

Crash Course in Building Science:

Why Homes Work And Fail

OUTLINE

- **Why Building Science is Important**
- **Building Science Key Components**
- **Controlling Air Flow**
- **Controlling Thermal Flow**
- **Controlling Moisture Flow**
- **Applying the Principals**

AIR~HEAT~WATER



WHY IS BUILDING SCIENCE IMPORTANT?

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We all want a home that is...

- **Affordable**
- **Comfortable**
- **Healthy**
- **Durable**

WHY IS BUILDING SCIENCE IMPORTANT?

**For your home to do its job,
it must separate**

The inside...

...from the outside.



WHY IS BUILDING SCIENCE IMPORTANT?

If those problem areas aren't addressed, you're probably letting in:

- **Wind**
- **Rain**
- **Ground water**
- **Uncomfortable temperatures**
- **Humidity**
- **Bugs and pests**

WHY IS BUILDING SCIENCE IMPORTANT?

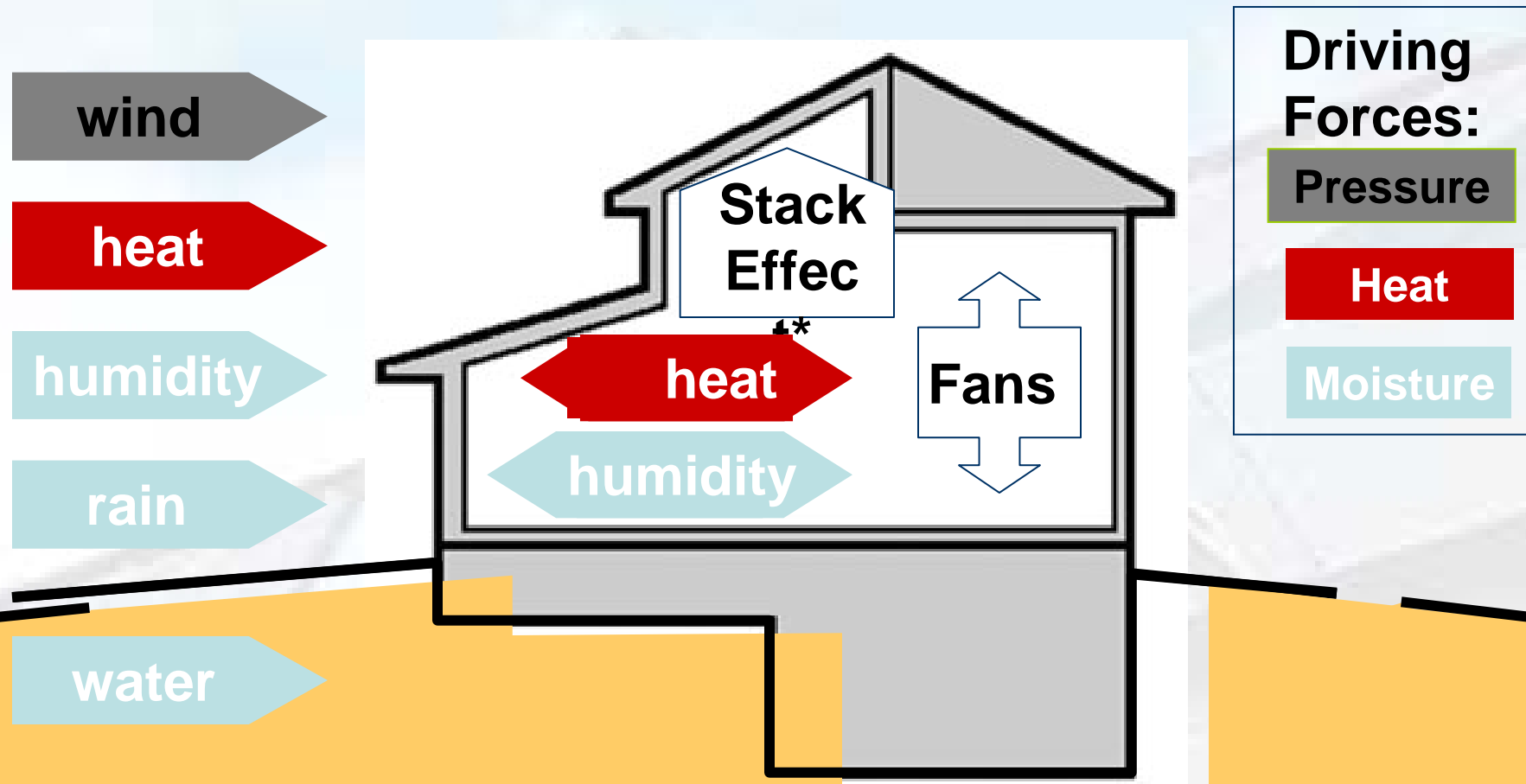


To understand how to most effectively keep these things out of our homes, let's take a look at some key components to high performance homes...



BUILDING SCIENCE KEY COMPONENTS

FORCES ON YOUR HOME



*Stack effect is a convective loop throughout the entire house cause by differences in pressure.

FORCES ON YOUR HOME

Driving Forces always move
in the same direction:

More

- Pressure
- Moisture
- Heat

to

Less

- Pressure
- Moisture
- Heat

DRIVING FORCES

Conditions needed for air leakage:

1. Holes
2. Driving Forces (pressure) Across the Holes



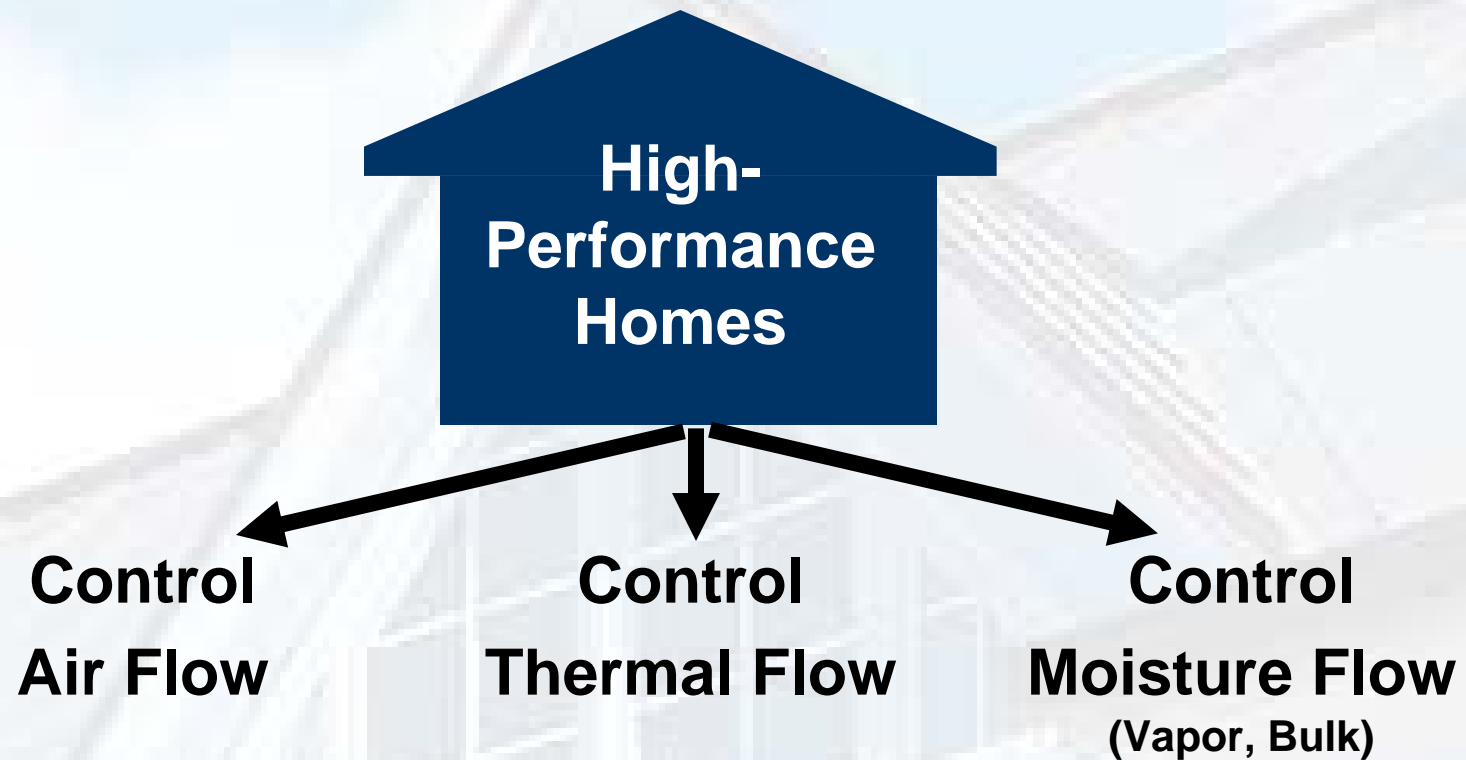
Air will take path of least resistance through largest hole.

FORCES ON YOUR HOME



Keeping this simple rule in mind, there are three major driving forces that need to be controlled...

BUILDING SCIENCE KEY COMPONENTS



HIGH PERFORMANCE HOMES

Why:

Affordable
Comfortable
Healthy
Durable

How:

Control
Air Flow

Driving
Forces

Stack
Effect

Fans

Control
Thermal Flow

Conduction

Convection

Radiation

Control
Moisture Flow

Bulk

Vapor

What:

In the sections the follow, we'll discuss these components and how they can explain common problems we see in homes.

**INVISIBLE
AIR**



CONTROLLING AIR FLOW

CONTROLLING AIR FLOW

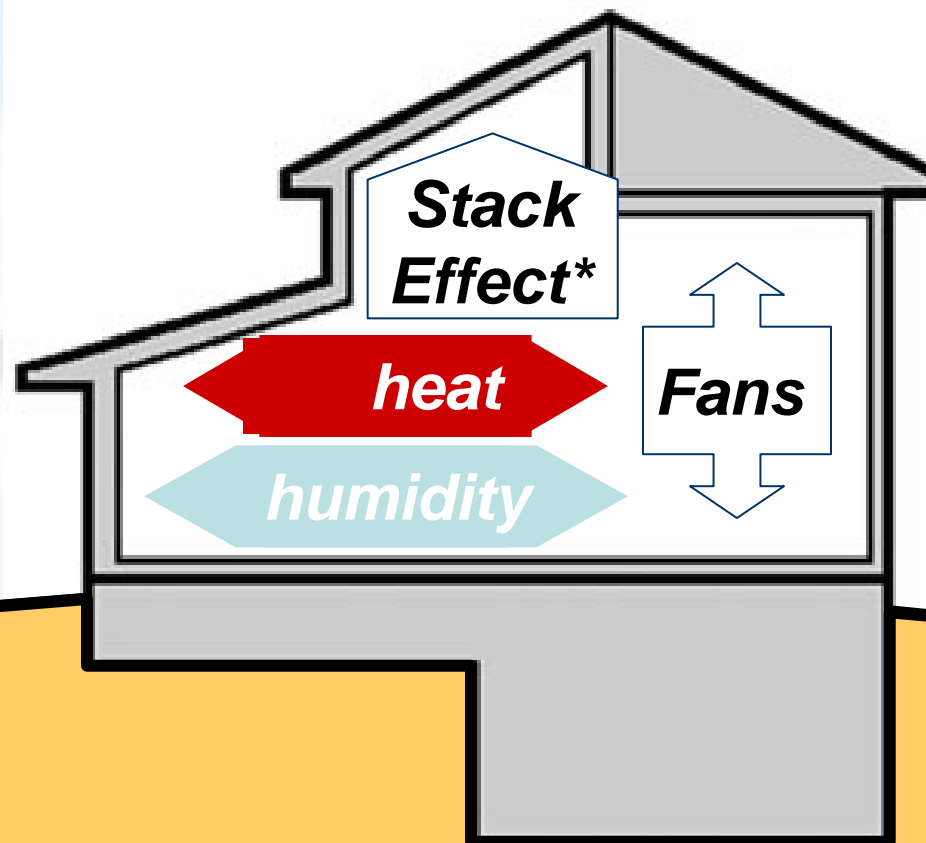
wind

heat

humidity

rain

water



Driving Forces:

Pressure

Heat

Moisture

*Stack effect is a convective loop throughout the entire house caused by differences in pressure.

HERE ARE THE LARGER HOLES

Access Panels

Ceiling fixtures

Sill Plates

Vents

Door Openings

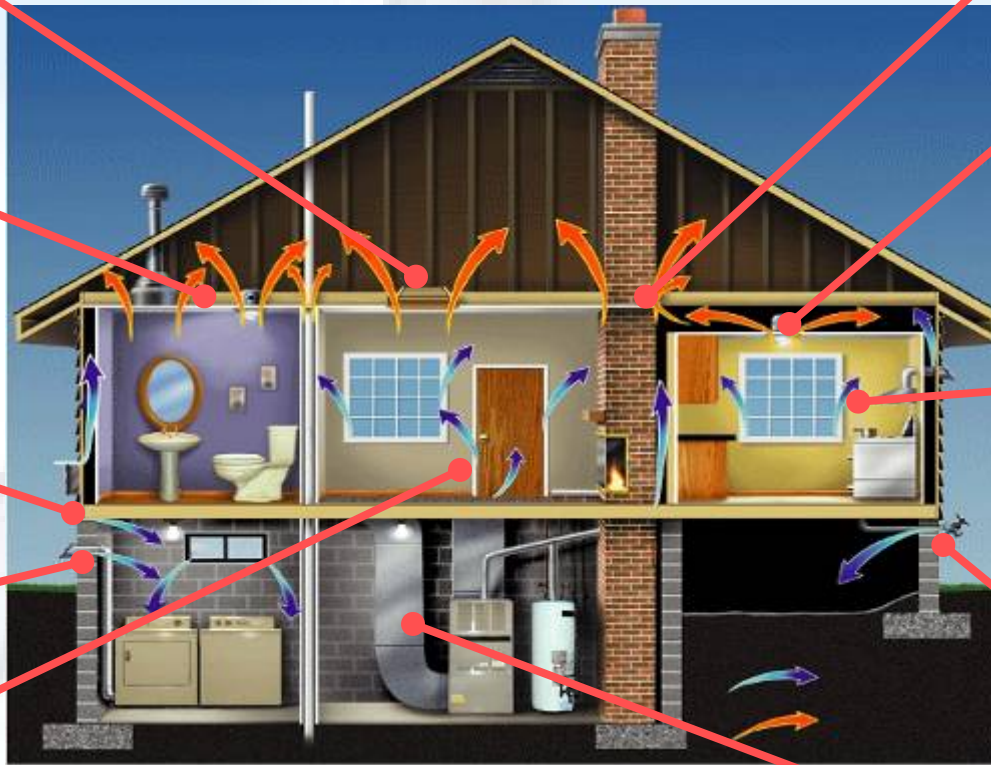
Chases

Dropped Ceilings

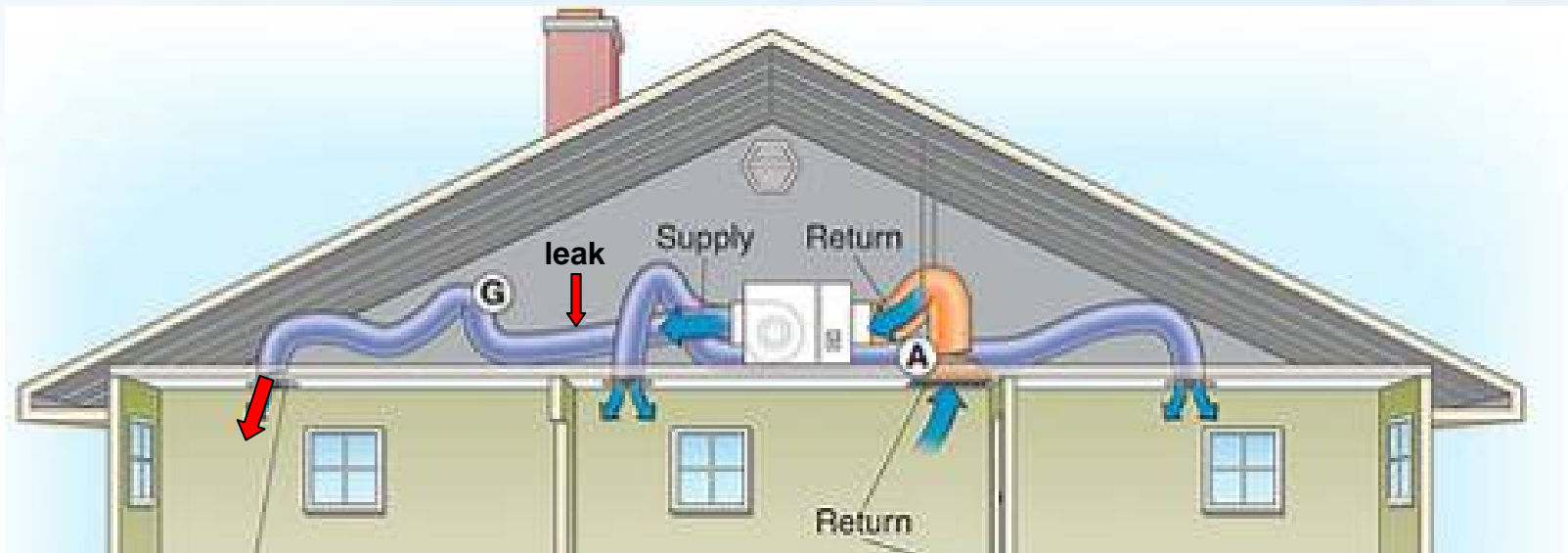
Window Openings

Plumbing Penetrations

Ducts



LEAKY RETURN DUCTS

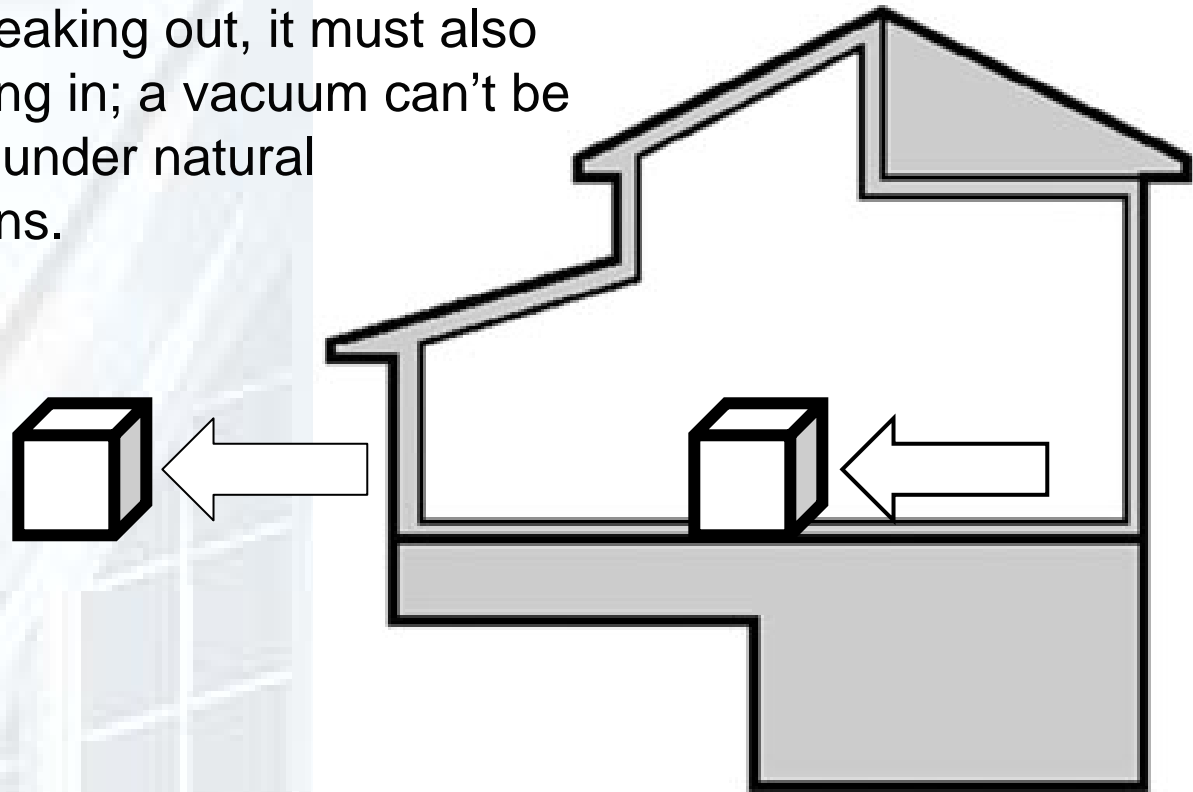


Hot attic air enters your home in the summer!

CONTROLLING AIR FLOW

One Out = One In

If air is leaking out, it must also be leaking in; a vacuum can't be created under natural conditions.



Courtesy of Southface Institute

CONTROLLING AIR FLOW: ONE OUT = ONE IN = LOTS AIR FLOW

Homes have many fans inside of them. Let's look at one that is often ignored: the exhaust fan for clothes dryers.



- *200 cfm (on average)*
- *60 minute cycle*
- *12,000 cubic feet out*
 - *(from laundry room into dryer → exhaust outdoors)*
- *12,000 cubic feet in*
 - *(from the holes with least resistance)*

WHERE DOES AIR COME IN FROM?

Average size (2,000sq.ft.) home = ~18,000 cubic feet

As a result, just running the clothes dryer for a 60 minute cycle will replace approximately 2/3 of all the air in the home.



Homes often have their laundry rooms situated next to or near the garage. Dangerous fumes like carbon monoxide could be pulled into your home with unwanted air flow.

WHERE DOES AIR COME IN FROM?

- Carbon Monoxide poisoning is a leading cause of unintentional poisoning deaths in the U.S.
- Unintentional CO exposure accounts for an estimated 15,000 emergency department visits and 500 unintentional deaths in the U.S. each year.
- **Health effects of CO exposure include:**
 - disorientation
 - unconsciousness
 - long-term neurological disabilities
 - coma
 - cardio respiratory failure
 - death

CONTROLLING AIR FLOW: FANS/PRESSURES IN HOMES



<i>Exhaust</i>	<i>CFM</i>
Clothes Dryers:	150 – 250
Bath Exhaust Fans:	50 – 100
Kitchen Exhaust Fan:	100 – 1,500+
Whole-House Fans:	~2,500 – 5,000+
Central Vacuums:	~100
Fireplaces (pull in air for combustion):	up to 400
Stack Affect (convection loop):	~15 - 30

All these add up to **10,000's cubic feet of air** passing through walls, floors and roof assemblies.

HEAT



**CONTROLLING
THERMAL FLOW**

CONTROLLING THERMAL FLOW

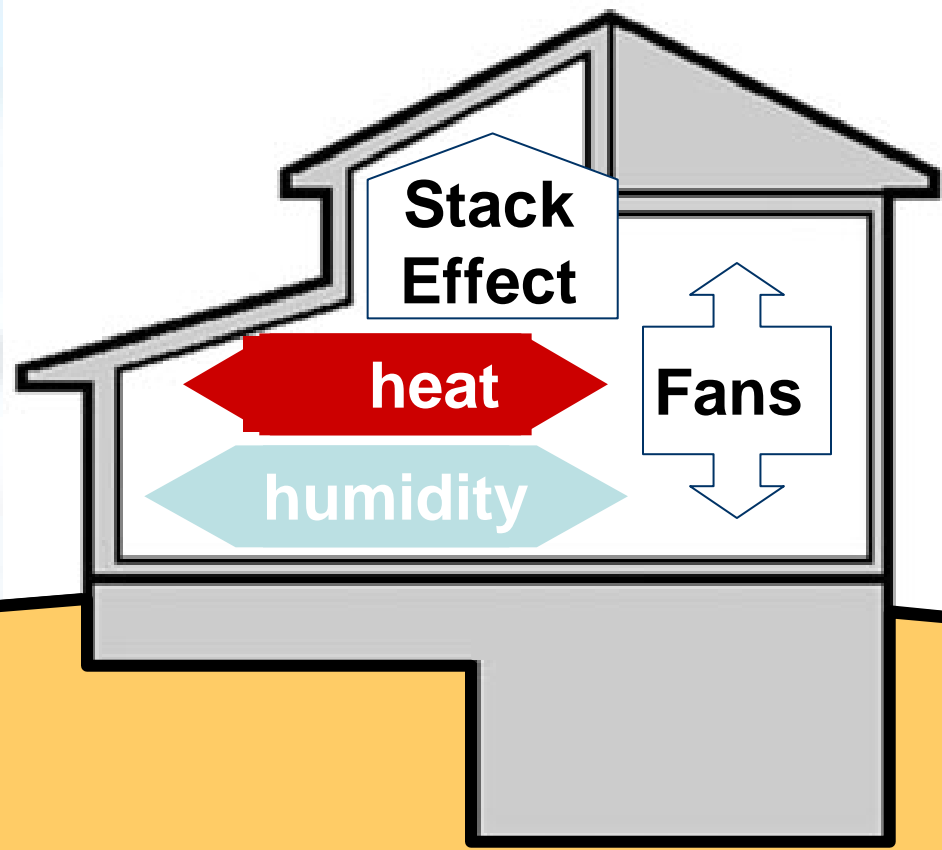
wind

heat

humidity

rain

water



Driving Forces:
Pressure
Heat
Moisture

CONTROLLING THERMAL FLOW



Heat can flow in and out of your home in several different ways:

**Conduction
Convection
And Radiation**

CONTROLLING THERMAL FLOW: CONDUCTION

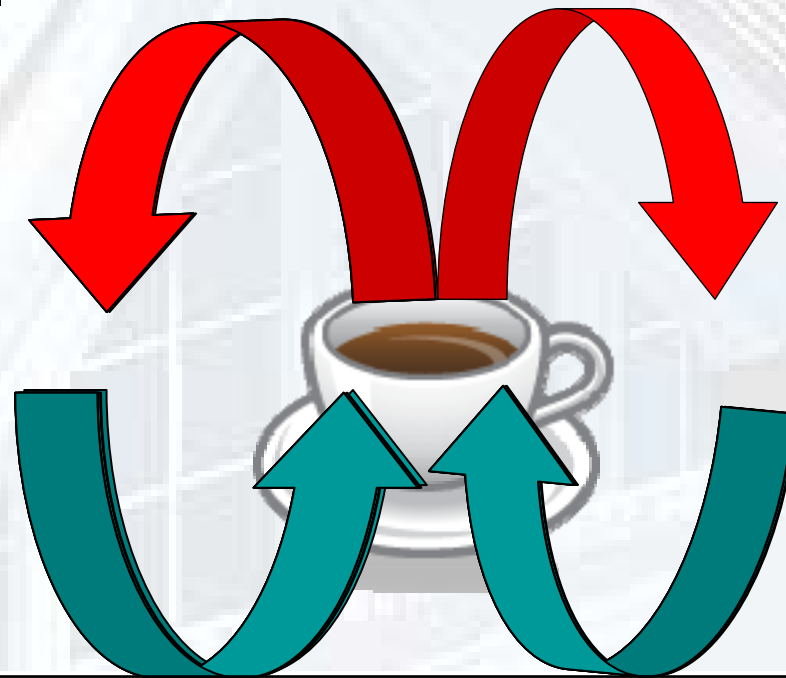
Conduction is where heat energy is transferred from molecule to molecule by direct contact.



By sitting on a cold rock, your body heat will transfer from you, to the rock through conduction.

CONTROLLING THERMAL FLOW: CONVECTION

Through convection, heat in a gas or liquid is transferred by the circulation of currents from one region to another.



CONTROLLING THERMAL FLOW: RADIATION

- Through radiation, electromagnetic rays are emitted from the surface of an object due to its higher temperature as compared to its surroundings.



CONTROLLING THERMAL FLOW

Mean Radiant Temperature (MRT) dominates comfort.
(40% > than ambient temp.)

**So in other
words...**

**If you lose control of
surface temperatures,
you lose control of
comfort!**



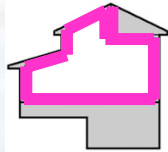
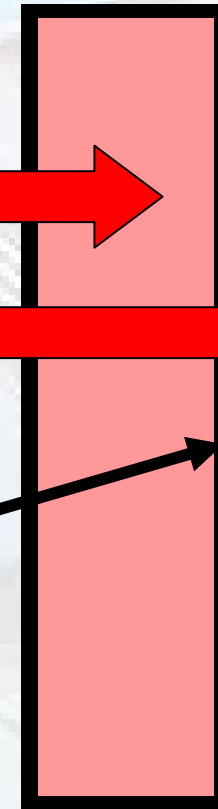
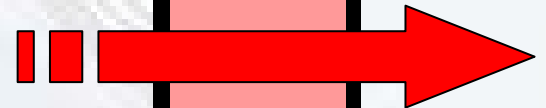
CONTROLLING THERMAL FLOW

**Most insulation
is NOT an air barrier***

Resists Conduction



Air Flow



**any solid material that blocks air flow
including sealing at edges and seams*

CONSIDER THE FORCES OF AIRFLOW ON YOUR HOME

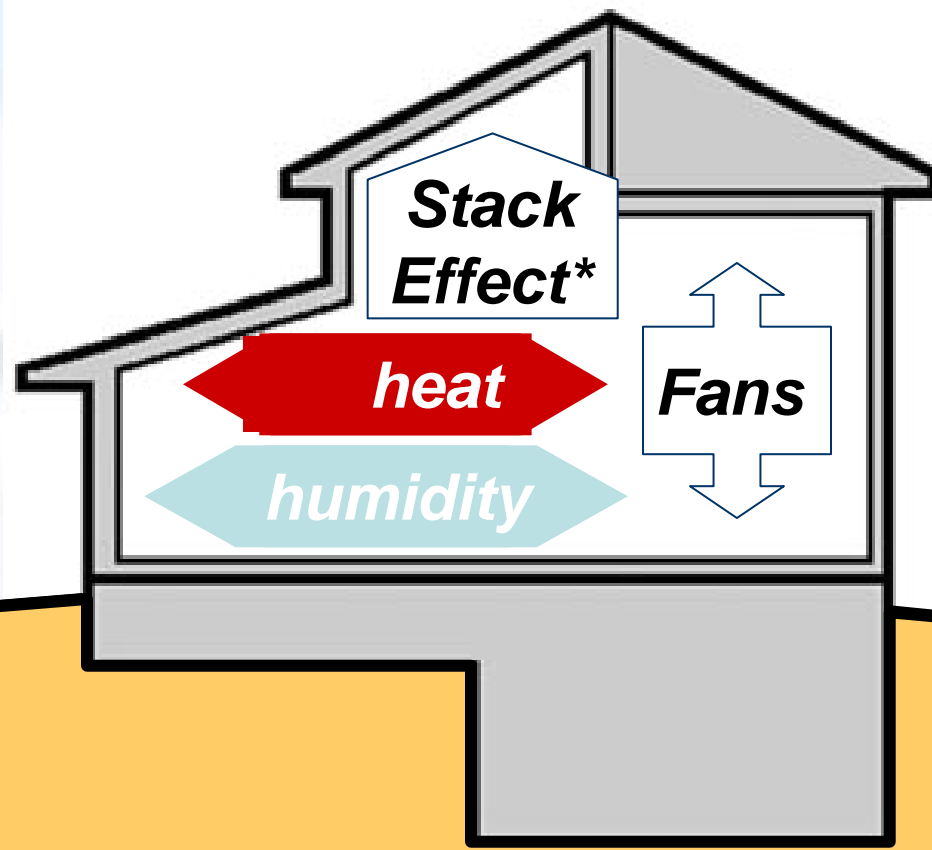
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- Driving Forces:**
- Pressure
 - Heat
 - Moisture

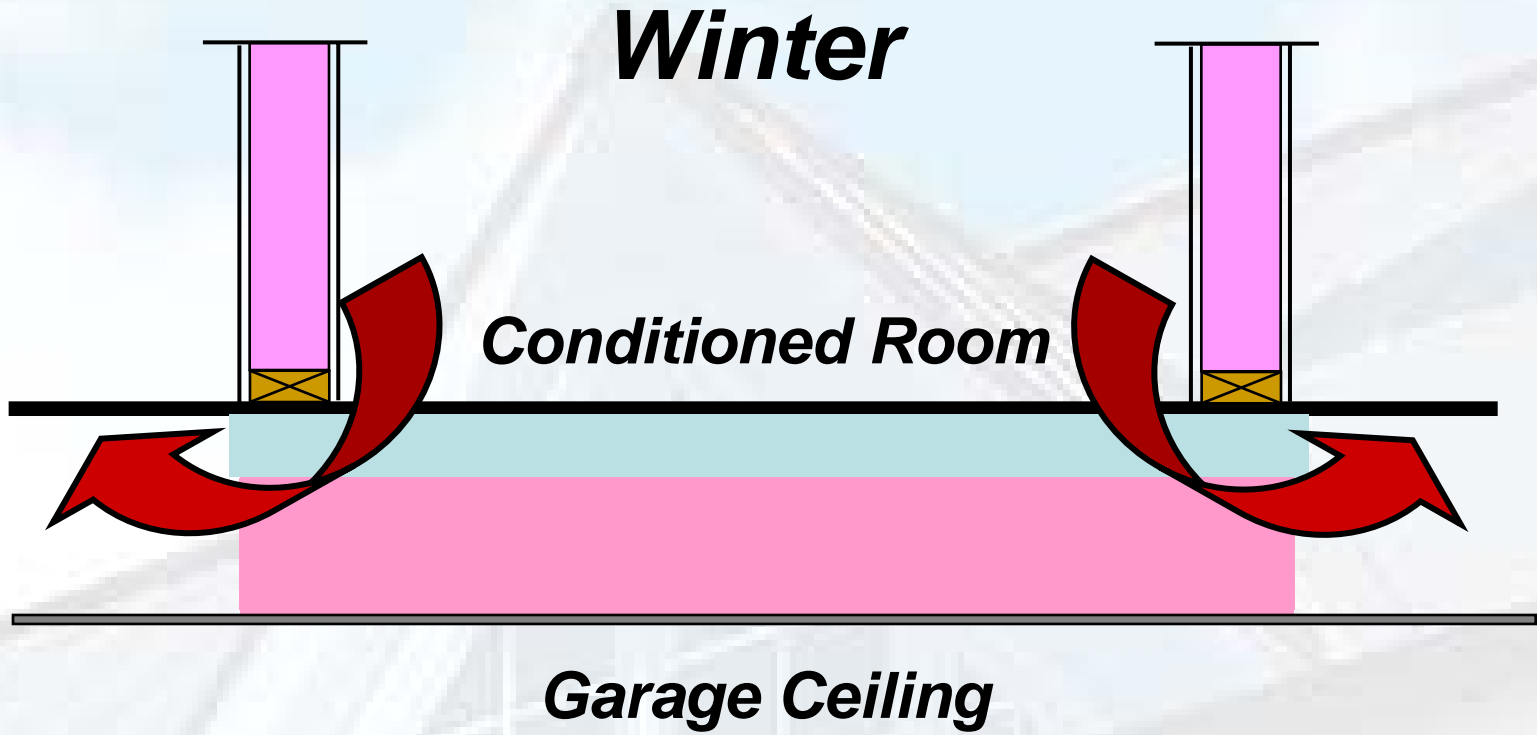
*Stack effect is a convective loop throughout the entire house cause by differences in pressure

CONTROLLING THERMAL FLOW:
**BONUS ROOM
OVER GARAGE**



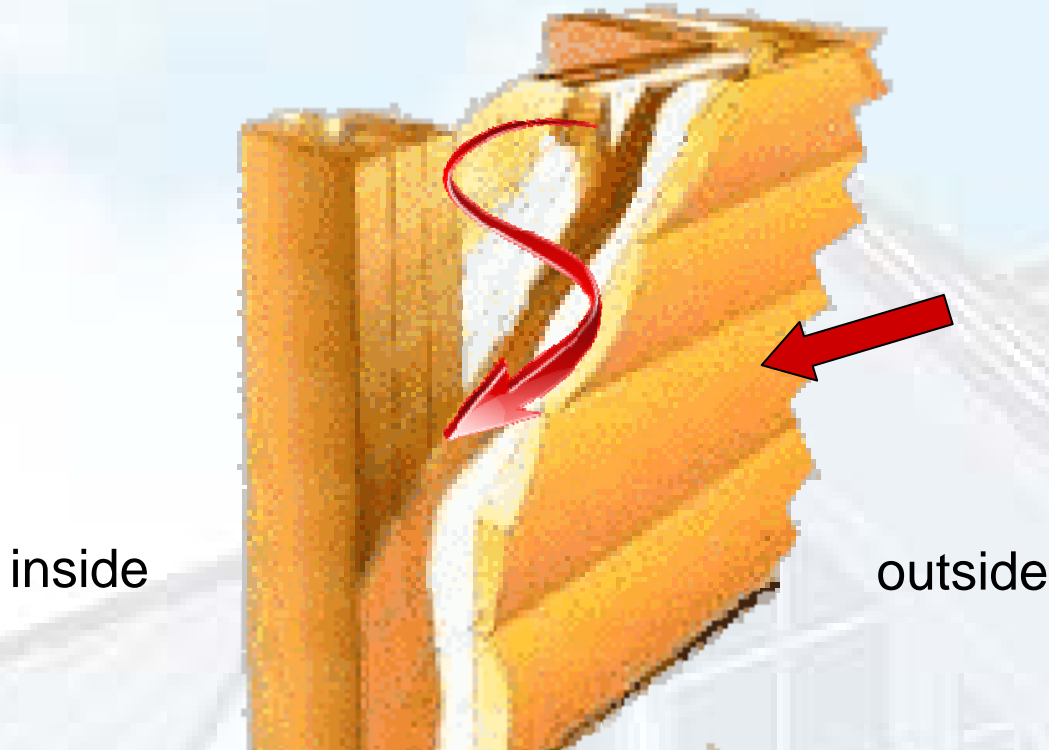
Without proper insulation and an air barrier in the floor, hot air flows in during the summer...

CONTROLLING THERMAL FLOW:
**BONUS ROOM
OVER GARAGE**



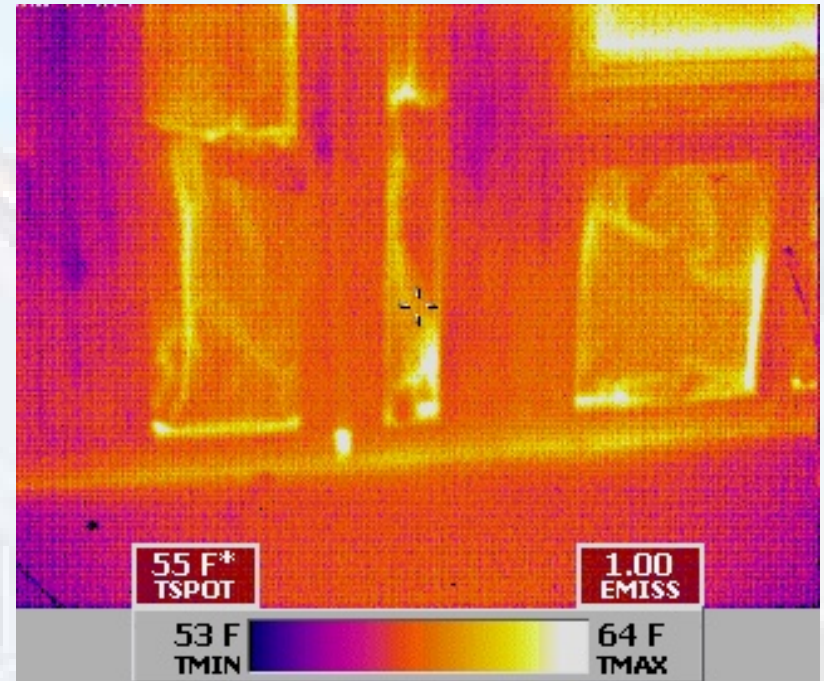
...and out during the winter.

CONTROLLING THERMAL FLOW: CONDUCTION THROUGH FRAMING



Thermal bridging occurs when materials that are poor insulators (i.e. wood) come in contact with each other as shown here, allowing heat to radiate through.

CONTROLLING THERMAL FLOW: CONDUCTION THROUGH FRAMING



The infrared image on the right shows thermal conduction where several wood studs are lined up next to each other, rather than leaving room for insulation.

Notice the cooler temperature where the studs are, indicating that heat is escaping more easily through the wood.

MOISTURE



CONTROLLING MOISTURE FLOW

CONTROLLING MOISTURE FLOW

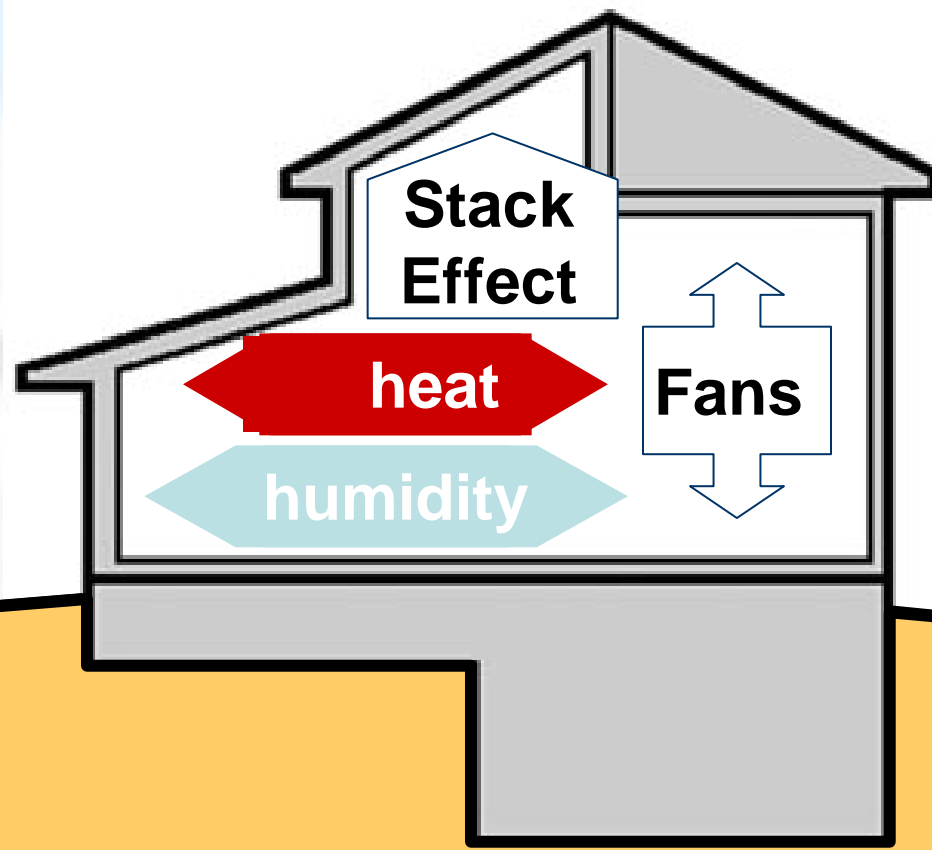
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Driving Forces:
Pressure

Heat

Moisture

CONTROLLING MOISTURE FLOW

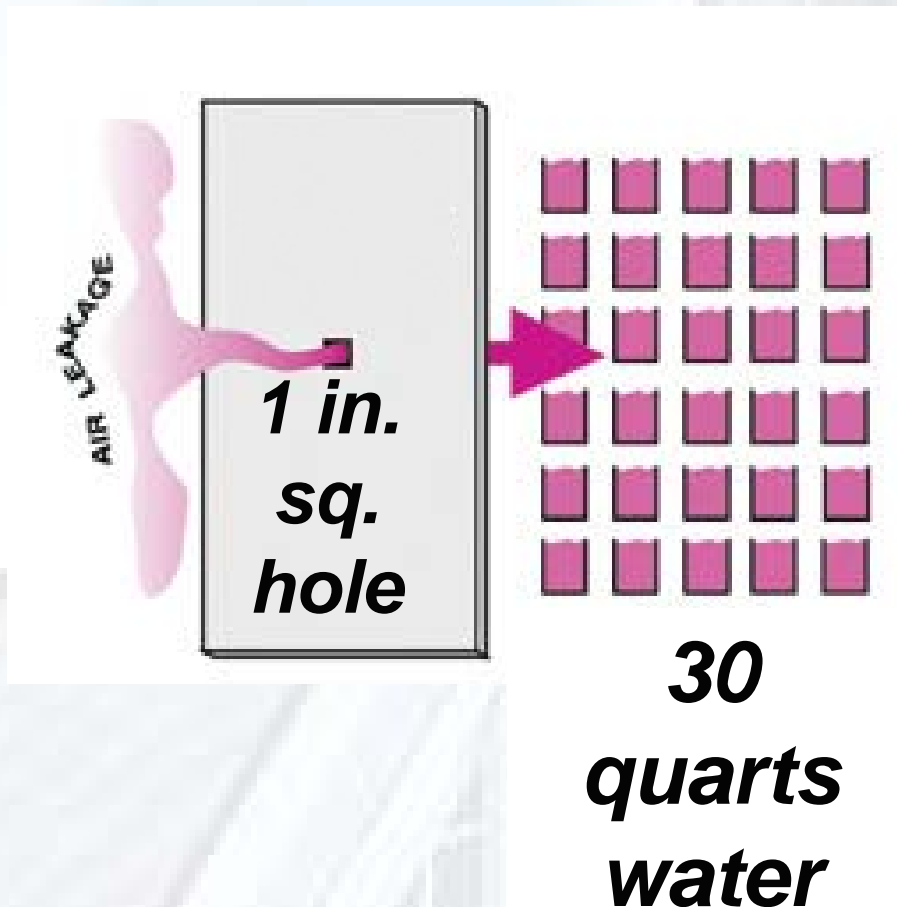


**While keeping the rain from leaking
in your home is important, most
moisture damage comes from air
flow, because**

ALL air carries moisture.

CONTROLLING MOISTURE FLOW

Example: 4' x 8' Sheet of Gypsum Board*



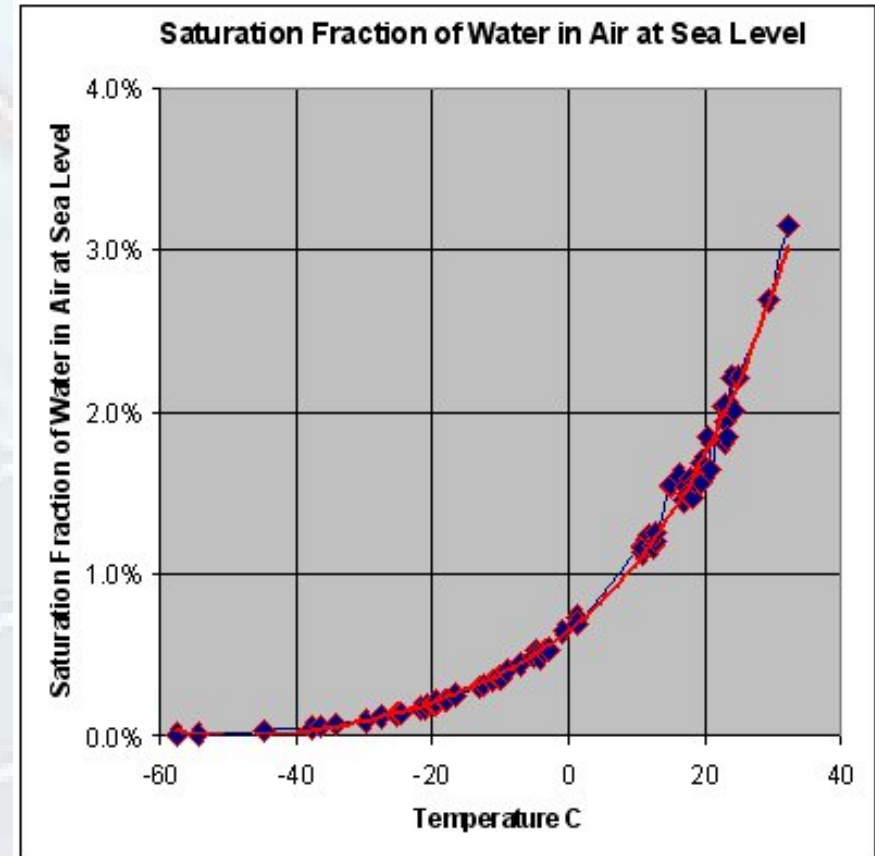
Air leakage will ultimately lead to moisture problems for your home.

This is the volume of water that enters a 1 square inch hole in your home over the course of one heating season.

*Interior at 7°F

WHY MOISTURE IS A PROBLEM

The dew point is the temperature at which air must be cooled for water vapor to condense into water.



The dew point changes based on the relative humidity in the air

SOLVING PROBLEMS



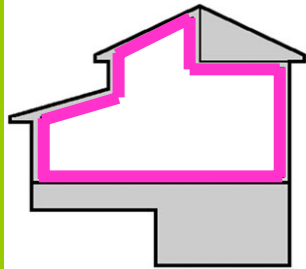
The building science principles behind energy efficient homes provide the basis for a compelling value proposition.

This section will discuss these principles used to create homes that are comfortable, durable, affordable, efficient .

HOW TO APPLY BUILDING SCIENCE



*Proper
Insulation*



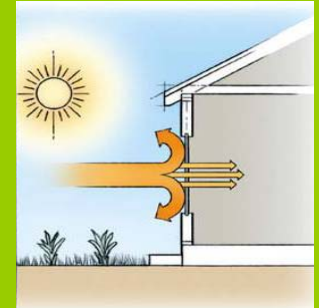
*Complete
Air Barrier*



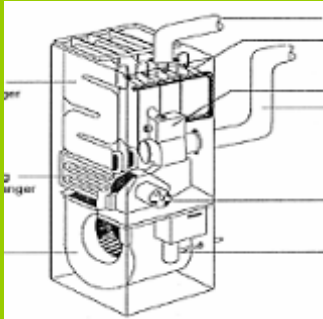
*Air
Sealing*



*Tight
Ducts*



*Advanced
Windows*



*Efficient
Equipment*



*Right
Sizing*



*Field
Verification*

Blower Door Test

The Blower Door test measures how much air leaks out of a home's envelope by studying at how much air must be removed from the home to reach a certain pressure level, thus testing the efficiency of the building envelope.



Duct Blaster Test

Duct blaster test measures the leakiness of the home's duct system.

The average new American home duct system has about 20-30% air leakage.



FOR MORE INFORMATION



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<http://www.usahers.com>

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Henry @ 904-233-7299