Public Education Seminar Series

Session 1: Energy and Water Efficiency Basics

September 12th, 2015
Jim Riggins, info@secres.org
Overview

- The Thermal Boundary
- Space Heating and Cooling
- Appliances
- Lighting
- Water Consumption
- Myths vs Building Science
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
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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Where Does the Energy Go?

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

Source: U.S. EPA
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 must be air sealed and insulated
- 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

Stack Effect in a Two Story House

Areas of High and Low Pressure Accelerate Air Leakage and Energy Loss
Air Movement Through a House: High to Low Pressure

Stack Effect in a Two Story House

Wind

Duct Leakage

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)
# Air Barrier vs. Vapor Barrier

<table>
<thead>
<tr>
<th>Air Barrier</th>
<th>Vapor Barrier</th>
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</thead>
<tbody>
<tr>
<td>- Stops air flow but breathes water vapor</td>
<td>- Stops air flow and water vapor</td>
</tr>
<tr>
<td>- Examples: plywood, oriented strand board (OSB), drywall, Thermoply</td>
<td>- Polyethylene plastic sheet, closed cell spray foam, rigid polystyrene (blue, pink) and polyisocyanurate (tan) foam, vinyl wall paper</td>
</tr>
</tbody>
</table>
Where is the Thermal Boundary?
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

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

Plastic sheet under drywall will trap moisture from concrete.
Vapor Diffusion a Slow Small Process vs. Air Leakage

Diffusion

4x8 sheet of gypsum board
Interior at 70°F and 40% RH

1/3 quart of water

Air Leakage

4x8 sheet of gypsum board with a 1 in² hole
Interior at 70°F and 40% RH

30 quarts of water

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
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)
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
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
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
Irrigation

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Interior Water Consumption

- **Toilets: Maximum Performance (MaP) testing**
  - [www.map-testing.com](http://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 and 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

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

- Tankless vs. Tank
- Conventional vs. Condensing
- Atmospheric vs. Power vs. Direct Vent
- Electric vs. N. Gas
- Conventional Electric vs. Hybrid Heat Pump
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
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!
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
Energy Myths vs. Building Science

- Myth: One can seal a house too much...a house needs to breathe.
- Reality:
  - A house can never be too tight...but it can be under-ventilated
  - Best to “Make it tight and ventilate right” using efficient, controlled ventilation
Myth: Add more insulation to stop air leaks into attic.

Reality:
- Fiberglass and cellulose are not air barriers
- Air leakage typically wastes more energy than insufficient insulation
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
Resources

- Appliance, Furnace, Air Conditioning, Fans Search: [www.energystar.gov](http://www.energystar.gov)
- Light bulb and appliance review: [www.consumerreports.org](http://www.consumerreports.org)
- WaterSense Product Search: [www.epa.gov/WaterSense/product_search.html](http://www.epa.gov/WaterSense/product_search.html)
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)
# Mechanical Heating Options

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

<table>
<thead>
<tr>
<th>Condensing</th>
<th>Non-Condensing</th>
</tr>
</thead>
<tbody>
<tr>
<td>90+% Efficiencies</td>
<td>80% Efficient</td>
</tr>
<tr>
<td>Direct vent (Sealed Combustion)</td>
<td>Pulls combustion air from house</td>
</tr>
<tr>
<td>Eliminate combustion make-up air ducts</td>
<td>Building code requirements for make-up air</td>
</tr>
<tr>
<td>Will not depressurize house (when direct vent)</td>
<td></td>
</tr>
</tbody>
</table>

### Annual Fuel Cost for Typical 3000 Sq Ft House

- **Condensing:** $950
- **Non-Condensing:** $1070
# Mechanical Cooling Options

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