INTEGRATED DESIGN/PERFORMANCE BASED DESIGN AND BUILDING SCIENCE FUNDAMENTALS

Performance Based Design

Performance Based Design

1. Put together an Integrated Design team including (as appropriate):
   - Owner
   - Designer(s) – architect, interior, landscape
   - Engineer(s) – structural , mechanical
   - General Contractor
   - Key subcontractors – HVAC, insulation, electrical, plumbing
   - Energy Expert
2. Create vision for project, identifying a clear direction for the building design and implementation.
3. Establish energy performance goals at the very beginning of every project (ideally before a site is even chosen)

Performance Based Design

Performance Based Design

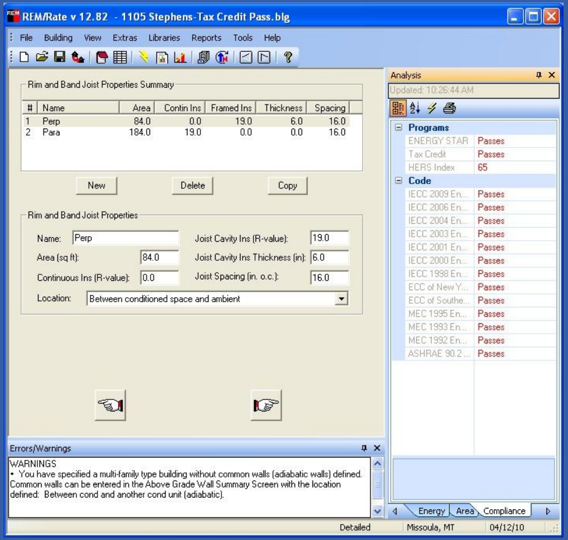
Energy Performance Benchmarks

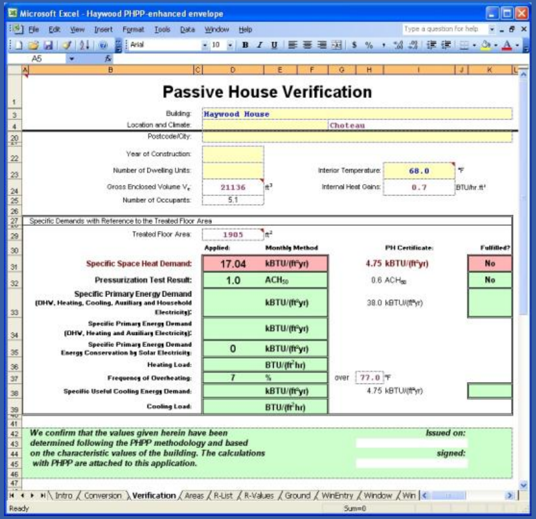
- Energy Star Northwest (not up to code)
- Worst – Code (2009 IECC)
- Improved – design team establishes its own improved performance goal (e.g. % better than code or xxxx BTUs/sf)
- Recognized – e.g. 2030 Challenge (establishes energy performance goals that improve every five years until reaching net-zero by 2030. 2010 Imperative sets goal of 60% better than IECC-2003)
- Excellent – Passive House Standard requires ≤4,750 Btu/sf/yr (heating/cooling), ≤38,100 Btu/sf/yr (Primary Energy), ≤ 0.6 ACH50 (approximately 90% better than 2006IECC)
- Best – Net Zero Energy

Performance Based Design

Gaging Energy Performance

- Energy Star - Prescriptive
- Code – Prescriptive or simulated (REScheck, REMRate, Energy10, etc.)
- Improved performance goal – Computer simulated (compares proposed building with min. code building)
- 2030 Challenge – Computer simulated
- Passive House Standard – Passive House Planning Package (PHPP) software
- Net Zero Energy – Computer simulated
- (- the proof is in the pudding!)





Energy Efficient Design Steps

1) Establish Energy Goal
2) Carefully Select Site
3) Design Building to meet optimize passive solar elements (in depth principles next week)
4) DRAW PRELIMINARY MODEL (sketchup)
5) USE ENERGY MODELING SOFTWARE TO ESTABLISH BUILDING ENVELOPE TO MEET ENERGY GOALS
6) IF NEEDED, MODIFY MODEL TO MEET GOALS (MODEL WILL ALMOST ALWAYS NEED TO BE MODIFIED)
7) COMMUNICATE WITH INTEGRATED DESIGN TEAM (from beginning of design through completion of construction)
8) COMPLETE DESIGN AND BUILD HOME (a whole course in itself)
9) TEST BUILDING AIR TIGHTNESS AND MECHANICAL SYSTEMS
10) MONITOR ENERGY USE

IN ORDER TO DESIGN AND BUILD ENERGY EFFICIENTLY WE NEED TO FOLLOW THE PRINCIPLES OF BUILDING SCIENCE

WHAT IS BUILDING SCIENCE??

What is Building Science?

Building Science is the study of how buildings interact with their environment.

Primarily it looks at the physics of how

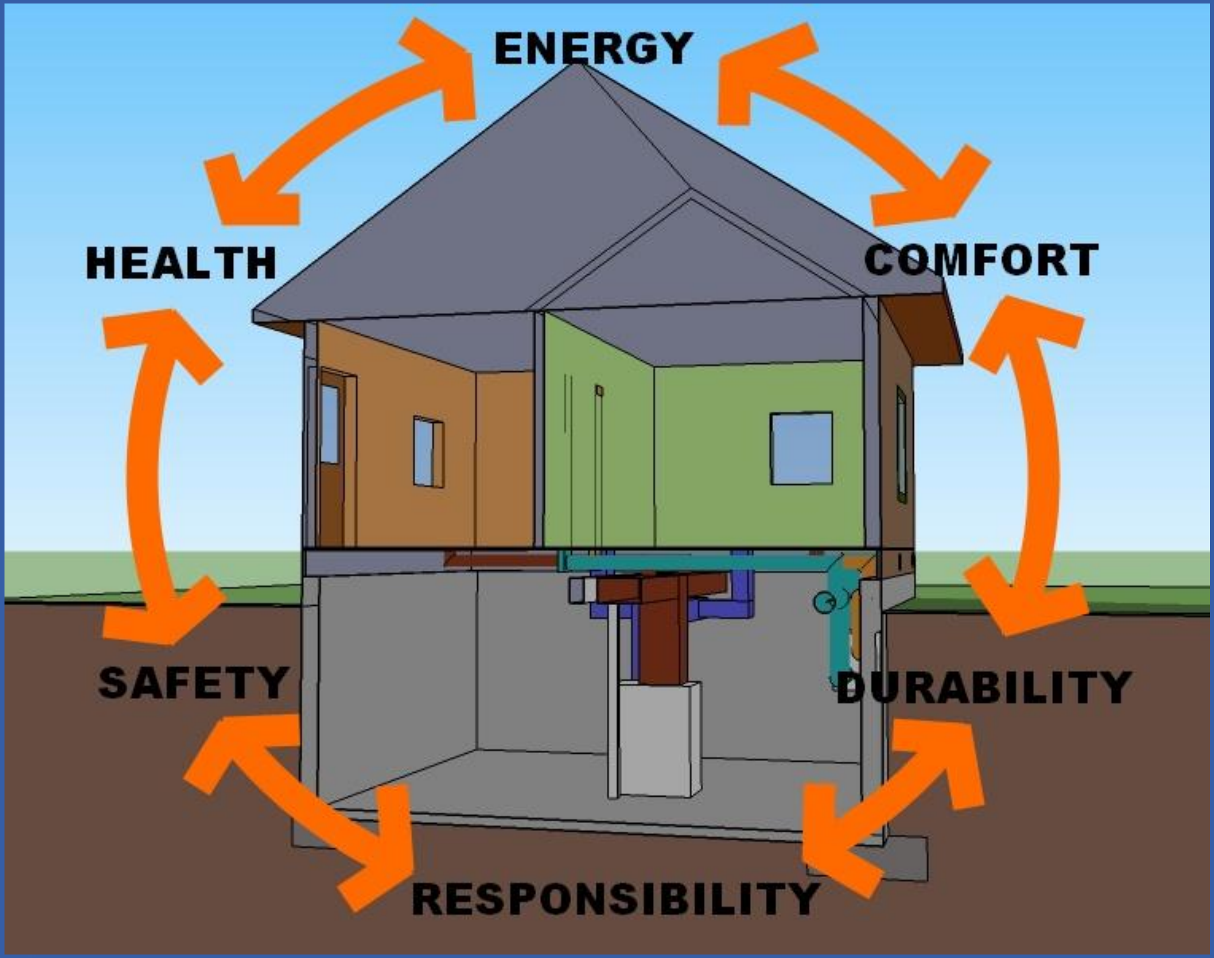
Heat

Air &

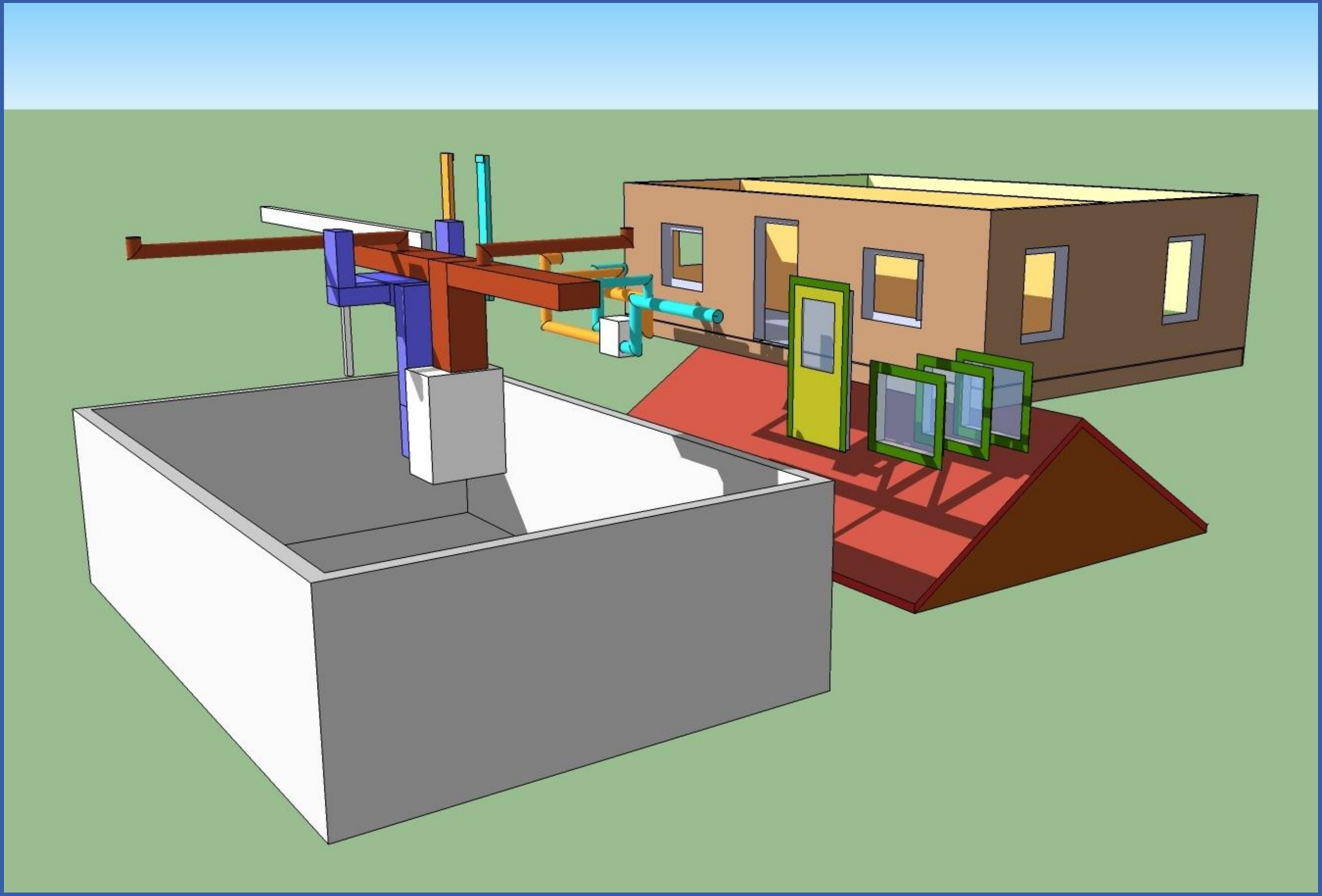
Moisture

behave in buildings.

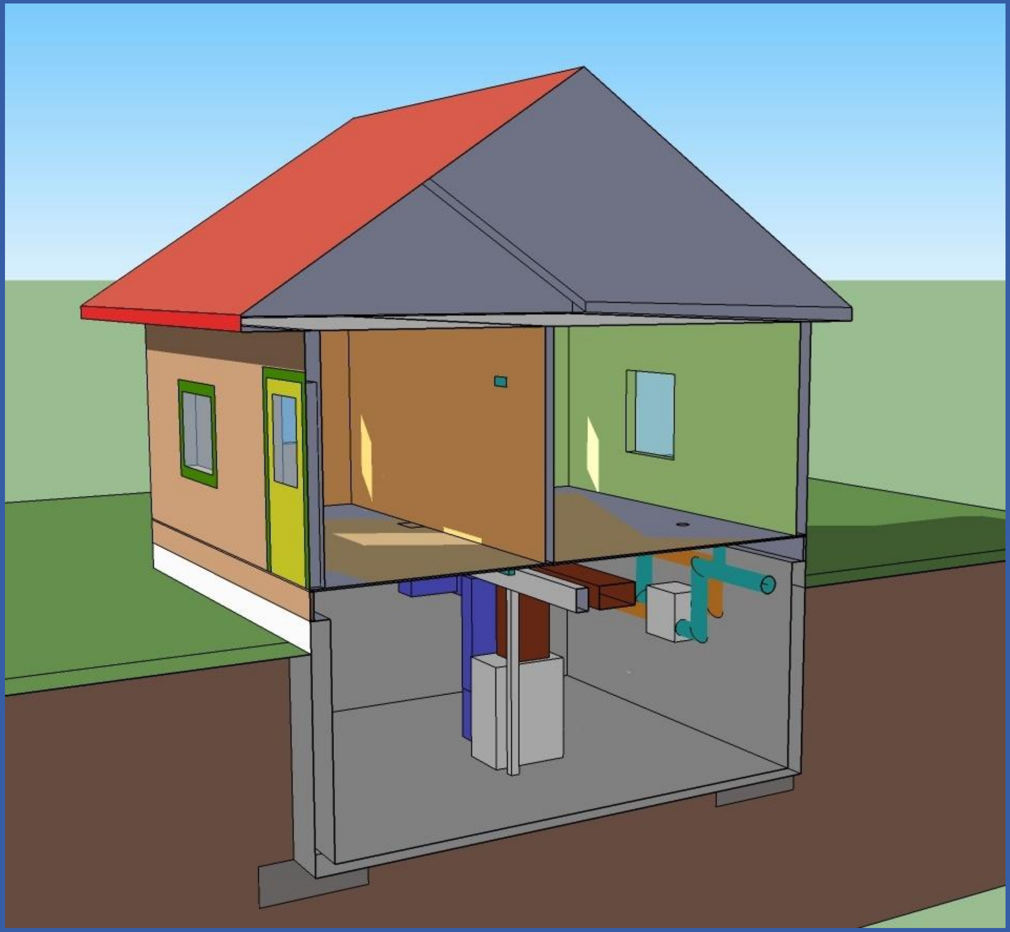
Seeing a House as a Complete System



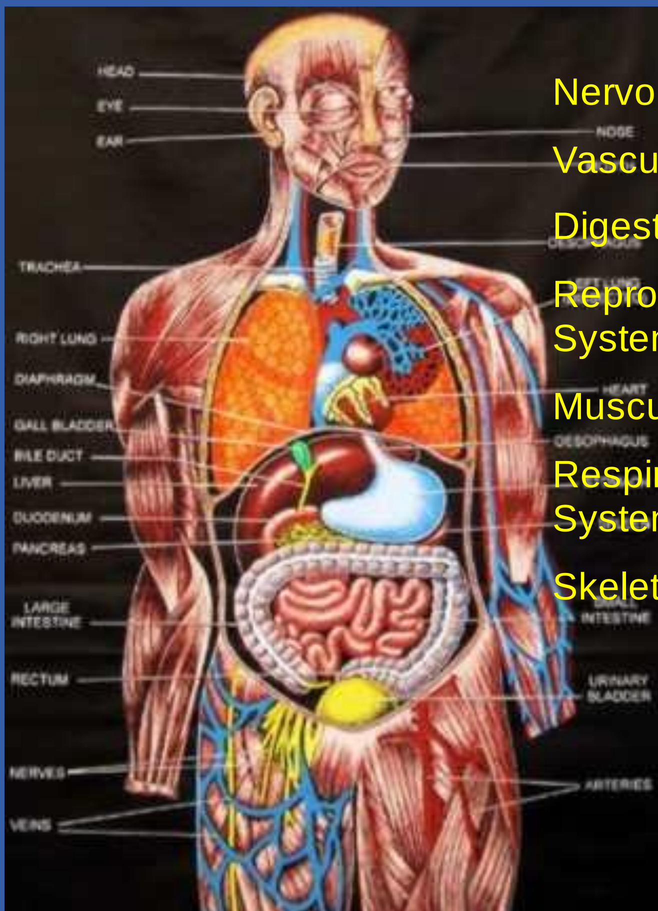
A house is not just a collection of parts and materials



The parts and materials have to be assembled in the right way in order to create a functioning system

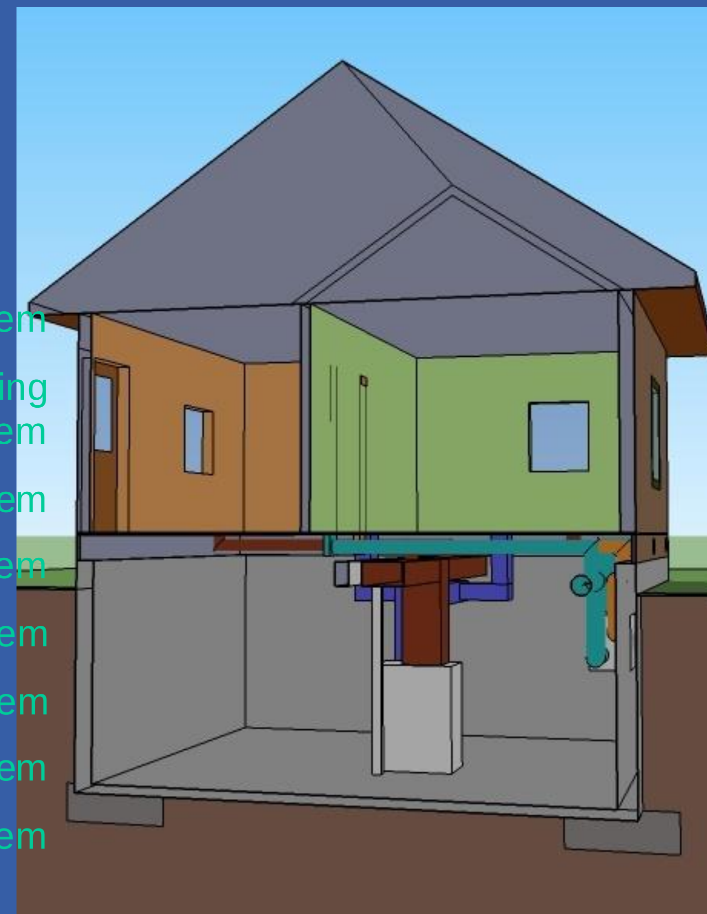


Like a human body, a house is made up of a lot of different systems



Nervous System
Vascular System
Digestive System
Reproductive System
Muscular System
Respiratory System
Skeletal system

Structural System
Waterproofing System
Plumbing System
Electrical System
Heating System
Ventilation System
Insulation System
Air-barrier System



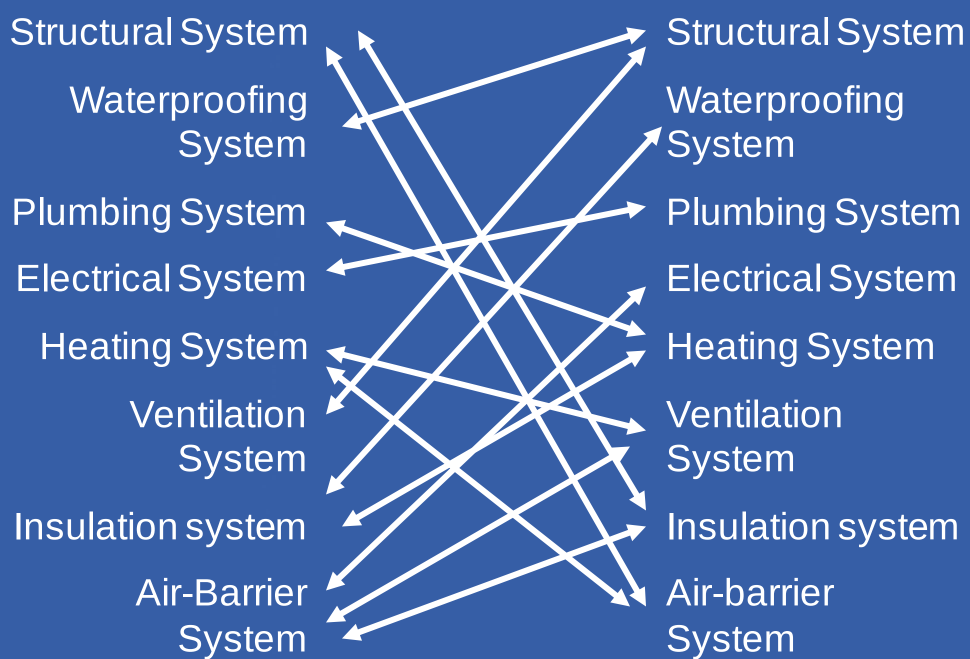
This is not an insulation system

THIS is an insulation system!

This is not a heating system

THIS is a heating system!

All of these different systems interact in complex ways in every building.



Understanding, predicting, and managing these interactions requires a thorough knowledge of ***Building Science***

HEAT

Moves from

High Heat → *Low Heat*

by

Conduction

Convection

Radiation &

Condensation/Evaporation

AIR

Moves from

High Pressure → *Low Pressure*

driven by

Wind

Thermal &

Mechanical

forces.

MOISTURE VAPOR

Moves from

High Relative Humidity → *Low Relative Humidity*

by

Diffusion &

Air Leakage

And CONDENSES if it reaches a

Dew Point

The Building Scientist

Uses their understanding of how heat, air, and moisture behave to ensure that the various SYSTEMS interact in beneficial ways to create buildings that are

SAFE

HEALTHY

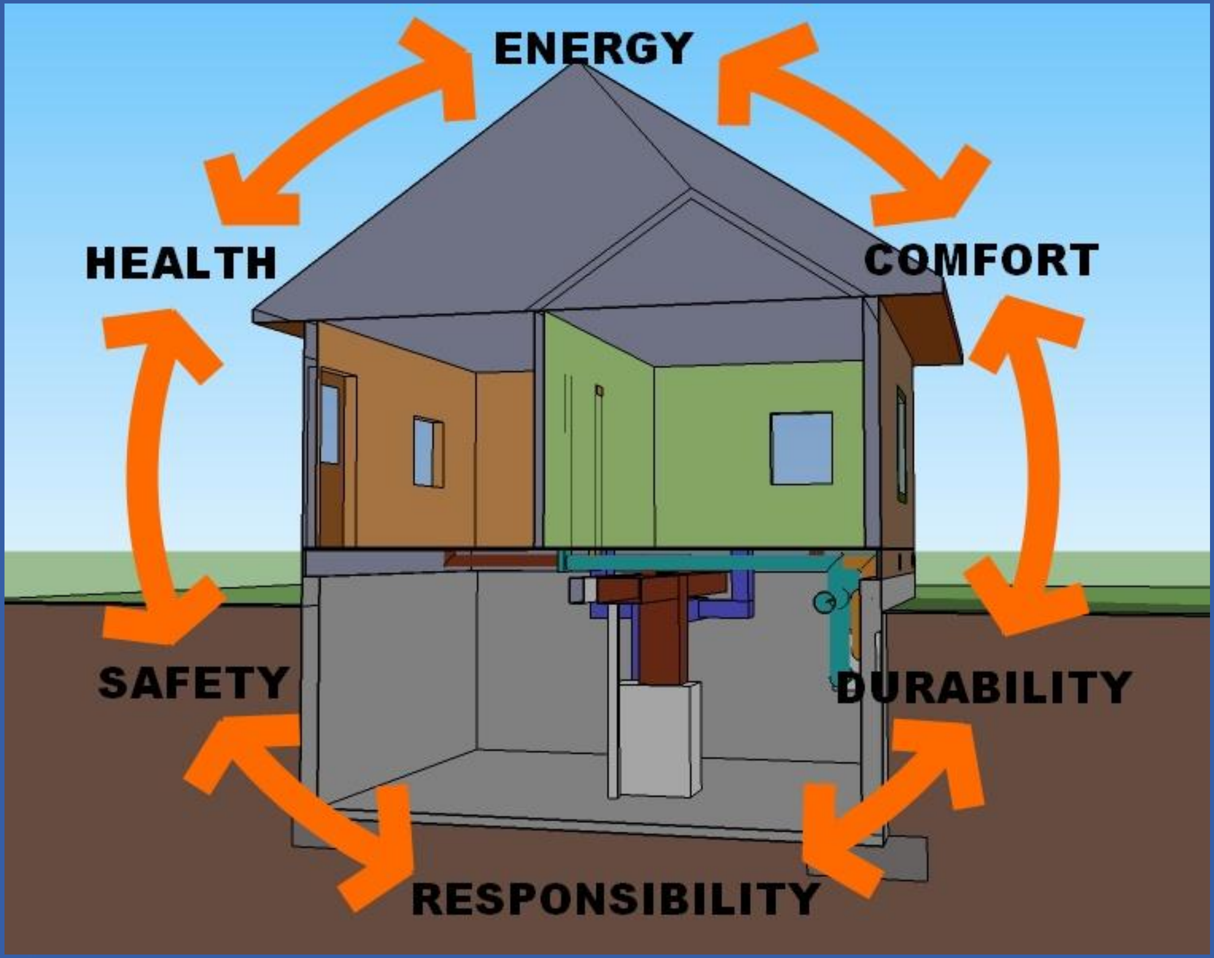
DURABLE

RESPONSBILE

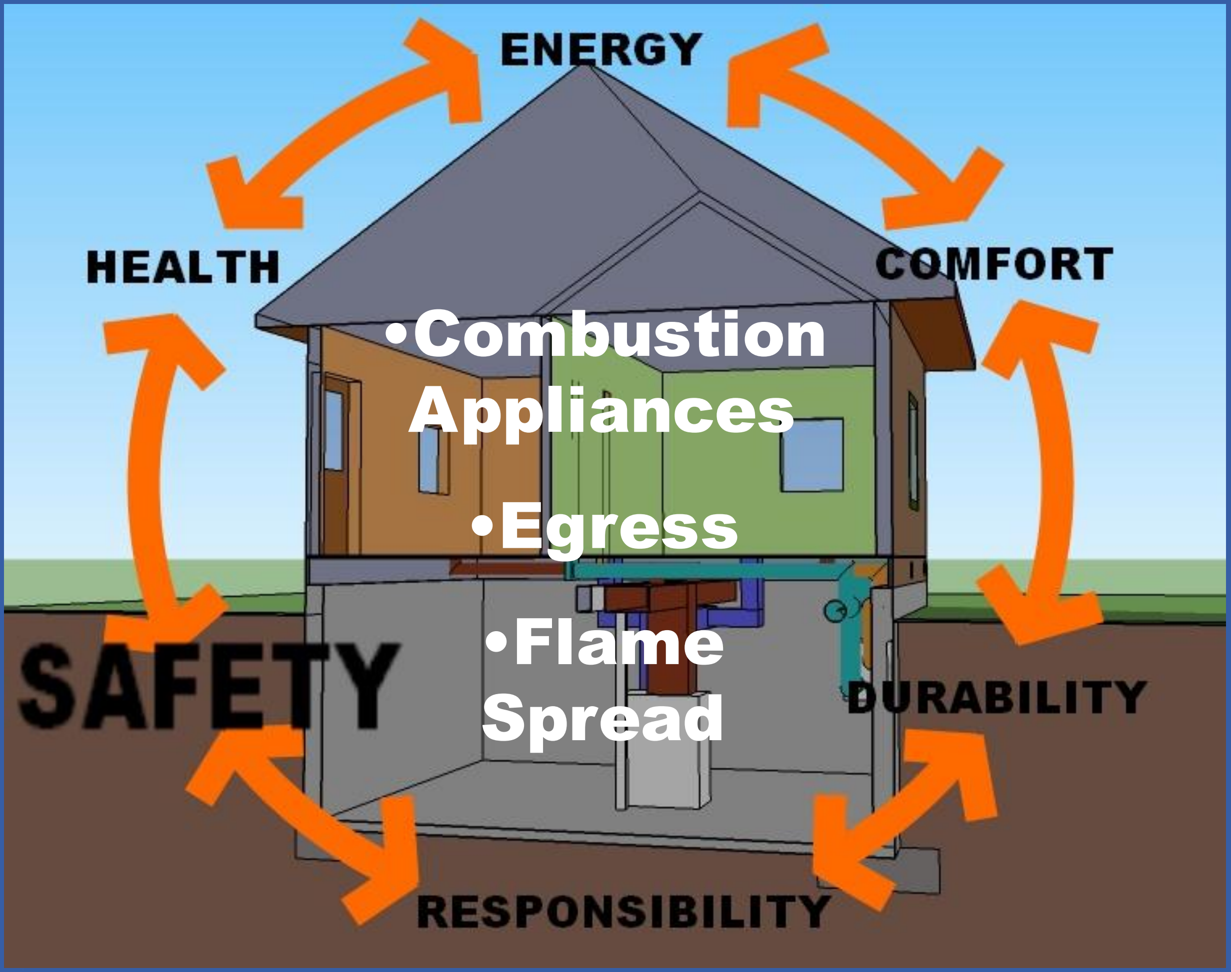
COMFORTABLE &

ENERGY EFFICIENT

Seeing a House as a Complete System

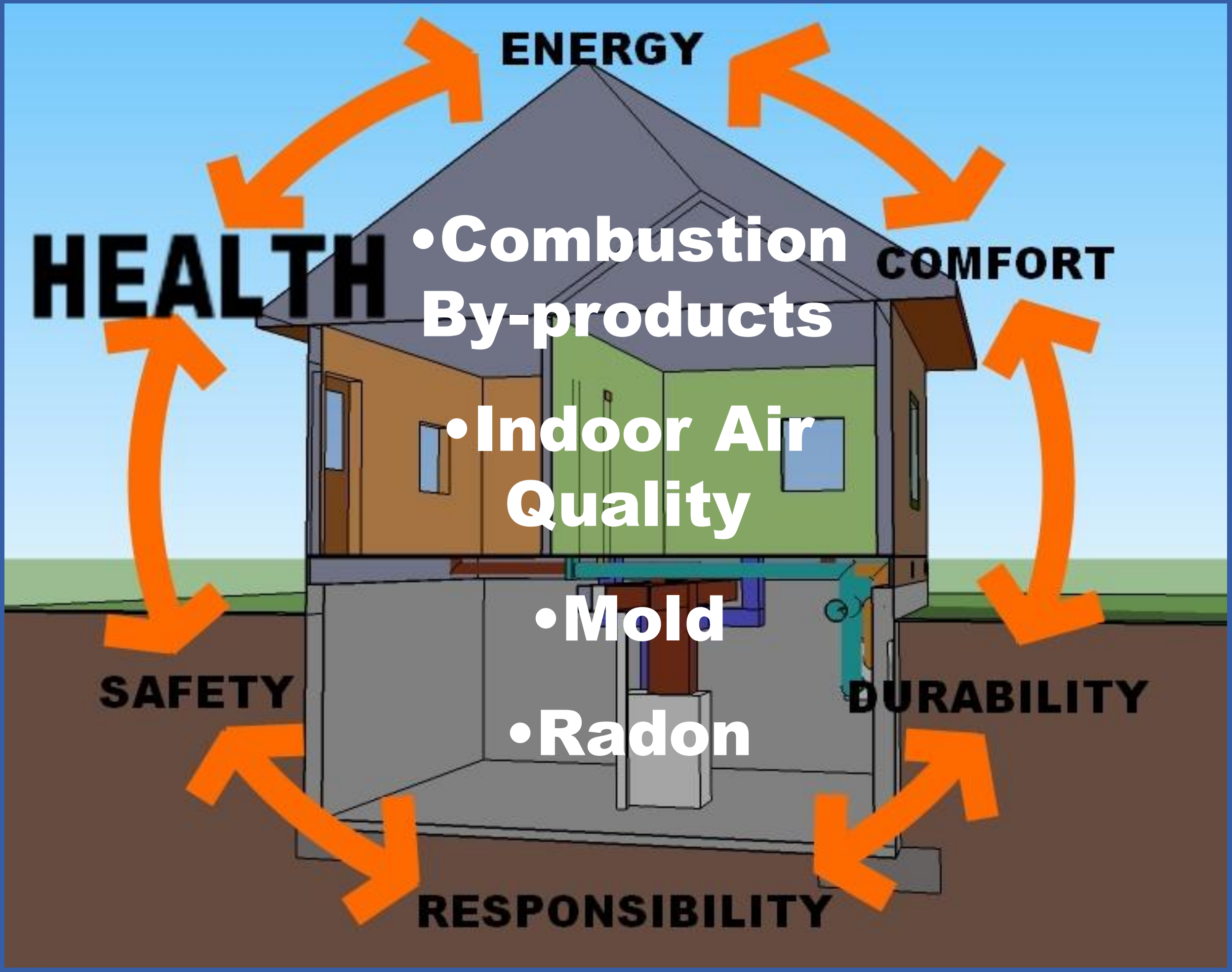


Safety



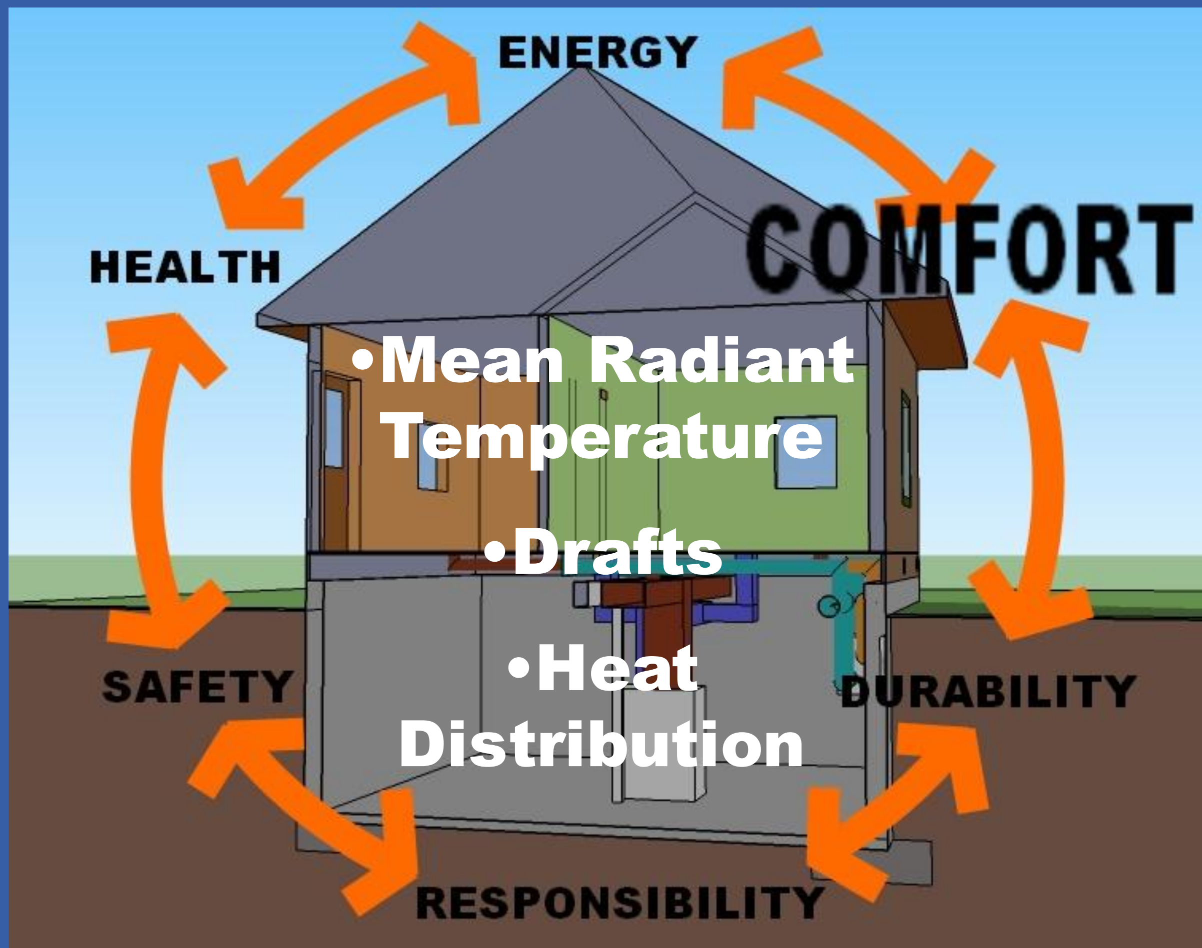
- Combustion Appliances
- Egress
- Flame Spread

Health



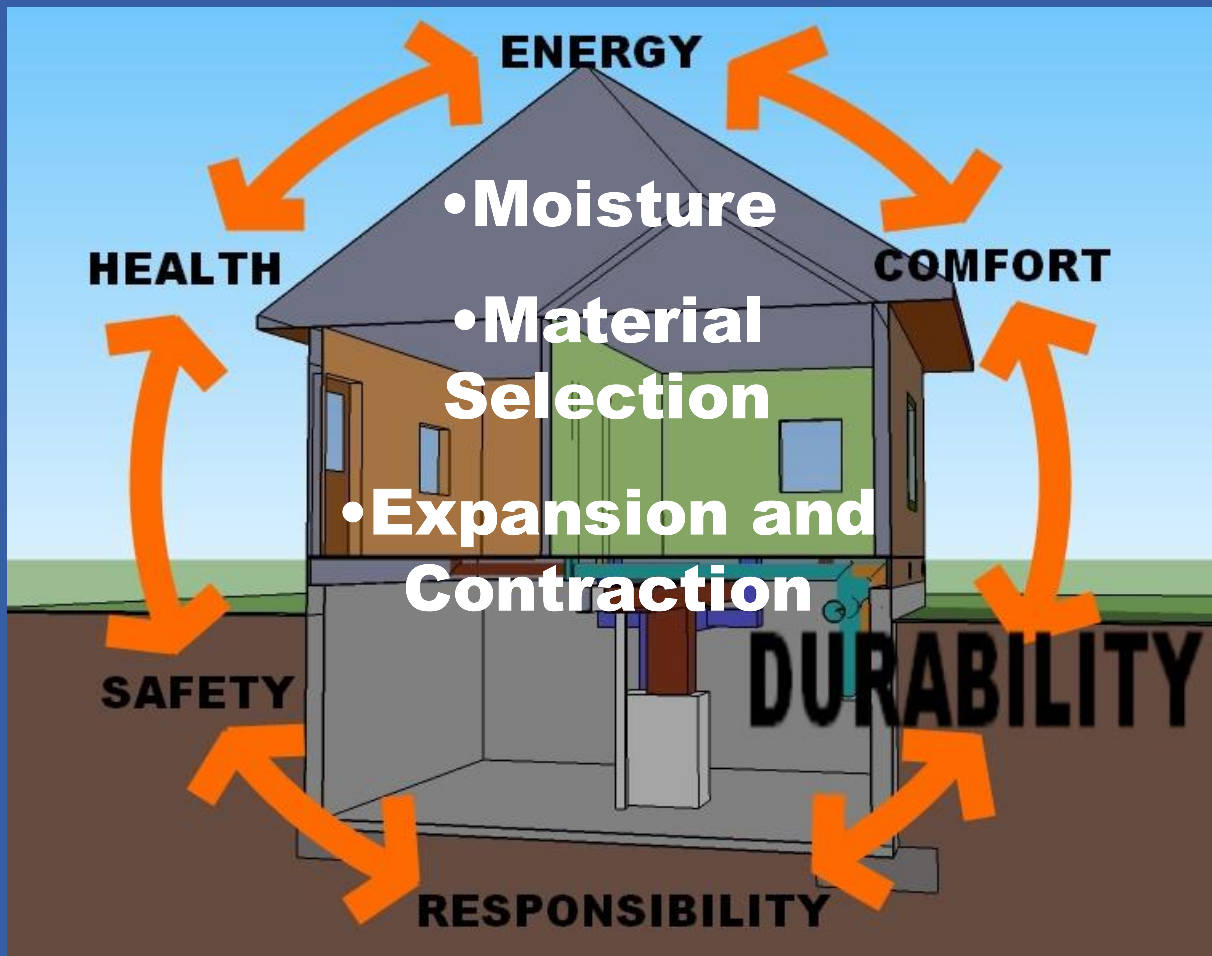
- Combustion By-products
- Indoor Air Quality
- Mold
- Radon

Comfort



- Mean Radiant Temperature
- Drafts
- Heat Distribution

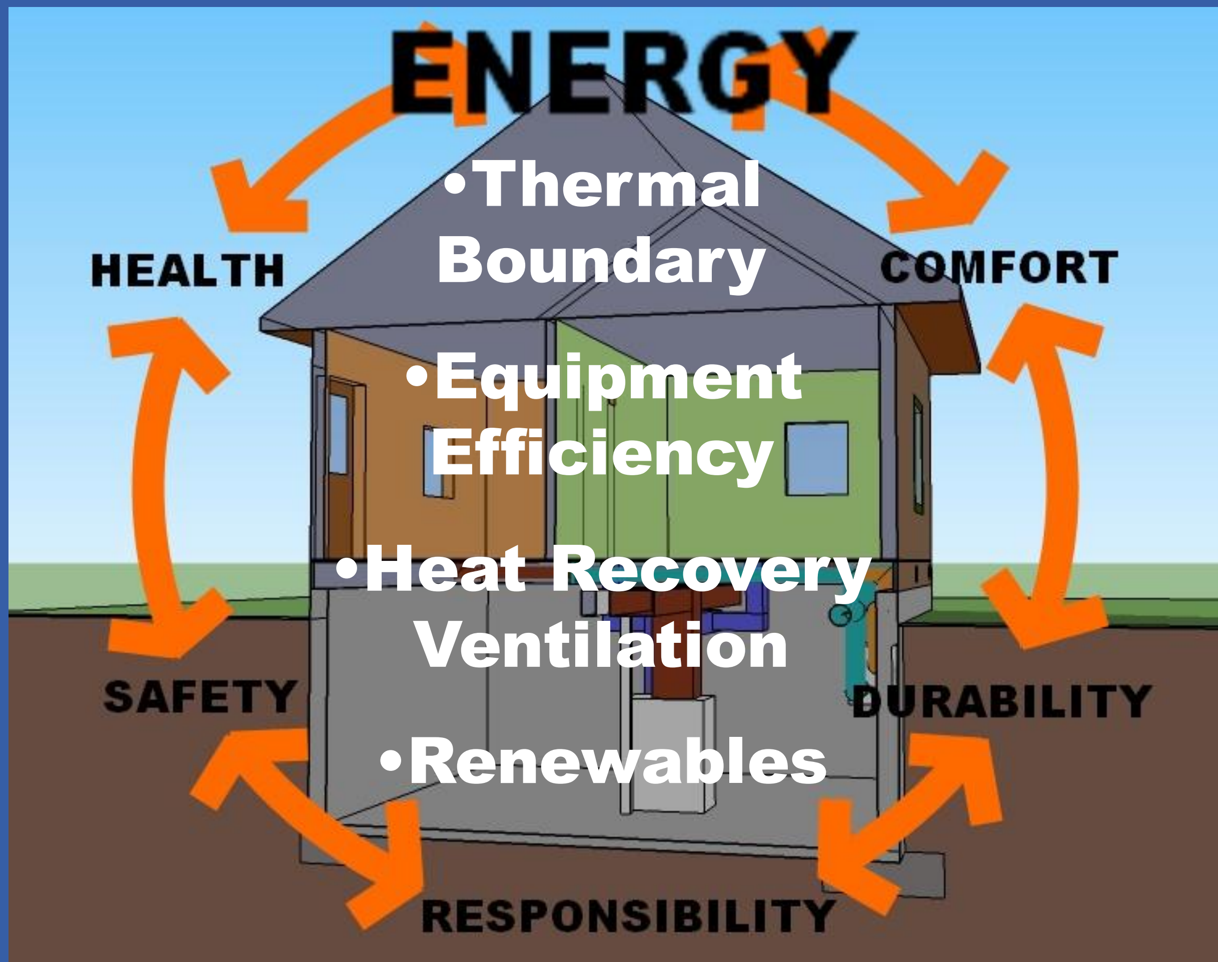
Durability



- Moisture
- Material Selection
- Expansion and Contraction

Responsibility

Energy Efficiency

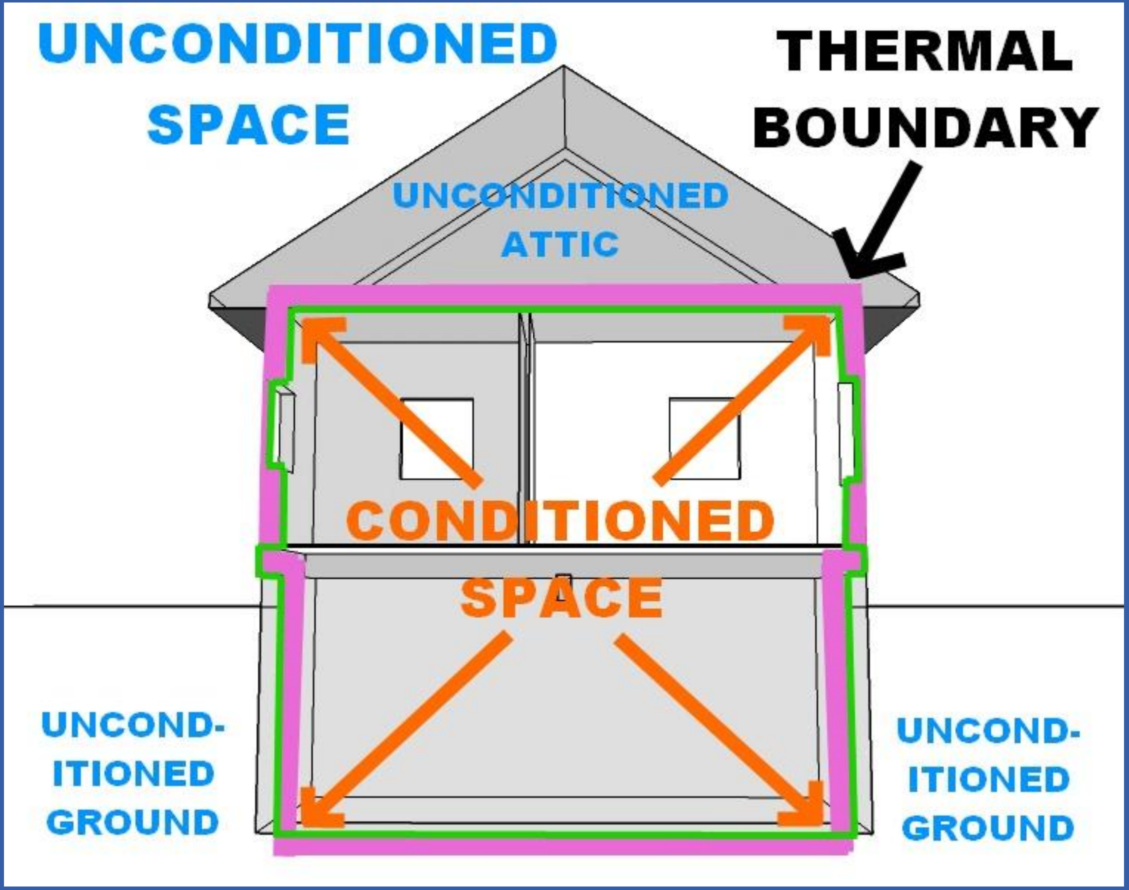


- Thermal Boundary
- Equipment Efficiency
- Heat Recovery Ventilation
- Renewables

Thermal Boundary

THERMAL BOUNDARY

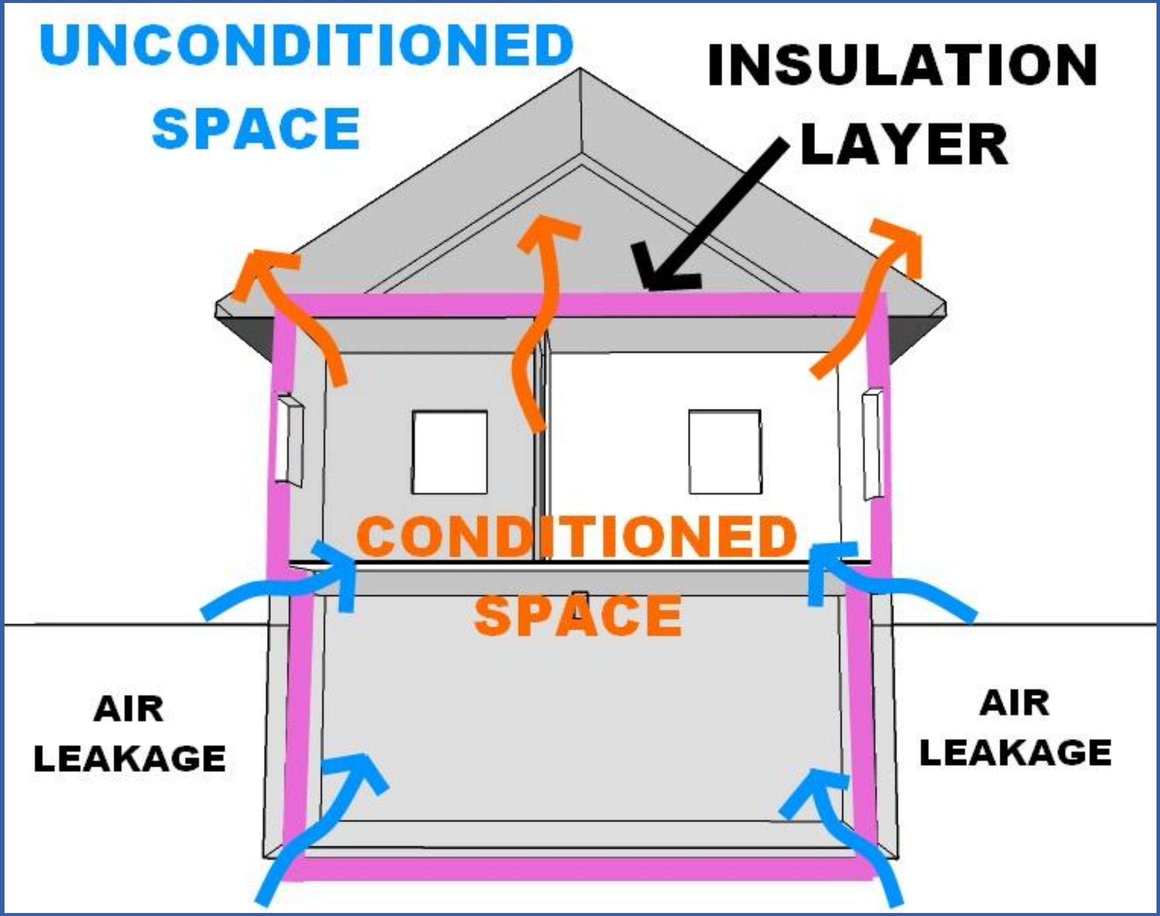
- Consists of BOTH insulation and air barrier
- Continuous around entire Conditioned Space
- Separates Conditioned Space from Unconditioned Space



Insulation Layer

Insulation

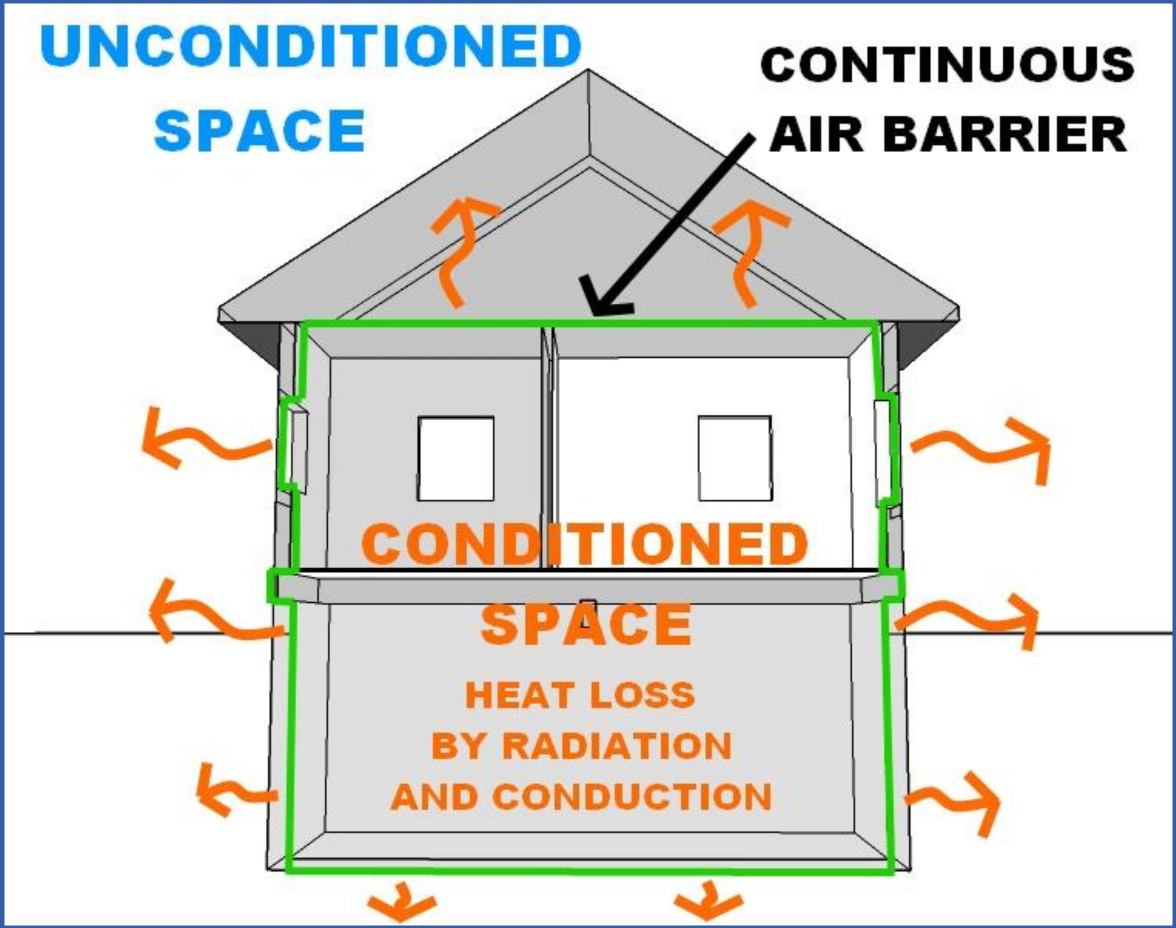
- Should be continuous around the entire Conditioned Space
- DOES NOT NECESSARILY STOP AIR MOVEMENT which can lead to heat loss
- Does not necessarily stop Moisture Vapor movement which can lead to condensation



Air Barrier

Air Barrier

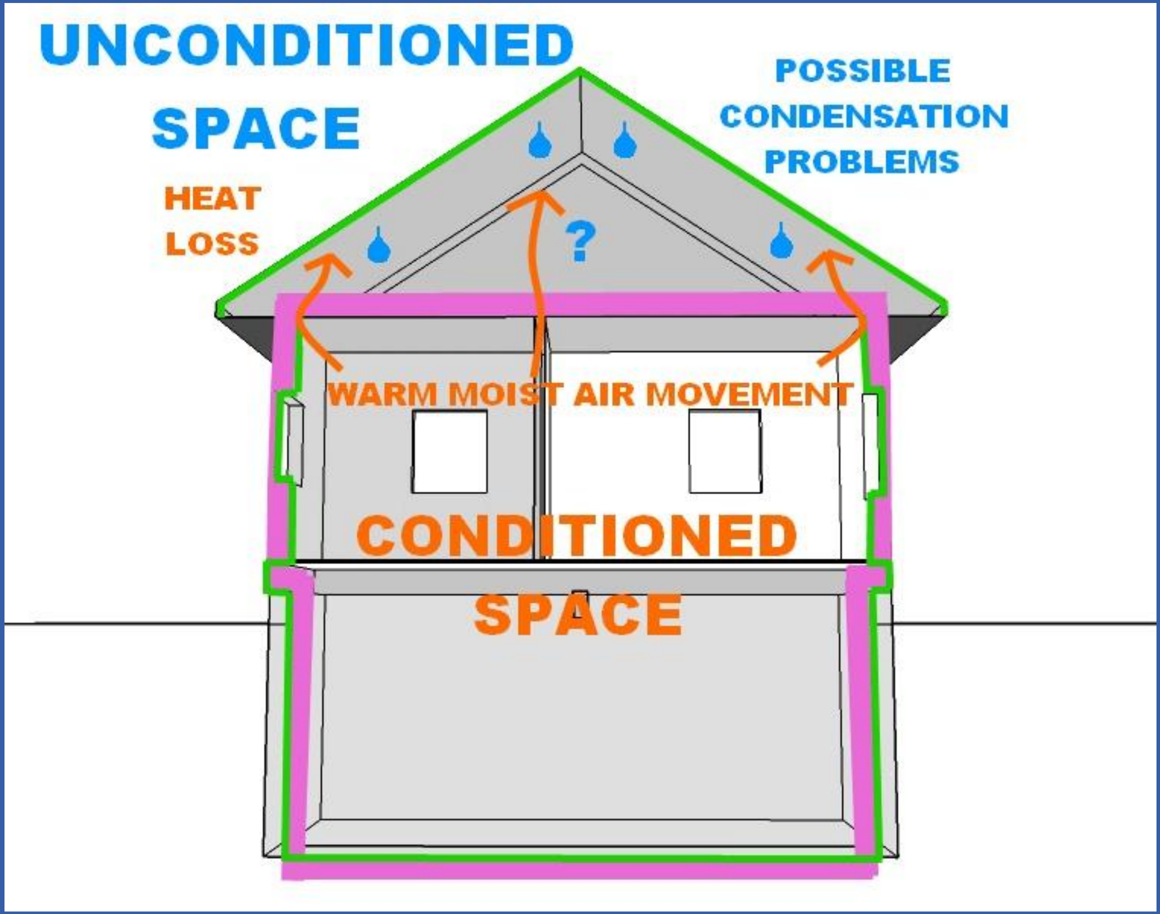
- Should also be continuous around the entire Conditioned Space
- Should be in contact with the insulation at all times
- Does not necessarily stop heat conduction or radiation which can lead to heat loss
- Does not necessarily stop Water Vapor movement which can lead to condensation



Misalignment of Insulation and Air Barrier

Air Barrier

- **Should be in contact with the insulation at all times**
- **Misalignment can lead to severe heat loss and possible condensation problems**
- **Beware of unvented spaces summer and winter**



Controlling Condensation

Air Barrier

- **Far more moisture travels through building assemblies via air leakage than via diffusion**
- **An effective air barrier is the most important step towards controlling condensation and moisture problems**

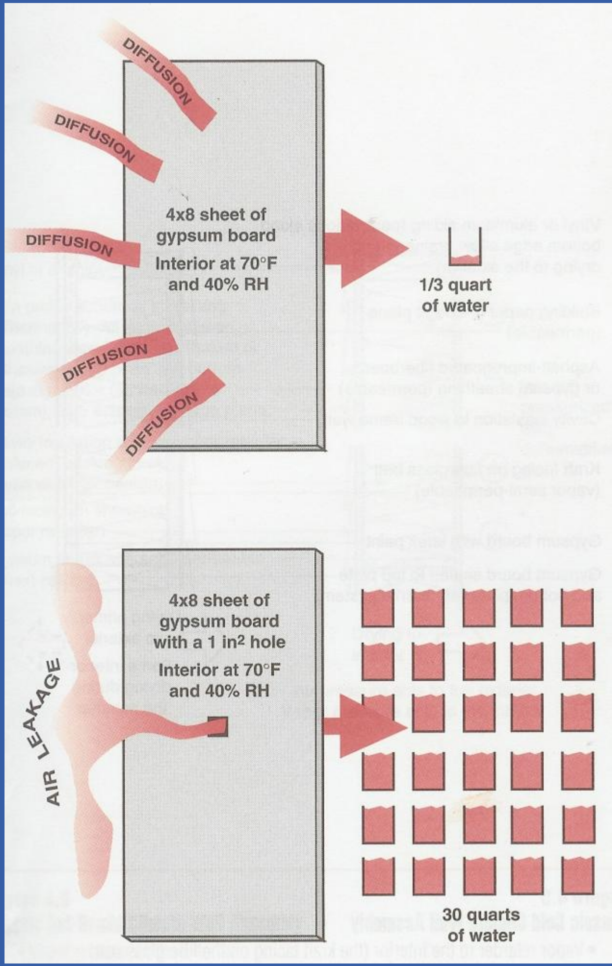


Image Source – "Builder's Guide to Cold Climates" by Joseph Lstiburek, p.121.

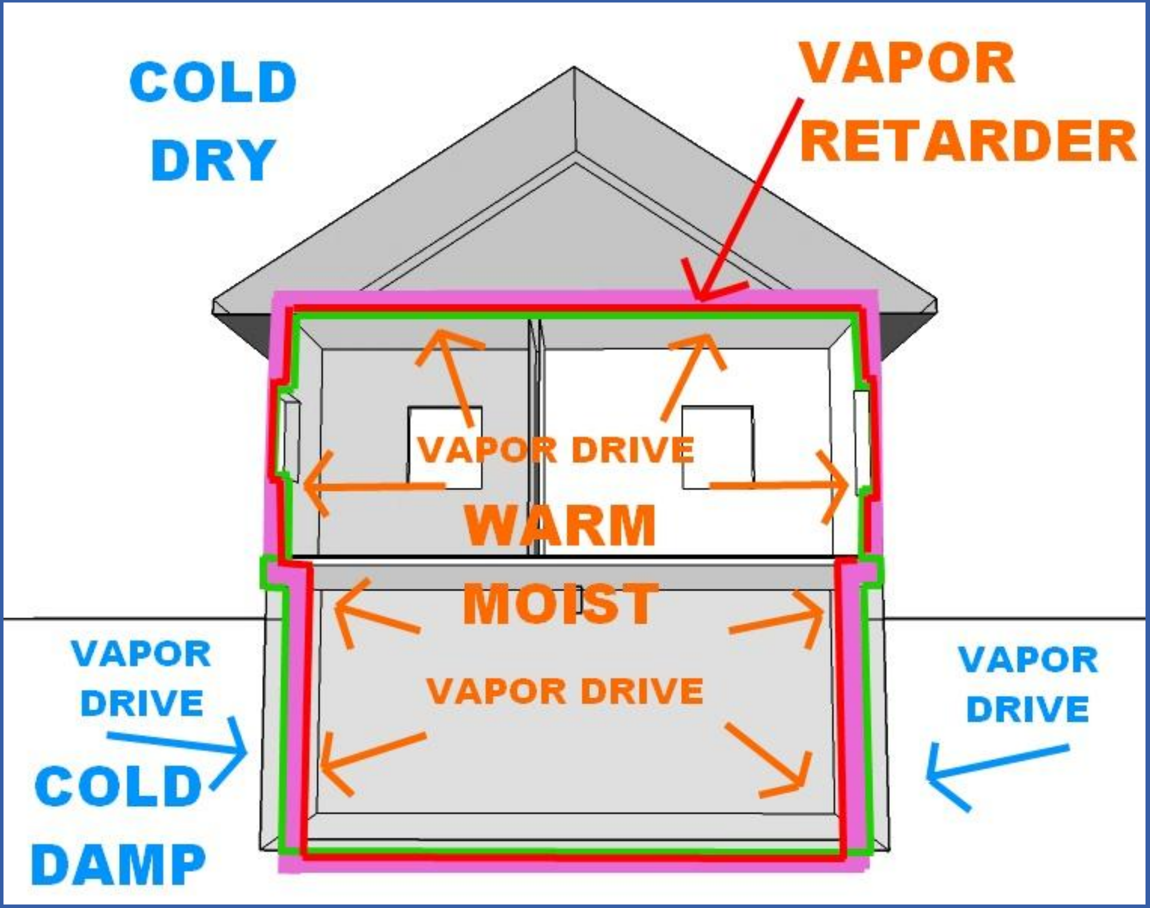
Published by Building Science Press

"In most cold climates over an entire heating season, 1/3 of a quart of water can be collected by diffusion through gypsum board without a vapor retarder; 30 quarts of water can be collected through air leakage."

Controlling Condensation

Vapor Retarders

- In a cold, dry climate like Montana the **interior** (warm) surface generally should be **less permeable** than the exterior (cold) surface
- Basements are particularly difficult because there is vapor drive from both inside and outside
- **Only some** insulation and air barrier materials are vapor retarders



Controlling Condensation

Dew Point

- **Occurs in building assemblies when a surface becomes cold enough for water vapor to condense**
- **This is a function of the surface temperature and the relative humidity of the air**
- **Very humid air does not require a very cold surface to cause moisture to condense**