Poor Spray foam installation
Insulating is a system

More choices offer better performance
Careful installation of all insulating systems are essential for good performance
Blown cellulose insulation
High density blown fiberglass
SPF- spray polyurethane foam
SPF- spray polyurethane foam
Again....benefits of exterior insulation
New products and techniques
Surface temperature calculation - 2 x 6 walls, w/ R-19 insulation

Temp. @ sheathing = 17.1°F

70°F / 30% RH, Dewpoint = 37.2°F

12°F

Air leakage can cause condensation

4% of total thermal resistance is outside (only OSB)
Climate Zone 6 - 2 x 6 wall, R-19 cavity Insulation

Temperature at cavity side of sheathing - R-19 cavity w/ R-10 ext.

Dewpoint at 30% RH, 70°F

Potential for condensation

Mean daily temperature
Surface temperature calculation - 2 x 6 walls, w/ R-19 insulation + R 10 ext.

Temp. @ sheathing

\[ \text{In} = 70^\circ F / 30\% \text{ RH} \]
\[ \text{DewPoint temp.} = 37.2^\circ F \]

\[ \text{Out} = 12^\circ F \]

41% of the total wall R-value is outside sheathing plane (OSB)
Minneapolis, MN - 2 x 6 wall w/ R-10 foam sheathing

Temperature at cavity side of sheathing - R-19 cavity w/ R-10 ext.

Dewpoint at 30% RH, 70°F
Dewpoint at 25% RH, 70°F

Potential for condensation

Mean daily temperature

MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR
Class III Vapor retarders (semi-permeable) are permitted if:

Permeance of $< 10$ or $> 1.0$

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Minimum Cont. Insulation R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 x 4 walls</td>
</tr>
<tr>
<td>Marine &amp; Zone 4</td>
<td>R-2.5</td>
</tr>
<tr>
<td>Zone 5</td>
<td>R-5</td>
</tr>
<tr>
<td>Zone 6</td>
<td>R-7.5</td>
</tr>
<tr>
<td>Zones 7 &amp; 8</td>
<td>R-10</td>
</tr>
</tbody>
</table>
Summary of Proper Insulation

- R-Value is assured
- Reduce thermal bridging
- Calculation for load & equipment match
- Thermal comfort is provided
- Sound reduction occurs
- Energy savings
Innovative wall systems

- Alternate methods can provide benefits
Wood dominated industry

Wood constitutes 84% of residential construction

1.3 million single family detached built annually

What constitutes the other 16%?
Structurally insulated panels provide high R-Value assemblies
ICF Subdivision
Window Systems
Windows

- Provided natural light and ventilation
- Passive solar heat
- Architectural element
- 1/3 to 2/3 thirds of total AC loads
What defines high performance windows?

- Heat gain & heat loss reduction
- Energy efficiency
- UV light reduction
- Durability
- Wind and rain resistance

Four technologies are common:

1. Low emissivity coatings
2. Insulated spacers
3. Gas filled
4. Insulated frame tech.
Windows exhibit each type of heat transfer – both summer and winter!

- **Conduction** – through the frame, spacer, and glass
- **Convection** – inside, outside, and between the glass
- **Radiation** – direct, re-radiated, inside, outside, and between the glass
Summertime Heat Gain

Windows exhibit each type of heat transfer – both summer and winter!

Conduction – through the frame, spacer, and glass

Radiation – direct, re-radiated, inside, outside and between the glass

Convection – inside, outside and between the glass
HIGH PERFORMANCE HOMES AND KEY WINDOW
CONSIDERATIONS YOU DON’T GENERALLY THINK
OF…

- Solar energy gain
- AC loads
- Comfort
- Condensation
- Installation
- COST
Windows and Thermal Comfort

http://www.cardinalcorp.com/technology/applications/comfort-calculator/
Windows and Thermal Comfort

Comfort Calculator

BACK OF ROOM COMFORT ONLY
In this location, the winter night comfort is better than the summer day comfort with the room vents open.

COMFORT WITH SHADES OPEN
In this location, the winter night comfort is better than the summer day comfort with the room vents open.

WINTER NIGHT

SUMMER DAY

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>GLASS TYPE</th>
<th>INSULATION</th>
<th>WINDOW AIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>TORONTO, ON</td>
<td>2P</td>
<td>1.8MM</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>MEDIUM</td>
<td>AIR</td>
<td>CLASS 1</td>
<td></td>
</tr>
</tbody>
</table>

| ENERGIE      | 3.12       | 0.60       |
| HEAT TRANS    | 82%        | 0.75       |
| LIGHT TRANS   |            |            |
Windows and Thermal Comfort
Does Triple Pane really make a difference?

ASHRAE 55 and Windows: Zone 5-6:
  – 1m from glass, patio door
  – Winter: Acceptable room side glass threshold temp= 57F or 14C
  – Summer: Discomfort comes from any hour/elevation with solar gain greater than 70 btu/hr-ft²·°F

• Single, metal frame:
  – Winter: 3000+ hrs of discomfort
  – Summer: 300+ hrs of discomfort

• Double, insulated, SHGC 0.55
  – Winter: 500+ hrs of discomfort
  – Summer: 75+ hrs of discomfort

• Triple: insulated, SHGC 0.22
  – Winter: negligible
  – Summer: negligible
WHY PICK BETTER THAN MINIMUM GLASS?
Effective R-value
Triple Glazing vs. R5 Sheathing

A building with R20 batt walls and triple glazed windows has a **Higher Effective R-value** than a building with R20 batts walls + **R5** sheathing and double glazed windows.
Effective R-value
Triple Glazing vs. R10 Sheathing

A building with R20 batt walls and triple glazed windows has a Higher Effective R-value than a building with R20 batts walls + R10 sheathing and double glazed windows.

ABOVE 20% Window-to-Wall Ratio USE Triple Glazing
House before & after improvements

Standard Clear Double Glazed
U = .65
SHGC = .68
4.0 Ton AC Unit

Double Glazed Low-e, Low SHGC
U = .32
SHGC = .32
2.5 Ton AC Unit

A Tale of Two Houses
Condensation Resistance

Healthy Relative Humidity and Windows.

- Bacteria
- Viruses
- Fungi
- Mites
- Respiratory Infections
- Allergic Rhinitis and Asthma
- Chemical Interactions
- Ozone Production

ASHRAE recommended winter design level vs. % Relative Humidity.
Condensation Resistance

Healthy Relative Humidity and Windows.

![Graph showing conditions for window condensation](image)

- Triple-pane with two low-e coatings
- Double-pane
- Single-pane

![Image of condensation on window](image)
A Deeper Look:

Why better windows are suddenly a no-brainer

• Overall effective R value at 12.5% WWR: Triple Pane (U 1.1>) is equivalent to adding more continuous insulation (R5) to a 2x6 wall.

• No learning curve for framer and trades

• Increased condensation resistance for owner(higher interior RH)

• Potential decrease in AC or ASHP tonnage cost

• Annual operating expense decreased by approx. $200 annually(with both heating and cooling combined)

• Occupant more comfortable in the living room easy chair….
In your experience how much control do you have on orientation, site-scaping & house design?
Roof Systems
What does a roof system need?

- Protection from rain penetration
- Drainage
- Flashing
- Durability
- Ventilation (always needed?)
- Proper insulation levels

Sound like our wall systems?
Hipped roof details make insulating difficult
Warm air heats the underside of the roof sheathing in winter, melts the snow and then refreezes causing ice damming.

Air leakage into house and through exterior wall insulation.

Insulation gap between baffle at the top of the exterior wall.

Attic ventilation air.
Ice Damn formation

HEAT LOSS BY CONDUCTION

HEAT DUCT

WET INSULATION

DAMMED WATER

ICE DAM

AIR LEAKAGE BY CONVECTION
Ventilated attics need good design

VENTILATED ATTICS NEED TO BE WELL DESIGNED

Attic ventilation air

Insulation baffle

Blown-in insulation

Airseal sealant
Attic Ventilation Strategies
Ceiling height changes

When creating a tray ceiling with vertical sides, the wall portion should be sheathed to fully contain the insulation. The sheathing should extend past the upper ceiling to the depth of the insulation.

Tray or coffered ceilings with slopes over 3:12 must be insulated with materials that do not "slump" on the steep slope of the ceiling.
Airsealing at wall to roof interface
Conditioning the Indoors

- Heating, cooling, ventilation and indoor air quality
Are we ready for the changes?
Be Aware…

- Energy Efficiency ≠ Comfort
- Builders typically have more comfort complaints than high bill complaints
- If you can’t provide comfort, energy efficiency could be set back 20 years
- Need to remember comfort fundamentals
Let’s Start with Defining Comfort

- Air temperature
- Humidity
- Air speed - drafts
- Surrounding surface temperatures
- Gender, age, activities of occupants
- Metabolic rate & clothing
Comfort – Finding the sweet spot

Applies to Operative Temperature

Figure 2: The new Graphic Comfort Zone Method, Figure 5.2.1.1 in Standard 55-2010 (IP version shown).
Operative Temperature

Operative temperature:
• The average of the mean radiant and ambient air temperatures, weighted by their respective heat transfer coefficients.

• Thermostats respond to air temperature

• Human thermal comfort responds to operative temperature
Can we meet the expectations of our customers?

### Residential Single-Zone and Multi-Zone Systems

**Minimum / Maximum Recommended Values for Comfort and Safety**

<table>
<thead>
<tr>
<th>Comfort Item</th>
<th>Heating Season</th>
<th>Cooling Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermostat setpoint (design)</td>
<td>70°F</td>
<td>75°F</td>
</tr>
<tr>
<td>Relative humidity (RH)</td>
<td>30% RH maximum (20 – 30% RH is desirable)</td>
<td>55% RH maximum (25 – 50% RH is desirable)</td>
</tr>
<tr>
<td>Dry-bulb temperature at the thermostat</td>
<td>Setpoint temperature ±2°F</td>
<td>Setpoint temperature ±3°F (single-zone) Setpoint temperature ±2°F (multi-zone)</td>
</tr>
<tr>
<td>Dry-bulb temperature in any conditioned room</td>
<td>Setpoint temperature ±2°F</td>
<td>Setpoint temperature ±3°F (single-zone) Setpoint temperature ±2°F (multi-zone)</td>
</tr>
<tr>
<td>Room-to-room temperature differences (i.e., same level)</td>
<td>4°F maximum</td>
<td>6°F maximum (single-zone) 4°F maximum (multi-zone)</td>
</tr>
<tr>
<td>Floor-to-floor temperature differences (i.e., different levels)</td>
<td>4°F maximum</td>
<td>6°F maximum (single-zone) 4°F maximum (multi-zone)</td>
</tr>
<tr>
<td>Floor temperature (slab floors or floors over unconditioned space)</td>
<td>65°F minimum at 4” above the floor for 70°F thermostat setting [not applicable near outside walls]</td>
<td>----</td>
</tr>
<tr>
<td>Air filtration – MINIMUM EFFECTIVENESS&lt;sup&gt;2&lt;/sup&gt;</td>
<td>MERV&lt;sup&gt;δ&lt;/sup&gt; rating of 4 – 6 [Standard disposable media filter]</td>
<td>MERV&lt;sup&gt;δ&lt;/sup&gt; rating of 4 – 6 [Standard disposable media filter]</td>
</tr>
<tr>
<td>Air filtration – BETTER EFFECTIVENESS&lt;sup&gt;2&lt;/sup&gt;</td>
<td>MERV&lt;sup&gt;δ&lt;/sup&gt; rating of 8 – 11 [1-2” residential pleated filter]</td>
<td>MERV&lt;sup&gt;δ&lt;/sup&gt; rating of 8 – 11 [1-2” residential pleated filter]</td>
</tr>
<tr>
<td>Ventilation (outdoor air introduced into the occupied space)</td>
<td>0.35 air changes per hour (ACH) [for any infiltration-ventilation combination]</td>
<td>0.35 air changes per hour (ACH) [for any infiltration-ventilation combination]</td>
</tr>
<tr>
<td>Air circulation within room&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Size and location of supply outlets selected for optimum heating performance / low resistance return path required for every room</td>
<td>Size and location of supply outlets selected for optimum cooling performance / low resistance return path required for every room</td>
</tr>
</tbody>
</table>

**ACCA Comfort Guidelines**
## Comfort – A starting point

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>75 °F</td>
<td>+/- 3 °F</td>
</tr>
<tr>
<td>Winter</td>
<td>72 °F</td>
<td>+/- 3 °F</td>
</tr>
<tr>
<td><strong>Humidity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>50%</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>Winter</td>
<td>35%</td>
<td>+/- 5%</td>
</tr>
<tr>
<td><strong>Foot Comfort</strong></td>
<td>63 °F</td>
<td>+/- 3 °F</td>
</tr>
</tbody>
</table>
## Heating & Cooling Systems

### Fuel choices
- Electric
- Gas
- Oil
- Wood
- Solar
- Combinations

### Distribution choices
- Central Forced air
- Radiant
  - In-floor
  - Baseboard
- Ductless
- Space heaters
1) Get heating & cooling capacity right
Heat Flow Formulas

Conduction heat flow (through walls, ceilings, floors)

\[ \text{Conduction heat flow} = \frac{\text{Surface Area} \times \text{Temp. Diff.}}{R - \text{value}} \]

Radiant flow (through glass)

\[ \text{Radiant flow} = \text{Surface area} \times \text{Solar incidence} \times \text{Solar Heat Gain Coefficient} \]

Heat flow by air (via air leakage or ventilation)

\[ \text{Heat flow by air} = \text{Volume of air (CFM)} \times \text{Temp. Diff.} \times 1.1 \]
HEATING – Get the Size Right

- Do Room-by-Room heat loss & gain calculation

Based on:
- Design Day - Winter
- Conduction losses through enclosure
- Air leakage through enclosure
- Heat losses through ducts in unconditioned space
Minneapolis, MN
- design conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>ASHRAE 99% / 1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter, design dry bulb (F)</td>
<td>-15°F</td>
</tr>
<tr>
<td>Summer, design dry bulb (F)</td>
<td>91°F</td>
</tr>
<tr>
<td>Summer, design wet bulb (F)</td>
<td>71.6°F</td>
</tr>
<tr>
<td>Degree days-heating</td>
<td>7981</td>
</tr>
<tr>
<td>Degree days-cooling</td>
<td>682</td>
</tr>
<tr>
<td>Precipitation</td>
<td>28”</td>
</tr>
<tr>
<td>Solar incidence - South, July</td>
<td></td>
</tr>
</tbody>
</table>
Proper Manual J Calculations

- Numerous software packages exist
- All rely on proper data input and appropriate assumptions

Common Errors:
- Fudging design day conditions
- Using default values for air tightness, windows, insulation
- Using improper ventilation rates

Don’t tolerate oversizing, Manual J compliant programs have safety factors built in already
Impact of Improper Sizing

- Short cycling
- Poor humidity control
- Poor temperature control
- Noise
- Extra cost for equipment & duct work
- Possibly higher energy bills
Heating Loads - HP Home Versus Standard

ENERGY STAR HOME

- Walls: 31%
- Windows & Doors: 6%
- Ceilings: 4%
- Infiltration: 14%
- Ventilation: 10%

TRADITIONAL DATA ENTRY

- Walls: 30%
- Windows & Doors: 33%
- Floors: 4%
- Ceilings: 4%
- Infiltration: 28%
- Ventilation: 0%
Cooling Loads - HP Home Versus Standard

**Energy Star Home**
- Internal: 14%
- Ducts: 5%
- Walls: 11%
- Windows & Doors: 50%
- Ceilings: 8%
- Floors: 0%
- Infiltration: 3%
- Ventilation: 9%
- Total: 22,357

**Traditional Data Entry**
- Internal: 10%
- Ducts: 4%
- Walls: 15%
- Windows & Doors: 57%
- Ceilings: 5%
- Floors: 0%
- Infiltration: 9%
- Ventilation: 0%
- Total: 46,687

*Cooling - Sensible + Latent Loads*
Provide your Contractor with Good Information

- Insulation levels
  - Wall and attic insulation levels
  - Foundation insulation
- Window data - use NFRC ratings
  - Solar heat gain coefficients
  - U values
- House Air leakage - (this is often the single biggest variable)
  - Provide blower door test values
Approved Software Guides Better Inputs
2) Select the right equipment
Good System Selection

- Use manufacturer’s technical manuals to match:
  - Required heat output
  - Required cooling output
    - Sensible & latent (moisture) loads
  - Fan / airflow delivery capacity and static pressure
Preferred furnace choices

- Sealed combustion chamber
- Venting system decoupled from house pressures
- Efficiencies of 90%+
- High efficiency blower motors - ECM
- Two/multi stage heating
Direct vent appliances

fan-assisted exhaust

cold

hot

induced draft fan

power vented gas water heater

gas

inside

outside

fan-assisted exhaust

combustion air

sealed combustion unit

high efficiency gas furnace
Preferred AC choices

- Outdoor condenser matched to indoor coil
- SEER ratings of 14+
- High efficiency blower motors - ECM
- Two-stage cooling
- Dehumidification cycles
- Inverter for simple connection to solar
High Performance homes need more efficient motors!

• Capable of meeting small loads, part loads and full loads!
• Use 1/5 of original PSC motor types.
• Run efficiently at a variety of speeds (Modulation)
• Equipment lasts longer
• Enables balanced temperatures throughout home
• Enhances Ventilation “Effectiveness”
What about Heat Pumps?

• Is it the first thing to do?
• Reliance on electric grid
• Can do water or air
• High Performance homes help reduce capital cost
Energy Efficiency

- Heat pumps are hard to overlook
- Low ambient temperature units: COPs of 2 to 4
- Be mindful of HSPF rating points and operating conditions – cold weather:
  - Zone 5+ + 8.6 HSPF+
  - Dual Fuel /Auxillary back up as gas vs electric.
Example of a different strategy
- Ductless opportunities

• Provides zoning
• Can target specific high load areas
• In very high performance homes, it could provide all heating & cooling needs
3) Design the ducts correctly
Manual D provides a duct sizing schedule to deliver the air to the space intended.
HVAC by Design

- Properly size system
- Optimize duct layout
Ducts & equipment in conditioned space

A closet & dropped ceiling

Use direct vent equipment
Ducts in conditioned space will be cooler in summer, warmer in winter.
A dropped ceiling in the hallway can be effective.

Place the ducts in conditioned space.
Ducts are now properly insulated and any duct leakage is to the interior.
Properly sized and located grilles “throw” air to the perimeter windows and walls.
Conditioned attics are an option

It can raise the value of a home
Open web floor joist systems
Layout your floors to accommodate duct work.
Buried Ducts are an Option
Sealing Ducts Matters!!!

- Getting air where you need it
- Allowing balancing & seasonal adjustment to work
- Empowers zoning to work
Seal Ducts

Mastic with a brush is quickest & best
Low Load Homes suffer from lack of air flow-THROW and MIXING! (Not lack of Returns)
COOLING
350 FPM
S=SUPPLY  R=RETURN
FLOOR REGISTERS AT PERIMETER
Choose Proper Diffusers with Velocity and "Throw" in Mind
Zoning will become more important

- Matching seasonal load adjustments
- Example – basements
- Accurate delivery of part loads
- Making best use of equipment capacity
Ducted Returns will become expected

• A good choice is to hard duct returns...strategically to a centralized location
Return Air Paths

Graphics Courtesy of Building Science Corp.
A single return requires transfer grilles to provide a return path, and avoid pressurizing bedrooms

Note: not an IECC requirement
Grille located high in wall on bedroom side to avoid blockage by furniture.

Cavity is sealed tight, drywall glued to studs and plates on both sides.

Grille located low in wall on hallway side.

10-inch dia. flex duct (typ.)

Sealant

Ceiling grille

Wall cavity
Combination Systems

- Fully Insulated Cabinet – Lowers operating sound.
- High-Efficiency Hot Water Coil – Provides exceptional heat transfer and efficient operation.
- Electronic Control – Automatically controls unit’s operation.
- Heavy-Gauge Steel Cabinet – Offers long-lasting reliability with a durable, baked-on enamel finish.
- Variable Speed Blower Motor – Designed for comfort and efficiency while minimizing sound.
- Multi-Position Design – Allows greater installation flexibility.

Hot water air handler

Condensing Water Heater
Controls
Verification / Commissioning
Testing for performance
Simple Testing Can Help

- Verify performance before the Design Day
- 3-4 measurements
- Matched to the design
- Matched to manufacturer’s specifications
1) Duct pressures

0.15” to 0.25”
40 – 60 Pa
2) Airflow at Air Handler
3) Airflow at Registers
4) Refrigerate Verification
5) Temperature rises
## Valuable Resources

### ENERGY STAR Certified Homes, Version 3 (Rev. 07)

**HVAC System Quality Installation Contractor Checklist**

2. **Heating & Cooling System Design**
   - Parameters used in the design calculations shall reflect home to be built, specifically, outdoor design temperatures, home orientation, number of bedrooms, conditioned floor area, window area, predominant window performance and insulation levels, infiltration rate, mechanical ventilation rate, presence of MERV5 or better filter, and indoor temperature setpoints = 70°F for heating; 75°F for cooling.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Box</th>
<th>Builder Verified</th>
<th>Cont. Verified</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Heat Loss / Gain Method:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2 Duct Design Method:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3 Equipment Selection Method:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4 Outdoor Design Temperatures:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2.5 Orientation of Rated Home (e.g., North, South):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6 Number of Occupants Served by System:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.7 Conditioned Floor Area in Rated Home:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.8 Window Area in Rated Home:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.9 Predominant Window SHGC in Rated Home:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.10 Infiltration Rate in Rated Home:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.11 Mechanical Ventilation Rate in Rated Home:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.12 Design Latent Heat Gain:</td>
<td></td>
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</tr>
<tr>
<td>2.13 Design Sensible Heat Gain:</td>
<td></td>
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<tr>
<td>2.14 Design Total Heat Gain:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.15 Design Total Heat Loss:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2.16 Design Airflow:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.17 Design Duct Static Pressure:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.18 Full Load Calculations Report Attached</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hot Water
Expectations have Changed
Hot Water Usage Relevance

• Hot water use is still on its way up
• Wait times are an issue
  • Waste of water
  • Perception of energy waste

Main uses for household hot water

Source: Canadian Building Energy End-Use Data and Analysis Centre
DOMESTIC HOT WATER IS A BIG DEAL

- In ZERH’S DHW is tied with space heating as the 2nd largest load

![Pie chart showing energy loads]

- Heating 13%
- Hot Water 12.5%
- Occupant /Baseload 67.5%
- Air Conditioning 3%
- HRV /Fans 4%

Occupants Loads 67.5%
### Minimum 2016 Requirements

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Storage:</th>
<th>Tankless:</th>
<th>Example EF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas</strong></td>
<td>$&lt;55 \text{ US gal.}$</td>
<td>$&gt;55 \text{ US gal.}$</td>
<td>40 US gal = 0.62, 60 US gal = 0.75</td>
</tr>
<tr>
<td></td>
<td>$\text{EF} = 0.675 - (\text{gal} \times 0.0015)$</td>
<td>$\text{EF} = 0.8012 - (\text{gal} \times 0.00078)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Tankless:</strong></td>
<td></td>
<td>Typical = 0.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\text{EF} = 0.82 - (\text{gal} \times 0.0019)$</td>
<td></td>
</tr>
<tr>
<td><strong>Oil</strong></td>
<td></td>
<td>$\text{EF} = 0.68 - (\text{gal} \times 0.0019)$</td>
<td>50 gal = 0.585</td>
</tr>
<tr>
<td><strong>Electric</strong></td>
<td>$&lt;55 \text{ gal.}$</td>
<td>$&gt;55 \text{ gal.}$</td>
<td>40 gal = 0.95, 60 gal = 1.98</td>
</tr>
<tr>
<td></td>
<td>$\text{EF} = 0.960 - (\text{gal} \times 0.0003)$</td>
<td>$\text{EF} = 2.057 - (\text{gal} \times 0.00113)$</td>
<td></td>
</tr>
</tbody>
</table>
What’s the Right Choice?

- Fuel access?
- Number of people?
- Patterns of use?
- Space / location limits?
- Climate zone?
- Efficiency of the home?
- Other mechanicals?
- Expectations of clients?
- Other?
Water Heaters

- Traditional Tank: EF < 0.60
- Tankless: $\text{Tankless} = +0.80$
- Condensing water heater: $=0.86$
Tankless Water Heaters

Strengths

• Low stand-by losses
• EFs from 0.80 to high 0.90’s possible
• Wall installation frees up floor space
• Continuous supply of hot water
• Great flexibility
  • Point of use temperature controls
  • Locate supplementary units near point of use
  • Combo space & water heating capabilities
• Safe operation with direct venting
• New technologies reduce wait times - recirc. and internal storage tanks
Heat Pump Water Heaters

Strengths

• Very high EFs – 2.30+ possible
• Similar footprint as existing storage
• Provides cooling & dehumidification to the space
• Electric back-up
• Particularly useful in “Net zero-energy” homes to complement solar thermal & solar PV.
Solar Thermal Water Heaters

- A great preheat strategy for tankless, storage water heaters & HPWHs – increases their capacity
- 50-60% of annual hot water needs are easily provided
- Excess hot water can be used to heat swimming pools
- Requires freeze protection & annual maintenance
Indoor Air Quality is Important to our Clients

20% of households have someone with asthma, allergies or respiratory problems

...poor IAQ may cost 10’s of billions annually in lost productivity

Air cleaners are a $1.2 Billion industry

EPA
IAQ…Why is it a bigger issue than ever?

Change in the **way we build**
- Tighter
- More chemicals
- Air conditioning

Change in the **way we live**
- 90% of time indoors
- Don’t open windows
- More moisture

Change in **products we use**
- Carpets & furnishings
- Cleaners & hygiene
- More “stuff” inside
1. Remove Pollutants

2. Source control
   - “Seal” or Isolate
   - If you can’t remove it find a way to isolate or seal it

3. Ventilate
   - Dilute pollutants with “fresh” outdoor air
   - Point source removal

4. Filter

IAQ Control Strategies
Ventilation - a system or means of providing fresh air.

Webster New Collegiate Dictionary

We used to ventilate with windows, now we don’t

All homes need Capacity for Mechanical Ventilation

• To control moisture
• To remove common pollutants
• To ensure good indoor air quality for occupants
How Much Ventilation?
ASHRAE 62.2 - 2013

Whole House - Continuous “Capacity”

Based on # of occupants & size of home

CFM = (# of bedrooms + 1) x 7.5 + (0.03 x cond. ft²)

OR USE THE TABLE

<table>
<thead>
<tr>
<th>Floor Area Sq. ft</th>
<th># of Bedrooms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>&lt;1500</td>
<td>60</td>
</tr>
<tr>
<td>1501 - 2500</td>
<td>90</td>
</tr>
<tr>
<td>2501 - 3500</td>
<td>120</td>
</tr>
<tr>
<td>3501 - 5000</td>
<td>165</td>
</tr>
</tbody>
</table>

Controls moisture and common occupant pollutants
## ASHRAE 62.2 Minimum Exhaust Flow Rate

<table>
<thead>
<tr>
<th>Location</th>
<th>Continuous</th>
<th>Intermittent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen</td>
<td>60 CFM</td>
<td>100 CFM</td>
</tr>
<tr>
<td>Bathroom</td>
<td>20 CFM</td>
<td>50 CFM</td>
</tr>
</tbody>
</table>

## HVI Kitchen Range Exhaust Flow Rate

<table>
<thead>
<tr>
<th>Location of Range</th>
<th>Recommended per Linear Ft of Range</th>
<th>Minimum per Linear Ft of Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Against a Wall</td>
<td>100 CFM</td>
<td>40 CFM</td>
</tr>
<tr>
<td>In an Island</td>
<td>150 CFM</td>
<td>50 CFM</td>
</tr>
</tbody>
</table>

For Gas Ranges recommend 100 CFM / 10,000 BTUs of burner capacity
Types of Mechanical Ventilation

Graphic courtesy of Building Science Corporation

Exhaust  Supply  Balanced
Ventilation Opportunities

**Rated, Tested, Labeled Product**
- Always use HVI Certified fans
- Choose ENERGY STAR Qualified Fan and HRVs

[Logo for TESTED/CERTIFIED, Home Ventilating Institute]
[Logo for ENERGY STAR]
Exhaust Only Ventilation

• Specify good quiet fans in bathrooms and kitchen

• Bath fans with sound ratings under 1.5 sones

• Can be used for point source control or general ventilation

• Use timers or other controls to extend usage

• Recall that large exhaust fans can cause negative pressure
Control Strategies for “Continuous” Exhaust

Fan manufacturers have many new, helpful control strategies:

- Continuous Low
- High speed occupancy
- Cycle timed
Balanced ventilation with heat or energy recovery

• Remote mounted multiple room pick-up and delivery

• Draw from the common area and supply to all bedrooms

• Central fan integration is also used
Installation Options

- There are different options for installation depending on application needs
- Often the furnace duct system is used to distribute fresh air
- When possible, run exhaust ducts from bathrooms & kitchens
Balanced Ventilation with Heat Recovery

- HRVs / ERVs for continuous ventilation
- Choose Home Ventilating Institute (HVI) certified
- Select units with the right air flow.

Simplified or Return – Return Installation method
Ventilation is an important part of the House as a System

• Allows for houses to be built tighter
• Provides interior moisture and pollutant control

Ventilation will impact other HVAC systems

• Impact on HVAC load calculations
• Impact on moisture balance
• Impact on house pressures
• Impact on control strategies
Air leakage / ventilation heat loss
= CFM x temp. difference x 1.1
= 60 x 100 x 1.1 = 6600 BTUs/hr
The Lungs of the Home

Stale air to outside

Fresh air to the home

Fresh air from outside

Stale air from the home

Recovery core
HRVs / ERVs - Balancing Flows
HRV’s - ERV’s what’s the difference?

Heat Recovery Ventilation
- Allows transfer of sensible heat or temperature difference

Energy Recovery Ventilation
- Allows both sensible and latent transfer
- Moisture transfer
  - Reduces cooling loads in humid climates
  - Avoids over-drying in winter

Poly or Aluminum Core

Permeable Core
## The Cost of Ventilation – 75 CFM continuous

<table>
<thead>
<tr>
<th>Proximity</th>
<th>Electric costs</th>
<th>Gas heat costs</th>
<th>Gas heat costs</th>
<th>Gas heat costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$0.06 / kW</td>
<td>$1.20 / Therm</td>
<td>$1.20 / Therm</td>
<td>$1.20 / Therm</td>
</tr>
<tr>
<td>North (Duluth, MN)</td>
<td>$225/yr</td>
<td>$260/yr</td>
<td>$290/yr</td>
<td></td>
</tr>
<tr>
<td>Mixed (Louisville, KY)</td>
<td>$145/yr</td>
<td>$195/yr</td>
<td>$240/yr</td>
<td></td>
</tr>
<tr>
<td>Hot, Humid (Miami, Fl)</td>
<td>$ 125/yr</td>
<td>$195/yr</td>
<td>$285/yr</td>
<td></td>
</tr>
</tbody>
</table>
Proper ventilation enables tighter homes

*This can save:*

- $200 - $250 /yr in the north
- $125 - $175 /yr in mixed climates
- $75 - $125 /yr in southern climates
- ECM motors on air handlers, fans and ERVs can help save even more
Ventilation Impact on combustion appliances
Testing for depressurization

- Specific concern with natural draft appliances; wood burning fireplaces, gas log sets
- Tight houses with large exhausts can cause negative pressure
- Chimneys can overcome -5 Pa (-0.02”w.g.) pressure
- Test and provide make-up air if required
What about make-up air?

Fan manufacturers have new, helpful strategies.

Over 400 CFM??
The importance of Dehumidification

Sensible loads are down:
• Better windows
• Better walls
• Better ceilings

Latent loads are up:
• More time indoors
• More plumbing
• More consistent ventilation

HVAC design must include dehumidification, to supplement air conditioning
Humidification Applications

- Winter in cold climates
- Large homes with low occupancy levels

Sizing:

- Required capacity is a function of:
  - Air tightness of the home
  - Ventilation strategies
  - Occupancy generation
Filtration
Filtration
Filtration is the 4th of IAQ strategies: Remove, Seal, Ventilate, then Filter

- Filtration at the furnace works and is cost effective
- Commonly located in the return duct of the air handler
- Choose a filter with a rating of MERV 10 or better
- The better the filter, the more it restricts air flow, understand the appliance needs
Filtration Options

HEPA Filters
- Work to eliminate pollutant sources before spending money on HEPA
- MERV 16-20
- Very restrictive on airflow, they need their own fan system
- Available in ducted or portable units
Mechanical Systems

- HVAC
- Heating
- Ventilation (something new?)
- Part of the indoor Air Quality Conversation
- Air Conditioning
- Fireplaces
- Lighting and Appliances
- Humidification & Dehumidification
Heating & Cooling Systems Summary

- Ensure combustion safety
- Get equipment and duct sizes right
- Make good equipment choices
- Get ducts into conditioned spaces
- Get ducts sealed
- Test the performance
Appliances Make a Difference!
Appliance energy use and water use is growing.

- Heating and Cooling: 38%
- Water Heating: 14%
- Refrigerator: 10%
- Lighting: 6%
- Appliances, Home Electronics, Etc.: 32%
Appliances, Lights & Plug Loads
An EPA water efficiency retrofit study indicated the total water use was reduced to 40 gallons per person per day - 39% reduction

Source: Aquacraft, Boulder, CO
Lighting Efficiency
Water Efficient Fixtures

Faucets < 1.8 GPM

Shower heads < 2.0 GPM

Front load washers save 60%

Toilet with < 1.3 Gallons
Renewable Energy Systems
Creating better envelopes

Include ventilation on every project, performance and rationalize costs

Choose effective, efficient, quiet fans and appliances

Challenge your mechanical contractor to participate in your quest improving total system performance
Green Building Programs
Changing your process
Where does actual change begin?

Image courtesy of: Seth Godin
Who will be responsible for change?

- Select key people
  - Top management
  - Top field staff
  - Key sub-contractors
  - Testing professionals
  - Architects & designers
  - Sales management staff
Creating a plan to move forward

- Define the concerns, plan for the solution and set a timeframe
What Now?

Tomorrow
■ Evaluate flashing
■ Review insulation quality
■ Review duct installations
■ Test a few homes to establish your basis

Two Weeks
■ Review bids for change
■ Create internal teams responsible for change
■ Set goals for future direction
Create goals and prioritize them by both complexity and risk

<table>
<thead>
<tr>
<th>Construction Detail</th>
<th>Timeframe: 1 to 6 months</th>
<th>Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Combustion safety</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atmospherically vented furnace</td>
<td>Sealed combustion furnace</td>
<td>1</td>
</tr>
<tr>
<td>Return plenum connected to garage</td>
<td>Seal duct with water-based mastic, like RCD-6</td>
<td>3</td>
</tr>
<tr>
<td>&quot;Fresh&quot; air intake connected to garage</td>
<td>Seal all duct seams with water-based mastic and protect duct with dropped soffit</td>
<td>2</td>
</tr>
<tr>
<td>Leaky house/garage wall connection</td>
<td>Continuous air sealing</td>
<td>2</td>
</tr>
<tr>
<td><strong>Water Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flashing at Roof/Wall Connections</td>
<td>Kick-out flashing, proper lapping of Tyvek and step flashing raw wood attached to Hardie w/o priming,</td>
<td>2</td>
</tr>
<tr>
<td>Window flashing</td>
<td>Pan flashing, proper installation sequence and integration with Tyvek</td>
<td>4</td>
</tr>
<tr>
<td>Penetration flashing</td>
<td>Correct hole sizes, Tyvek Flex Wrap patches, Tyvek lapping detail</td>
<td>2</td>
</tr>
<tr>
<td>Flashing attention to detail</td>
<td>Taping seams &amp; tears, proper lapping, ensuring full-coverage</td>
<td>1</td>
</tr>
<tr>
<td><strong>Thermal Shell Improvements</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walls</td>
<td>Ensure insulation is installed properly - must be fulld depth, no gaps, or compression</td>
<td>2</td>
</tr>
<tr>
<td>Attics</td>
<td>Insulation must be installed to consistent depth, proper sequencing of Framing and Mechanical trades</td>
<td>2</td>
</tr>
<tr>
<td><strong>Air Sealing</strong></td>
<td>Seal large air leaks with combination of proper blocking and gun foam</td>
<td>2</td>
</tr>
<tr>
<td>Bypasses</td>
<td>Seal house to garage connection</td>
<td>2</td>
</tr>
</tbody>
</table>
Marketing for Performance

- Selling the benefits of health, safety,
- durability & performance
THE CONSUMER: ARE THEY REALLY SATISFIED?

71% think it’s important
35% satisfied with current home

36% Satisfaction Gap

“very energy efficient with low monthly utility costs.”

Source: The Housing Satisfaction Gap: What People Want but Don’t Have, Demand Institute, 2014
THE CONSUMER: THEY KNOW MOST HOUSING IS LESS EFFICIENT

- High Utility Bills
- Poor Comfort
- Health Concerns
- Moisture Issues
- Excessive Bugs/Pests
- Durability Problems
- Obsolete Technology

Meet 85% of Your Competition
Marketing and communicating
Our homes are 30% more efficient than homes built to state code standards.
Communicating to buyers

"What You Can’t See Really Matters"

Our homes are 30% more efficient than homes built to state code standards
THE CONSUMER AND HIGH PERFORMANCE HOMES

HOW TO TALK LIKE A NORMAL PERSON

Fresh Air Machine!
How consumers feel about the term “low-VOC”

- Few knew which products actually emit VOCs.
- Only 21% said they understand the term.
- A majority (54%) actually found this term undesirable.
The right words make the purchaser feel...
Matching High Performance Features to **Emotion**
Translate Technical Features into **Benefits**

**DOE Building Science Translator**

Tool for Sales and Marketing Professions

[www.basc.energy.gov](http://www.basc.energy.gov)
Tools for improving your business

constructioninstruction.com
Get Started !!

- Develop new standards for performance
- Train your crews and subcontractors
- Reward new ideas to improve a technique
- Demonstrate new features in models
- Market your leadership position
- Document performance improvements
- Solicit customer testimonials
“A small group of thoughtful people could change the world...

...Indeed it is the only thing that ever has”

Margaret Mead
“When we build let us think that we build forever. Let it not be for present delight nor present use alone. Let it be such work as our descendants will thank us for…”

John Ruskin (1819 to 1901)
Thank You

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