Residential Building Performance & Engineering

Nexxt Builders LLC

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Overview

- Understanding Energy Basics
- Building a Tight Thermal Envelope
- Designing an Efficient HV/AC System
- Insuring Proper Ventilation


Energy Basics

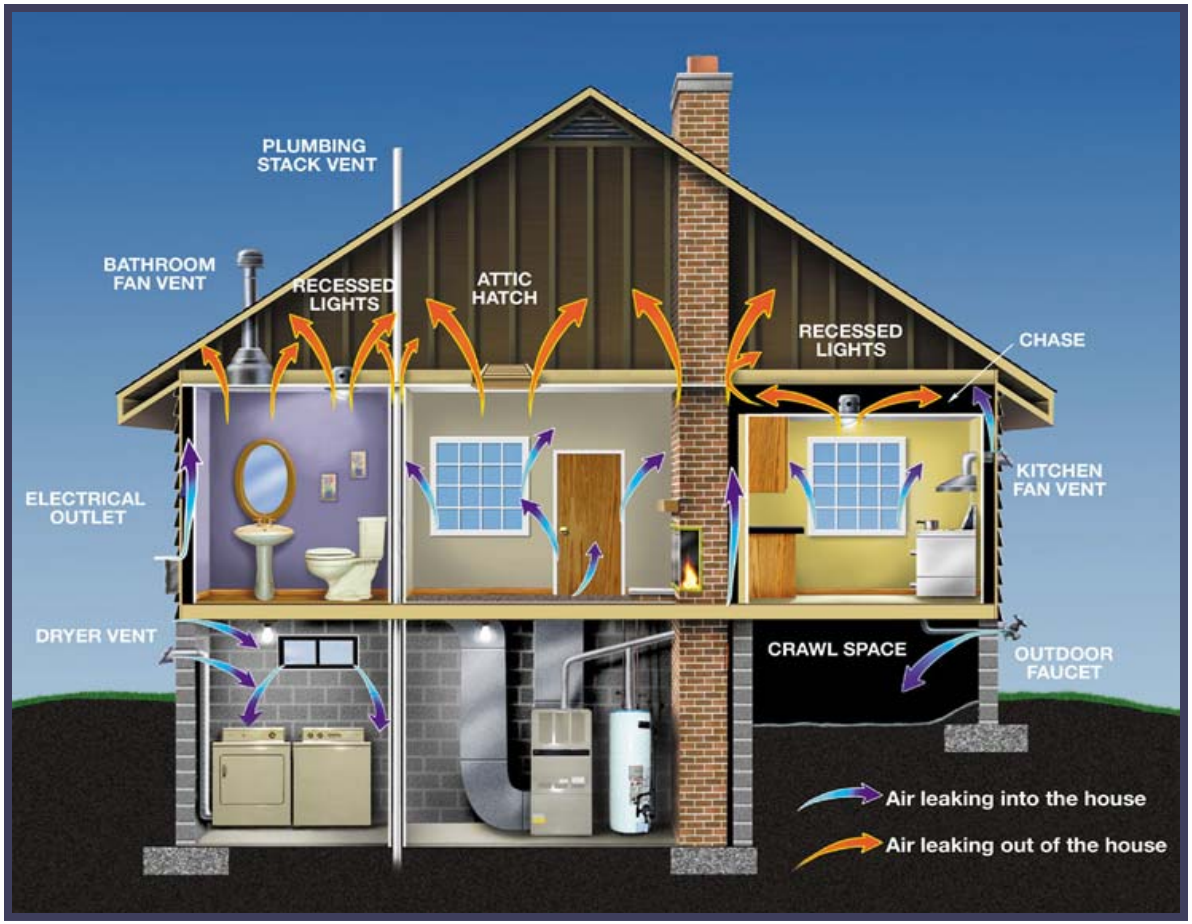
Heat Transfer

- Conduction- movement of heat through solid materials
  - Example- the heat in cup of hot coffee on cold day will move through the cup and out to the cold
  - Thermal insulation is designed to minimize and slow down this process through floors, walls, ceiling, windows, and roof
  - Movement of heat happens in all directions- i.e. “heat rises” , but it also moves through gaps in walls, ceilings, floors

Heat Transfer

- Convection- heat transfer through the movement of fluid or air
  - The **stack effect** is what most people refer to when they say “Heat Rises”
  - HV/AC system – The movement of air by a electric blower
  - Outside wind– Contrary to popular belief, the effect of average wind on home is minimal

Heat Transfer

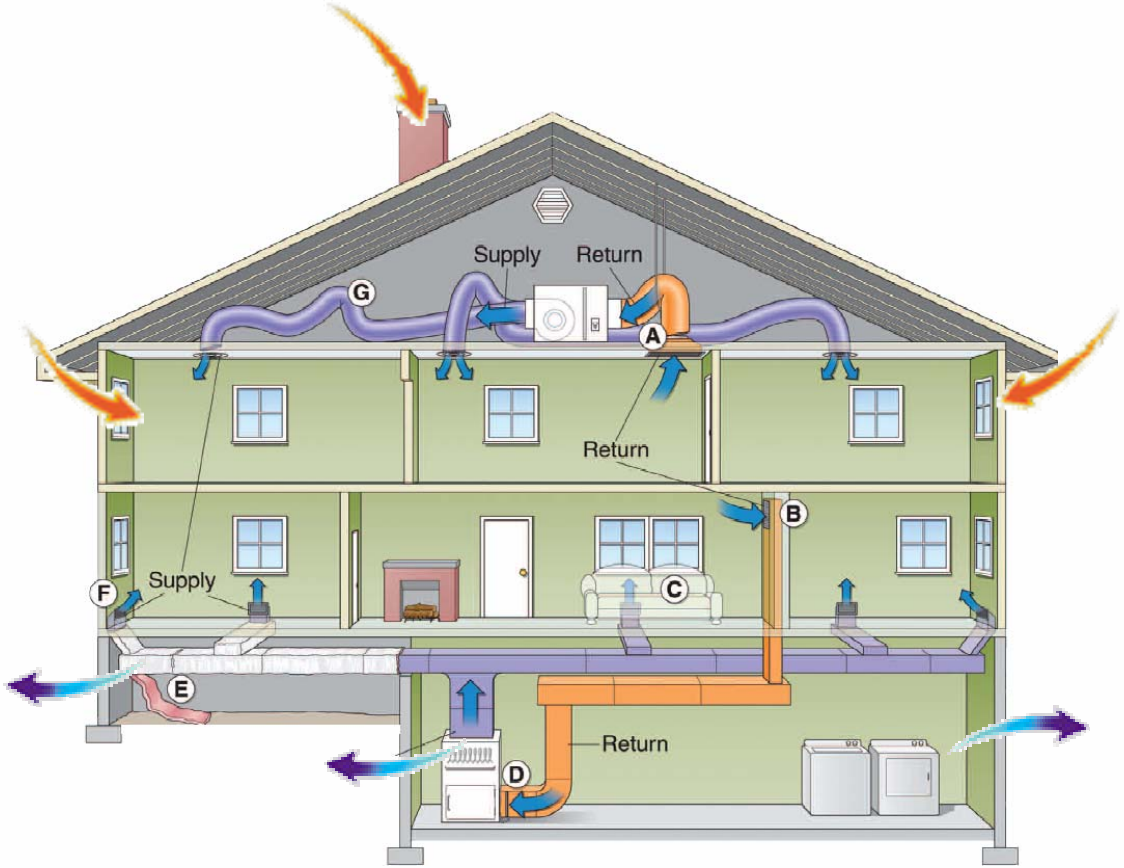


US Energy Star Program - http://www.energystar.gov/

Stack Effect - Winter

- As air becomes heated, it rises
- Warm air **leaks out** through gaps in the upper building envelope
- Cold air **leaks in** to replace warm air through gaps in lower building envelope
- There is a direct relationship between the force of air movement inside the home to the difference between interior and exterior temperatures
- Stack effect can create air quality issues

Heat Transfer



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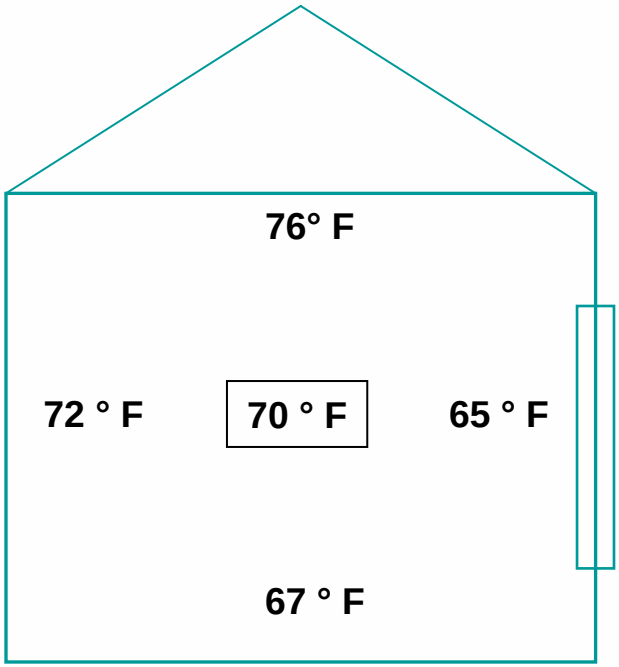
Stack Effect Summer

- Cold dense air sinks and **leaks out** through gaps in the lower building envelope
- Warm air **leaks in** through gaps in the upper building envelope
- Biggest cause of hot second floors is the 140°F attic

Heat Transfer

- Radiation-the transfer of heat from one object to another through space
  - Need a direct **line of sight**
  - **Solar heat gain** is the biggest cause of AC loads in the summer
  - Low E-film on windows reduces heat loads by reducing **solar radiation**
  - Argon gas between window pane reduces **heat conduction**

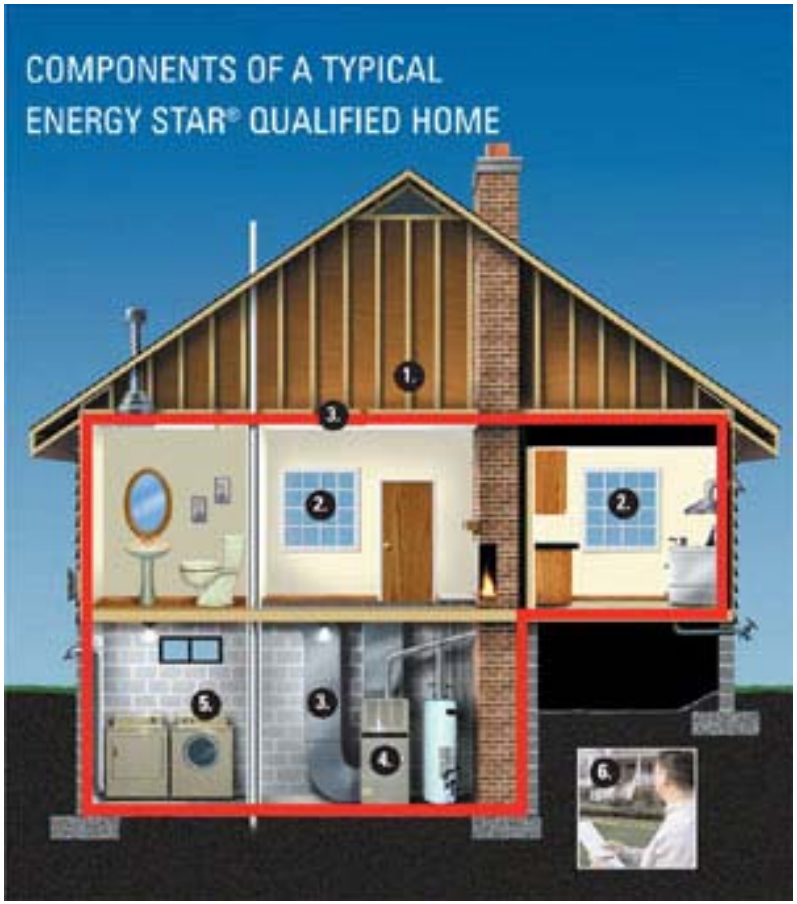
Mean Radiant Temperature



1. Average room temperature is **70°F**
2. Sitting near the window can make one feel the temperature is **65° F**
3. Walking on the cold floor may be too cold for comfort at **67°F**
4. To keep the room comfortable, the thermostat may be set to **72°F**


Thermal
Envelope

Thermal Envelope



US Energy Star Program - http://www.energystar.gov/

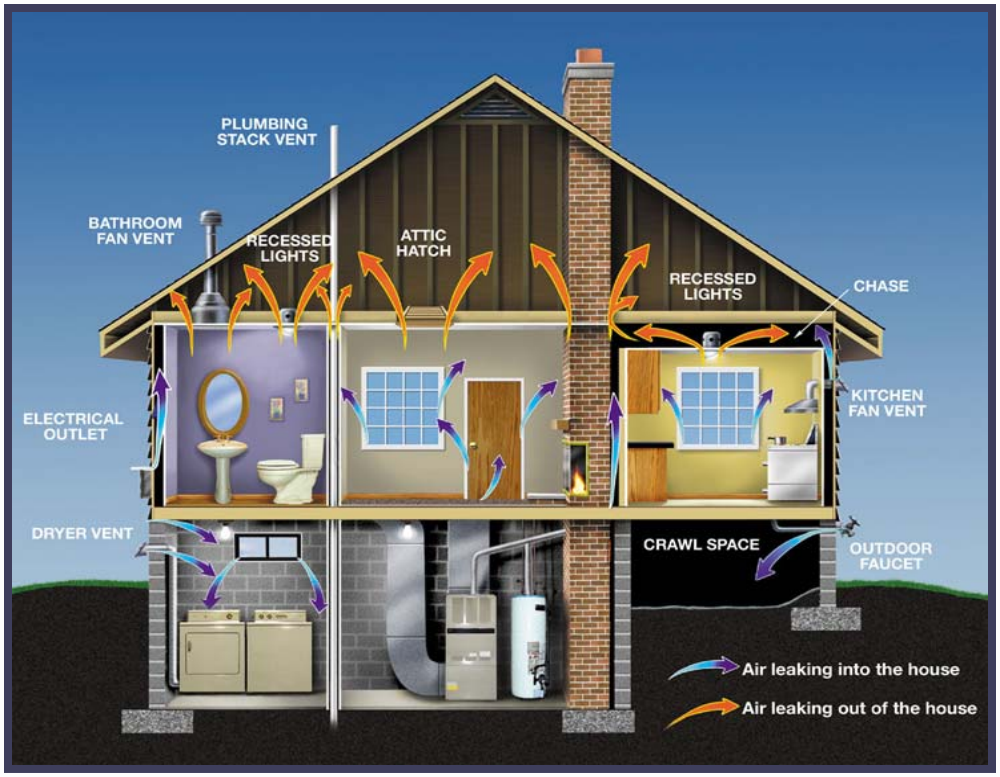
- A clearly defined thermal boundary of a building that separates conditioned space from unconditioned space

An Effective Thermal Envelope

- Is continuous and uninterrupted
- Creates an effective air barrier
- Controls water vapor
- Reduces the transfer of energy

Air Barriers

- The common misconception "**A house has to breathe**"
- House wrap and sheathing
- Fiberglass and cellulose insulation can **act as a filter**
- Most air leaks take place in **complex assemblies**
- Can a house be **"too air tight"**
- **Controlled fresh air**



Controlling Vapor

- By code a vapor barrier is a material with a permeability of **less than 1 Perm** (i.e. polyethylene).
- A 500 ft crawl space can produce up to 5 gallons of water vapor per day
- In most regions of the country, building codes now **allow for conditioned crawl spaces**
- Basement slabs must have **vapor barrier** (typical 6 mil poly)
- In cold climates, concrete slabs should have at least **1" of high density foam** to prevent condensation

Wet Basement Solutions Inc- http://www.wbsnh.com/

Controlling Vapor

- Properly vent dryers, bathroom fans, and kitchen exhaust
- An average family of four through normal activity can produce up to 3 gallons of water vapor (US Department of Energy)
- During the heating season, air leaks into the cold attic can cause condensation and result in frost, mildew or structural damage

Minimize Thermal Transfer

- ***R-value*** is the measurement of how effectively a material resists the transfer of heat via conduction. The higher the R-value, the less heat transfer can take place.

- **Common Min. R-Values**
  - Basement slabs 0-14
  - Exposed floors 13-30
  - Exterior Walls 13-25
  - Ceilings 30-60

Common Type of Insulation

- Fiberglass Batts, R-Value 3/ in
- Loose fill Fiberglass, R-value 1.8/ in
- Loose fill Cellulose, R –value 3.3/in
- Rigid Foam Board, R-value 3/in -7/in
- Spray-in Foam, R-value 3/in -7/in

Energy codes vary. Always check your local building code to ensure compliance.

Minimize Thermal Transfer

Using Spray Foam

- Open Cell Spray foam- R-value 3.4 / in
- Sprays on and expands to 100 times its size
- Will expand and fill all voids including odd shapes and hard to reach crevasses
- Acts as a excellent thermal and air barrier
- To achieve R-19 value in 2x6 wall, a cavity is filled 2/3

Minimize Thermal Transfer

- Unvented Attics
  - Until recently, the IRC required attics to be vented
  - The foam is sprayed directly onto the sheathing
  - Anything below the foam becomes conditioned space
  - Lowers cooling load on AC
  - If there are leaks in HV/AC ducts, it remains within conditioned space

Efficient Windows

Reading the label

- **U-Factor**-this represents conductive heat loss. The lower the number, the better the window.
- **U-Factor** is the inverse of R-Value
- **SHGC**- the amount of direct solar radiant heat gain
- **SHGC**- if this is lower, less summer heat gain
- **Visible Transmittance-** measure of how much visible light gets through
- **Air Leakage-** the equivalent cubic feet of air passing through a square foot of window area
- **Condensation Resistance-** ability of the window to resist condensation- higher is better

Efficient Windows

Cold Climate

- **U-Factor**-is the primary concern.
- **SHGC**- higher SHGC for south facing windows- free solar heat gain
- **SHGC-** lower SHGC for east – west windows

Mixed Climate

- Compromise between the two

Hot Climate

- **SHGC**- is the primary concern. Minimize amount of direct solar radiant heat gain
- **Low- E**- coating reduces radiant heat gains. The coating reflects the radiant rays away from the home
- **VT**- should be higher than SHGC


Efficient
HV/AC

Overview

- Gas Furnaces
- Air-Heat Pumps
- Geothermal-Heat Pumps
- A/C

Gas Furnaces

90%+ AFUE Direct Vent

1. Separate intake & exhaust
2. Combustion air sourced from outside
3. Efficiency up to 96%
4. Easy to vent- horizontal or vertical with Schd. 40 PVC

80% AFUE Conventional

1. Single exhaust
2. Combustion air sourced from inside house
3. Efficiency up to 85%
4. Requires galvanized or brick flue- minimum clearance requirements

AFUE

AFUE (annual fuel utilization efficiency) is the measurement of how efficiently a gas furnace or boiler will operate over an entire heating season.

The AFUE is expressed as a percentage of the amount of energy consumed by the system that is actually converted to useful heat.

New 95% Furnace vs. Old 75% Furnace at $1.13 / Therm
Potential Saving of $92/ month- for a 2,200 home (15 hours use / day)

Heat Pumps and HSPF

1. HSPF (heating seasonal performance factor) is the measurement of how efficiently heat pumps will operate in their heating mode over an entire normal heating season. The higher the HSPF, the more efficient the system.

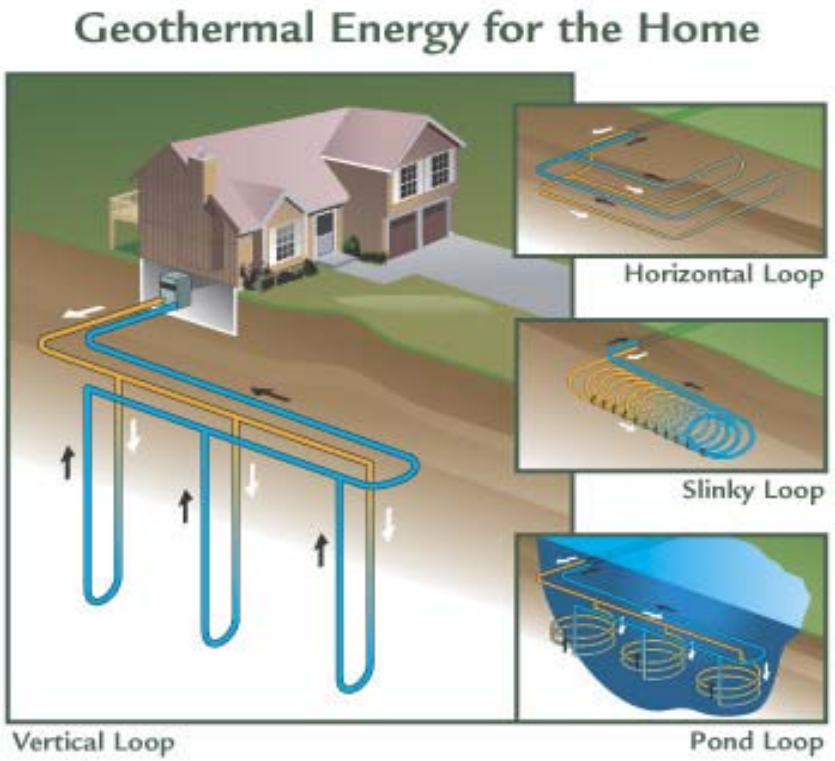
2. Most heat pumps installed today have HSPFs in the 7.0 to 8.0 range, meaning they operate with seasonal efficiencies of anywhere from 205% to 234%.

3. This means that, for every one Btu-worth of energy they use over the entire heating season, these systems will put out anywhere from 2.05 to 2.34 Btu of heat.

Air - Heat Pumps

1. Rating HSPF 6 – 9 (200% to 300%)
2. Requires more air movement than furnaces
3. Optimal efficiency when outdoor air temp is above 40° F
4. Auxiliary heat costs 2-3 times more than compressor driven system

Geothermal-Heat Pumps



1. Extract heat from earth or water
2. Ground temperature more stable (50°F) than air – more efficient than air heat pumps
3. May not need auxiliary heat
4. Even more efficient for cooling
5. Up to 31 EER
6. Expensive- up to $100,000

EER (energy efficiency ratio) is a measure of how efficiently a cooling system will operate when the outdoor temperature is at a specific level (usually 95° F). A higher EER means the system is more efficient.

Comparison

Outdoor Temperature	Fuel Type	Fuel Unit	Fuel Price Per Unit (dollars)	Heating Appliance Type	Type of Efficiency Rating	Effiency Rating or Estimate	Approx. Efficiency (%)	Fuel Cost Per Million Btu (dollars)
30°	Electricity	KiloWatt-hour	$0.111	Air-Source Heat Pump	HSPF	5.5	161%	**$ 20.09**
55°	Electricity	KiloWatt-hour	$0.111	Air-Source Heat Pump	HSPF	*8.5*	249%	**$ 13.00**
30°	Electricity	KiloWatt-hour	$0.111	Geothermal Heat Pump	COP	4.0	400%	**$ 3.33**
55°	Electricity	KiloWatt-hour	$0.111	Geothermal Heat Pump	COP	4.0	400%	**$ 3.33**
30°	Natural Gas	Therm	$1.33	Furnace	AFUE	95.0	95%	**$ 14.03**

A/C

1. SEER rating 10 – 21
2. Efficiency increases after 10-15 minutes operation
3. Proper sizing based on climate
4. Reduces solar & internal gain

SEER

1. *SEER* (seasonal energy efficiency ratio) measures how efficiently a residential central cooling system (air conditioner or heat pump) will operate over an entire cooling season, as opposed to a single outdoor temperature.

2. SEER= $\frac{\text{Seasonal Btu of cooling}}{\text{Seasonal Watts Used}}$

3. 10 = $\frac{129{,}600{,}000}{12{,}960{,}000}$ Total Cost = $1,296 Cost / Month = $324

4. 20 = $\frac{129{,}600{,}000}{6{,}480{,}000}$ Total Cost = $648 Cost / Month = $162

(based on 5-ton unit, 18 hrs/day, 4 months/year, $0.10 / kWh)

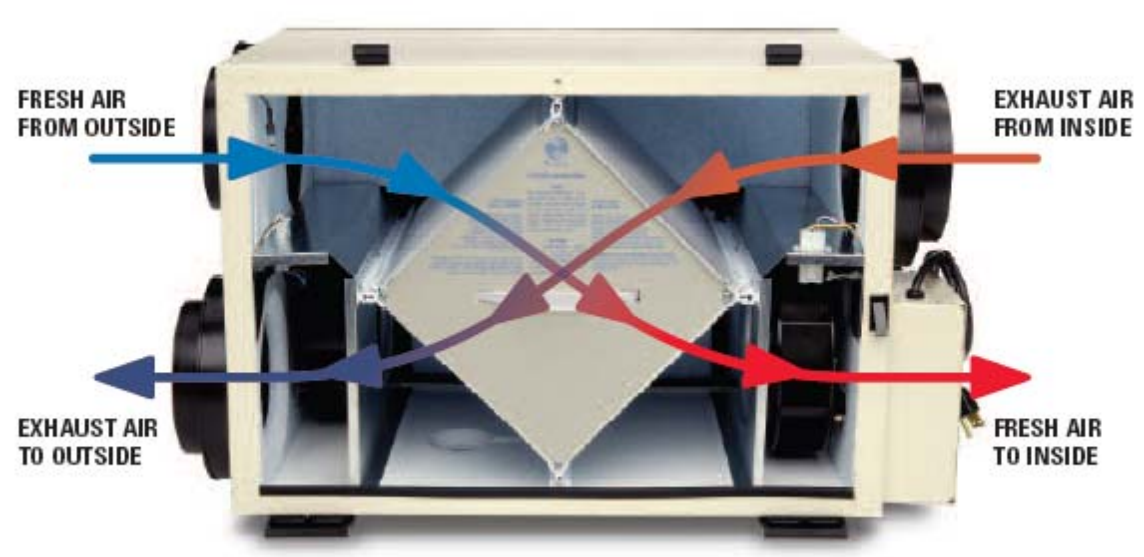
Proper Ventilation

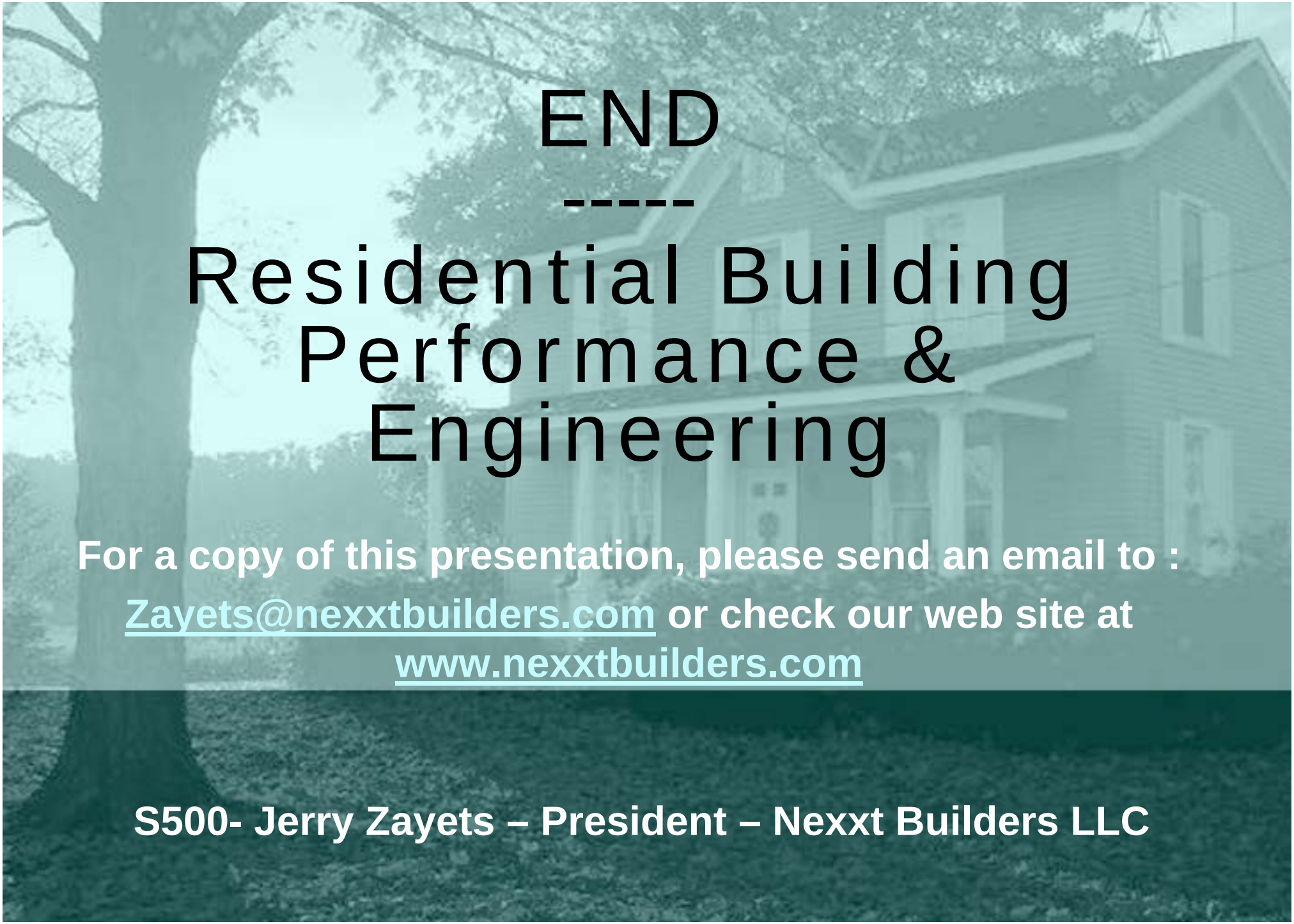
- Energy Recovery Ventilation and Heat Recovery Ventilation- 300 CFM -1200CFM
- Bathroom exhaust fans – 70 CFM – 120 CFM
- Kitchen exhaust hoods – 100 CFM – 300 CFM

Proper Ventilation

Energy Recovery Ventilation

- Pull air from bathrooms, kitchen and bedrooms, it run the air through heat exchanger and it pre-heats incoming air
- Stale and fresh air don’t mix but move through recovering up to 85% of the radiant energy
- ERV can be tied in to the return lines of HV/AC system





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