MT USGBC Chapter Conference
September 13, 2008

ENERGY STAR & LEED H Designer/Builder Training

ENERGY STAR

NorthWestern Energy

Dale Horton, Architect, Sustainable Energy Program Manager

National Center for Appropriate Technology

Offices:
- Montana
- California
- Pennsylvania
- Iowa
- Arkansas
- Louisiana

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Residential Energy

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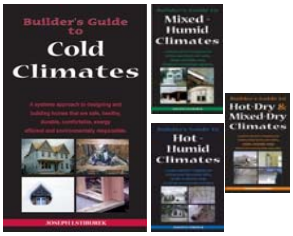

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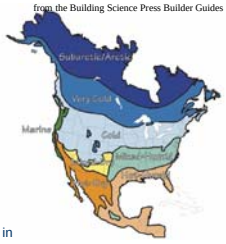
For more excellent publications and building science information from Building Science Corporation refer to their web site: **www.buildingscience.com**

Hygro-Thermal Regions

from the Building Science Press Builder Guides



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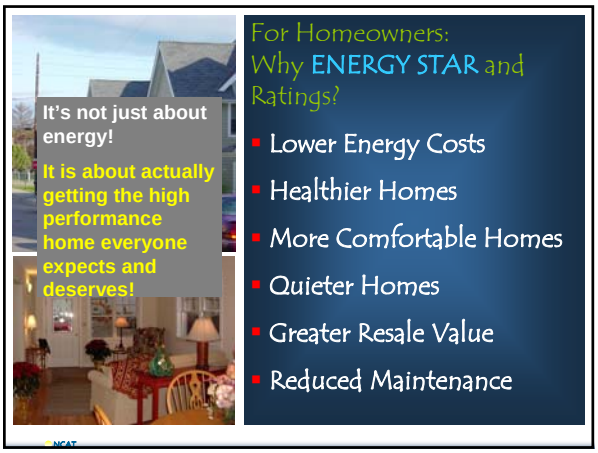
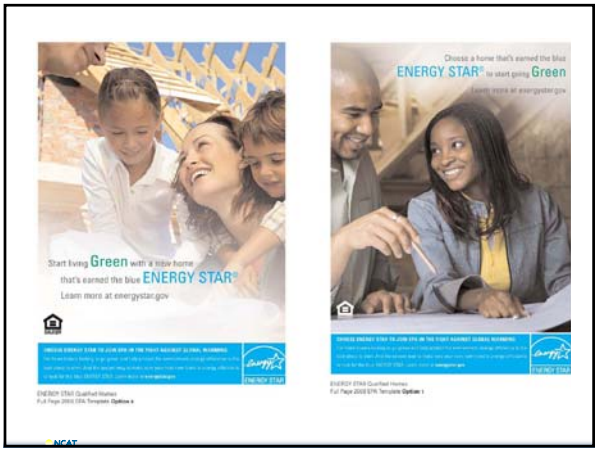
Introduction and Overview

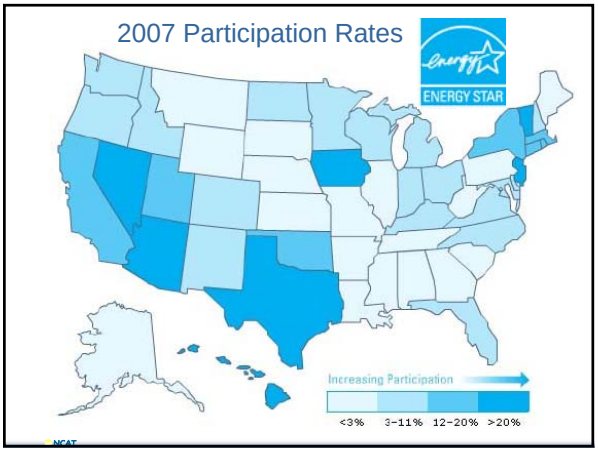
Section 1

US Carbon Dioxide Emissions

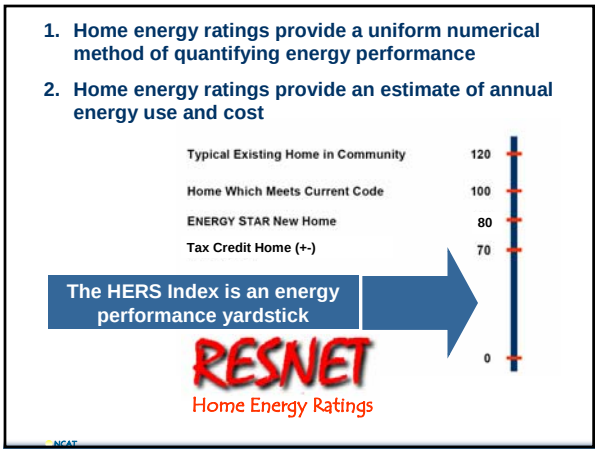
Buildings and the Environment: A Statistical Summary Compiled by: u.s. Environmental Protection Agency Green Building Workgroup
December 20, 2004

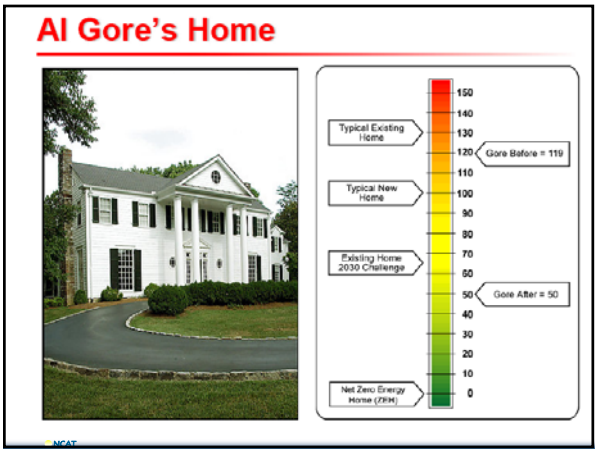






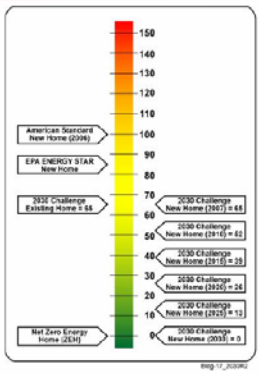
1. Home energy ratings provide a uniform numerical method of quantifying energy performance
2. Home energy ratings provide an estimate of annual energy use and cost

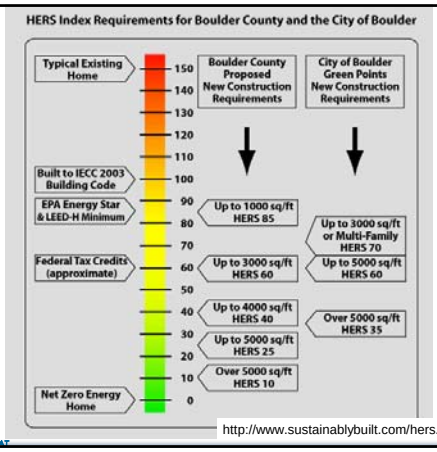




The 2030 Challenge

- Challenge that all new American homes will be carbon neutral by 2030
- Adopted by:
  - U.S. Conference of Mayors
  - American Institute of Architects
  - ASHREA
- Adopted RESNET HERS Index for residential challenge





http://www.sustainablybuilt.com/hers.html

ASSURING BETTER PERFORMANCE

ENERGY STAR

Unless you're prepared to break the laws of physics, energy efficiency delivers:

- Lower Utility **Cost**
- More **Comfort**
- More **Durability**
- Improved **Indoor Air Quality**
- Protect **Environment**

BUILDER VALUE PROPOSITION

ENERGY STAR

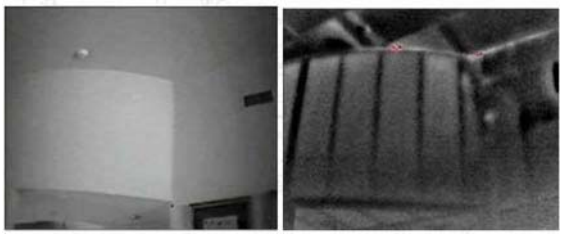
- **Reduced Risk**
  - Mold Litigation
  - Comfort Complaints
  - Fixing Trades Mistakes
  - Catching up to Competition
- **Improved Reputation**
  - Quality Builder
  - Innovation Leader

What's this worth to your bottom-line?

CHANGING WORLD: BUILDER LIABILITY: NEW STORM

ENERGY STAR

Defects no longer hidden...



CHANGING WORLD:
BUILDER LIABILITY

ENERGY STAR

Liability insurance is scarce and expensive

"If you deliver a safe, durable and efficient home, you typically won't be sued."
Stan Luhr, Risk Auditor

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CHANGING WORLD:
BUILDER LIABILITY: NEW STORM

ENERGY STAR

air leakage in envelope

air leakage in ducts

air leakage and air barriers in envelope

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SHOULD BUILDERS CARE ABOUT IAQ?

ENERGY STAR

- ***Asthma Epidemic***
  (20 million Americans have it); ~2 million ER visits per year
- ***Increasing Risks of Radon***
  >20,000 lung cancer deaths per year
- ***Increasing Respiratory Problems***
  widespread indoor dampness (e.g. wet basements and visible mold)
- ***Chemical Pollutants***
  EPA estimates 2-5 times more than outdoor air

Now consider this:
People spend >90% of their time indoors, and >60% in their homes!

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NEW SPEC: PERFORMANCE PATH REQTS.

ENERGY STAR

- ***Insulation inspection for full R-value***
- ***Thermal Bypass Inspection Checklist***
- ***Right-sized" cooling equipment***
  - *Leakage ≤ 6 cfm to outdoors/100 sq. ft.*
  - *Min. 1 ENERGY STAR Product category*
  - *No on-site power generation trade-off*
  - *Max. 20% screw-in CLF light sockets*
  - *Programmable thermostats with heat pumps must have "Adaptive Recovery"*

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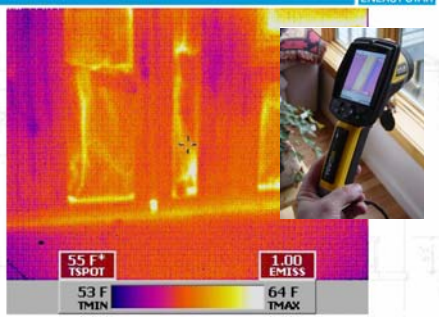
FUTURE ISSUE: THERMAL BRIDGING

ENERGY STAR



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FUTURE ISSUE: THERMAL BRIDGING

ENERGY STAR

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What is LEED?

Leadership in Energy & Environmental Design

LEED FOR HOMES

Materials and information can be found at - www.usgbc.org

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LEED for Homes is a floating point rating system with 4 Certification Levels.

This scale slides per a calculation which considers the square footage of the house per bedroom ratio. For a 4 bedroom 2,600sf Home the scale is:

- **Platinum: 90 – 129**
- **Gold: 75 – 89**
- **Silver: 60 – 74**
- **Certified: 45 – 59**

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LEED for Homes Points

LEED FOR HOMES

	No. Prereq. Measures		Min. No. Pts Required		Max. No. Pts. Available	
Innovation and Design Process	4	22%	0	0%	9	7%
Location and Linkages	0	0%	0	0%	10	8%
Sustainable Sites	2	11%	5	31%	21	16%
Water Efficiency	0	0%	3	19%	15	12%
Energy and Atmosphere	1	6%	0	0%	38	29%
Materials and Resources	3	17%	2	13%	14	11%
Indoor Environmental Quality	7	39%	6	38%	20	15%
Awareness and Education	1	6%	0	0%	3	2%
	18	100%	16	100%	130	100%

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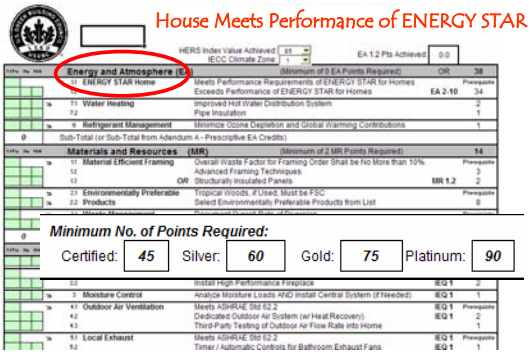
LEED for Homes — U.S. GREEN BUILDING COUNCIL

House Meets Performance of ENERGY STAR



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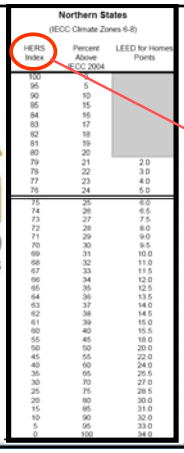
LEED FOR HOMES



LEED for Homes Points Based on HERS Index

RESNET

Home Energy Ratings

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LEED for Homes Component Approach

				NWENERGY STAR
Insulation				
EA 2.1	Basic Insulation	Ch 4 IECC Grade II, TBCH	Req'd	NA
EA 2.2	Enhanced Insulation	Exceed Ch4 IECC 5% Grade I, TBCH	2 Pts	Similar Not Spec'd
Air Infiltration				
EA 3.1	Reduced Envel Leakage	Max 5.0 ACH50	Req'd	7.0 ACH50
EA 3.2	Greatly Reduced Envel Leakage	Max 3.5 ACH50	2 Pts	
	or Minimal Envel Leakage	Max 2.0 ACH50	3 Pts	
Windows				
EA 4.1	Good Windows	U-factor <=0.35	Req'd	0.35
EA 4.2	Enhanced Windows	U-factor <=0.31	2 Pts	
EA 4.3	or Exceptional Windows	U-factor <=0.28	3 Pts	
Heating and Cooling Distribution System				
Forced Air Systems				
EA 5.1	Reduced Distribution Losses	Duct Leakage to Outside<=4cfm/100SF @25PA No wall cavities	Req'd	Similar
EA 5.2	Greatly Reduced Dist Losses	Duct Leakage to Outside<=3cfm/100SF @25PA	2 Pts	
EA 5.3	or Minimal Distribution Losses	Duct Leakage to Outside<=1cfm/100SF @25PA Air handler/ducts in conditioned space Air handler/ducts unconcealed	3 Pts	
Non-ducted HVAC Systems (e.g., Hydonic Systems)				
EA 5.1	Reduced Distribution Losses	R3 around pipes in unconditioned spaces	Req'd	Similar
EA 5.2	Greatly Reduced Dist Losses	System entirely within conditioned envelope	2 Pts	
EA 5.3	Minimal Distribution Losses	Outdoor Reset Control	3 Pts	
Space Heating and Cooling Equipment				
EA 6.1	Good HVAC Design/Installation	ACCA Manual J, EN National Install, Prog Therm AC/ASHP; 13 SEER, 8.2 HSPF Furnaces; 80AFUE Boilers: 85 AFUE	Req'd	Manual J 13 SEER, 8.5 HSPF 90 AFUE 83 AFUE
EA 6.2	High Efficiency HVAC	AC/ASHP; 14 SEER, 8.6 HSPF Furnaces; 92AFUE Boilers: 87 AFUE	2 Pts	
EA 6.3	or Very High Efficiency HVAC	AC/ASHP; 15 SEER, 9.0 HSPF Furnaces; 94 AFUE Boilers: 90 AFUE	3 Pts	
Water Heating				
EA 7.1	Efficient Hot Water Distribution	Specified system design	2 Pts	NA
EA 7.2	Pipe Insulation	R4 All pipes	1 Pt	Code 1/2"
EA 7.3	Eff Domestic HW Equipment	Electric 50 gal EF>=0.92 Gas 40 ga EF>=0.61	1 Pt 1 Pt	EF 0.93
Lighting				
EA 8.1	Energy Star Lights	>4 ES fixtures or lamps	Req'd	50% ES Lamps
EA 8.2	Improved Lighting	Indoor Outdoor: all on sensor control	0.5 Pts 1.0 Pts	
EA 8.3	or Advanced Lighting Package	60% ES Hardwired Fixt's, 100% Hardwired Fans	3 Pts	

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Zero Energy Home Display
Washington, DC, Mall, April 2001

Zero Energy Home

New Generation of Cost-Effective Buildings

- Net Metering.
- Net Metering
- Solar Electricity
- Solar Hot Water
- Passive Solar Design
- Super insulation
- Super Windows
- Energy Efficient Lighting
- Energy Star Appliances
- Whole House Sealing
- Controlled Ventilation

END GAME: CARBON NEUTRAL HOME

ENERGY STAR

Optimized energy efficiency plus some combination of renewable energy to offset remaining energy loads:

- *Passive Solar*
- *Solar Hot Water Heating*
- *Active Solar Heating/Cooling*
- *Renewable Electric Generation (PV, Wind)*
- *Green Tags*
- *Planting Trees*

Administration & Program

Section 2

1. **Home energy ratings provide a uniform numerical method of quantifying energy performance**
2. **Home energy ratings provide an estimate of annual energy use and cost**

EPA/DOE/IRS

Performance Based Home Energy Ratings

Rating Training Provider

Rating Provider

Home Energy Rater

ENERGY STAR Rating *	Existing Home Rating	Tax Credit Rating

* - Not available in OR or WA.

Federal Tax Credit for New Homes

➔$2000 to home builders (site-built and manufactured homes)
50% of the heating and cooling energy of the 2004 IECC and uses a SEER 13 air conditioner.

Building envelope improvements must account for at least 1/5 of the 50% energy savings.

➔$1000 to manufactured home producers
30% or that qualify for Energy Star Homes program

➔These credits are available for homes placed in service (i.e. ready and available for use) from January 1, 2006, through December 31, 2008

➔These credits go to the builder or producer of the home

Energy Efficient Home Credit - IRS Form 8908

"…qualified energy efficiency homes meeting the 50% standard that were **sold during the tax year**."

➔"Reduce the expenses incurred in the construction of each new home by the amount of the credit."

➔This is a business tax credit

- What about an owner-builder?
- What year must the credit be taken?

NCAT Disclaimer: We are not accountants, so go find your own interpretation.

Energy Mortgages

➔Increases the home buying power of consumers by allowing the lender to increase the borrower's income

➔Increases their homes appraised value

➔Energy Improvement Mortgage (EIM) – Helps finance the cost energy upgrades of an existing home by including the costs of improvements in the mortgage

➔Energy Efficient Mortgage (EEM) – Allows homebuyers to qualify for a new house loan that includes the cost of energy improvements by taking into account lower energy costs

Energy Mortgages

Primary Lenders

Process loans then sell to secondary lenders (Fannie Mae, Freddie Mac) to obtain more capital to fund new loans

Secondary Lenders

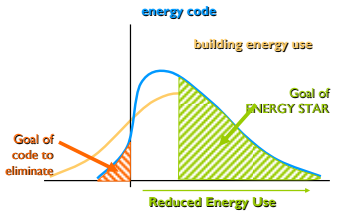
Fannie Mae (FHLMC)
Federal National Mortgage Association

Freddie Mac (FNMA)
Federal Home Loan Mortgage Corp.

Federal Housing Administration (FHA)

Veterens Administration (VA)

ENERGY STAR Moves Energy Efficiency Beyond Current Code

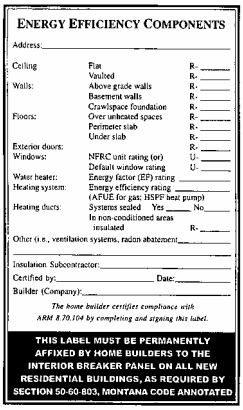


Adapted from a Better Bricks presentation prepared by Paladino & Assoc.

RESIDENTIAL BUILDINGS ENERGY CODE SUMMARY

Overview

Montana State Energy Efficiency Components Label



ENERGY EFFICIENCY COMPONENTS

Address:

Ceiling:	Flat	R-
	Vaulted	R-
Walls:	Above grade walls	R-
	Basement walls	R-
	Crawlspace foundation	R-
Floors:	Over unheated spaces	R-
	Perimeter slab	R-
	Under slab	R-
Exterior ducts:		R-
Windows:	NFRC unit rating (or)	U-
	Default window rating	U-
Water heater:	Energy factor (EF) rating	
Heating system:	Energy efficiency rating (AFUE for gas; HSPF heat pump)	
Heating ducts:	Systems sealed Yes ____ No____ In non-conditioned areas insulated	R-

Other (i.e., ventilation systems, radon abatement):

Insulation Subcontractor:

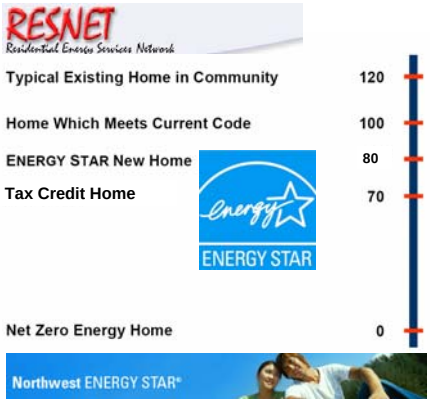
Certified by: Date:

Builder (Company):

The home builder certifies compliance with ARM 8.70.104 by completing and signing this label.

THIS LABEL MUST BE PERMANENTLY AFFIXED BY HOME BUILDERS TO THE INTERIOR BREAKER PANEL ON ALL NEW RESIDENTIAL BUILDINGS, AS REQUIRED BY SECTION 50-60-803, MONTANA CODE ANNOTATED

ENERGY STAR is a US EPA program that helps businesses and individuals reduce energy use and protect the environment through “superior energy efficiency.”



When reguired?	
HERS Rating	No
National ES	Yes
NWESH	No
LEEDH	Yes

www.NorthwestENERGYSTAR.com

www.NorthwestENERGYSTAR.com

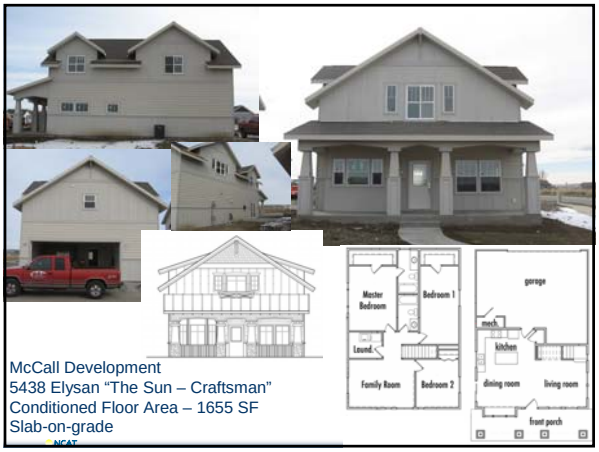
Builder Partnership Agreement includes:

- Company address & contact information
- Program benefits and requirements
- Use of ES name & label for promotion
- Disclaimers

Builder Partnership Agreement

ESHNW Prescriptive Approach

McCall Development
1626 Stony Meadow "The Gallatin"
Conditioned floor area – 3019 SF
Full Basement



McCall Development
5438 Elysan "The Sun – Craftsman"
Conditioned Floor Area – 1655 SF
Slab-on-grade

McCall Development ENERGY STAR Incremental Costs

Basement Insulation (with framing)	$1,500
Furnace Upgrade	$700
Duct Sealing	$400
Building Tightening	$600
Water Heater Upgrade	$200
Verification/Performance Testing	$400
Lighting Upgrades	$200
Total	$4,000

	Stony Meadow			Elysan		
Weather Site	Helena			Helena		
Utility	NWE			NWE		
Conditioned Floor Area	3019			1655		
Foundation Type	Basement			Slab-on-grade		
	Code	NWESH		Code	NWESH	
HERS Index	85	61		83	69	
ENERGY STAR	Fails	Passes		Fails	Passes	
Tax Credit	Fails	Passes		Fails	Fails	
Ann. MMBtu/Yr	172.8	120.7	70%	113.1	93.8	83%
Ann. Energy Cost	$2,652	$2,005	76%	$1,671	$1,413	85%
Ann. Cost Savings		$647			$258	
Added Cost		$4,000			$2,500	
Simple Payback		6.5			9.7	
30 Year Savings (Energy Cost Escalation Rate)						
30Y Savings (1%)		$21,254			$8,975	
30Y Savings (3%)		$29,069			$12,274	
30Y Savings (5%)		$40,594			$17,141	
30Y Savings (10%)		$100,506			$42,439	
30 Year NPV Savings, 8% Discount Rate (Energy Cost Escalation Rate)						
30Y NPV Sav (1%)		$7,559			$3,192	
30Y NPV Sav (3%)		$9,272			$3,915	
30Y NPV Sav (5%)		$11,619			$4,906	
30Y NPV Sav (10%)		$22,426			$9,470	

Energy and Construction Fundamentals

Energy and Construction Fundamentals

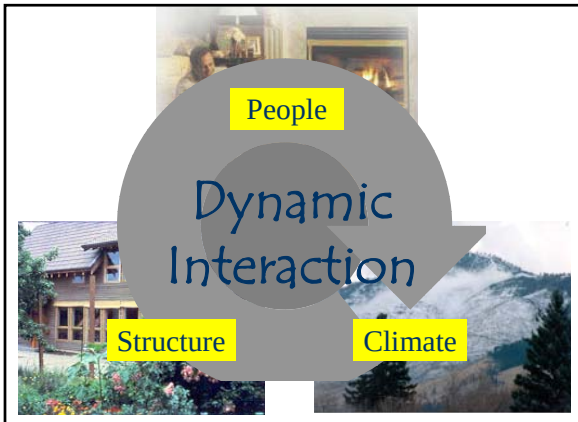
Energy Fundamentals

Comfort
Heat Loss Calculations
Building Tightness
Building Shell
Insulation Grading
Windows/Doors
Thermal Bypass Checklist
Solar

Why We Don't Build Them Like We Used To.

Thank God!

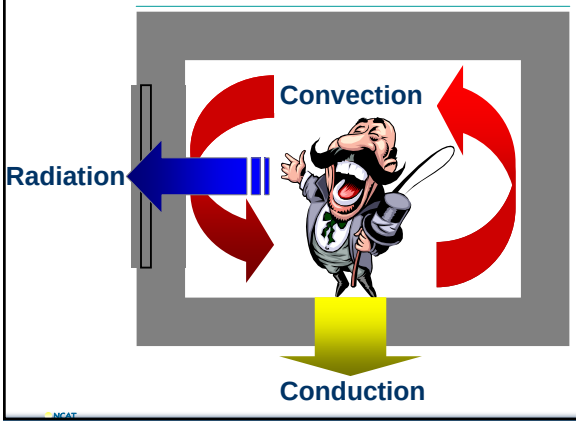
- Because We Know Better (Building Science)
- Better Testing and Diagnostics
- Mandatory Codes/Minimum Standards
- Voluntary Energy/Green Certifications
  - ENERGY STAR
  - LEED for Homes
  - NAHB Green Building Guidelines
  - Green Built
  - Earth Advantage

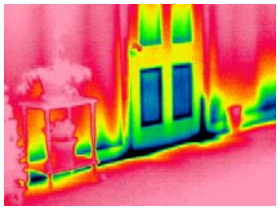


Heat Flow or Transfer

Hot → Cold

Heat Transfer Mechanisms





Conduction

- Heat conducts through and between solid objects by direct contact
- Molecules vibrate more vigorously, passing heat through the material
- Generally the slowest of the three heat transfer methods

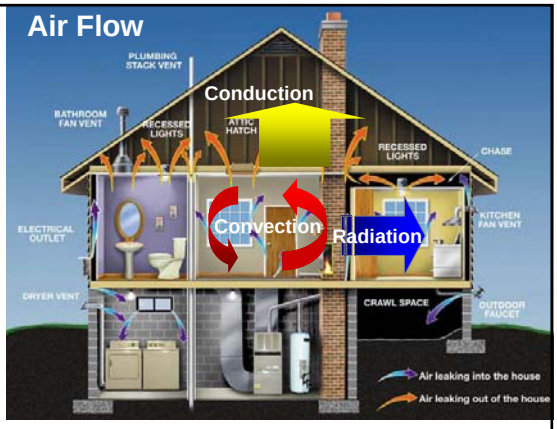
Source - Residential Energy

Convection

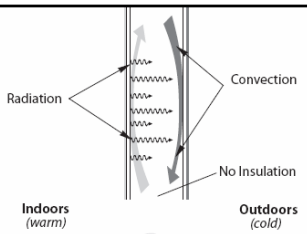
- Heat transfer by a moving fluid like air or water.
- Caused by density difference between warmer and cooler parts of fluid
- Heat transfer by convection can be more rapid than conduction because the molecules physically move

Radiation

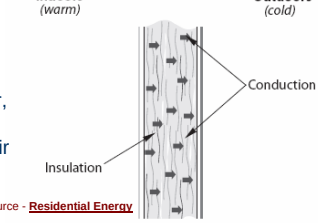
- Hot surfaces are able to warm objects distant from them because they have a higher temperature.
- Radiation requires a temperature difference and a gap, it travels by "line of sight" and is blocked by an opaque object.



Uninsulated walls transmit heat through its air space by convection and radiation



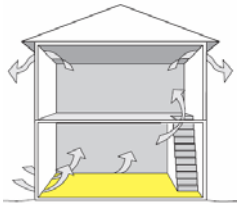
Insulated walls, in general, reduce convection and radiation heat transfer, heat mush conduct through many small air pockets

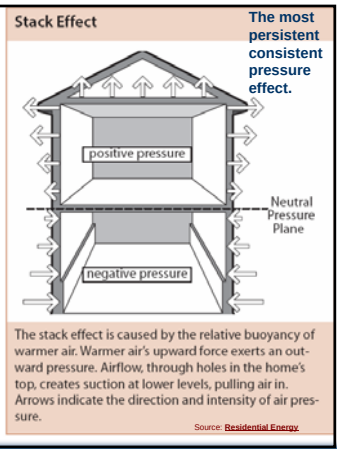


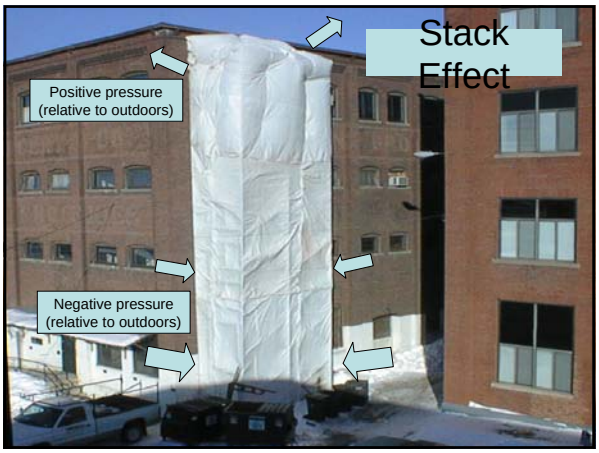
Source - Residential Energy

Stack Effect

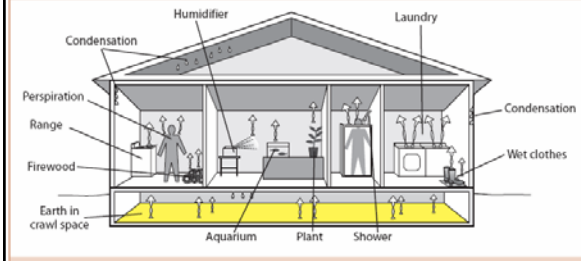
The tendency of warm buoyant air to rise and leak out of the top of the building and be replaced by colder outside air entering the bottom of the building.







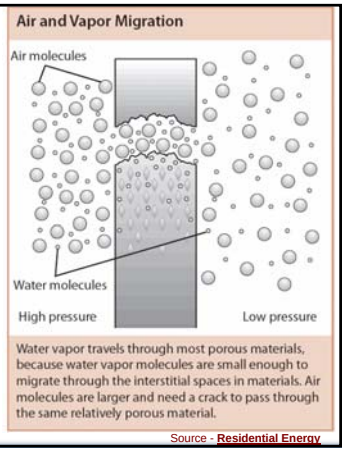
Moisture Flow



A variety of household sources release water vapor into the air. When the relative humidity rises and outdoor temperatures fall, the water vapor changes to liquid water—a process called condensation. Condensation occurs near the sources of water vapor and in the colder areas of the building. Shell insulation helps reduce these condensing surfaces.

Source: Residential Energy

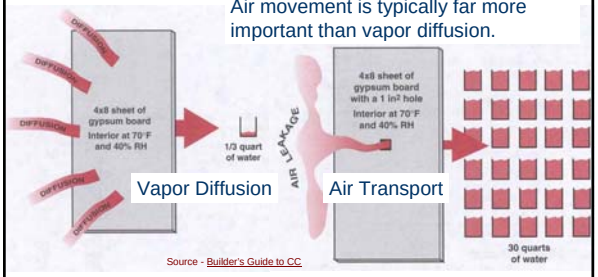
Air movement is by far the most important method of moisture transfer in a house



Water vapor travels through most porous materials, because water vapor molecules are small enough to migrate through the interstitial spaces in materials. Air molecules are larger and need a crack to pass through the same relatively porous material.

Source - Residential Energy

Air movement is typically far more important than vapor diffusion.



Source - Builder's Guide to CC

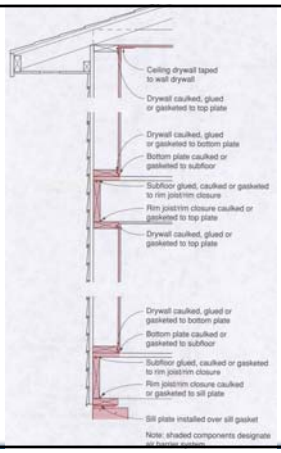
In most cold climates during a heating season……..

Water vapor moves in two ways:

- Vapor Diffusion (movement through solid material)
- Air Transport

Interior Air Barrier Using Drywall and Framing

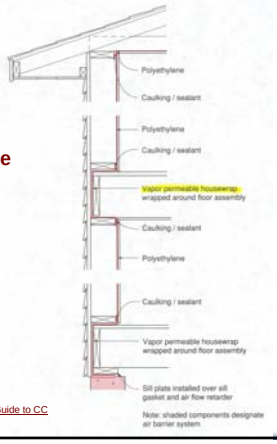
P95 BGCC



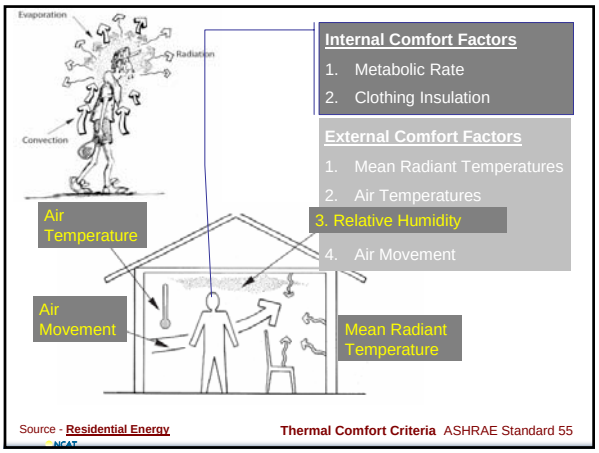
Source - Builder's Guide to CC

Interior Air Barrier Using Polyethylene

P96 BGCC



Source - Builder's Guide to CC



Insulation R-Values per Inch

Insulation Type	R/inch
Fiberglass batts, blown, board	2.4–4.4
Cellulose blown	3.0–3.6
Mineral wool batts, blown, board	2.4–4.4
Vermiculite or perlite	2.3–2.7
Expanded polystyrene (white)	3.6–4.2
Extruded polystyrene (blue/pink)	5.0
Polyisocyanurate board	5.6–7.6

R-values vary by insulation type, density, and the quality of installation.

Source - Residential Energy

R- values measure thermal resistance

R-value is the inverse of U-value: R=1/U and U=1/R

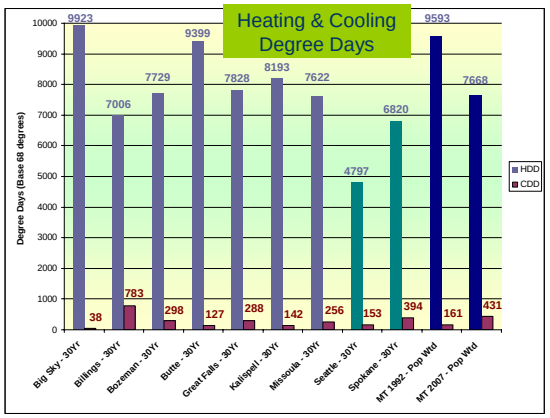
R-values are additive, U-values are not additive

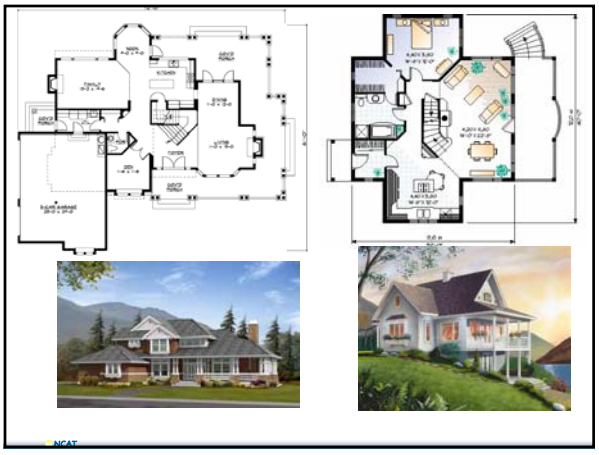
R-values of a series of components can be added; the inverse of this sum will be the

➔R1 + R2 = R total

➔U1 + U2 = Garbage

➔R= 1/U and U= 1/R



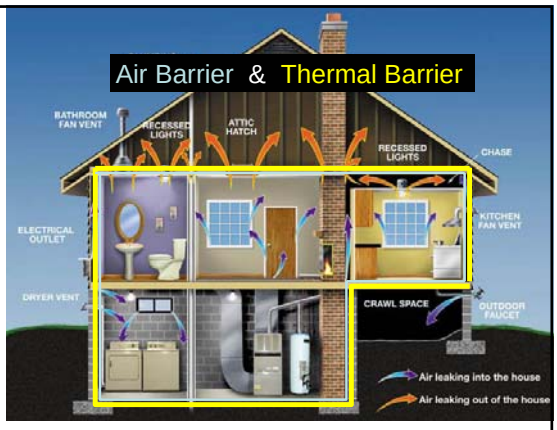


The Most Significant Air Leaks:

- Plumbing Vent Stacks
- Cavity Ducting
- Electrical Penetrations
- Flue and Chimney Chases

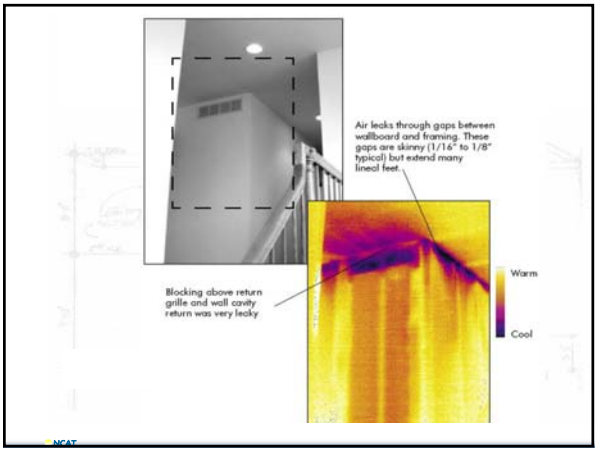
Less Significant Air Leaks:

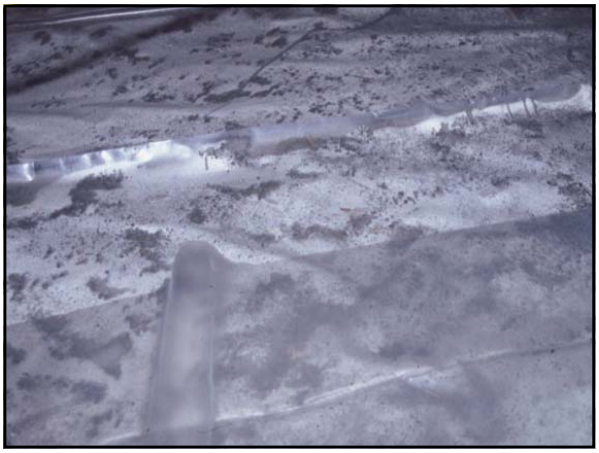
- Doors and Windows

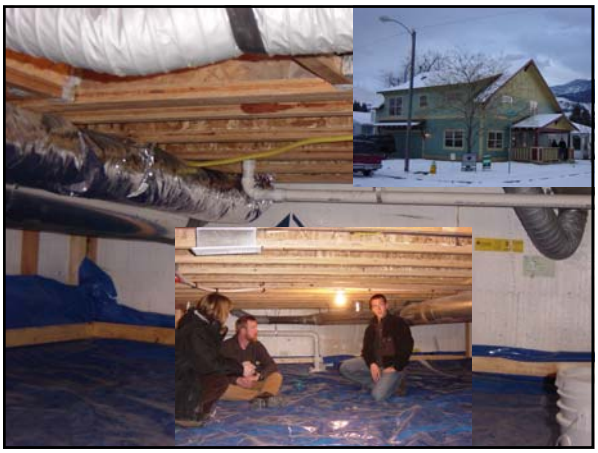


Moisture

- Water related to 90% of building and material failures (ASHRAE)
- Estimated $9 Billion/year in repairs







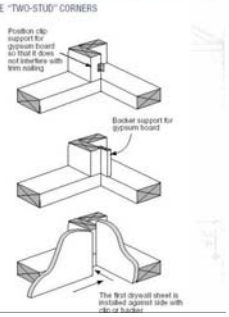

Alternative Basement Systems

Interior Basement Insulation

CORNER FRAMING

ENERGY STAR

Courtesy of Building Science Corp.



Courtesy of Southface Institute

WHY SPRAY FOAM

ENERGY STAR

Closed Cell Foam = *Air Barrier + Insulation*

Consider using at:

- *Band Joists*
- *Behind Tubs/Showers*
- *Cantilevered Floors*
- *Conditioned Space Above Garage*
- *Party Walls (must be fire-proof)*

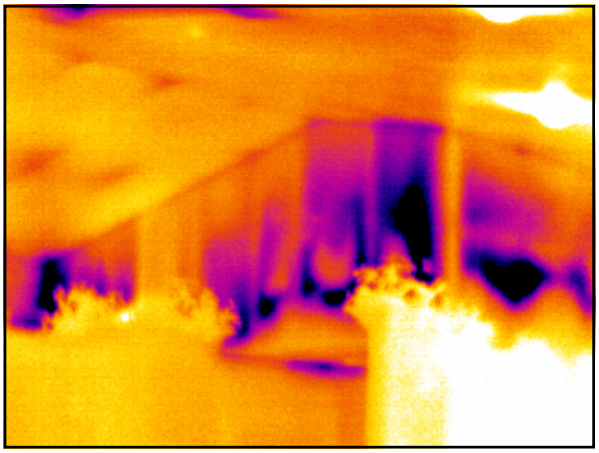
WHY INSULATED SHEATHING

ENERGY STAR

Rigid Insulation = *Air Barrier + Insulation + Thermal Break*

Where code acceptable, consider using at:

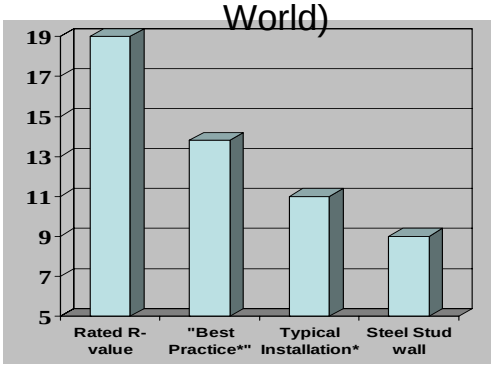
- *Exterior Sheathing*
- *Attic Knee Walls*
- *Skylight Shafts*
- *Porch/House Interface*



Why is it So Bad?

- The gaps and spaces dominate the heat loss
- No matter how much insulation you pile up next to a gap, the heat loss through the gap is not reduced at all
- The larger the initial R-value, the greater the effect

Fiberglass Batts (Real World)



Correct Installation

Blown-in Blanket (BIB) Fiberglass

Damp spray cellulose

Spray Foams

- Excellent air sealing characteristics
- Excellent “fit” because it expands to fill spaces and glues itself to surfaces

Insulation Quick Comparison (A work in progress.)

Material	Type	R-Value	Ozone Depleting Blowing Agent	Density	Vapor Retarder Perm Rating	Recycled Content	Common or Brand Name
Fiberglass	batts	3.6	No	3 pcf	Permeable	Doubtful	
	loose fill	3.2	No	2-3 pcf	Permeable	Doubtful	
Cellulose	Loose Dry	3.4	No	1.5-2.0 pcf	Permeable	Yes	
	Wet Blown	4.0	No		Permeable	Yes	
Expanded Polystyrene	Rigid Board	4.0	No	low 1 pcf	Permeable	Doubtful	beadboard
	Rigid Board	4.0	No	high 2-3 pcf	Semi-impermeable	Doubtful	
Extruded Polystyrene	Rigid Board	5.0	Yes	2 pcf	Semi-impermeable	Doubtful	Styrofoam Blue Board
Polyisocyanurate	Rigid Board	7.0	Yes	3 pcf	Imperm w/ facing	Doubtful	Thermax
Polyurethane	Spray Foam	3.6-3.8	No, water	low 0.5 pcf	Permeable	Doubtful	Icynene, Sealection 500
	Spray Foam	3.7-3.6	No, soy	low 0.5 pcf	Permeable	Doubtful	Biobase 501, Healthy Seal
	Spray Foam	5.5	No, soy	high 1.7 pcf	Semi-impermeable	Doubtful	Biobase 1701
	Spray Foam	6.0 - 8.0	Yes	high 2 pcf	Semi-impermeable	Doubtful	

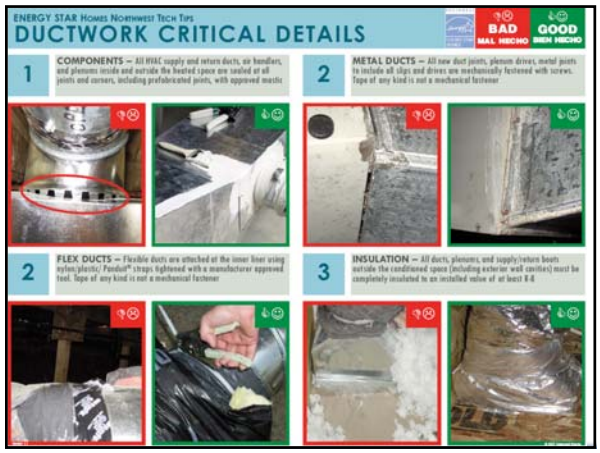
Remarks:
1. Fiberglass is susceptable to convective currents and poor installation and may contain formaldehyde.
2. Styrene and urethane insulations may give off toxic gases when if burned.
3. In general, low density foams are open cell and high density foams are closed cell.
4. Vapor permeability of depends on thickness, especially with foams.

Perms	Vapor Impermeability
<=0.1	Impermeable
0.1> and <=1.0	Semi-impermeable
1.0> and <=10	Semi-permeable
>10	Permeable

Critical Construction Details

Section 4


ENERGY STAR Homes Northwest Tech Tips
AIR SEALING CRITICAL DETAILS
BAD MAL HECHO
GOOD BIEN HECHO
3 FIRE SEALING – Fire-rated caulking along with flashing or UL-rated collars must be installed continuous around all combustion flues and maintain proper clearance from combustion materials
4 ATTIC ACCESS – Access doors to knee wall or crawlspace areas, attic hatches, and drop down stairs are weather stripped and insulated
5 CAN LIGHTS – Recessed lighting fixtures installed in insulated assemblies are air tight and IC-rated and sealed to drywall with caulk, foam, or gasket
6 DOORS & WINDOWS – Backer rod or low expansion foam is used to seal around windows and doors

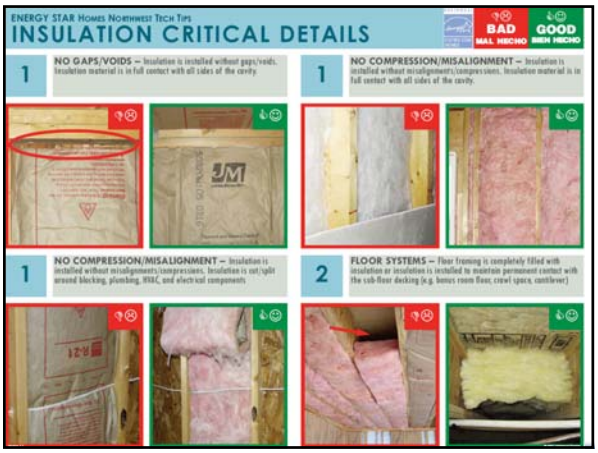

ENERGY STAR Homes Northwest Tech Tips
DUCTWORK CRITICAL DETAILS
BAD MAL HECHO
GOOD BIEN HECHO
1 COMPONENTS – All HVAC supply and return ducts, air handlers, and plenums inside and outside the heated space are sealed at all joints and corners, including prefabricated joints, with approved mastic
2 METAL DUCTS – All new duct joints, plenum drives, metal joints to include all slips and drives are mechanically fastened with screws. Tape of any kind is not a mechanical fastener
2 FLEX DUCTS – Flexible ducts are attached at the inner liner using nylon/plastic/ Panduit® straps tightened with a manufacturer approved tool. Tape of any kind is not a mechanical fastener
3 INSULATION – All ducts, plenums, and supply/return boots outside the conditioned space (including exterior wall cavities) must be completely insulated to an installed value of at least R-8


ENERGY STAR Homes Northwest Tech Tips
DUCTWORK CRITICAL DETAILS
BAD MAL HECHO
GOOD BIEN HECHO
4 NO FAKE DUCTS – Unlined building cavities are not used as ducts
5 ZONAL PRESSURE RELIEF – Conditioned rooms without dedicated returns (except baths, laundry, and closets) have jump ducts, transfer grills, or door undercuts to provide return air paths
5 ZONAL PRESSURE RELIEF – Conditioned rooms without dedicated returns (except baths, laundry, and closets) have jump ducts, transfer grills, or door undercuts to provide return air paths
7 DUCT SUPPORT – Ducts shall be cut to length and supported in such a manner to prevent air flow constriction


ENERGY STAR Homes Northwest Tech Tips
DUCTWORK CRITICAL DETAILS
BAD MAL HECHO
GOOD BIEN HECHO
8 SUPPORT & BENDS – Flexible duct (including spot ventilation) is supported at least every 4 feet and has no bends greater than 90°
8 SUPPORT & BENDS – Flexible duct (including spot ventilation) is supported at least every 4 feet and has no bends greater than 90°
9 PENETRATIONS – All HVAC penetrations to exterior/ unconditioned space (e.g. chases, shafts, refrigerant lines, etc) are air sealed with foam, caulk, or mastic. NO fibrous insulation is used to fill holes
10 SPOT VENTILATION – Spot ventilation (exhaust) duct work terminates to daylight


ENERGY STAR Homes Northwest Tech Tips
FRAMING CRITICAL DETAILS
BAD MAL HECHO
GOOD BIEN HECHO
1 BOTTOM PLATES – Bottom plates of all exterior walls and party/common walls (ALL floors), and vertical members at foundation step downs are caulked, gasketed, or glued
1 BOTTOM PLATES – Bottom plates of all exterior walls and party/common walls (ALL floors), and vertical members at foundation step downs are caulked, gasketed, or glued
2 PLATES AT KNEE WALLS – There is both a top and bottom plate installed at every knee wall
3 KNEE WALL BACKING – All knee walls are backed with a rigid material (e.g. wall to attic, skylight shaft, wall to porch roof, staircase to attic)

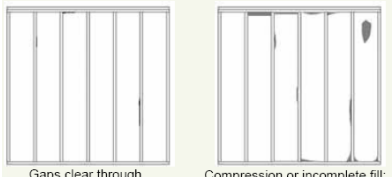

ENERGY STAR Homes Northwest Tech Tips
FRAMING CRITICAL DETAILS
BAD MAL HECHO
GOOD BIEN HECHO
3 SKYLIGHTS – All knee walls are backed with a rigid material (e.g. wall to attic, skylight shaft, wall to porch roof, staircase to attic)
4 DROPPED CEILINGS – All dropped ceilings/soffits are capped with a rigid material on the attic side and/or the exterior wall
5 CAP CHASES – All shafts/chases are capped
6 TUBS/SHOWERS/FIREPLACES – Insulation is installed behind showers, tubs, and fireplaces on exterior, attic, and party walls and rigid sheathing or other supporting material is installed to hold insulation in place



Grade I Assessment

Installed according to manufacturer's instructions, fills each cavity completely, no substantial gaps or voids, split and fit tightly around wiring and other services

Boundary condition for "Grade I"



Gaps clear through insulation– minimal

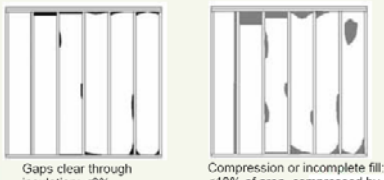
Compression or incomplete fill: <2% of area, compressed by <30% of intended thickness

Grade I is required if using national BOP

Grade II Assessment

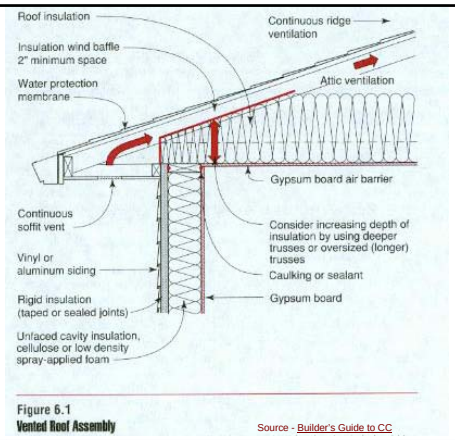
Moderate to frequent defects such as gaps around wiring, electrical outlets, plumbing, and other services; rounded edges or shoulders.

Boundary condition for "Grade II"

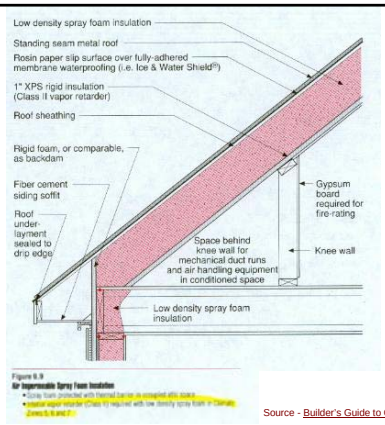


Gaps clear through insulation: <2%

Compression or incomplete fill: <10% of area, compressed by <30% of intended thickness



Source - Builder's Guide to CC

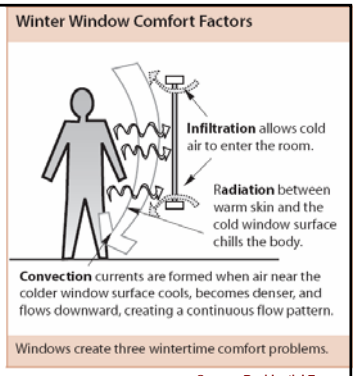


Source - Builder's Guide to CC

Window Surface Temperature

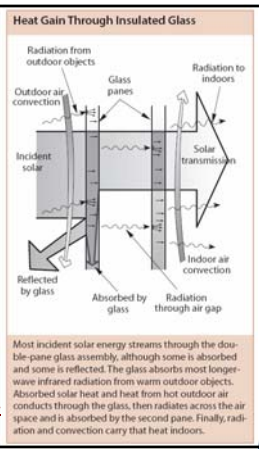
Glass surface temperature at 25°F outdoor, 70°F indoor temperature:

- Single glass 52 °F
- Double glass 59 °F
- Low E + Argon 62 °F
- High Performance 64 °F
  (Heat mirror films)



Source - Residential Energy

Windows transfer heat by conduction, radiation, and convection.



Source - Residential Energy

Energy Characteristics of Typical Window Glass Options

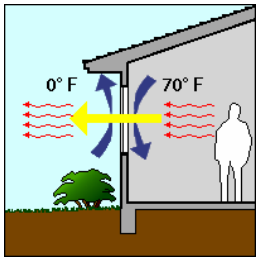
Glazing Assembly	U-factor	R-value	SHGC	VT
Single glass	1.1	0.9	0.87	0.90
Standard insulated glass	0.50	2.0	0.76	0.81
High-SHGC, low-e insulated glass	0.30	3.3	0.74	0.76
Medium-SHGC, low-e insulated glass	0.26	3.8	0.58	0.78
Low-SHGC, low-e insulated glass	0.29	3.4	0.41	0.65
Triple glazed 2 low-e insulated coatings	0.12	8.3	0.50	0.65

These values are for glass, not the entire window.

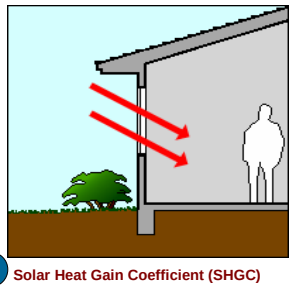
Source - Residential Energy

www.nfrc.org

A **U-Factor** measures how well a product prevents heat from escaping a home or building. U-Factor ratings generally fall between 0.20 and 1.20. The lower the U-Factor, the better a product is at keeping heat in. U-factor, takes into account more than conductivity. It also is affected by the airflow around the window.

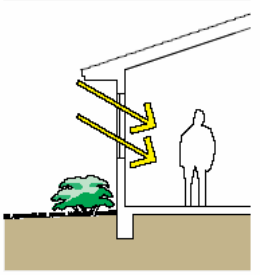


www.nfrc.org

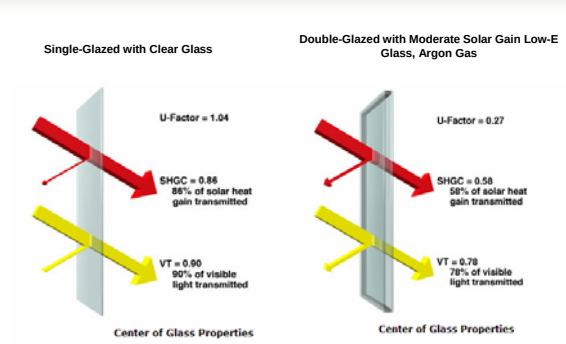


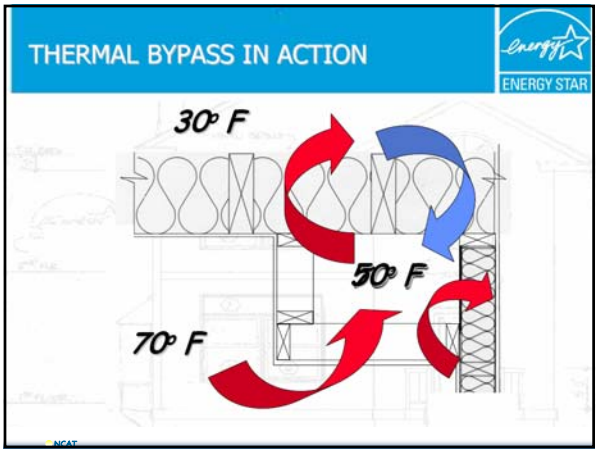
B **Solar Heat Gain Coefficient (SHGC)** measures how well a product blocks heat from the sun. SHGC is expressed as a number between 0 and 1. The lower the SHGC, the better a product is at blocking unwanted heat gain. Assumes the sun strikes the glass at 90 degrees.

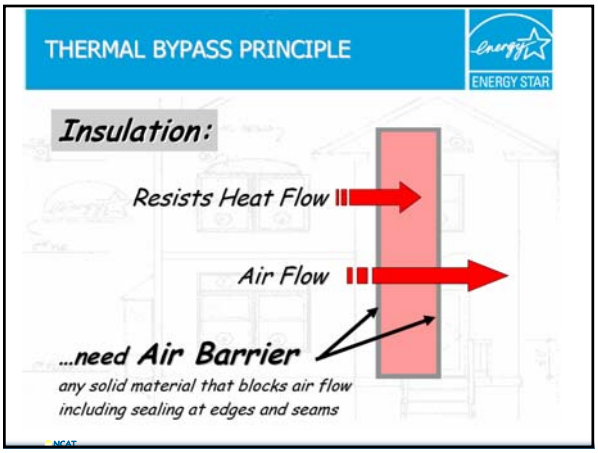
www.nfrc.org



C **Visible Transmittance (VT)** measures how much light comes through a glazing. VT is expressed as a number between 0 and 1. The higher the VT, the higher the potential for daylighting.







THERMAL BYPASS CHECKLIST:
1. INSULATION ALIGNMENT

THERMAL BYPASS CHECKLIST:
2. SHOWER/TUB EXTERIOR WALL

Courtesy of Building Science Corp.

THERMAL BYPASS CHECKLIST:
2. SHOWER/TUB EXTERIOR WALL

THERMAL BYPASS CHECKLIST:
3. INSULATED FLOOR OVER GARAGE

Improper insulation! It must touch the surface it is intended to insulate

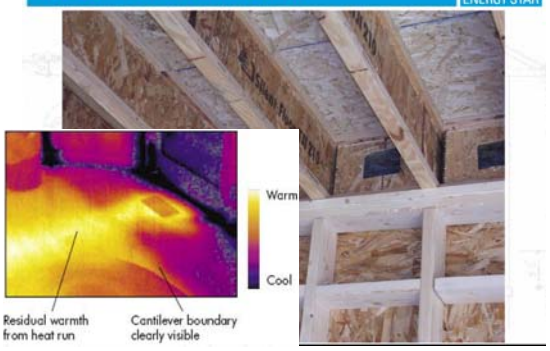
THERMAL BYPASS CHECKLIST:
4. ATTIC KNEE WALLS

Hot Wall

Courtesy of Building Science Corp.

THERMAL BYPASS CHECKLIST:
5. ATTIC ACCESS STAIRS

THERMAL BYPASS CHECKLIST:
6. CANTILEVERED FLOOR



THERMAL BYPASS CHECKLIST:
7. DUCT/PIPING PENETRATIONS

Airtight foam on pervious rock wool will not work.

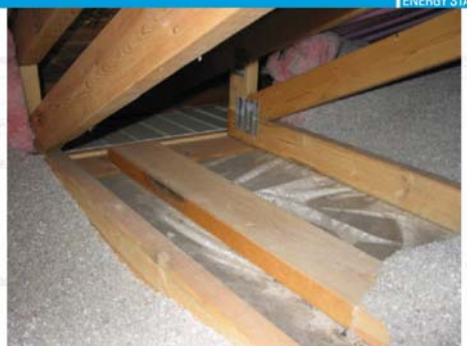
Courtesy of Advanced Energy Corporation

THERMAL BYPASS CHECKLIST:
8. FLUE SHAFT

Courtesy of Building Science Corp.

Image courtesy of EnergyLogic

THERMAL BYPASS CHECKLIST:
9. ATTIC EAVES



THERMAL BYPASS CHECKLIST:
9. ATTIC EAVES

Image courtesy of MaGrann Associates

THERMAL BYPASS CHECKLIST:
10. DROPPED CEILINGS

Courtesy of Building Science Corp.

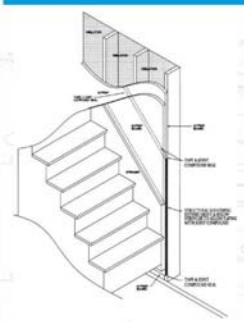
THERMAL BYPASS CHECKLIST:
10. DROPPED CEILINGS

Courtesy of Building Science Corp.

THERMAL BYPASS CHECKLIST:
11. FIREPLACE SHAFT WALL

Courtesy of Building Science Corp.

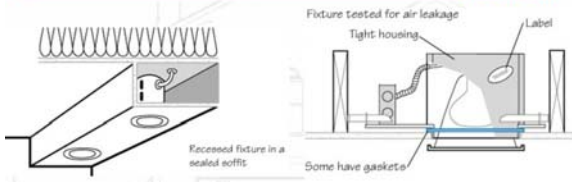
THERMAL BYPASS CHECKLIST:
12. STAIRCASE FRAMING



Courtesy of MaGrann Associates

Image courtesy of Energy Services Group

THERMAL BYPASS CHECKLIST:
13. RECESSED LIGHTING



Eliminate this air leakage by locating fixtures inside the insulated envelope or using insulated can, air-tight (ICAT) recessed fixtures.

THERMAL BYPASS CHECKLIST:
14. PORCH ROOF

ENERGY STAR

Courtesy of Energy Services Group

NCAT

THERMAL BYPASS CHECKLIST:
15. WHOLE-HOUSE FAN

ENERGY STAR

Problem: Whole-house fan is equivalent to a ~10 sq. ft. thermal hole

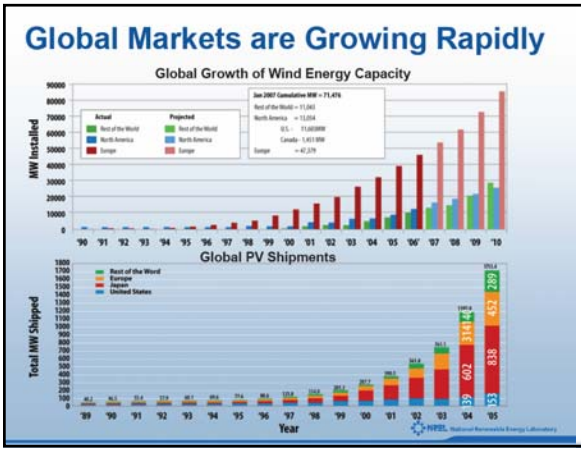
NCAT

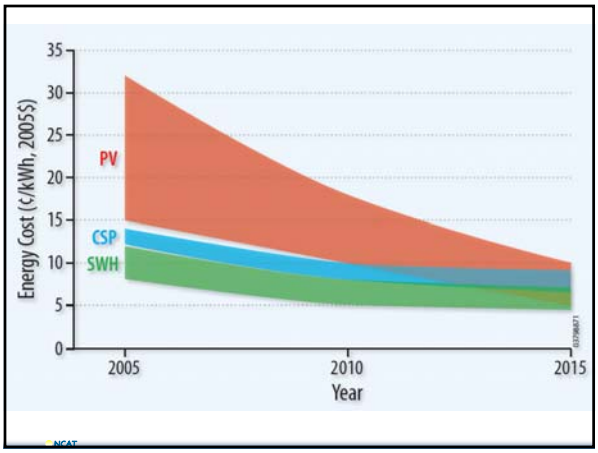
"[It's] time for the human race to enter the solar system."

...George W. Bush

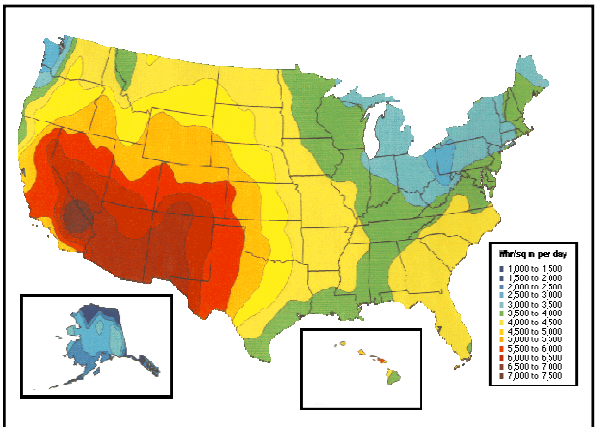
NCAT

Global Markets are Growing Rapidly

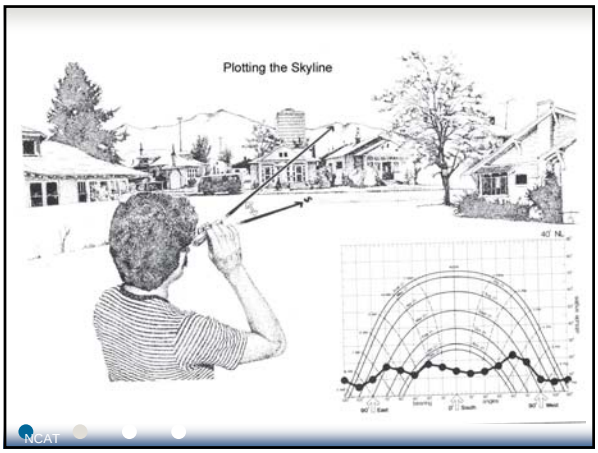




NCAT



NCAT

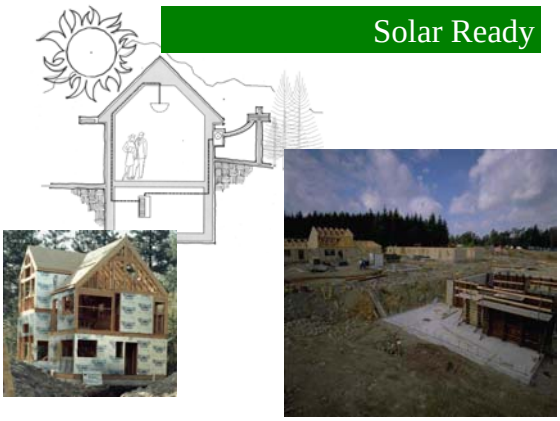


Solar Design Priorities (In Terms of Cost Effectiveness)

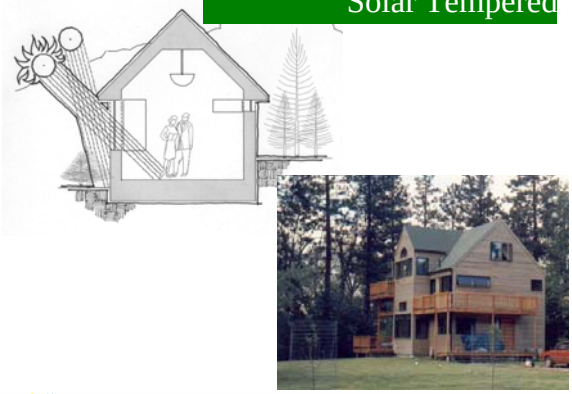
1. **Energy Efficiency**
2. Solar Tempering
3. Solar Hot Water
3. Passive Solar
4. Solar Electric

"Buildings must be worthy of solar energy systems." - Steven Strong

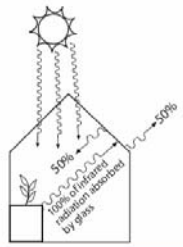
Solar Ready



Solar Tempered



Greenhouse Effect



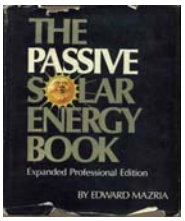
About 85% of solar heat is transmitted by the glass in this greenhouse. The heat is absorbed by objects inside the greenhouse. The objects re-radiate the heat as infrared radiation, which is nearly 100% absorbed by the glass. 50% of that absorbed heat is re-radiated outdoors and 50% is re-radiated indoors. Heat is therefore concentrated in the greenhouse and its temperature rises.

Source - Residential Energy

Passive Solar Design

"Since a building or some element of it is the passive system, the application of passive solar energy must be included in every step of the building's design."

–Edward Mazria, *The Passive Solar Energy Book*

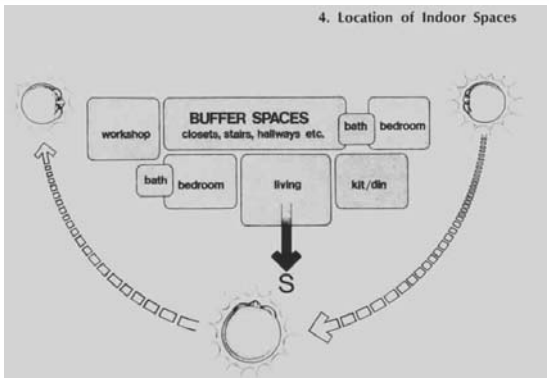


NCAT

Passive Solar Homes - Not for Everyone

1. First Cost (usually for thermal mass)
2. Floor Plan Layout and Window Location
3. Temperature Swings
4. Thermal Mass Finishes
5. Fading of Finishes (especially fabrics)

NCAT



NCAT

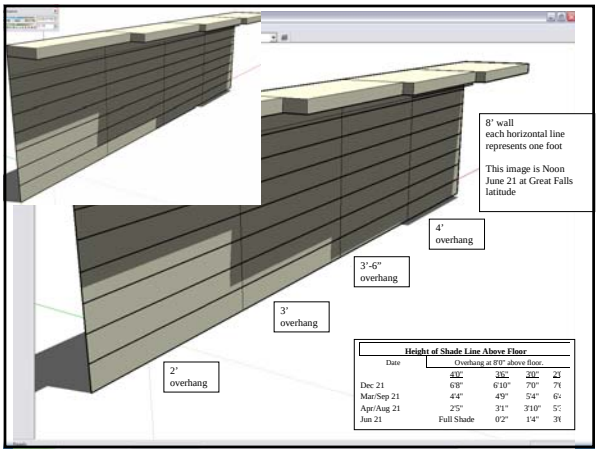
A Tale of One Square Foot of Glass

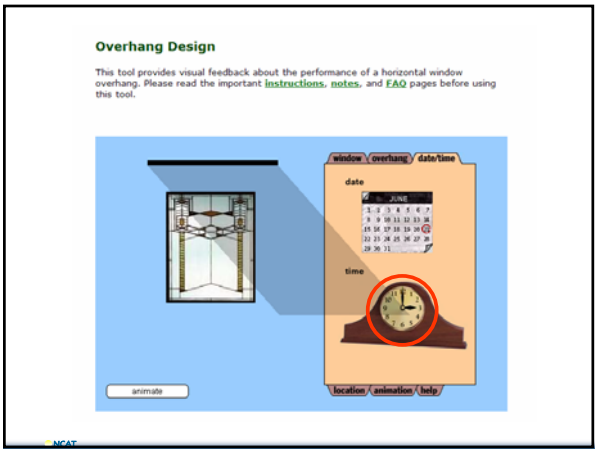
Subtitled: The Annual Heat Balance

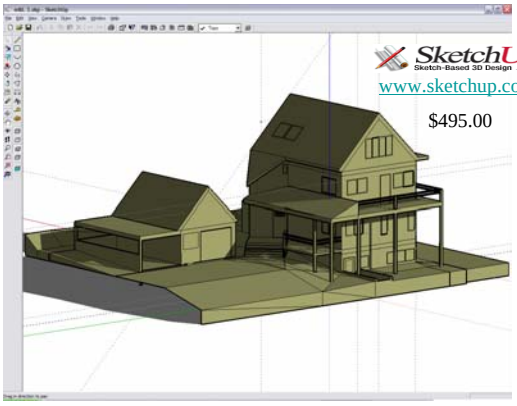
North Wall	-6 Btu/Year
North Wall Glass – R3 insulation (8h/d, 8m/yr)	-51 Btu/Year
South Wall Glass – No insulation	+50 Btu/Year
↖ This glass foot loses more energy than it gains in Dec-Jan.	
South Wall Glass – R3 insulation (8h/d, 8m/yr)	+60 Btu/Year

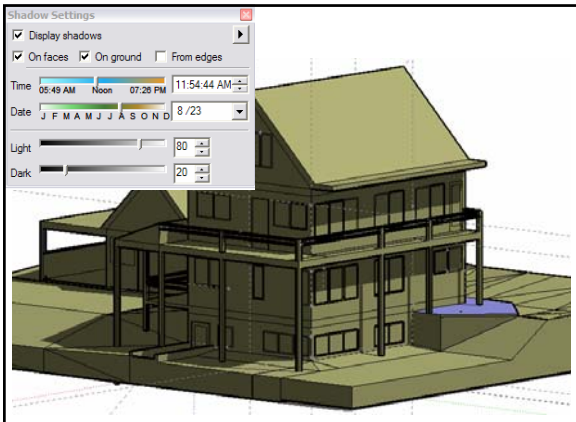
Assumptions:
SHGC = .53
U-value = .37
Wall R-value = 24

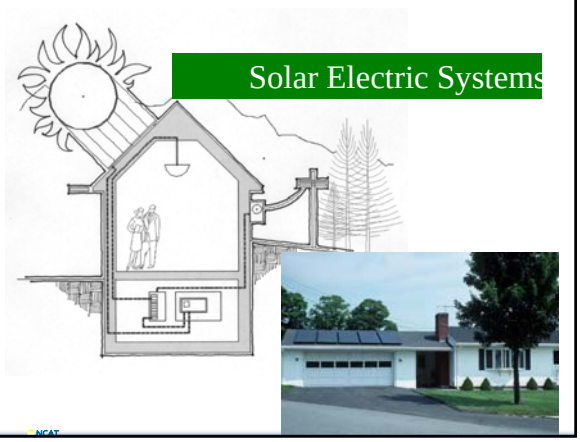
NCAT

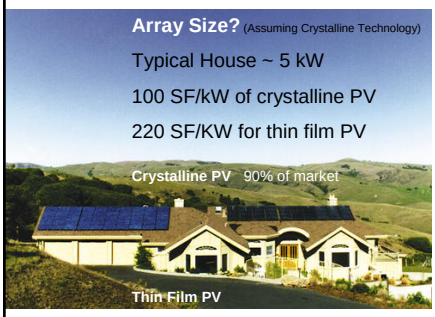




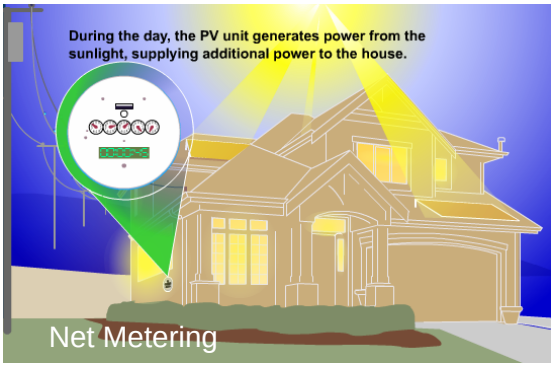






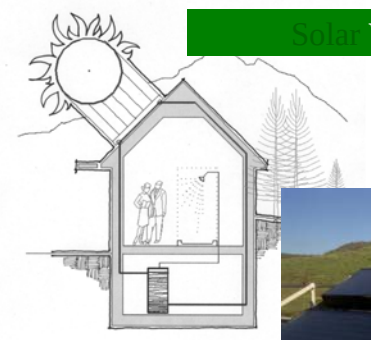


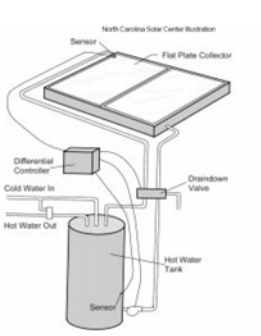
- Greatest Potential for Future Market Domination
- Uses less material and energy to manufacture



Graphic Credit: California Energy Commission

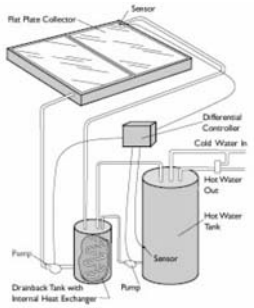
Solar Water Heating





Draindown Solar Water System

Potable water is circulated through collector, valves automatically open to draindown water for freeze protection. Water in collector is dumped



Drainback Solar Water System

A circulation fluid in used instead of potable water. Fluid is circulated through collector, which is transferred to potable water with heat exchanger. System operates on gravity for freeze protection. When pump shuts off the fluid drains into a storage tank.

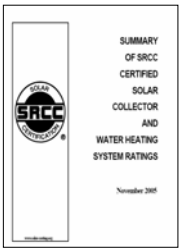
Domestic Water-Heating Systems

Solar Rating & Certification Corporation Directory.

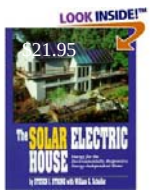
Solar Rating & Certification Corporation C/O Florida

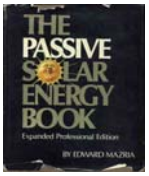
Solar Energy Center, 1679 Clearlake Road, Cocoa , FL

32922-5703; 407-638-1537.



http://www.solar-rating.org/default.htm





MONTANA Green Power

www.montanagreenpower.com

Heating, Cooling, Hot Water, Appliances and Lighting

Section 5

Section 6: Heating, Cooling, Hot Water, Appliances and Lighting

Heating

Cooling

Controls

Ducts

Hot Water

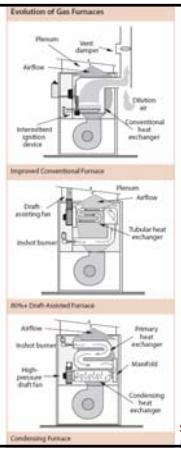
Appliances

Lighting

AFUE 64-65%

AFUE 78-82%

AFUE 90-96%



Source - Residential Energy

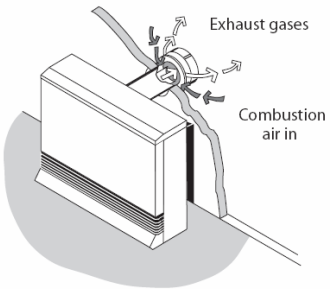
COMBUSTION SYSTEM HIGHLIGHTS:
POWER/DIRECT VENTED EQUIPMENT

ENERGY STAR

Benefits of Sealed Combustion

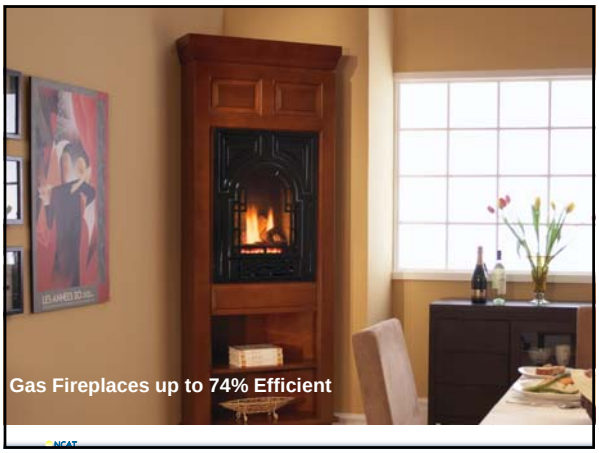
Energy-Efficient Gas Space Heater

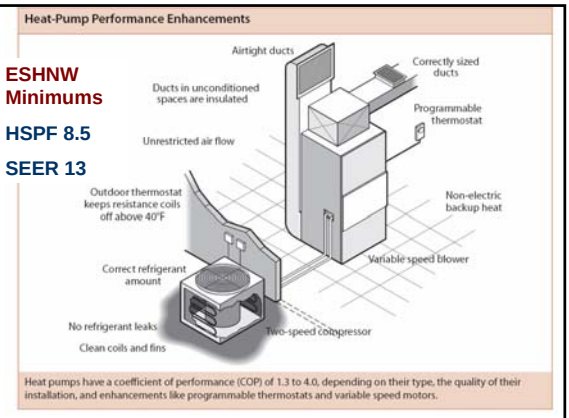
SSE of 78-82%



New sealed-combustion gas space heaters are safer and more efficient than older gas space heaters.

Source - Residential Energy





ESHNW Minimums

HSPF 8.5

SEER 13

Source - Residential Energy

ENERGY STAR

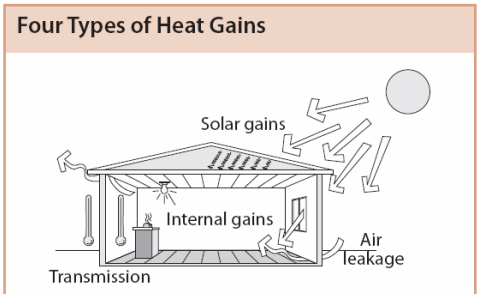
Air Source Heat Pumps

- Higher SEER
- Higher HSPF
- 20% more efficient than standard new models
- 20-50% more efficient than older models

ENERGY STAR

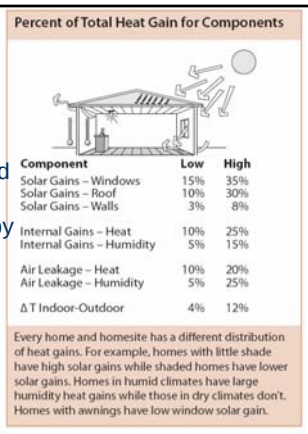
Geothermal Heat Pumps

- Geothermal heat pumps use the ground instead of outside air to provide heating
- Among the most efficient and comfortable heating and cooling technologies



Source - Residential Energy

Well planned landscaping can reduce an unshaded home's summer air conditioning costs by 15% to 50%

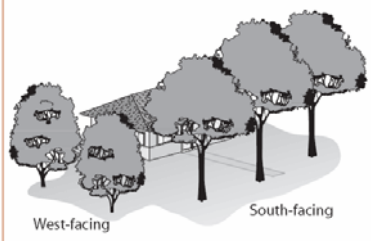


Source - Residential Energy

LBL studies have shown that summer daytime air temperatures are 3 to 6 degrees cooler in neighborhoods with mature tree canopies

Planting trees is ten time more cost effective than building power plants.

Energy-Saving Landscaping



Landscaping is the best long-term cooling investment for residences. Southern exposures need taller trees to block the higher angle of the sun from the south. East and west vegetation should block the lower-angle sun from entering windows during the summer.

Source - **Residential Energy**

HVAC PROPER INSTALLATION

- *Right-Sized Equipment (ACCA Manuals J/S)*
- *Engineered Duct Layout (ACCA Manual D)*
- *Register Design (ACCA Manual T)*
- *Duct Sealing/Testing*
- *Refrigerant Charge*
- *Air Flow Across Coil*
- *Air Flow Balance*

Air Conditioning Contractors of America

ENERGY STAR Programmable Thermostats

- Programmable thermostats automatically adjust temperature settings, save about $100 per year

- Store four or more temperature settings a day

- Adjust heating or air conditioning turn-on times as the outside temperature changes

COMBUSTION SYSTEM HIGHLIGHTS: CO ALARMS

CO ALARM

c UL us LISTED

COMBINED CO & SMOKE ALARM

Manual J Computer Calculation of Room Heat Flows and Air-Handler Airflows

Room	Area (ft^2)	Heating load (Btuh)	Cooling load (Btuh)	Heating Airflow (cfm)	Cooling Airflow (cfm)
Living room	255	4670	4568	188	221
Dining room	224	4219	2271	195	188
Kitchen	144	3201	2456	91	119
Bedroom 1	158	4410	1799	142	98
Bedroom 2	106	1730	771	53	41
Bedroom 3	99	3941	2492	151	136
Bathroom 1	80	1532	1206	65	78
Bathroom 2	60	771	521	29	39
Totals	1126	24,474	16,084	914	920

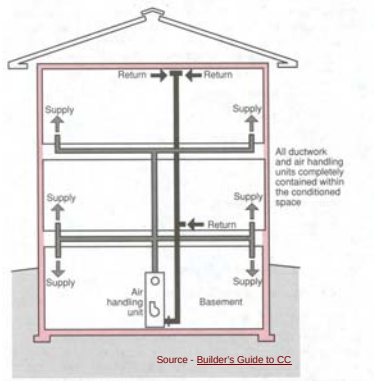
Manual J (Air Conditioning Contractors of America)

Source - **Residential Energy**

Ducts

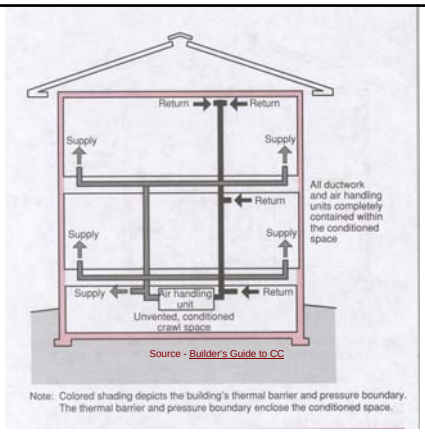
- ➔Should be located within the thermal envelope
- ➔Ducts need to be sealed, especially if outside the thermal envelope
- ➔Duct systems need to be designed
- ➔Design the supply registers

Trending toward:
- higher air velocity at outlet
- lower supply air temperature in heating mode longer run time
- be aware of air speed in occupied zones



Source - Builder's Guide to CC

Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.



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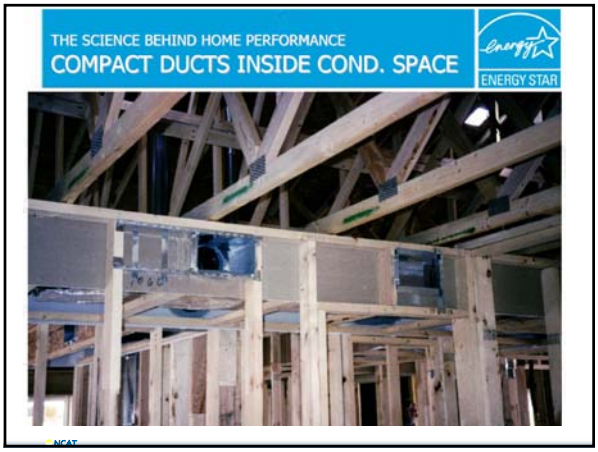
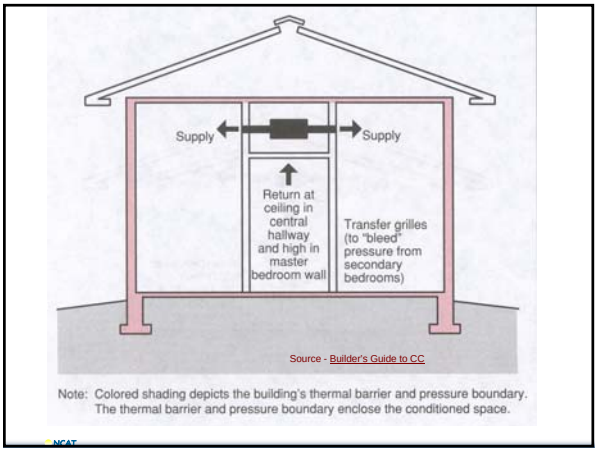




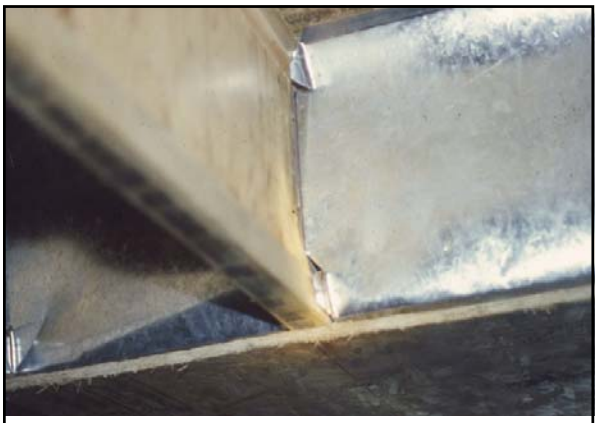
Source - Builder's Guide to CC

Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

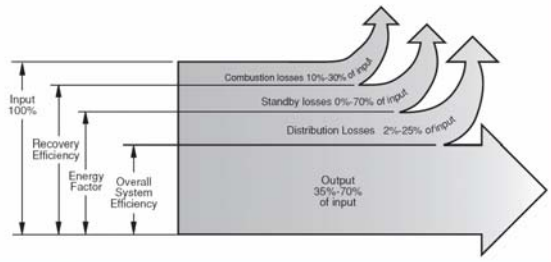
Building cavities as return ducts

Do these building cavities look airtight to you?

Avoid using building cavities as return ducts because they are difficult to air seal.



Water-Heating Efficiency

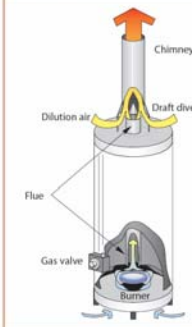


The various efficiencies used for rating water-heating systems account for losses in the combustion process, standby losses, and distribution losses.

Source - **Residential Energy**

ESHNW Minimum ER .61

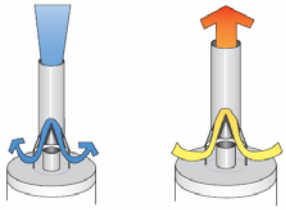
Standard Gas Water Heater



Combustion air enters the bottom, combusts with gas, then rises through the flue which is surrounded by water. The gases heat the water as they rise through the tank. Dilution air enters through the draft diverter.

Source - **Residential Energy**

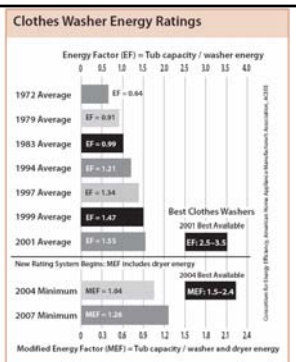
Function of a Draft Diverter



This device diverts down-drafts so they do not blow out the pilot light. The draft diverter also lets dilution air into the flue to relieve pressure that would otherwise pull directly on the burner, causing unnecessary excess air.

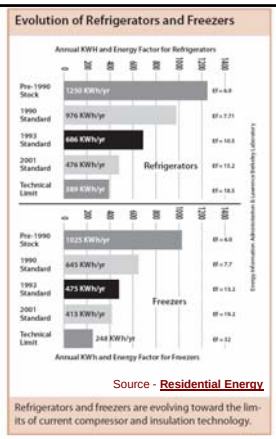
Source - **Residential Energy**

Clothes Washer Energy Ratings



Clothes washer energy ratings change in 2004 from Energy Factor (EF) to Modified Energy Factor (MEF). ENERGY STAR's new requirement for 2004 is MEF = 1.42.

Source - **Residential Energy**



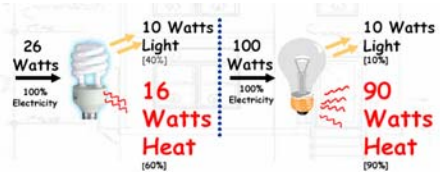
ENERGY STAR Clothes Washers

- Clean clothes using 50% less energy
- Extract more water from clothes during the spin cycle, reduces the drying time and saves energy and wear and tear on clothes.

ENERGY STAR Refrigerators

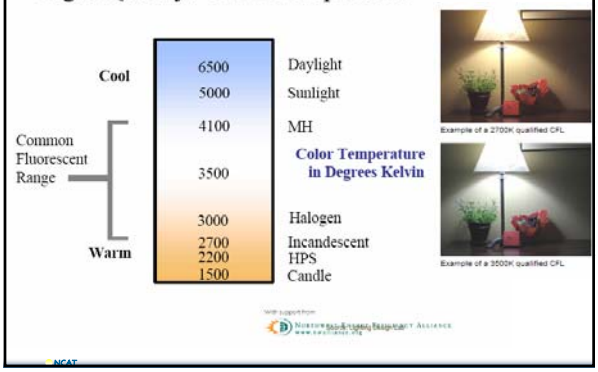
- High efficiency compressors
- Improved insulation
- More precise temperature and defrost mechanisms
- Use 15% less energy than required by current federal standards
- Use 40% less than conventional models sold in 2001

New v. Old Light Bulbs



- Use the 4-to-1 rule in finding a replacement bulb.

Light Quality: Color Temperature



Light Quality
Color Rendering Index (CRI)

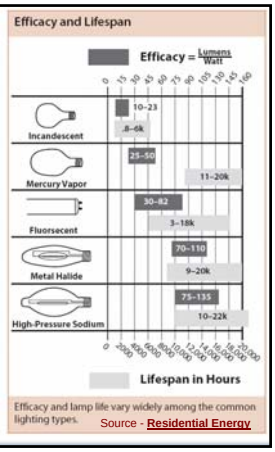
- CRI = How a lamp reproduces color accurately.
- The CRI scale ranges from 0 to 100.

** All ENERGY STAR Lamps intended for indoor use are 80 CRI or Higher

Lighting Type	Color Rendering Index
Incandescent	97–100
Fluorescent (Standard)	52–62
Fluorescent (T-8 & CFL)	81–90
Mercury vapor	22–52
Metal halide	60–90
High-pressure sodium	25–65

Source - Residential Energy

Efficacy = Lumens / Watt



LIGHT OUTPUT EQUIVALENCY

To determine which ENERGY STAR qualified light bulbs will provide the same amount of light as your current incandescent light bulbs, consult the following chart:

INCANDESCENT LIGHT BULBS	MINIMUM LIGHT OUTPUT	COMMON ENERGY STAR QUALIFIED LIGHT BULBS
WATTS	LUMENS	WATTS
40	450	9-13
60	800	13-15
75	1,100	18-25
100	1,600	23-30
150	2,600	30-52

LEARN MORE AT energystar.gov

CFL Sizes and Shapes

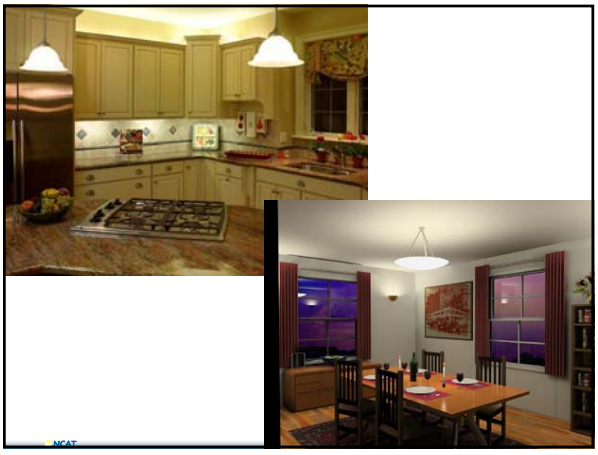
CFLs come in a variety of shapes and sizes. The majority of CFLs are designed to look identical to the incandescent light bulb version. The table below identifies the most popular CFL shapes that are available at retail:

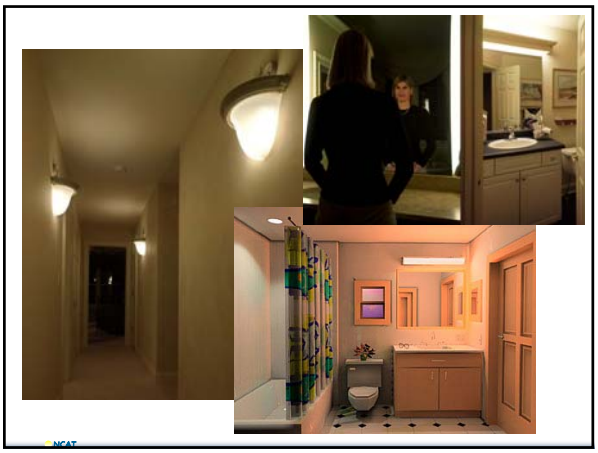
Bare Products		Covered Products			Reflector Products
Mini-Spiral or Twist	Tube or Universal	Incandescent/ A-line	Globe G25, G30, G40	Candelabra, Post or Bullet Shape	Indoor and Outdoor R20, R30, R40, PAR38
					

Bulb Disposal & Mercury

Fluorescent tubes & CFL's account for 1% of mercury (Hg) released in to the US annually. 87 % of US emissions are from coal burning power plants & incinerators. Energy savings from CFL's results in a net reduction of Hg releases through less coal use.

Check with your local solid waste agency for proper disposal suggestions.
- www.earth911.org
- www.lamprecycle.org





Recessed Cans

- Popular in many homes.
  - Can retrofit with screw-in Reflectors (R-lamps). Heat is an issue.
  - See http://www.pnl.gov/rlamps/index.stm
  - CFL fixtures are now available with the ballast outside of can & a pin-based bulb.
- ENERGY STAR cans allow for fewer cans and better light distribution

HERS Training: Mechanical Ventilation

Section 6

"Build it tight, ventilate it right."

WHAT POLLUTANTS AFFECT IAQ?

ENERGY STAR

- Biological pollutants
  - Mold & Mildew
  - Dust Mites & Pests
- Combustion products
  - CO, NO2, Smoke
- Radon & Soil gases
- Formaldehyde
- Other Chemicals
- Airborne Particles
  - Dust, Pollen

Linked to health problems ranging from minor respiratory irritation to death, depending on exposure and sensitivity

More IAQ Info available at: http://www.epa.gov/iag/ia-intro.html Or call 1-800-438-4318

House design and construction can reduce exposure risk for indoor air pollutants!

IAQ RISK REDUCTION PRINCIPLES

ENERGY STAR

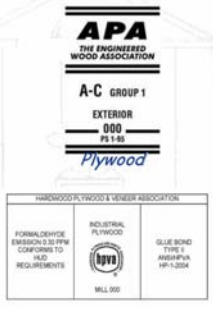
1. **Source Control**
   eliminate, substitute, or modify pollutant sources
2. **Dilution**
   ventilate to dilute unavoidable pollutants
3. **Filtration**
   remove targeted pollutants,
   last resort after source control & dilution

BUILDING MATERIALS HIGHLIGHTS: LOW-EMITTING MATERIALS

ENERGY STAR

MDF & Particleboard

Certified "Green" Carpeting



Infiltration versus Mechanical Ventilation

	Infiltration	Mechanical Ventilation
Reliable appropriate quantity of air	NO	Yes
Air delivered to appropriate spaces	NO	Yes
Can be shut off if house is unoccupied	NO	Yes
Quality of air good as outdoor air	NO	Yes

Note: This assumes mechanical system is properly designed.

Mechanical Ventilation

Introduction

ASHRAE 62.2

Exhaust and Supply Ventilation Systems

Balanced Ventilation Systems

Radon Mitigation

Mechanical Ventilation

REM/RATE assumes ASHRAE 62.2-2003

Requires continuous whole-building* mechanical ventilation based on conditioned floor area and # of bedrooms

7.5 cfm/bedroom +1 plus 1 cfm/100 SF

Example: 3-bedroom 2400 SF house

(7.5 cfm x (3+1)) + (2400/100) = 54 cfm

* - Mech exhaust system may include local exhaust fans.

Residential Energy's BTL is out-of-date

Mechanical Ventilation

Intermittent Mechanical Ventilation Example

A fan operated 30% of the time with cycle times of four hours (6 cycles/day) with a ventilation requirement of 40 cfm.

Ventilation Effectiveness 33% (from Table 4.2)

40 cfm/(.33 x .30) = 404 cfm

Ventilation Required

Fractional On-time Vent Effectiveness

The fan flow will have to equal or exceed 404 cfm

Section 5 Mechanical Ventilation

Introduction

ASHRAE 62.2

Exhaust and Supply Ventilation Systems

Balanced Ventilation Systems

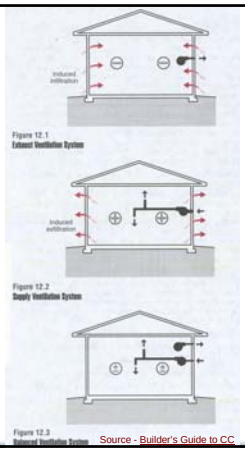
Radon Mitigation

Mechanical Ventilation System Types

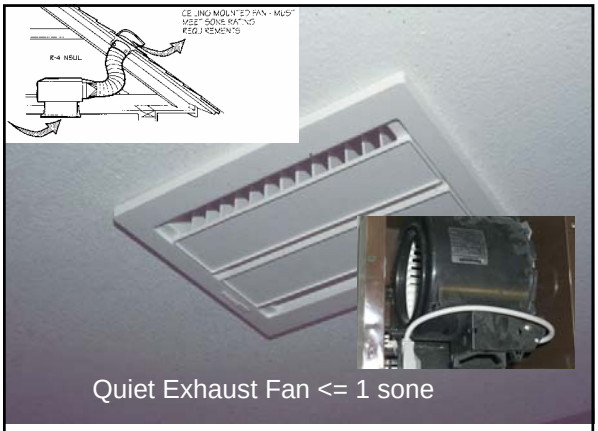
1. Exhaust Only
2. Supply Only

Balanced:

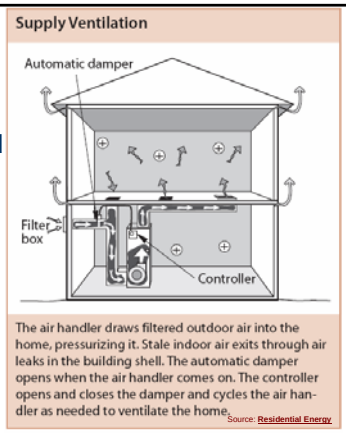
3. Spot exhaust w/ make-up air
4. Central exhaust without heat recovery
5 Central exhaust with Heat Recovery



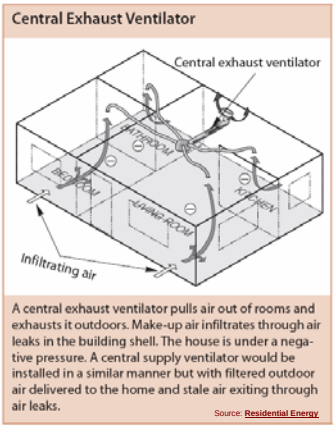
Source - Builder's Guide to CC



➔**Not Recommended for Cold Climates**



➔**Not Recommended for Hot Humid Climates**



Mechanical Ventilation

Introduction

ASHRAE 62.2

Exhaust and Supply Ventilation Systems

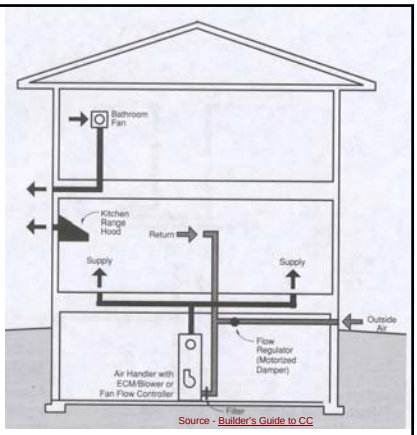
Balanced Ventilation Systems

Radon Mitigation

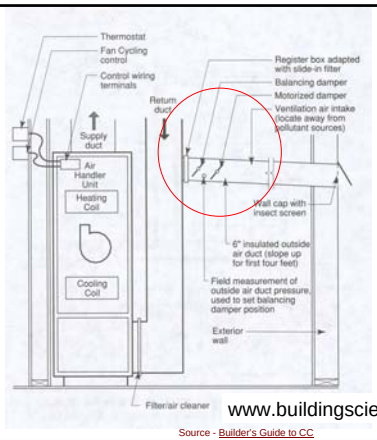
Arguments for Balanced Mechanical Ventilation Systems

1. Avoids problems of creating positive and negative pressures
2. More likely to actually provided design air quantities
3. Provides air through planned pathways, improves air quality
4. Many systems provide option for heat recovery

Spot exhaust w/ make-up air



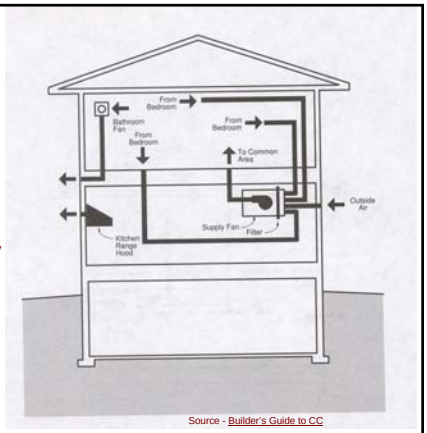
Source - Builder's Guide to CC



www.buildingscience.com

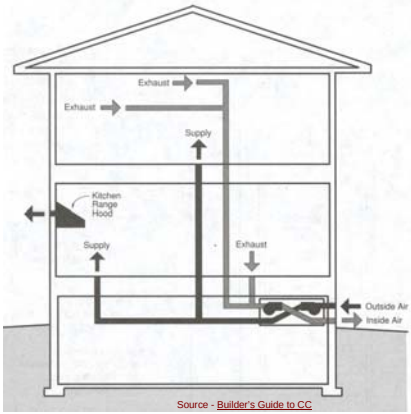
Source - Builder's Guide to CC

Central exhaust without heat recovery



Source - Builder's Guide to CC

Central Exhaust with Heat Recovery



Source - Builder's Guide to CC

Heat Recovery Ventilator

Heat exchanger plates separate the two airstreams while transferring heat from exhaust to intake

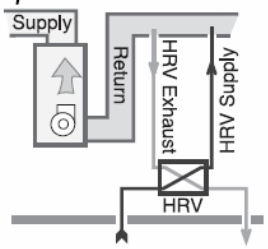
Exhaust air moves through the heat exchanger, heating its plastic or metal plates. The warm metal or plastic heats the incoming air, which moves in alternating spaces between plates, and in the opposite direction as the exhaust air.

Source: Residential Energy

Ventilation Controls

Typical Ventilator Ducting

Simplified Ventilator Installation



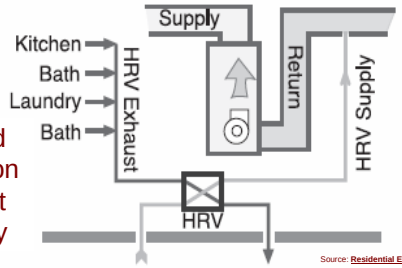
Not allowed in ESHNW

Least satisfactory of the three options, the simplified installation depends on proper duct sizing and air-handler airflow.

Source: Residential Energy

Typical Ventilator Ducting

Extended Ventilator Installation



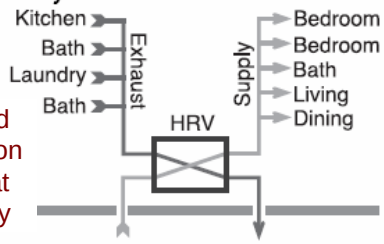
Balanced Ventilation with Heat Recovery

Source: Residential Energy

The extended installation requires the air handler's blower to bring exhaust air from the home.

Typical Ventilator Ducting

Fully Ducted Ventilator Installation



Balanced Ventilation with Heat Recovery

For airtight superinsulated homes in cool regions this system is very common. Heat may be supplied by central or space heat.

Source: Residential Energy

Mechanical Ventilation

Introduction

ASHRAE 62.2

Exhaust and Supply Ventilation Systems

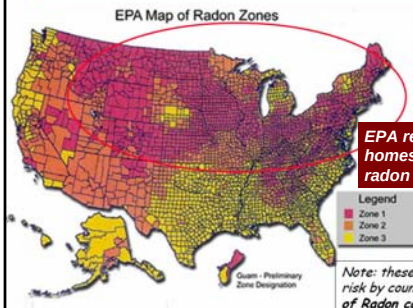
Balanced Ventilation Systems

Radon Mitigation

RADON CONTROL HIGHLIGHTS:
RADON RESISTANT CONSTRUCTION

ENERGY STAR

EPA Map of Radon Zones



Radon Risk is High in much of the U.S. Check State & local authorities for more detailed information on Radon risk in your area.

EPA recommends that all homes built in Zone 1 have radon reduction systems.

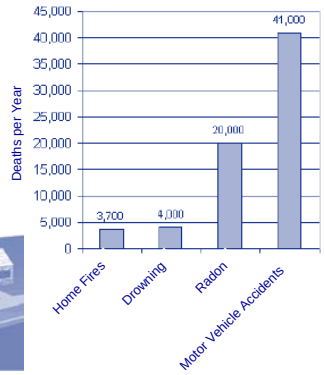
*Note: these maps indicate average risk by county. However, **High levels of Radon can be found anywhere, and soil gases may be toxic!***

http://www.epa.gov/radon/pdfs/buildradonout.pdf

Comparison of Death Risks

Is there a safe level of radon?

Can you test for radon before construction?

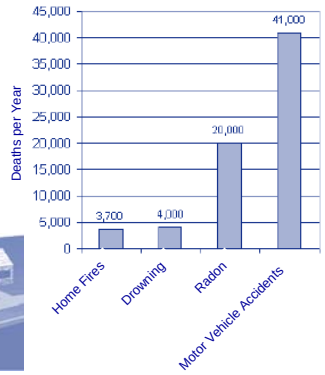


NCAT

Comparison of Death Risks

Is there a safe level of radon? **No.**

Can you test for radon before construction? **No.**

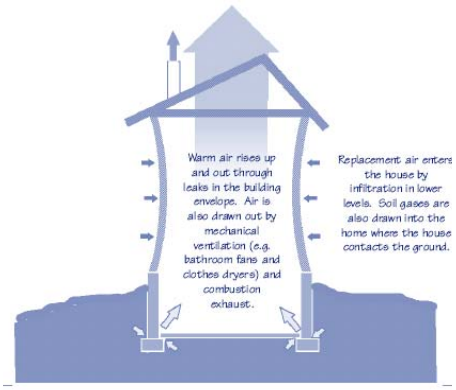


NCAT

How Does Radon Enter A House?

Common Radon Entry Points

NCAT



NCAT

RADON CONTROL HIGHLIGHTS:
RADON RESISTANT CONSTRUCTION

ENERGY STAR

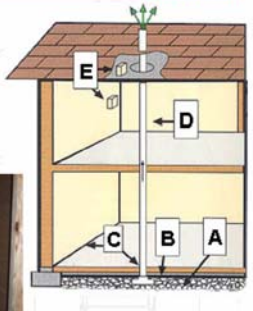
A. Gas Permeable Layer
(4" clean gravel)

B. Plastic Sheeting
(under slab or over crawl space)

C. Sealing and Caulking
(all openings in concrete floor)

D. Vent Pipe
(3 or 4 inch PVC pipe)

E. Junction Box
(if fan needed later)



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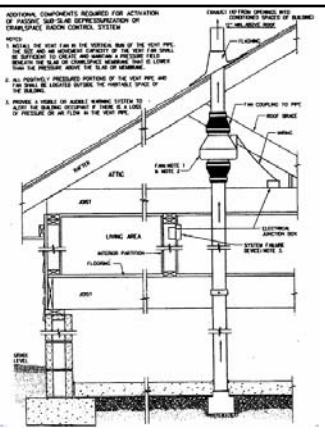
Architectural Drawing

Active Sub-Slab Depressurization System

Uses fan to mechanically draw air from beneath the slab (or membrane) through the vent pipe.



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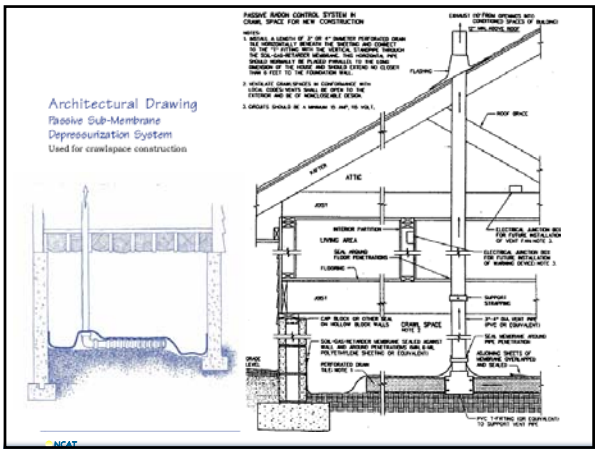


Performance Testing and Diagnostics

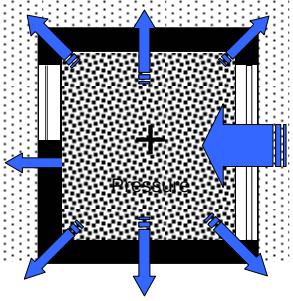
Section 7

CFM air in = CFM air out

House Pressurization

Pressure inside is greater than pressure outside, house is under positive pressure

House is under pressure with respect to (WRT) outside



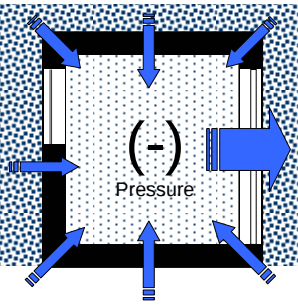
Result: Indoor conditioned air forced into structure.

CFM air in = CFM air out

House Depressurization

Pressure outside is greater than pressure inside, house is under negative pressure

House is under negative pressure with respect to (WRT) outside



Result: Outdoor air drawn into house.

Vocabulary To Know

- Air Pressure measured in Pascals
  249 pa = 1 inch wc
- Air Changes per Hour (ACH_{50} and ACH_{nat})
- CFM & CFM50
- Pressure Boundary
- Pressure Balance
- With Reference To (WRT)
- Neutral Pressure Plane

AIR FLOW BASICS

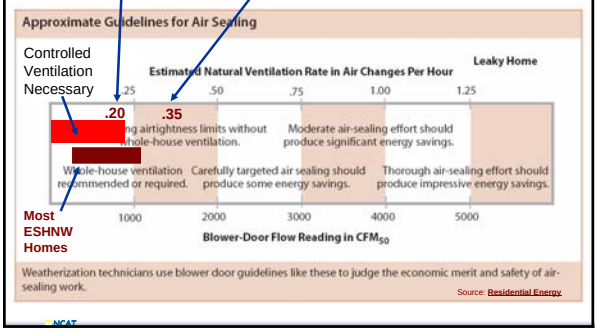
- For air to move, you need a hole and a driving force.
- Air always flows from high (or positive) pressure to low (or negative) pressure.
- For any building, or room within a building, CFM in always equals CFM Out

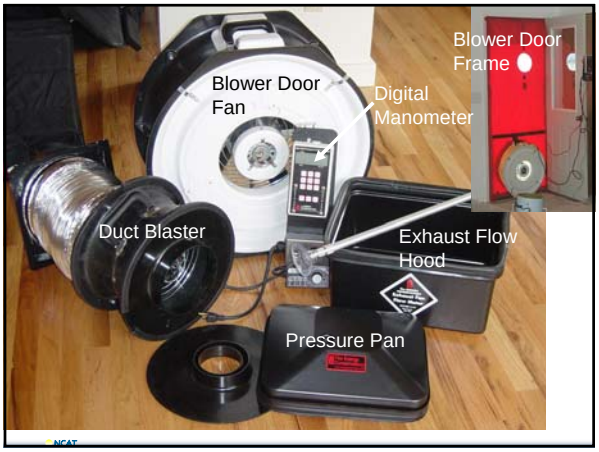
Typical Residential Pressures

Force	Induced Pressure
Wind	Ave. 4 Pa
Stack Effect	1 - 3 Pa
Exhaust Fans	1 - 5 Pa
Combustion Equipment	.5 - 1 Pa
Fireplaces	1 - 10 Pa
Air Handler (Duct Leakage)	.5 - 5 Pa
Typical Blower Door Test	50 Pa
Potential Back Draft Problems	3 Pa

NEEA assumes mechanical ventilation necessary below about 4 ACH_{50}

NEEA assumes average house tightness about 7 ACH_{50}





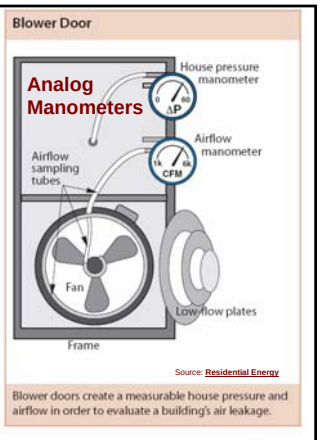
Blower Door Fundamentals

➔Fan depressurizes house

➔Measure fan pressure which yields fan air flow (CFM)

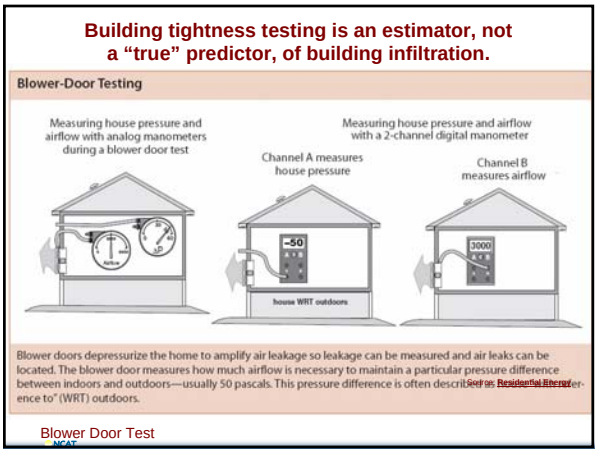
➔Air flow through fan equals air leakage into the house

➔Flow at test conditions (50 Pa) allows calculation of flow under natural conditions and air leakage area



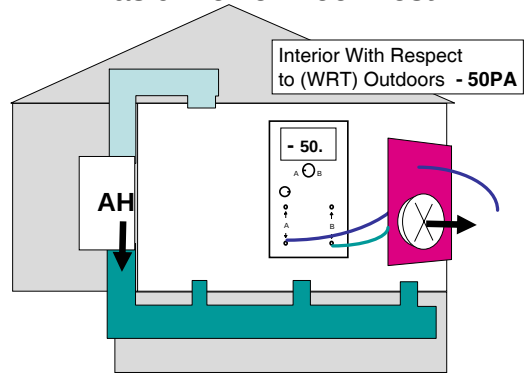
Blower Door Test

Building tightness testing is an estimator, not a "true" predictor, of building infiltration.



Blower Door Test

Basic Blower Door Test



Blower Door Test

Blower Door Math

To calculate air changes per hour at 50 Pa:

$$ACH_{50} = \frac{CFM_{50} \times 60}{\text{House Volume}}$$

To convert air change rate at 50 Pa to the air change rate at natural conditions:

$$ACH_{nat} = \frac{CFM_{50} \times 60}{n \times \text{House Volume}}$$

n – The correlation factor shown on the following slide.

Blower Door Test

Converting CFM50 to Air Change Values

(Provides Approximate Values)

n-Factor Table

Zone	# of stories →	1	1.5	2	3
1	Well-shielded	18.6	16.7	14.9	13.0
	Normal	15.5	14.0	12.4	10.9
	Exposed	14.0	12.6	11.2	9.8
2	Well-shielded	22.2	20.0	17.8	15.5
	Normal	18.5	16.7	14.8	13.0
	Exposed	16.7	15.0	13.3	11.7
3	Well-shielded	25.8	23.2	20.6	18.1
	Normal	21.5	19.4	17.2	15.1
	Exposed	19.4	17.4	15.5	13.5
4	Well-shielded	29.4	26.5	23.5	20.6
	Normal	24.5	22.1	19.6	17.2
	Exposed	22.1	19.8	17.6	15.4

Source: Residential Energy

$$ACH_n = \frac{ACH_{50}}{n}$$

$$ACH_{50} = ACH_n \times n$$

$$CFM_n = \frac{CFM_{50}}{n}$$

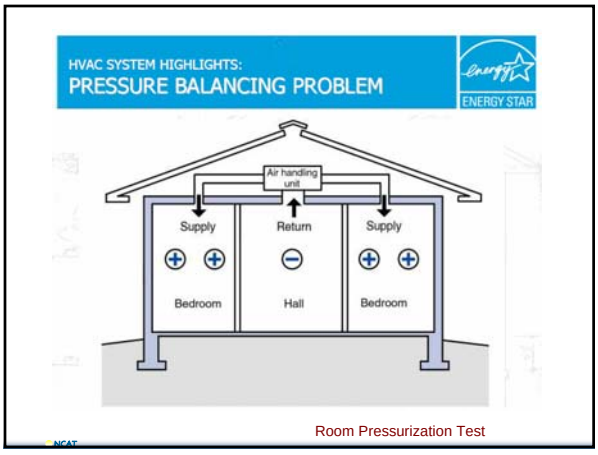
$$CFM_{50} = CFM_n \times n$$

Blower Door Test

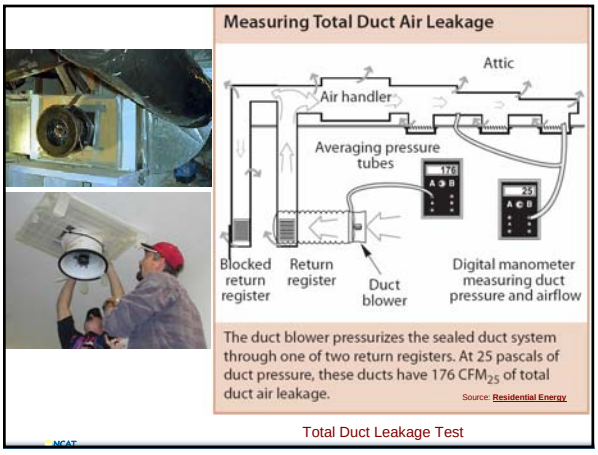
House Air Leakage Area Estimates

1. Divide CFM50 by 10 to get square inches of leakage area. (Simple but approximate)
2. Use TECTITE™ software from the Energy Conservatory with multi-point blower door test.

Blower Door Test

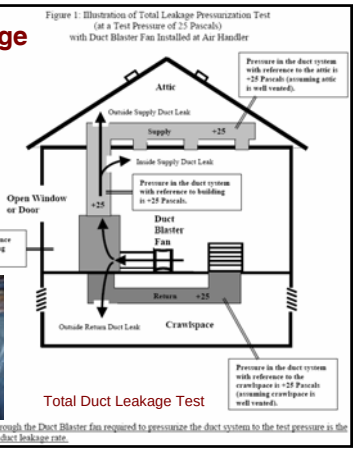


Room Pressurization Test



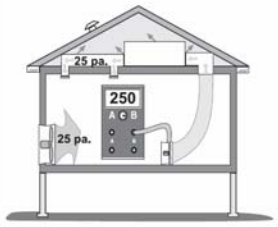
Total Duct Leakage Test

Total Duct Leakage Test



Total Duct Leakage Test

Measuring Duct Leakage to Outdoors

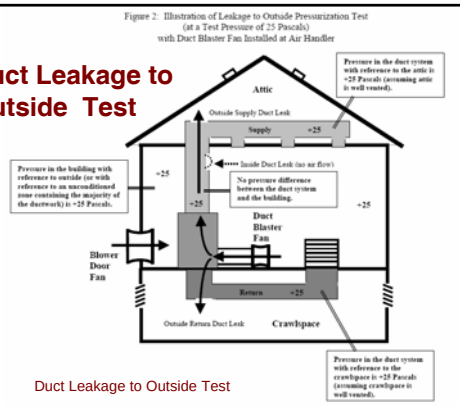


The house and its ducts are both pressurized to 25 pascals. When there is no pressure difference between the house and ducts there should be no airflow between them. All the airflow going through the duct blower (250 CFM_{25})is going outdoors. The same manometer measures both airflow and pressure differences, as required in this test.

Source: Residential Energy

Duct Leakage to Outside Test

Duct Leakage to Outside Test

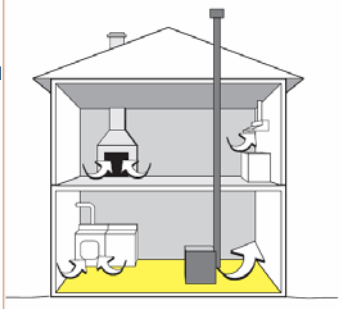


Duct Leakage to Outside Test

Exhaust Flows

- Designer range hoods 500-1200 CFM
- Older clothes dryers 150 CFM
- New clothes dryers 250-300 CFM
- Historically a typical 70 CFM fan will provide 30 CFM delivered air flow

Back-Drafting with Depressurization

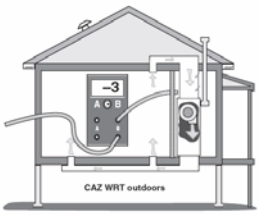


Appliances that exhaust air—such as dryers, fireplaces, and exhaust fans—create a suction that can cause the furnace chimney to back-draft indoors.

Source: Residential Energy

CAZ Test

Worst-Case Depressurization Test



Technicians create a worst-case condition for the naturally drafting chimney by activating the furnace, exhaust fans, and a clothes dryer at the same time. If the pressure difference between the combustion appliance zone (CAZ) and outdoors is more negative than 3 pascals, action is taken to mitigate the negative pressure.

Source: Residential Energy

CAZ Test

House Depressurization Limits (HGL)

Appliance Type	Depressurization Limits
Individual Natural Draft Water Heater (WH)	2 Pa
Natural Draft WH & Natural Draft Furnace or Boiler	3 Pa
Natural Draft WH & Induced Draft (ID) Furnace/Boiler	5 Pa
Individual Natural Draft Furnace/Boiler	5 Pa
Individual ID Furnace/Boiler	15 Pa
Power Vented & Sealed Combustion Appliances	>25 Pa

From Page 54 of the Minneapolis Blower Door Operation Manual published by the Energy Conservatory

CAZ Test

Exhaust Fan Flow Test

Dale Horton AIA, NCAT Sustainable Energy Program Manager
406721-9908
daleh@ncat.org

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