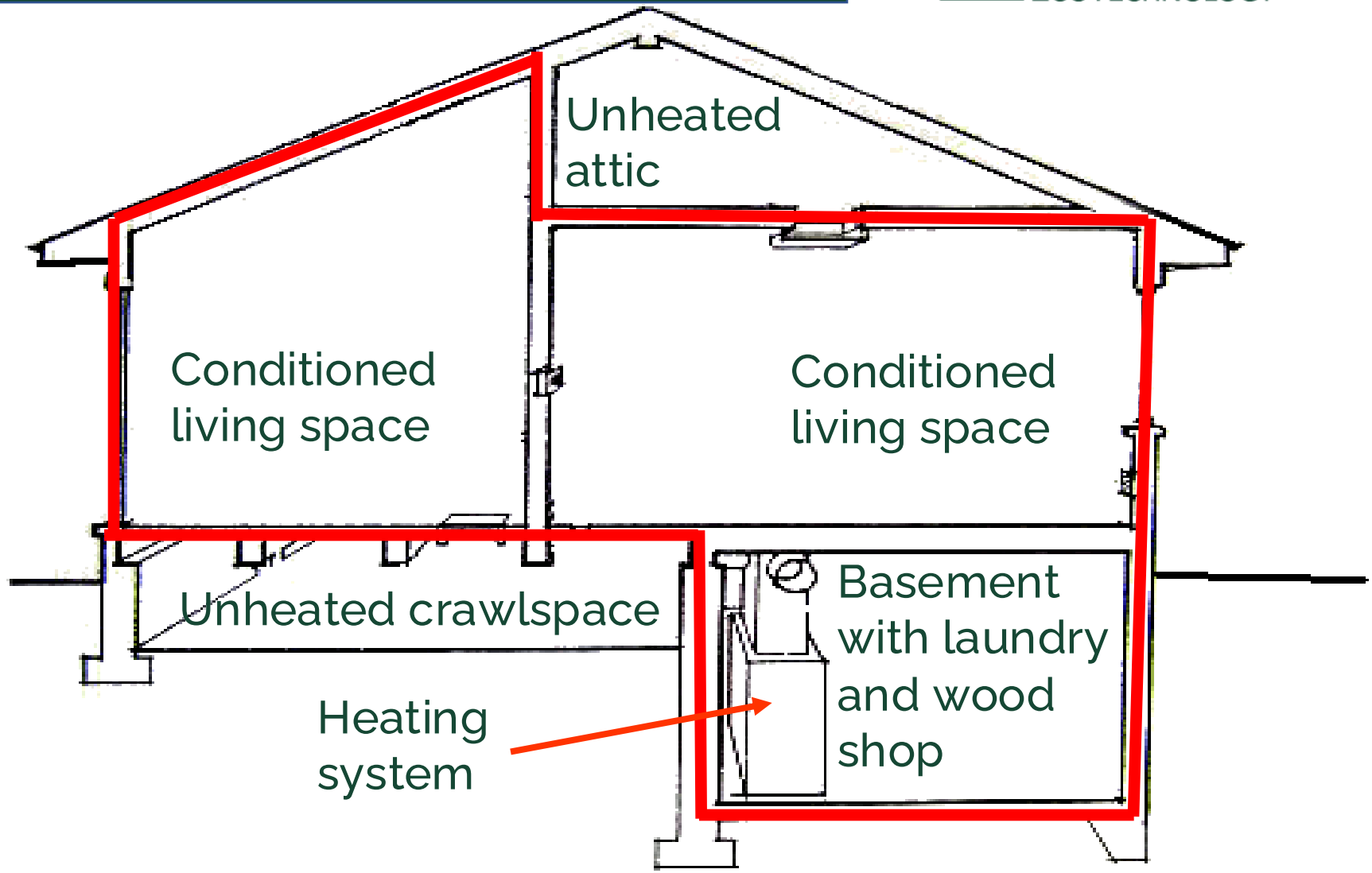


Correct Thermal Boundary

CET CENTER FOR ECOTECHNOLOGY



Exercise 2: Thermal Boundary

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Exercise 2: Thermal Boundary

CENTER FOR ECOTECHNOLOGY

1950's Addition

Exercise 2: Thermal Boundary

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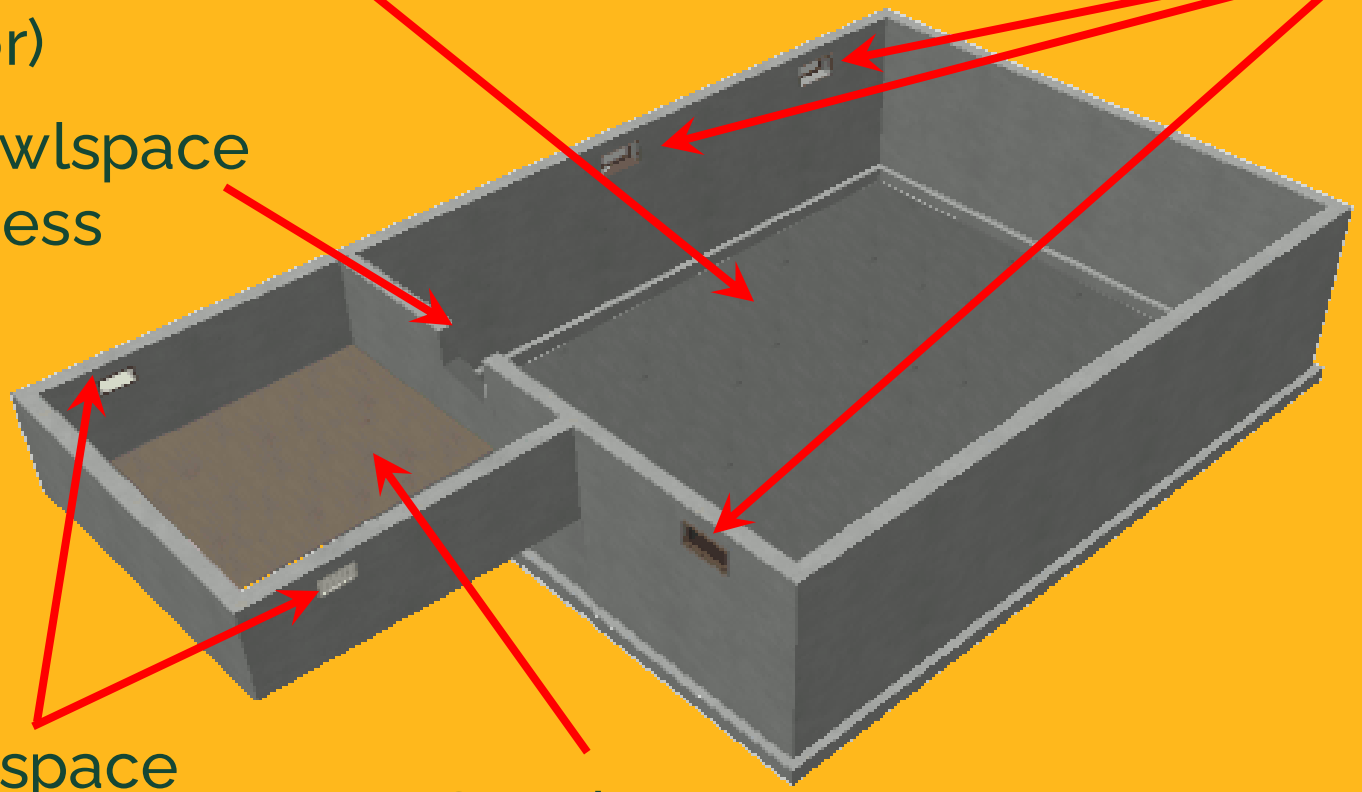

Exercise 2: Thermal Boundary

CET CENTER FOR ECOTECHNOLOGY

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Exercise 3: Thermal Boundary

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Exercise 3: Thermal Boundary

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Exercise 3: Thermal Boundary

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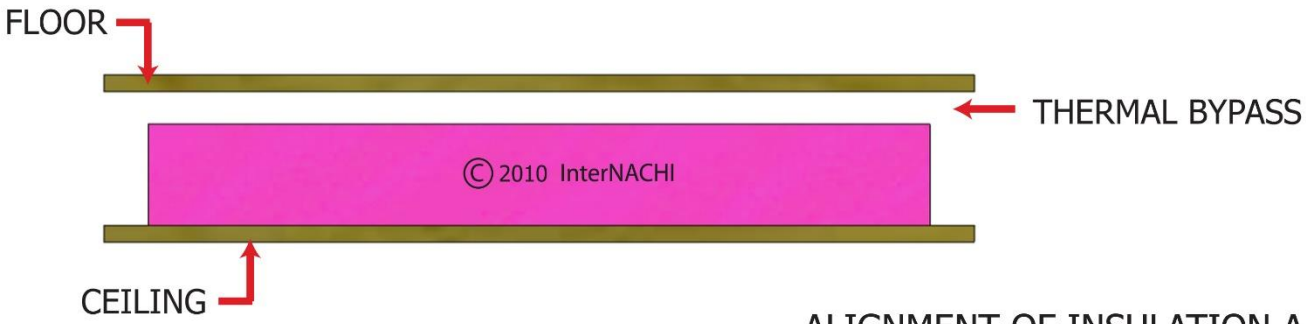
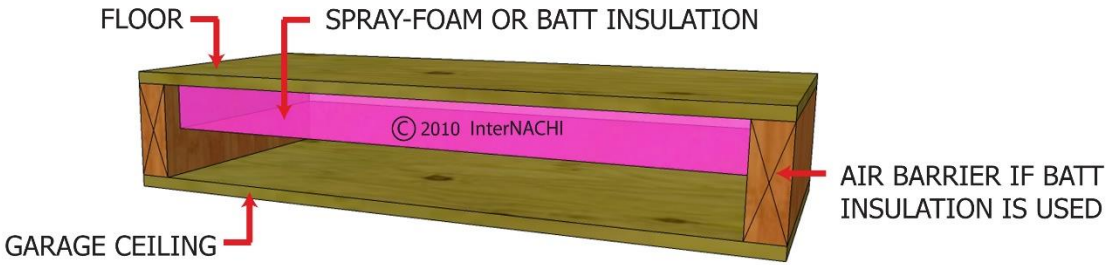
THERMAL BYPASS



ALIGNMENT OF INSULATION AND AIR BARRIER



Garage Insulation Defect

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Garage Insulation Defect

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Garage

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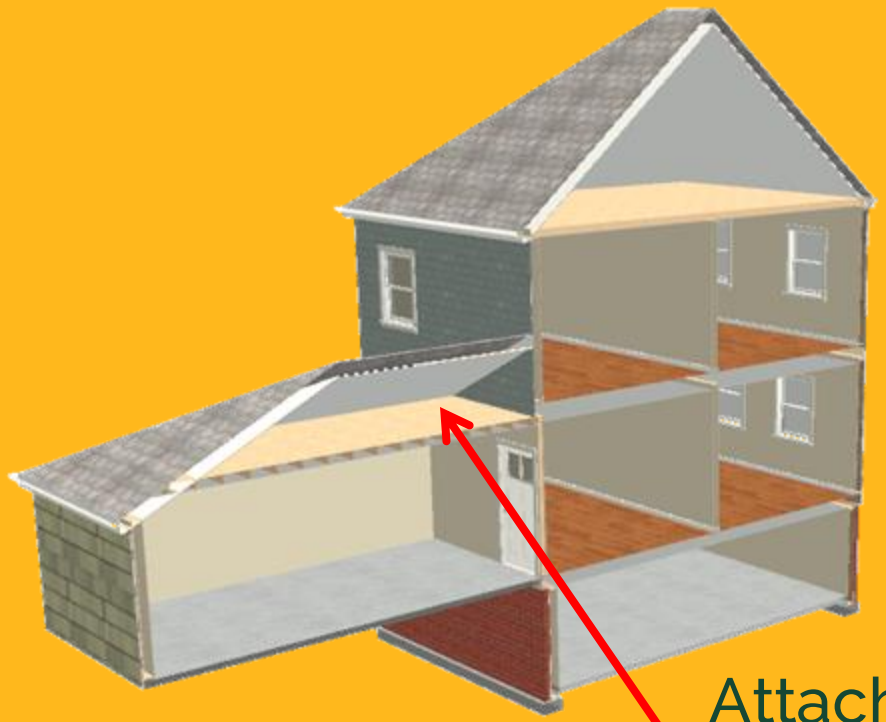

Thermal Boundary Front

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Thermal Boundary Front Answer

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Thermal Boundary Left

CET CENTER FOR ECOTECHNOLOGY

Thermal Boundary Left Answer

CET CENTER FOR ECOTECHNOLOGY

Thermal Boundary Rear

CET CENTER FOR ECOTECHNOLOGY

Thermal Boundary Rear Answer

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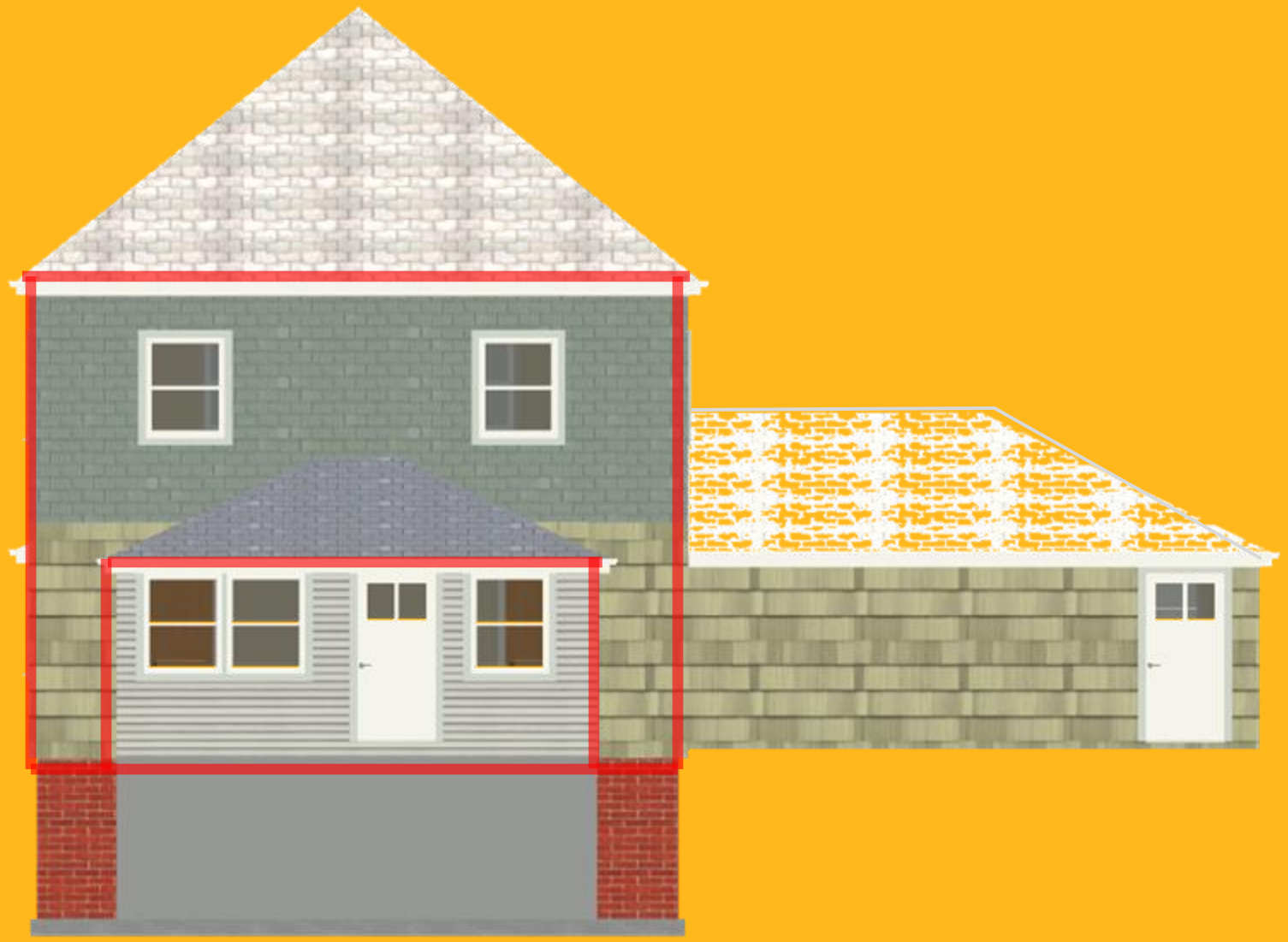

Cape Cod-Style Home

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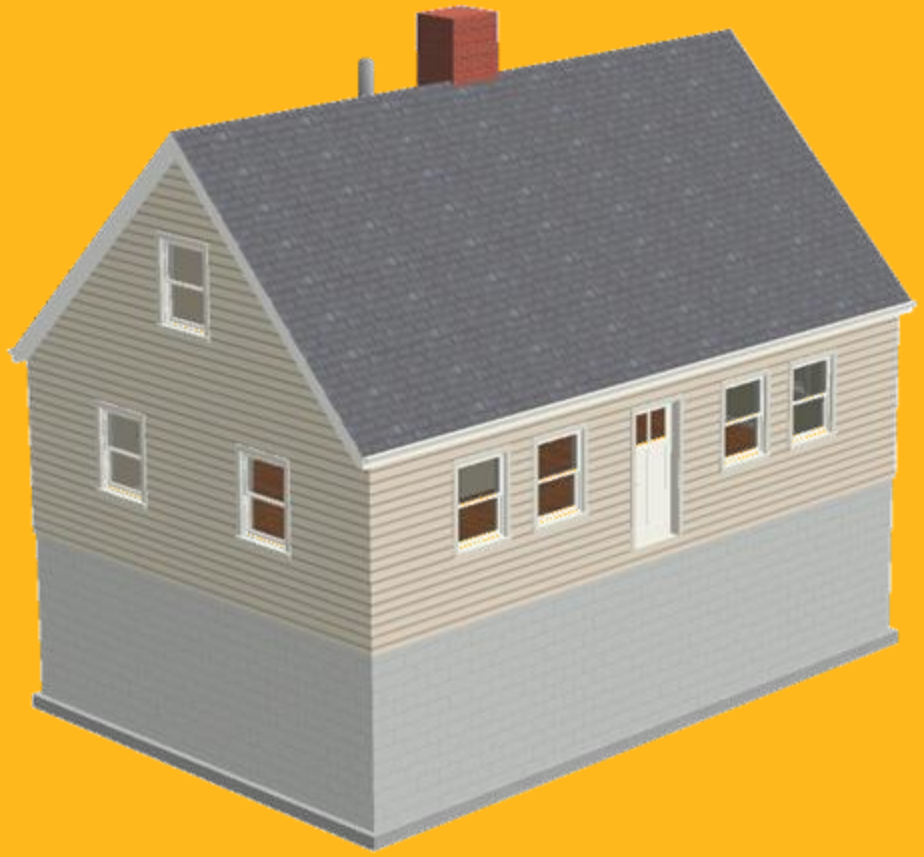

Cross Section

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Exercise: Thermal Boundary

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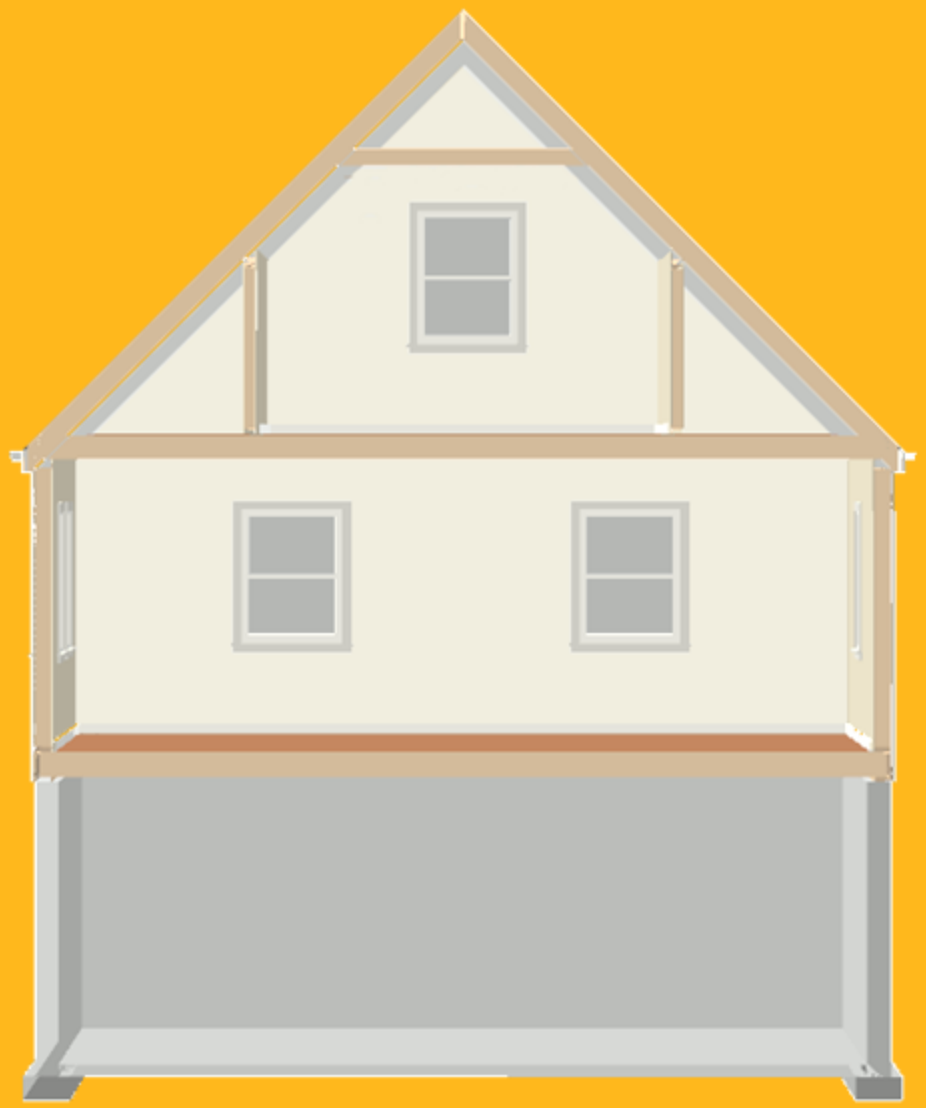

Thermal Boundary Option 1

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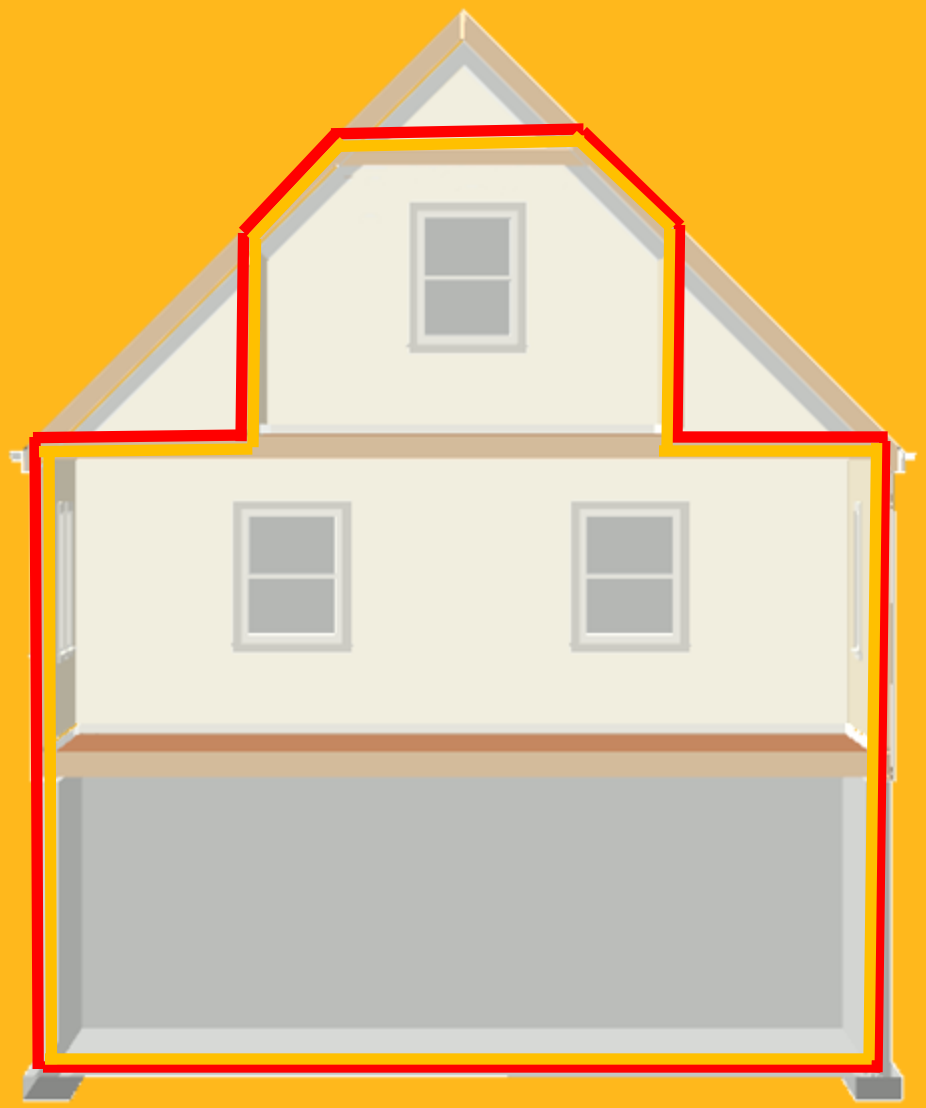
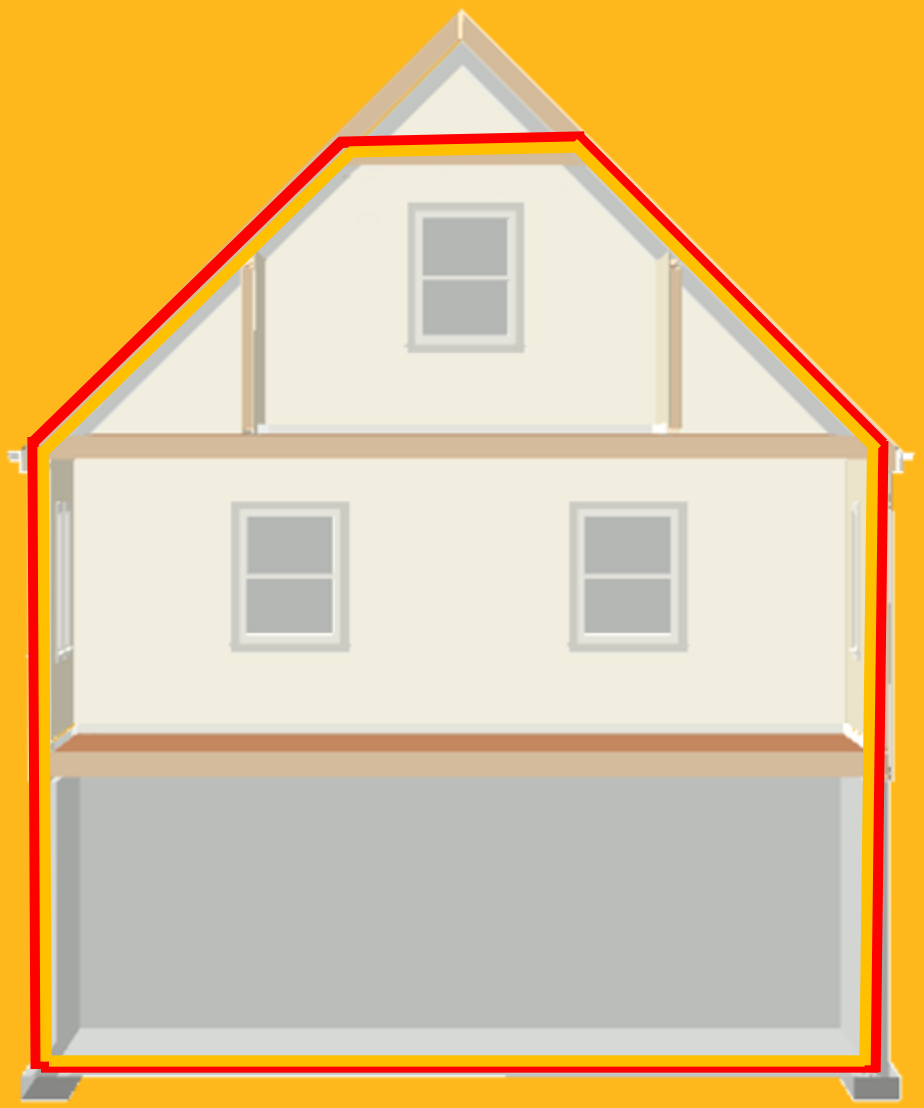


Thermal Boundary Option 2

CET CENTER FOR ECOTECHNOLOGY



Eligible Rebates

Program Requirements

- Eligible rebates can only be applied to insulation installed at the attic floor and kneewall
- Closed slopes are measured as wall area

Kneewall Attics

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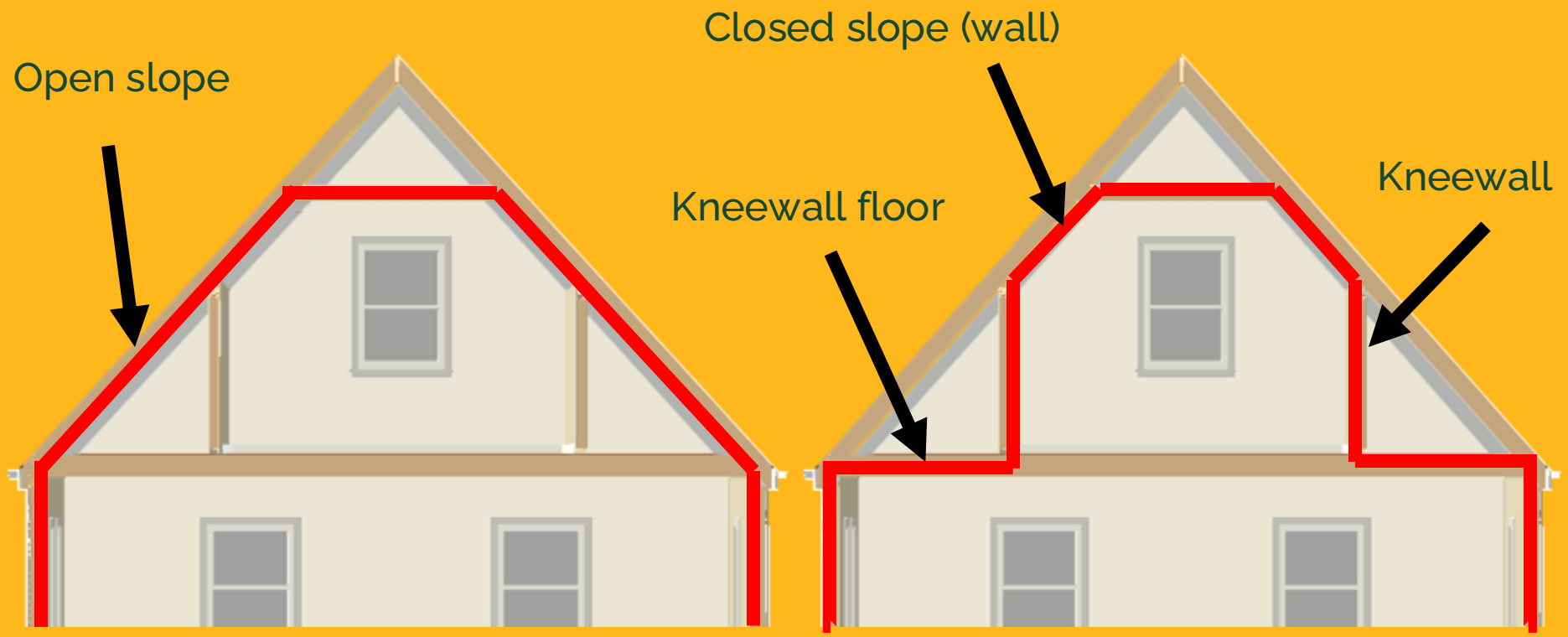
Compare these approaches



Kneewall Attics

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Compare these approaches

Not rebate eligible

Rebate eligible

Thermal Boundary Configurations

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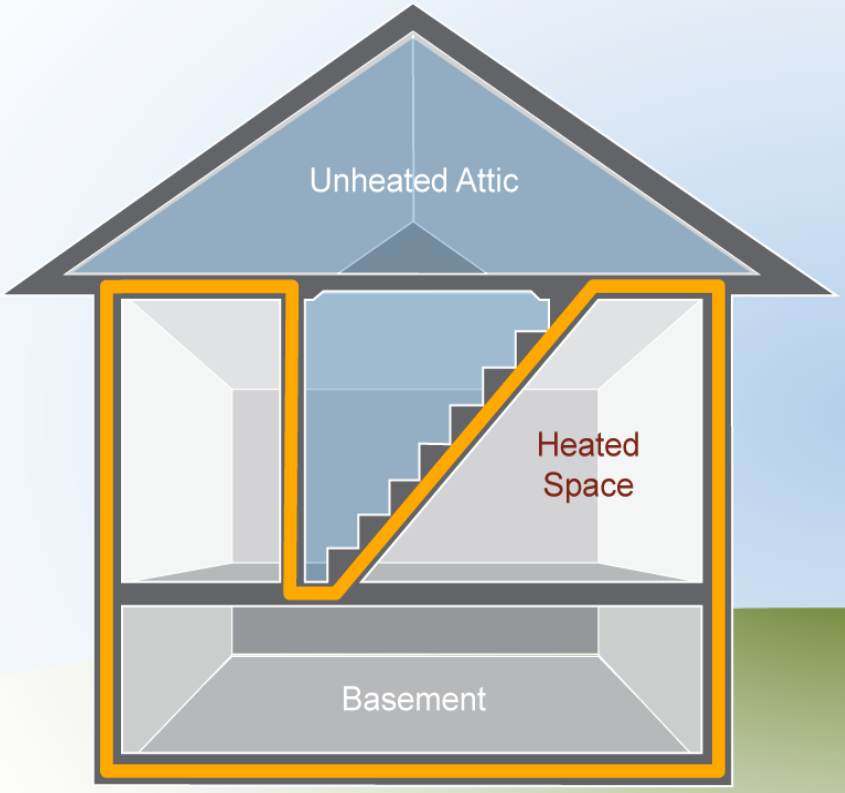
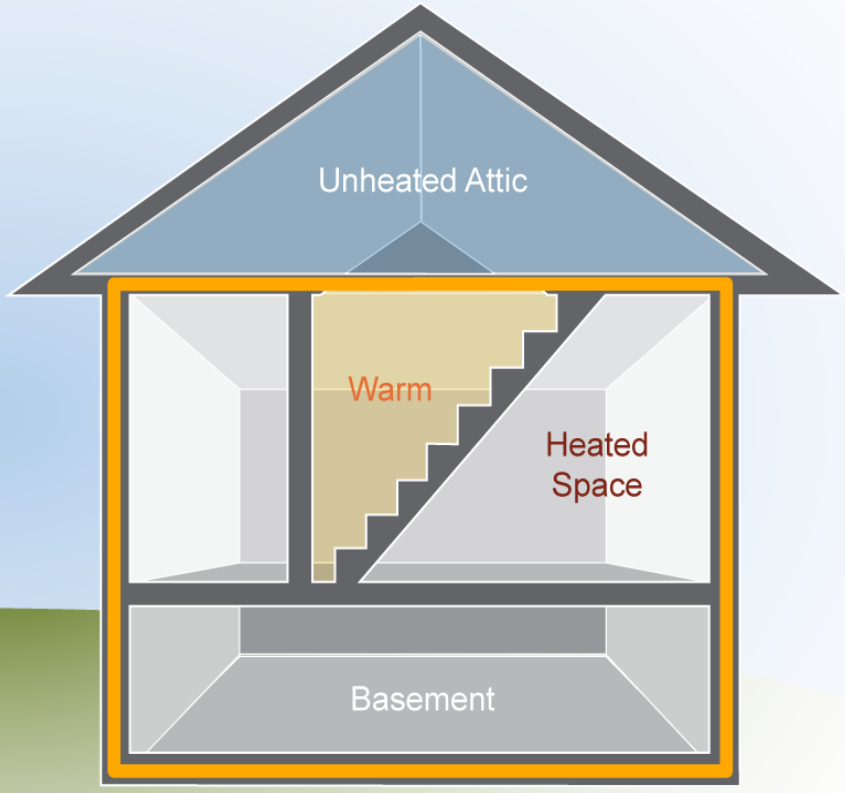
Stairs are *outside* the thermal boundary



Stairs are *inside* the thermal boundary



Excluding the Walk-Up

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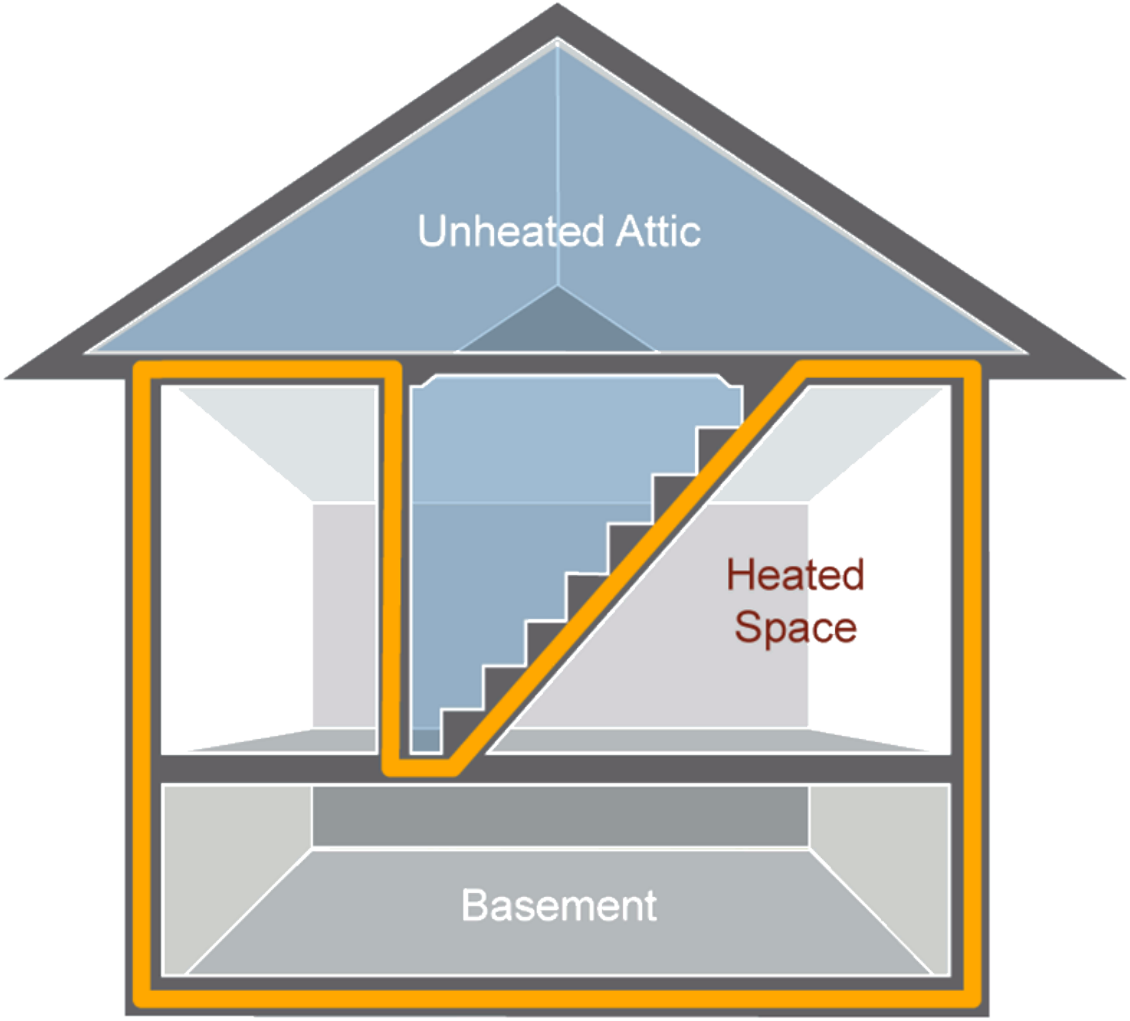
- Allows easier access to the attic
- Better when the client uses the attic often



Including the Attic Walk-Up

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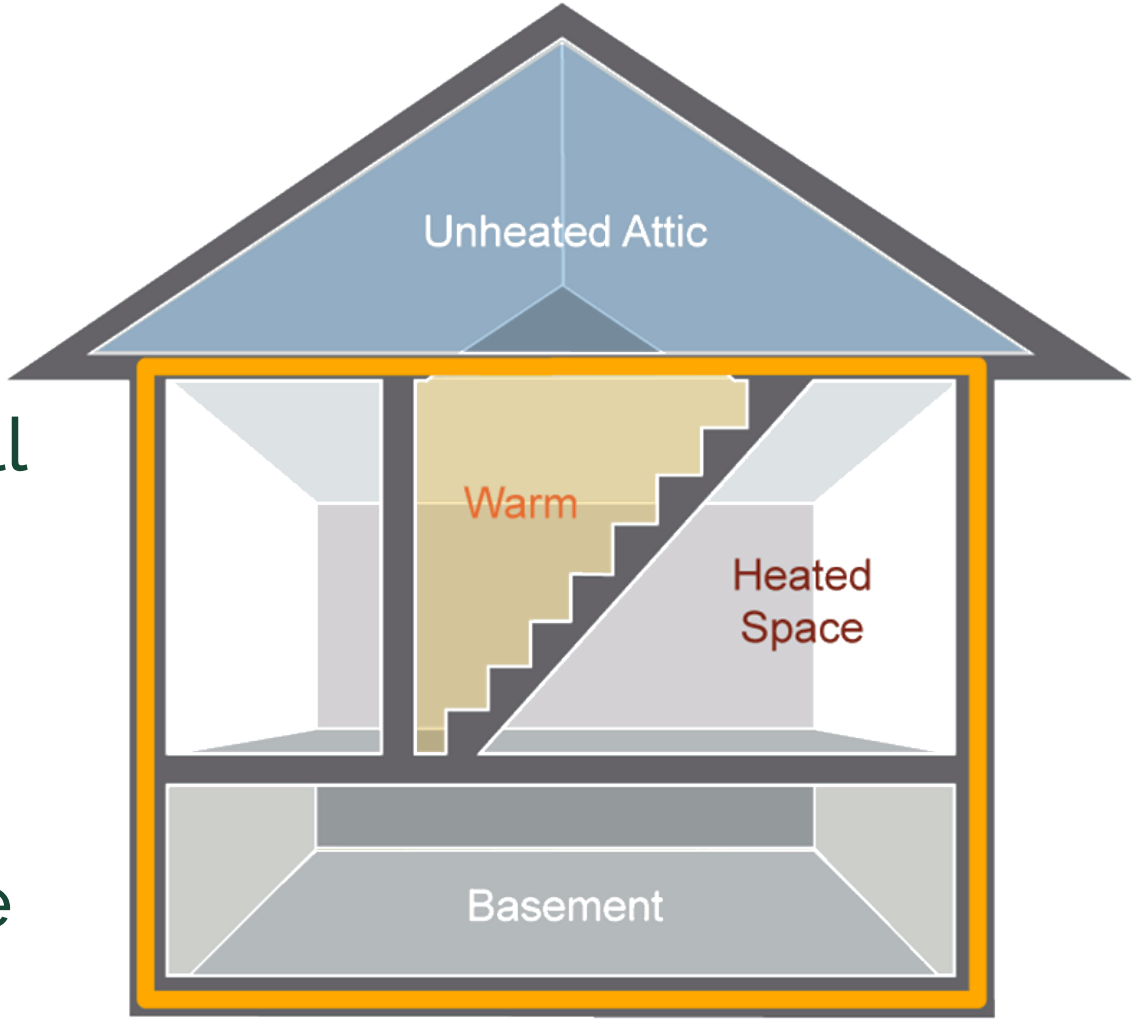
- Difficult to access the attic
- Quicker and cheaper to install
- More energy efficient
- Use when the client does not intend to use the attic space



Walk-up Stairs

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Summary: House as a System

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1. Every house is a system of interdependent parts.
2. Building failures are symptoms of larger issues.
3. Weatherization changes some components but affects the entire house as a system.

Summary: Heat

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1. Heat is the flow of thermal energy
2. Heat is measured in BTUs
3. Heat flows from hot to cold
4. Bigger temperature difference or Delta T (ΔT) = bigger heat flow (heat loss or gain)

Summary: Stack Effect

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What is the stack effect?

- Stack effect moves air:
  - Indoor air escapes
  - Outdoor air enters
  - Resulting air leakage costs money
- Stack effect depends on temperature and height
- Stack effect is reduced by air sealing at air barrier
- Greatest savings come from sealing the house's top and bottom

Summary: Moisture

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Moisture

- can damage buildings
- comes in three forms: bulk, vapor, and condensate
- is carried by air through buildings
- is measured as relative humidity in the air
- can encourage mold growth
- is affected by air sealing

Summary: Moisture

- Weatherizing buildings can affect the moisture conditions both positively and negatively
- Keep an eye out for potential moisture problems created by weatherization measures
- Existing moisture sources should be addressed prior to weatherizing the house

Summary

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- Thermal Boundary:
  - Separates conditioned and unconditioned space.
  - Should align with air barrier
  - Excluding water pipes increases risk of freezing
  - Boundary is not always in the right place
  - A continuous boundary is crucial