South Eastern Colorado Renewable Energy Society

Public Education Seminar Series

Session 1: Energy and Water Efficiency Basics

September 12th, 2015

Jim Riggins, info@secres.org

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Overview

- The Thermal Boundary
- Space Heating and Cooling
- Appliances
- Lighting
- Water Consumption
- Myths vs Building Science

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Upcoming Seminars

- October 10th: DIY and professional energy and water audits/assessments
- November 14th: Incentives and financing for efficiency upgrades
- December 12th: Renewable energy basics for homes and small businesses

All seminars held at the Conservation and Environmental Center

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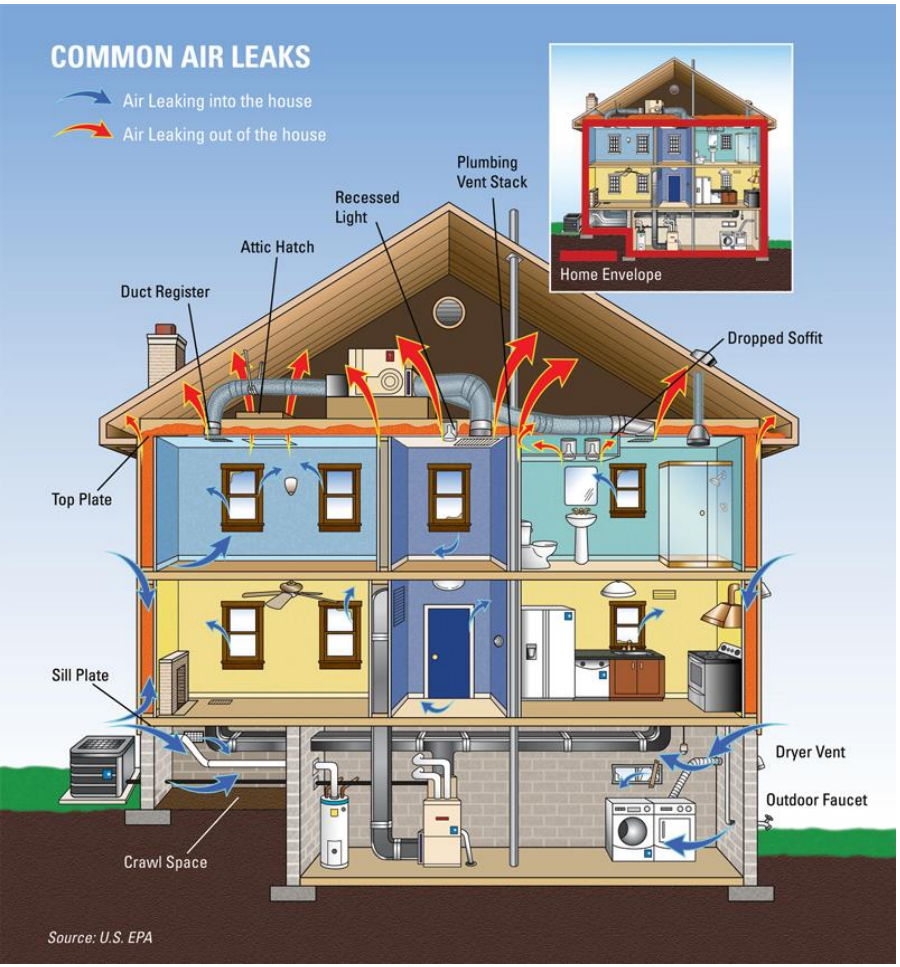
Benefits of Energy Efficiency



- U.S. Dept of Energy Study: 33% decrease in heating bills after weatherization
- Eliminate comfort problems
- Healthier air in the home
- 10% Efficiency Improvement eliminates 1400 pounds of emitted CO2

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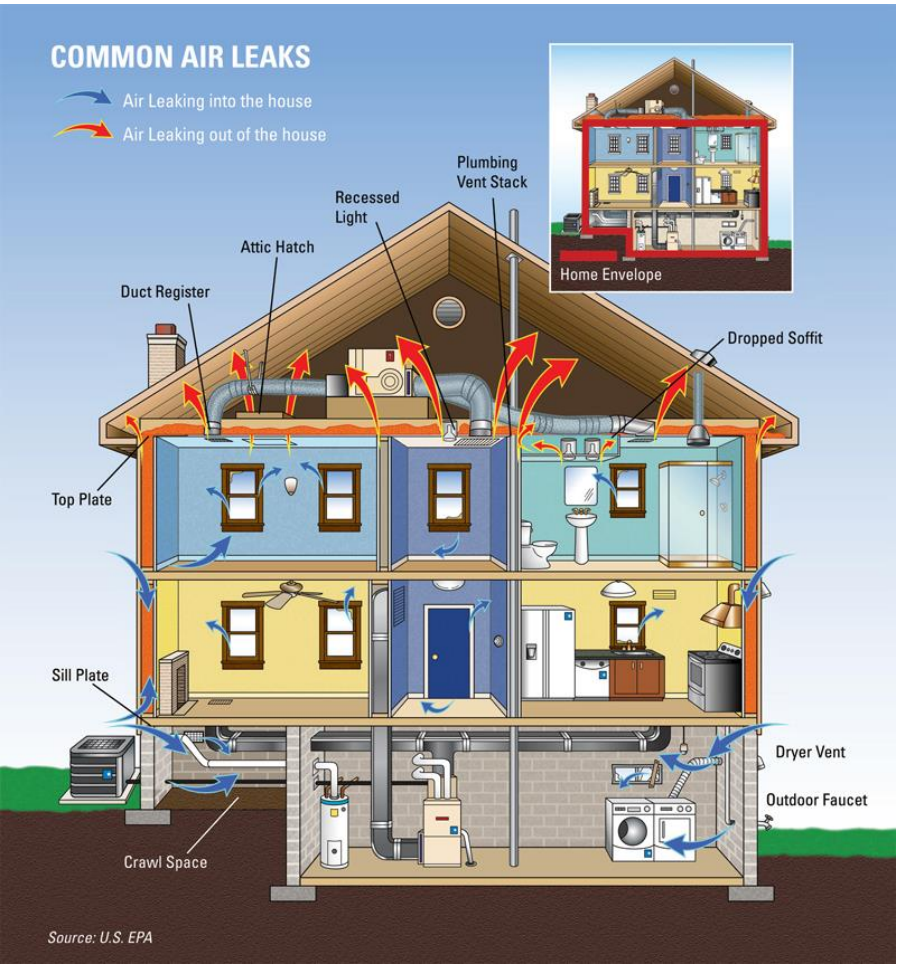
Benefits of Energy Efficiency



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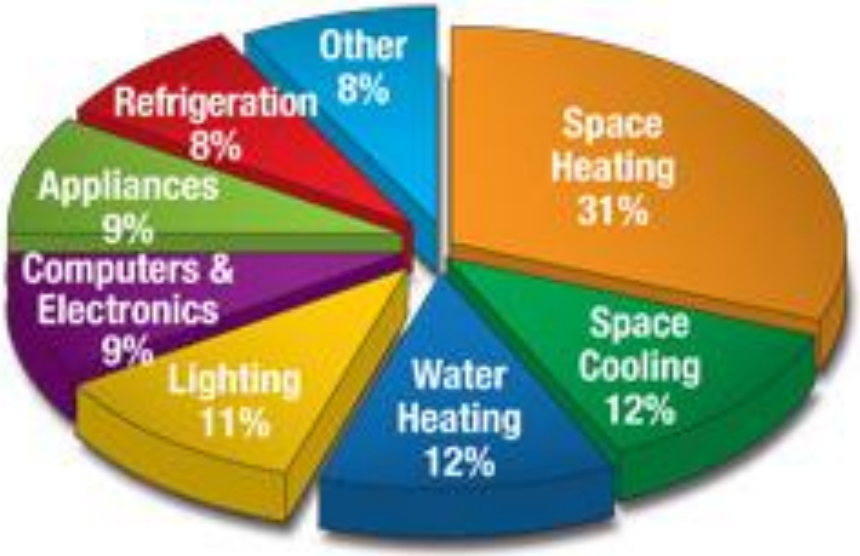
Where Does the Energy Go?



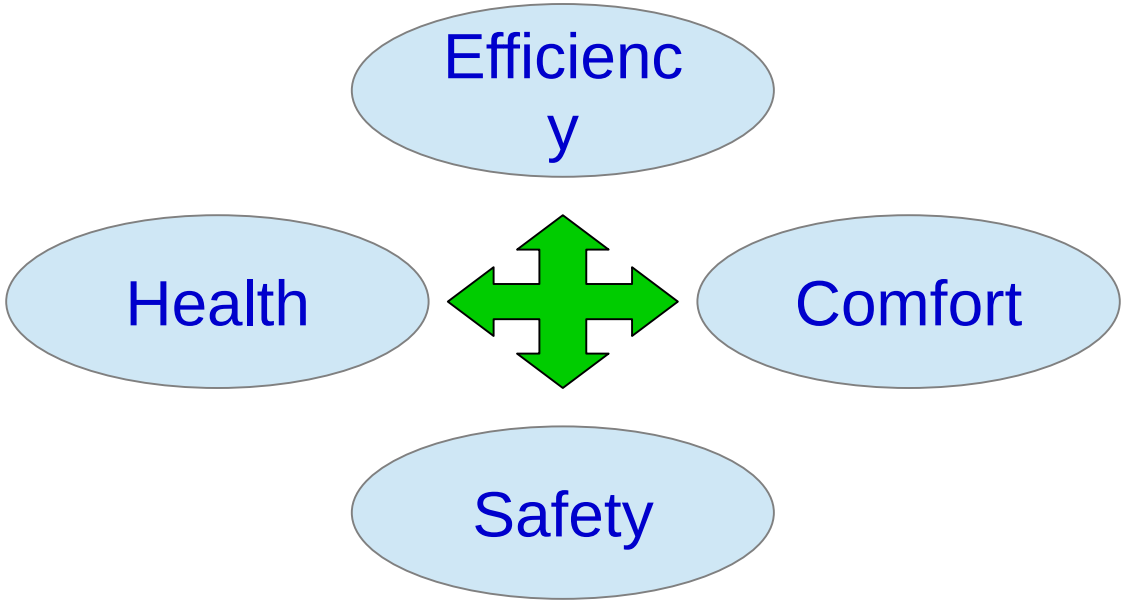
Source: U.S. EPA

- Largest Waste of Home Energy: duct and house air leaks and insulation problems
- Consumer electronics “phantom loads” growing rapidly

Cannot Consider Efficiency in Isolation

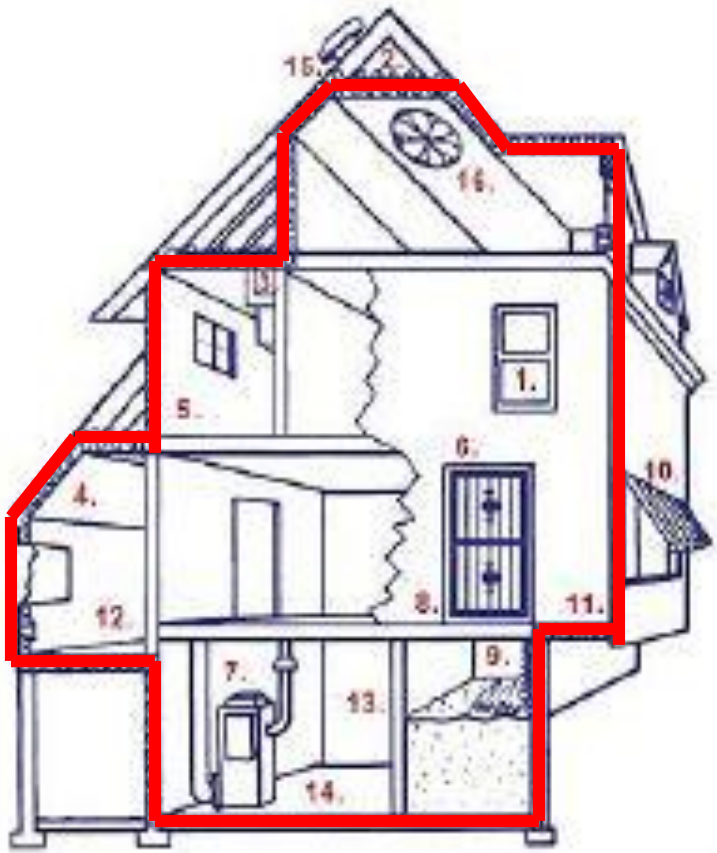
House is a "System of Systems"

- Heating / Cooling
- Ducts
- Water Heating
- Appliances
- Lighting
- Ventilation
- Insulation
- Air Barrier

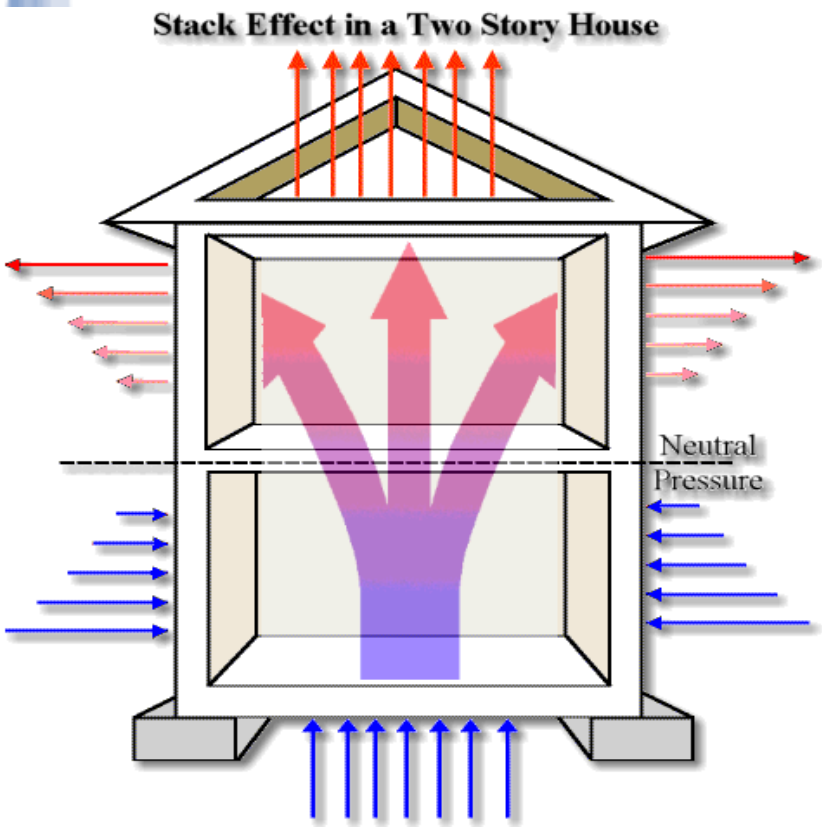


Key Point: Think "Thermal Boundary" Not Just "Insulation"

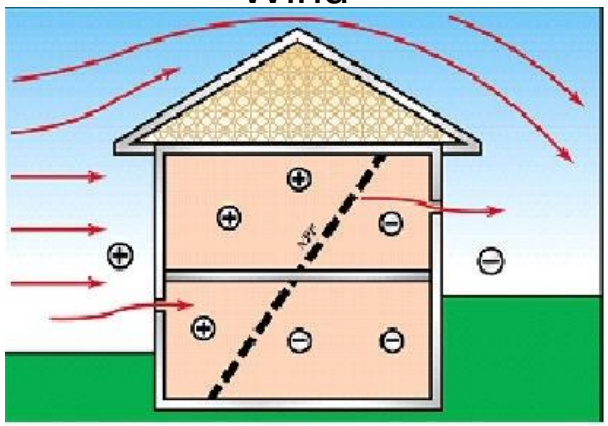
- The thermal boundary <u>must</u> be <u>air sealed</u> and <u>insulated</u>
- Adding fiber insulation over leaky attic floor is mostly ineffective
- Air Barrier vs Vapor Barrier: In most cases a breathable air barrier is desired
- A typical attic loses more energy through air leaks than under-insulation



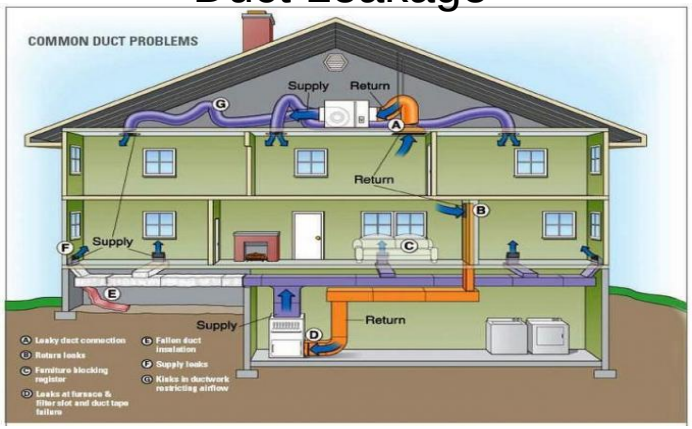
Air Movement Through a House: High to Low Pressure



Wind



Duct Leakage



Areas of High and Low Pressure Accelerate Air Leakage and Energy Loss

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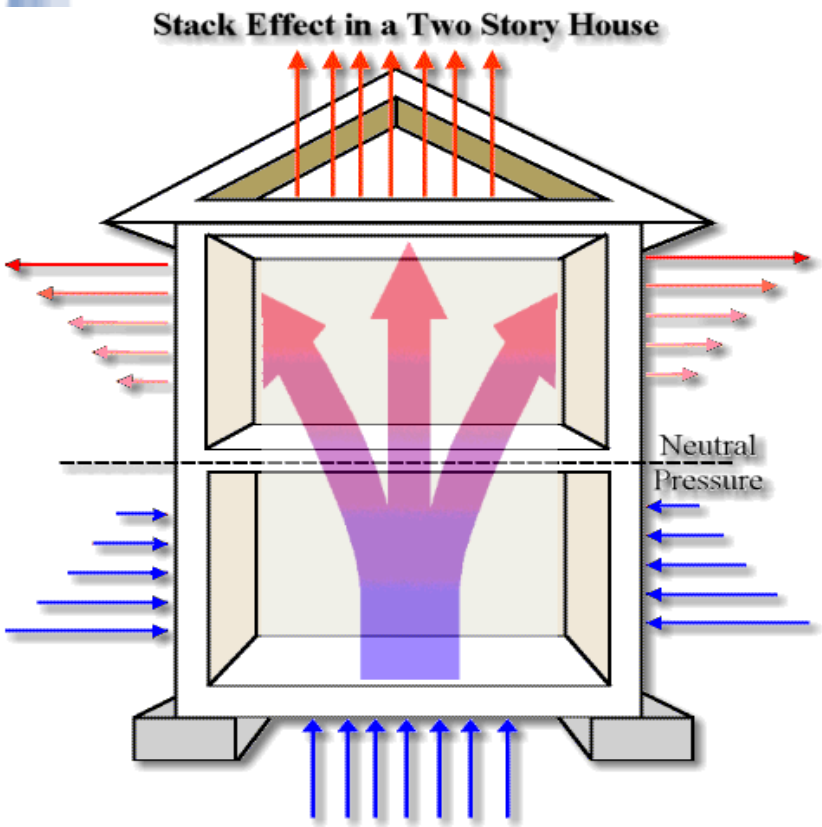

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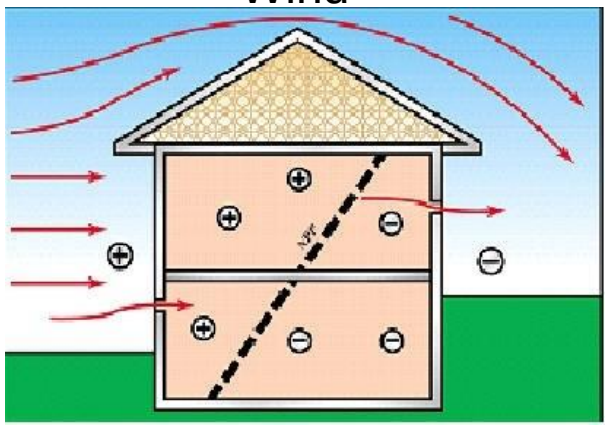

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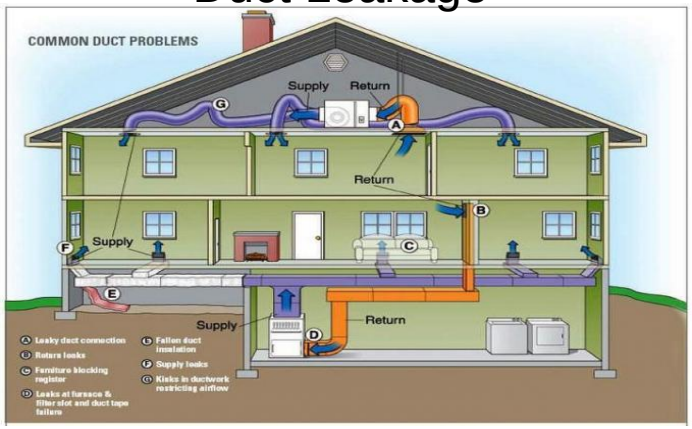
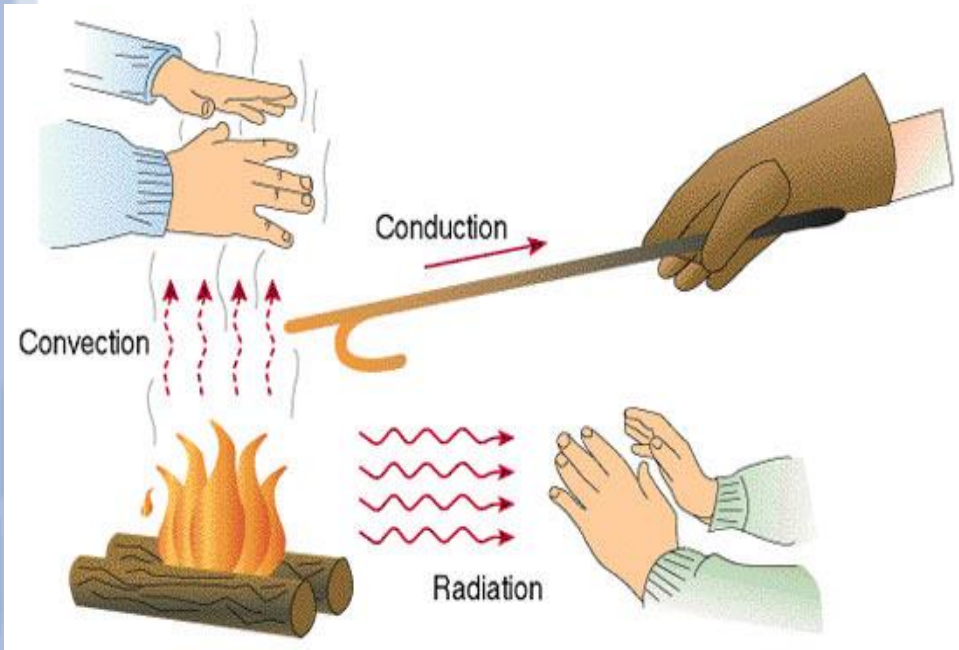


Areas of High and Low Pressure Accelerate Air Leakage and Energy Loss

The Mechanisms of Heat Transfer



- "R-value" is resistance to heat flow: Bigger is better
- Inverse of U-factor
- Wood Stud: R-1.25 per inch
- Fiberglass Batt Insulation: R-3.5 / in.
- Closed Cell Spray Foam: R-6.5 / in.
- Energy Star Window: R-3.3 (min)

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Air Barrier vs. Vapor Barrier

Air Barrier

- Stops air flow but breathes water vapor
- Examples: plywood, oriented strand board (OSB), drywall, Thermoply

Vapor Barrier

Stops air flow and water vapor

Polyethylene plastic sheet, closed cell spray foam, rigid polystyrene (blue, pink) and polyisocyanurate (tan) foam, vinyl wall paper

Where is the Thermal Boundary?

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Key Point: A House Should be as Air Tight as Possible

- Can a House be Too Tight: NO!
- Can a House be Under-Ventilated: YES
- Diagnostic testing (Blower Door Test) required to determine tightness and necessary ventilation

Build it Tight and Ventilate Right

Combustion Safety

Tight houses need:

- Combustion makeup air, or
- Direct vent furnace & water heater
- Combustion safety testing important for tight homes

Moisture: #1 Enemy of Most Building Materials

Small amount of repeated wetting can lead to:

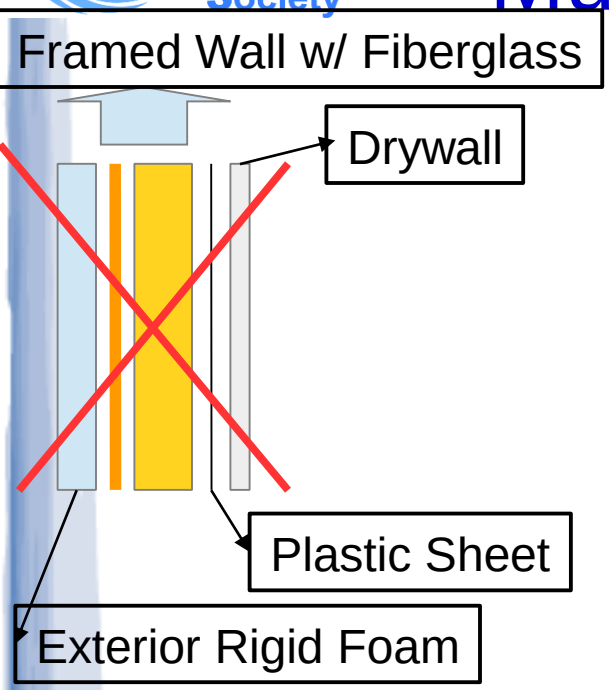
- Reduced R-value
- Mold, mildew
- Deterioration, rot

Moisture sources

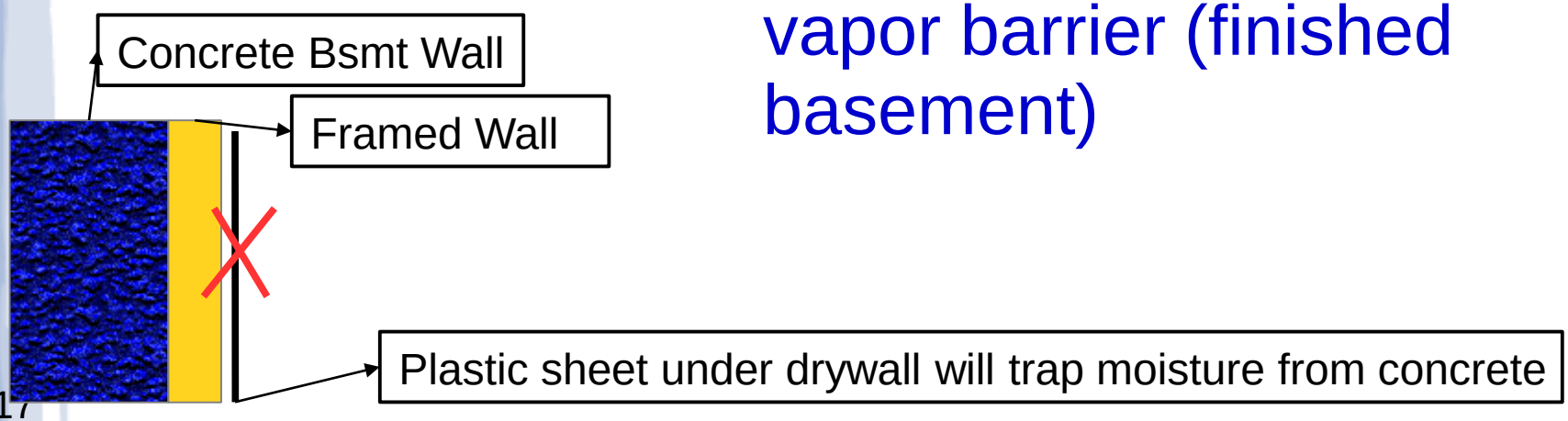
- Bulk water
- Vapor diffusion
- Air movement

Courtesy of DOW Building Materials

Key Point: Wall and Roof Units Must Breathe Water Vapor Either Inside or Outside

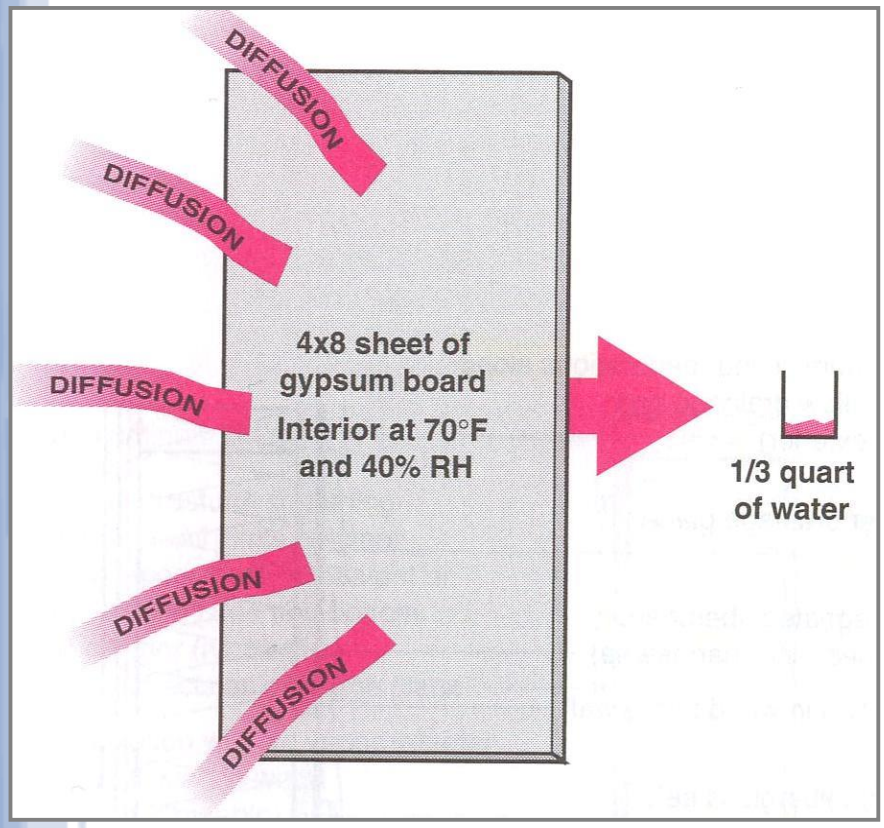


- <u>Never</u> trap a wall or roof cavity with vapor barriers on both sides
- <u>Never</u> cover the inside face of a framed wall over below grade concrete with a vapor barrier (finished basement)

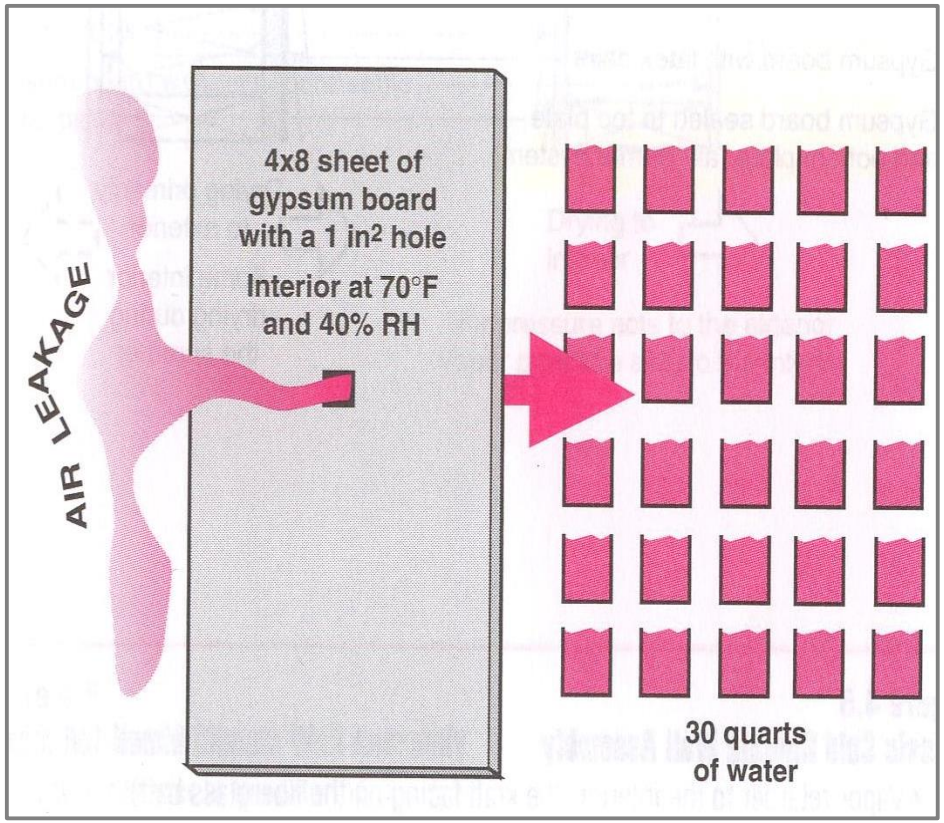


Vapor Diffusion a Slow Small Process vs. Air Leakage

Diffusion



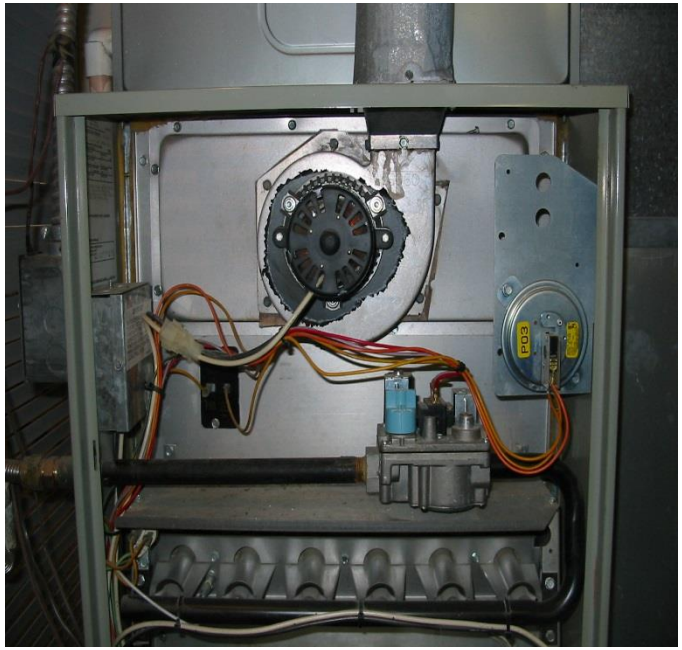
Air Leakage



From EEBA Builder's Guide to Cold Climates by Joseph Lstiburek

Space Heating

65% Efficient:
Standing Pilot



80% Efficient:
Spark Ignition

95% Efficient:
Condensing

Direct Vent, Condensing Furnaces also Offer:

- 55% more efficient motors;
- No indoor combustion air;
- Multiple fan and burner stages

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Space Cooling

- Relatively few cooling days
- Hard to recoup investment in air conditioning replacement or upgrade
- Cool, low humidity evenings create higher efficiency options
  - Evaporative coolers
  - Whole house fans
- Ensure proper attic ventilation and insulation
  - 1 sqft ventilation per 150 sqft attic floor area
  - Code requires 1:300 ratio
- Most cost effective option: block summer solar heat gain (windows and skylights)

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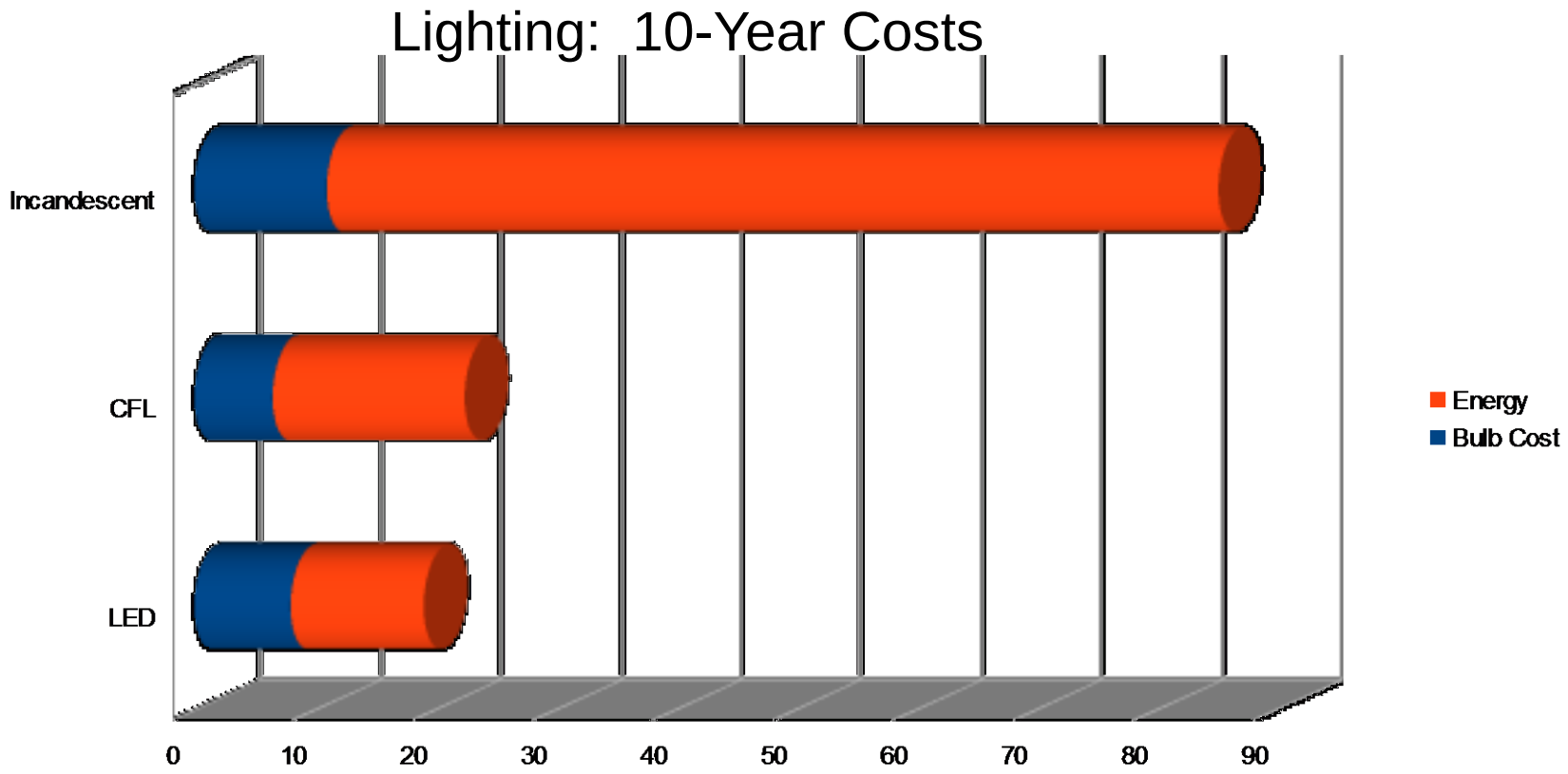
Appliances and Plug Loads

- Typical U.S. Household: 920 kilowatt-hours per month ($101)
  - Moderately efficient family: 800 kWh/month
  - Focused family: 400 kWh/month
- For typical appliances (excludes hot tubs!), refrigerators consume most electricity
  - Normally, replacing fridge >15 years old with ENERGY STAR model, the energy savings pays for new unit in 8 years
  - Decreased from 1200 kWh/year in 1990s to 550 kWh/year today
- Phantom loads approaching 20% to 25% of consumption
  - Energy consumed when device is “Off”
  - Example: DirecTV box = 22 to 25 watts when off but plugged in ($18 per year in wasted energy)

Lighting

- Typically the largest electric return on investment
- Incandescent Bulbs: 10% light + 90 % heat



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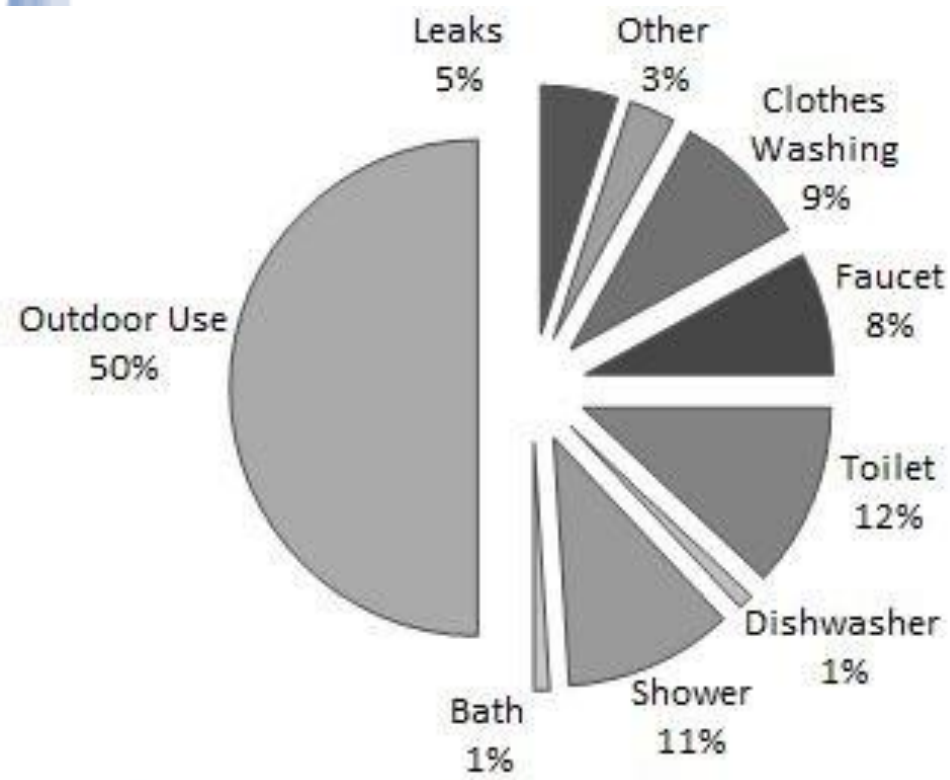
Lighting

- Conventional bulbs 10% efficient
  - Incandescent= 14 lumens/watt
  - CFL= 63 lumens/watt
  - LED= 92 lumens/watt
- Tube Fluorescent:
  - Avoid conventional T-12 (1.5” diameter) with magnetic ballast (43 watts)
  - Install T-8 (1” diameter) with electronic ballast (28 watts) or T-8 LED tube (Philips InstantFit series)
- Consider
  - Dimming: Not all CFL bulbs are dimmable
  - Outside use: CFLs very slow to brighten in cold weather
  - Recycling: CFLs contain trace mercury. Recyclable at all Home Depot

Water Efficiency

www.epa.gov/watersense/products/

Water Consumption



- EPA WaterSense: for plumbing fixtures as ENERGY STAR is for appliances
- ENERGY STAR rating for clothes and dish washers considers water consumption
- Most common leaks: irrigation and toilets

Source: Colorado State University Extension

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Irrigation

- STEP 1: Check for leaks!
- Adjust aiming and operating time to avoid runoff
- WaterSense Smart Controllers
  - Moisture and/or rain sensing
- Efficient Sprinklers
  - Drip irrigation most efficient
  - Large drop, stream spray heads
- Avoid mid-day to minimize evaporation
- Large scale savings must include elimination of “thirsty” turf

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Interior Water Consumption

- Toilets: Maximum Performance (MaP) testing
  - www.map-testing.com
  - Very good toilet: score 500 to 1000 (grams)
  - WaterSense: <= 1.2 gallons per flush

- Shower Heads: WaterSense- <=2.0 gpm
  - Tested for flow <u>and</u> quality of shower

- Faucet Aerators: WaterSense- <= 1.5 gpm
  - Available at 0.5 gpm

- Exposed Hot Water Pipes: Insulated?
- Appliance Use? Washers and Dishwashers

Water Heating

Tankless vs. Tank

Conventional vs. Condensing

Atmospheric vs. Power vs. Direct Vent

Electric vs. N. Gas

Conventional Electric vs. Hybrid Heat Pump

- Safety
- Efficiency
  - Conventional 56-70%
  - Condensing 90-96%
  - Electric 92-98%
  - Hybrid 200-250%
- Cost $600 - $2400
- Solar Augmentation?
- Boiler Sidearm Tank?

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Energy Myths vs. Building Science

- Myth: “Replace your windows and save 40% on your heating bills.” (Radio ad)
- Reality:
  - Even with single panes, heat loss through windows is 12% to 30% of total heating bill
  - Standard uncoated double pane vs. ENERGY STAR windows: R-2.2 vs. R-3.3
  - Old wood single pane vs. ENERGY STAR: R-1.0 vs. R-3.3

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Energy Myths vs. Building Science

- Myth: Save energy by turning down the thermostat and turning on gas fireplace
- Reality:
  - Typical furnace: 80% efficient
  - Typical gas fireplace: 15% to 35% efficient
  - Conventional wood fireplace: <5% efficient
- Fireplace pilot lights consume $12 to $20 per month. Turn them off in summer!

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Energy Myths vs. Building Science

- Myth: Always start in attic when adding new insulation
- Reality:
  - Typically, uninsulated basement or crawl space walls wastes 5 times more energy than an under-insulated attic
  - Know the payback time when considering additional attic insulation

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Energy Myths vs. Building Science

- Myth: One can seal a house too much...a house needs to breathe.
- Reality:
  - A house can <u>never</u> be too tight...but it can be under-ventilated
  - Best to "Make it tight and ventilate right" using efficient, controlled ventilation

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Energy Myths vs. Building Science

- Myth: Add more insulation to stop air leaks into attic.
- Reality:
  - Fiberglass and cellulose are <u>not</u> air barriers
  - Air leakage typically wastes more energy than insufficient insulation

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Energy Myths vs. Building Science

- Myth: Spray-in exterior wall foam is cost effective (in finished wall)
- Reality:
  - Sometimes true in 80 year old home with zero insulation
  - In typical 3000 sq ft house, cost> $1.70 per sqft, savings< $0.07 per sqft

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Resources

- Appliance, Furnace, Air Conditioning, Fans Search: www.energystar.gov
- Light bulb and appliance review: www.consumerreports.org
- WaterSense Product Search: www.epa.gov/WaterSense/product_search.html
- ENERGY STAR Seal and Insulate DIY Guide: energystar.gov/ia/partners/publications/pubdocs/DIY_Guide_May_2008.pdf?12dd-7c2e

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QUESTIONS?

Link to slides: secres.org/taming

Upcoming Sessions:

- October 10th: DIY and professional energy and water audits/assessments
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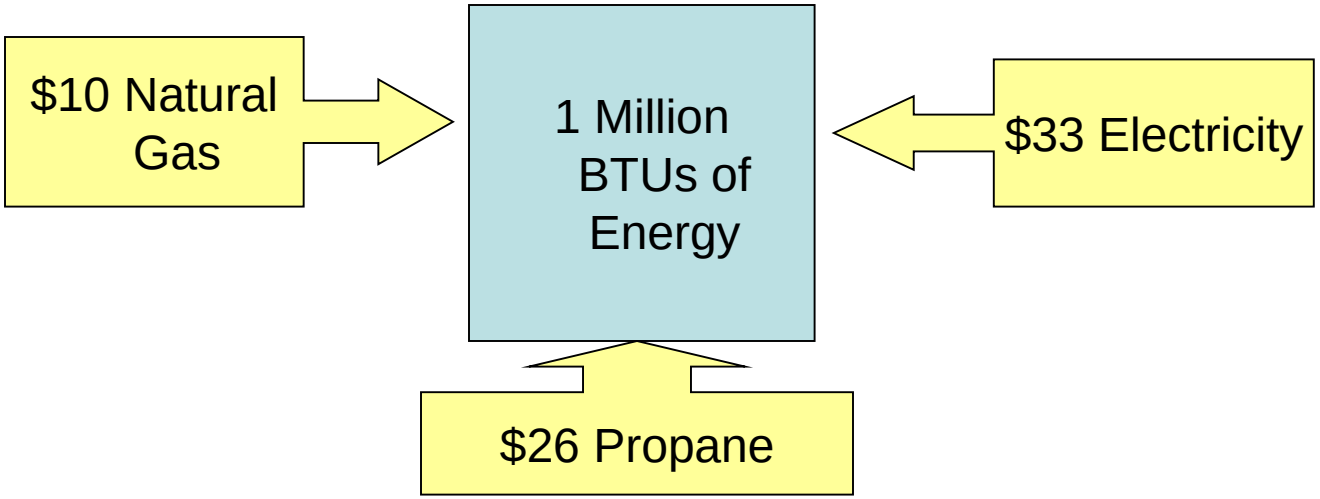
Backup

Heating Fuels and Current Costs



- Higher efficiency not always the most cost effective option
- Example for 90 MBTU annual heating requirement
  - 95% efficient gas furnace ($4500 installed): $900 fuel cost
  - 400% efficient electric ground source heat pump ($35,000 installed): $745 electricity cost
  - 197 year payback time

Selecting Heating and Cooling Equipment

- Step 1: Always first reduce heating and cooling requirements through passive means
- Step 2: Select balance between comfort, cost, ease of use, efficiency
- Step 3: Have equipment properly sized for actual requirements using industry standards (ACCA Manual J, Manual S)

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Mechanical Heating Options

Device	Cost	Pros	Cons
Gas Forced Air Furnace	$4500	• Efficiency up to 98% • Reliable •Cost •Compatible with a/c	•Requires ducts •Volatile fuel cost • Comfort, dust
Gas Boiler Hydronic Radiant	$6900	• Higher system efficiency than furnace •Comfort •Domestic water heat •Solar augmentation •Easy zoning	• No ducts for a/c • Response time • Higher cost than furnace
Ground Source Heat Pump	$35000	• Very high efficiency • Water-to-air or water-to-water •Partial heating of domestic hot water •Heating and cooling	• Cost •Misleading efficiency data: Circulation pump consumption
Mini-Split Air Source Heat Pump	$5500 (2 zones)	•Very high efficiency •Heating and cooling •Ductless	•Zoning and heat distribution

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Condensing vs. Non-Condensing Furnaces

Condensing

- 90+% Efficiencies
- Direct vent (Sealed Combustion)
- Eliminate combustion make-up air ducts
- Will not depressurize house (when direct vent)

Non-Condensing

80% Efficient

Pulls combustion air from house

Building code requirements for make-up air

$950	Annual Fuel Cost for Typical 3000 Sq Ft House	$1070

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Mechanical Cooling Options

Device	Cost	Pros	Cons
Conventional Air Conditioning	$3500 to $6000	• Reliability •Cost •Responsiveness	•Requires ducts •Electrical consumption
Direct Evaporative Cooler	$4500	• 1/4th energy use of a/c •No ducts •Cost	• Maintenance • Water consumption • Increased humidity
Whole House Fan	$500 to $1200	• 1/4th energy use of a/c • No ducts • Cost	• Control during day • Allows entry of pollen and allergens •Requires homeowner action to open/close windows
Mini-Split Air Conditioner	$4500	• Very high efficiency • No Ducts	•Zoning and distribution