

High Performance Housing

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SouthEast Building Conference July 14, 2005



High Performance Housing

- 30% 70% energy savings from efficiency and renewables
- Excellent comfort
- Outstanding indoor air quality
- Durable and low maintenance
- Disaster resistant (strong and leak free)
- Resource efficient ("Green")
- Marketable



Case Study: The Hoak Residence



4,250 sq. ft.

Leads-Hoak, Chasar



Ducts in conditioned space in unvented attic





Bonus room resulting from unvented attic





Heat Pump Water Heater

- Provides hot water
- Integrated with house cooling system to take advantage of free cooling and dehumidification provided by the HPWH





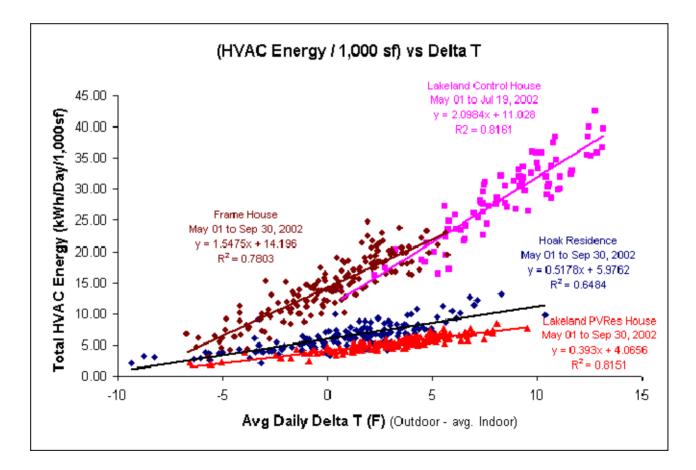
Two Side-by-side houses in Lakeland, FL

- In 1998 FSEC monitored the performance of two houses. The full featured zero energy house saved 70% in cooling energy.
- The Hoak residence compares favorably to the zero energy home as seen in data on next slide





Normalized Energy Use



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A Few Critical Elements

"Making the Invisible Visible"



fsec Applied Building Science

Theory & applications

High performance buildings

- Envelope
- Mechanicals

Promoting

- Indoor air quality,
- Durability,
- Comfort, and
- Energy efficiency





fsec Element Management

• Manage the Water

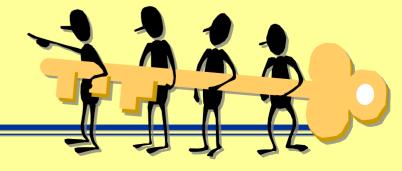
- Keep liquid water out of building
- Control water vapor

Manage the Air

- Produce dry air inside the building
- Direction of air flow (positive pressure)
- Control contaminants

Manage the Heat (Energy)

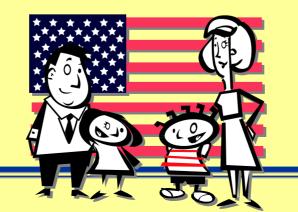
- Building envelope
- Windows & lighting
- Heating, Cooling & Ventilation systems
- Parasitic loads
- Alternate energy sources
- Testing & Commissioning







Health & Safety Building Durability Comfort Energy efficiency





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CONSTRUCTION

OCCUPANCY

Site

- Sand & sun
- Structure
 - Sticks & bricks
- Equipment
 - Fans & furnaces
- Finishings
 - Carpets & cabinets
 - Pastes & paints



People

- Off gassers
- Furnishings
 - Sponges
- Plants & Pets
 - What can I say...



fsec And It Should Be Able To...

Control...

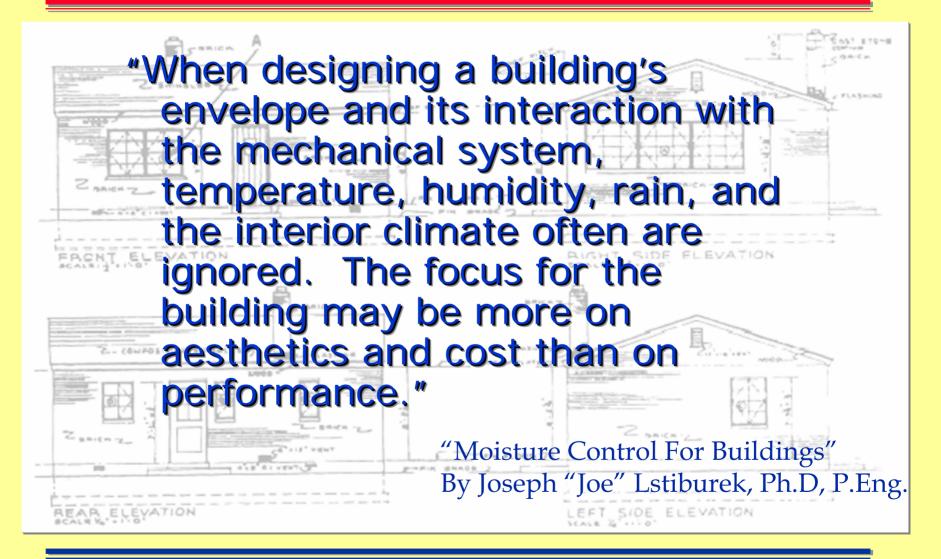
- Heat flow
- Air flow
- Moisture flow
- Rain penetration
- Light & solar gain
- Noise
- Be durable
- Provide strength & rigidity







See Thoughts On Design Priorities



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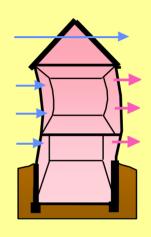
Manage the Air



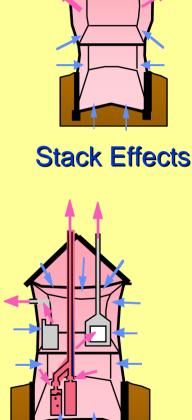




- Air + hole + driving force = airflow
- I cfm in = 1 cfm out
- High to Low
 - > Air Pressure
 - > Temperature
 - > Vapor Pressure



Wind



Mechanical Systems





Hot air rises



Cold air falls



fsec Uncontrolled Air Flow

- Air moving across the building envelope or between zones or cavities of the building, where the pathways of flow, the direction of flow, and the origin of the air are unknown, unspecified, or unintended.
- In-between floor spaces are used as chases for plumbing, ductwork and wiring. Batted insulation is not an air barrier and typically is moved.





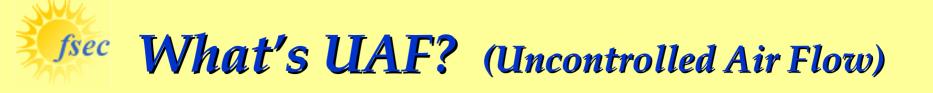
see Air Leakage: Two Variables

Airtightness of the building (hole size)

 Pressure differential across the leak site







- There are four primary forms of UAF
 - > Duct leakage
 - Restricted return air
 - > Unbalanced exhaust/make-up air
 - > Excessive building envelope leakage







Manage the Air: Duct leakage

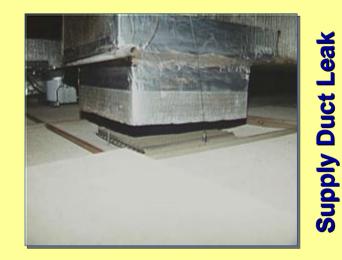




fsec Ducts and UAF?

Duct leakage –

- Air leaks out of or into ducts
 - Actively when fan on
 - Passively it's a hole!
- May cause pressure differences which moves air across the building envelope







Causes of Duct Leaks

 Use of sealing materials which are not durable over time

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- Improper application of sealing materials
- Building cavities used as a duct
- Lack of duct support

Failure to isolate plenum cavities from adjoining building structure

- Exposure to UV
- Rodent/human damage
- Poor design (diapered ducts)
- Workmanship

















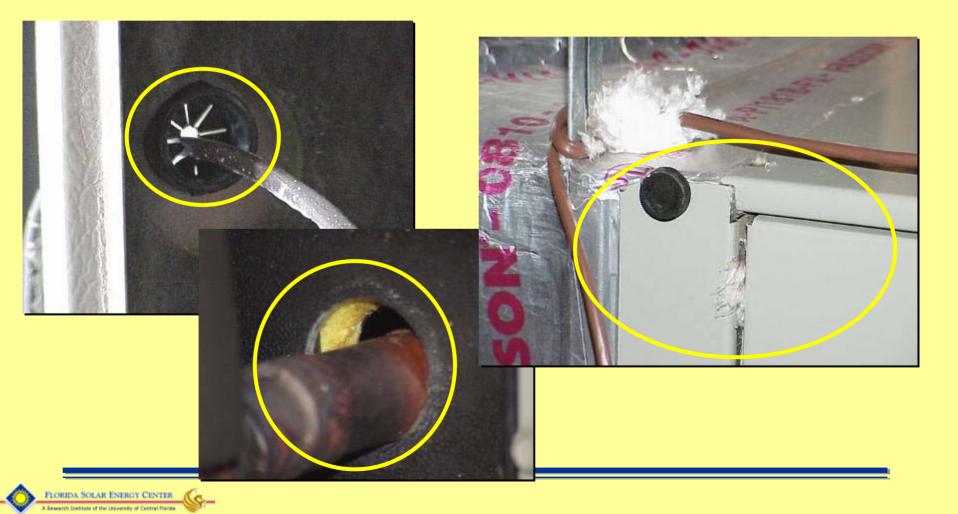






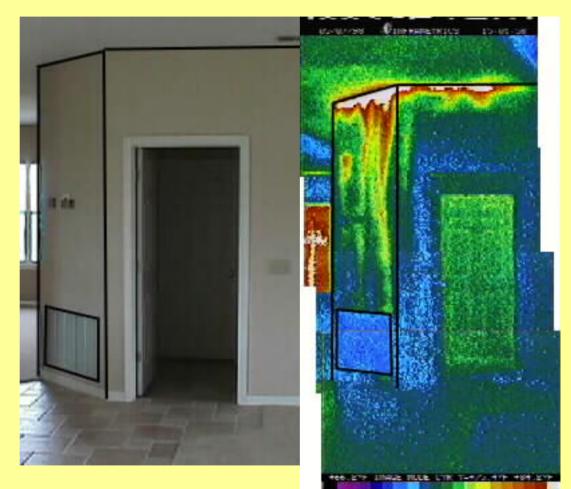


Wire & refrigerant line penetrations and panel seams



See Duct Leakage/Air Handlers

- Seeing is
 believing....
- Air handlers do this when *inside*
- What about AHUs in attics?
- Current tests
 show ~35 cfm
 leakage

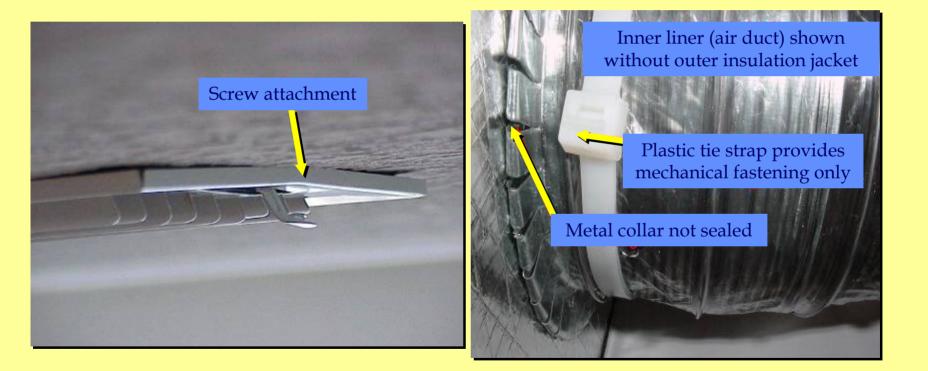








Sec Duct Connection Errors









Mechanical Fastening

- All joints between sections of air ducts & plenums, intermediate & terminal fittings & other components fastened to secure sections independently of the closure system.
- > Approved attachments include...
 - Fibrous glass duct clinching staples
 - Flexible duct drawbands
 - Sheet metal duct screws, rivets, welds, interlocking joints
 - Metal to fibrous glass duct bend taps or screw taps and flanges





Air Sealed

- Seal(ing): The use of welds, mastics, mastic+embedded fabric, adhesives, caulking, gaskets, pressure sensitive tapes, heat activated tapes, or combination, to close cracks, joints, seams and openings in the air barrier.
- Air Barrier: A material which impedes or restricts the free movement of air.
 - Fibrous glass duct the foil cladding
 - Flexible non-metal duct the non-porous core
 - Sheet metal duct metal in contact with air stream
 - Air handler units metal in contact with air stream



The Original DuctTapeCam with RemotePan

This live camera image is updated ASAP! Hit reload on your browser to get the latest image.



If the duct tape isn't responding right now, you can look at these previous images:

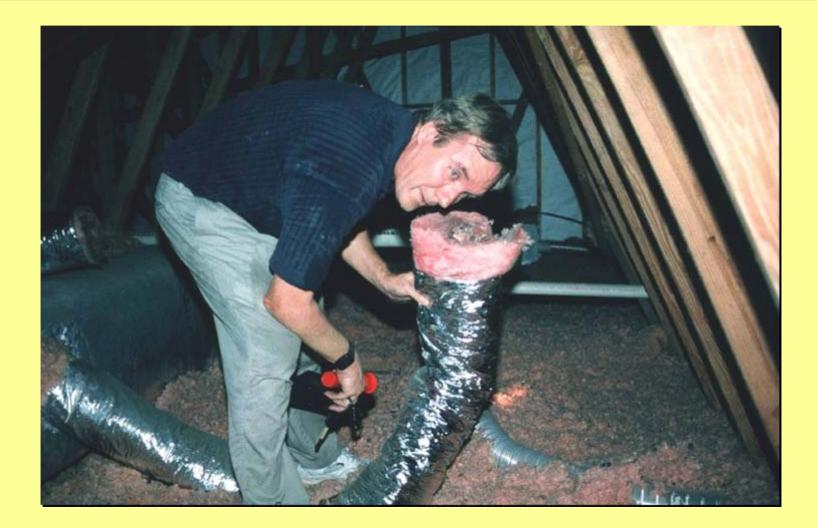
Early this morning / Yesterday evening / Feeding / Sleeping

[The Duct Tape page]

http://epb1.lbl.gov/EPB/ducts/











The Norm: Ducts in Unconditioned Spaces

Losses and Risks?

- IAQ Issues
- Durability Losses
- Conductive gains/losses
- Duct Leakage

Consequences

- Increased machine run time
 - Durability & Cost
- > Unplanned air exchange
 - Extreme thermal conditions
 - Mold, Condensation, & Rot
 - Allergens & Irritants





Reducing the Impact of Ducts *in Unconditioned Spaces*



Sealed and Insulated Ducts: continuous thermal barrier and sealed with mastic and mesh including the return plenum.



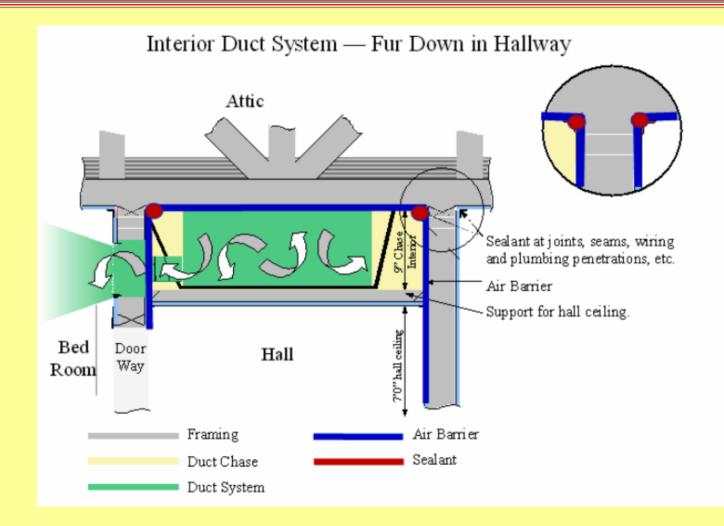
 Unvented Attics and Crawlspaces

 move the air and thermal barriers to the other side of the air distribution system



Interior Duct Systems – move the air distribution system to the inside of the house's thermal and air barriers.

Interior Ducts - Schematic



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Interior Duct Chase: Air Barrier in Place





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Manage the Air: Restricted return air



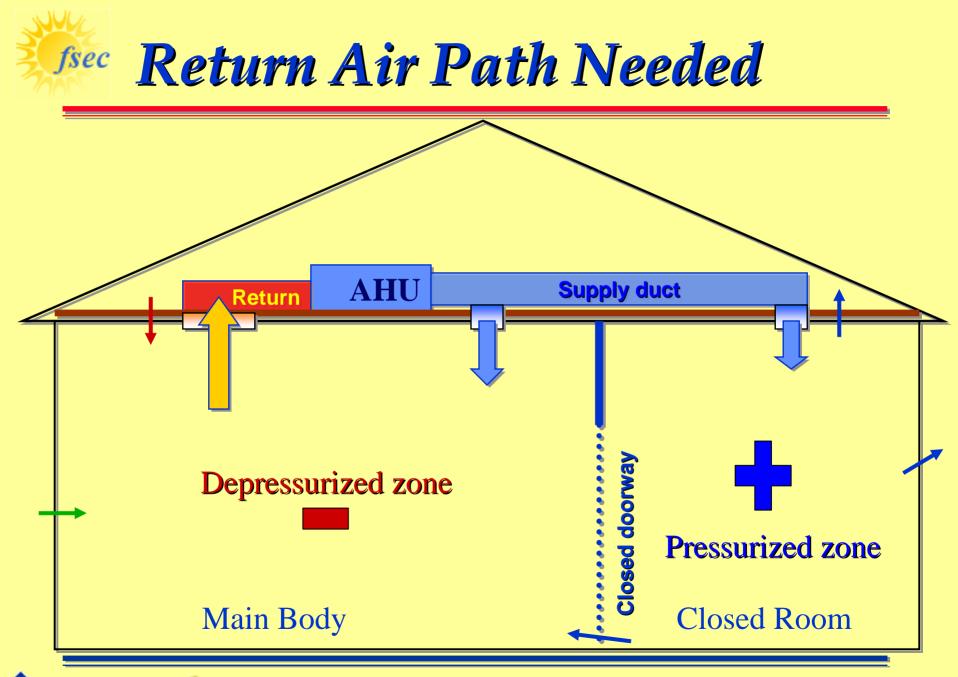




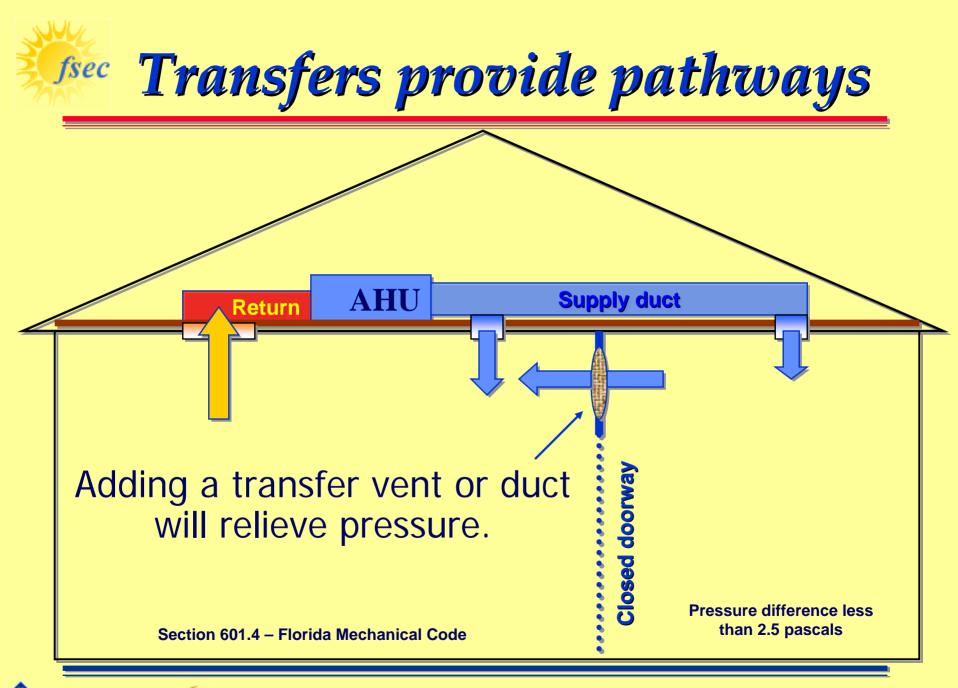














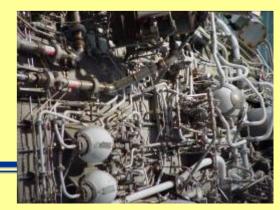




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Manage the Air: Unbalanced exhaust & make-up air



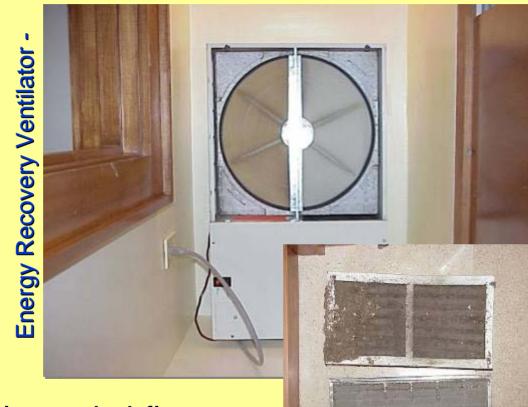






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fsec So what is wrong with this?



Outside Air Inlet

Changes in planned airflow across the building envelope – creates pressure imbalances

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•Rooftop exhaust ventilators run 24/7 pulling from each unit.

•"Make-up" air provided through holes to the exterior.

•Warm moist air condenses on cool interior surfaces





fsec The Attempt to Control

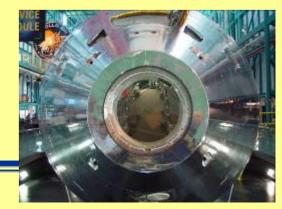


•Four 50 pint per day dehumidifiers operate 24/7

•Almost able to control interior RH to 50-55% with interior temp in low to mid 70s

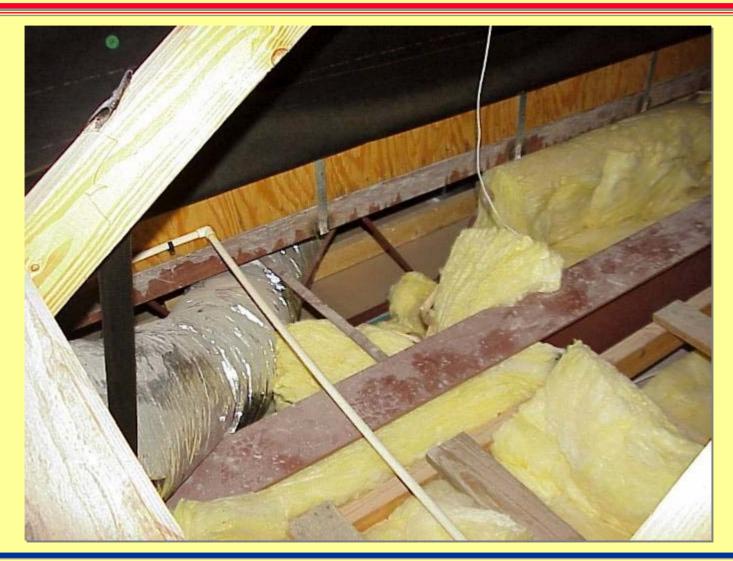


Manage the Air: Excessive building envelope leakage





Between floors exposed to attic











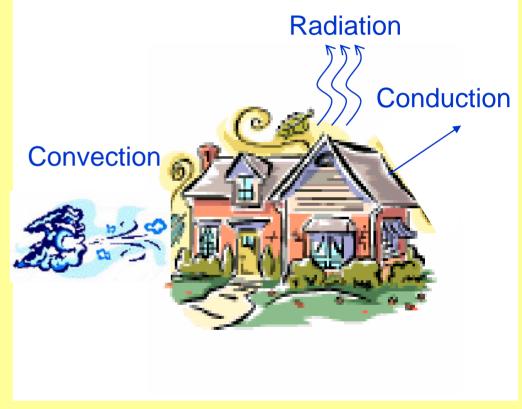
Manage the Heat





sec Movement of Heat

- Heat moves from areas of higher temperature to areas of lower temperature
- > 3 types of heat flow
 - Conduction
 - Convection
 - Radiation
- Insulation is designed to resist heat flow





fsec Thermal Insulation

Thermal insulations can be

- Fibrous,
- particulate,
- Film or sheet,
- block or monolithic,
- open-cell or closedcell, or
- composites of these materials that can be chemically or mechanically bound or supported.



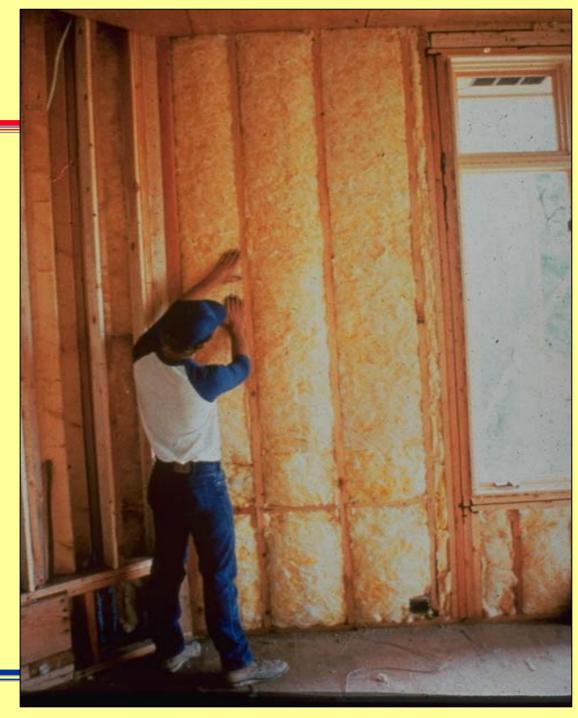




Careful installation of all insulating systems are **essential** for good performance

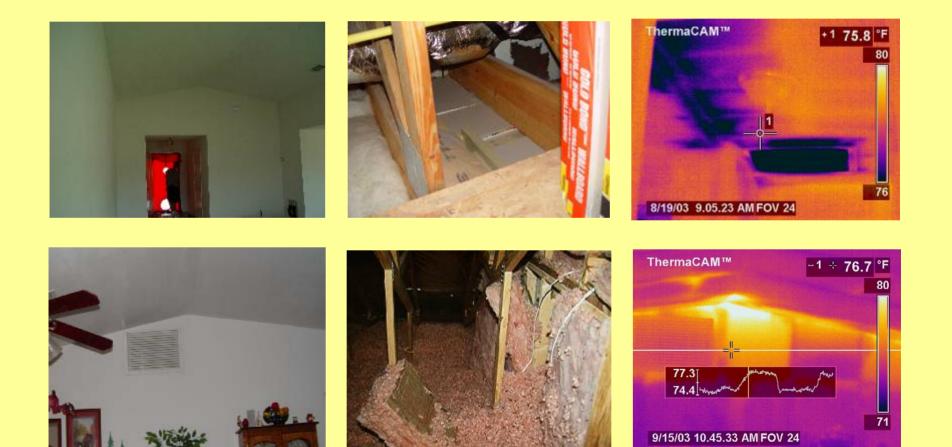
~Or~

If it looks sloppy, then so will be the performance.

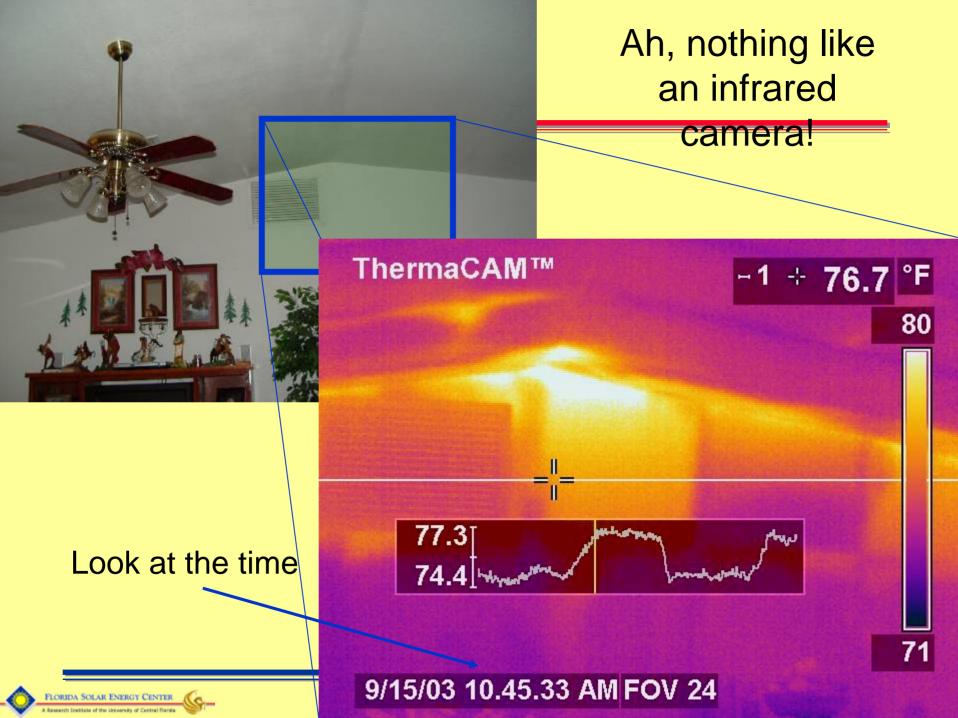












How To Void Insulation Effectiveness – Move Some Air Through It





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sec Kneewalls, Good & Bad

The best approach to knee walls is to apply a rigid backing of OSB, plywood, sheetrock or Thermoply[™]. The backing will assist the insulation installer to properly hang batts at this critical interface. The backing secures the insulation and creates a tighter cavity that will produce a better performing assembly.



Source: SystemVision™ Technical Bulletin F6



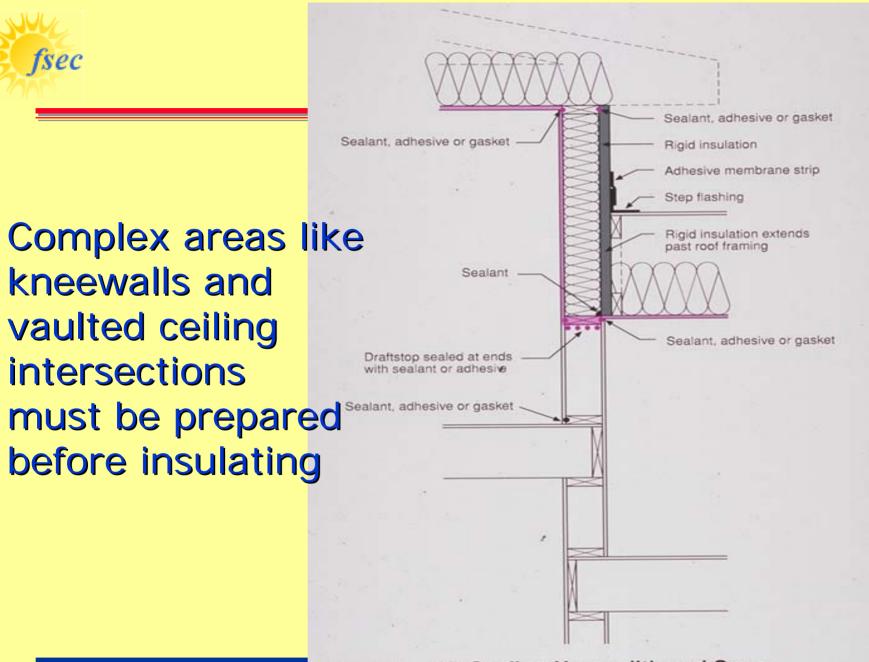


Figure 5s Air Sealing Unconditioned Space



Sec Air & Thermal Barrier Proximity

- Best to cap all dropped ceilings during the framing stage with OSB, plywood, sheetrock or Thermo-ply.
- Insulation can be easily run across the framerinstalled cap.
- Assures tighter house & insulation that performs.













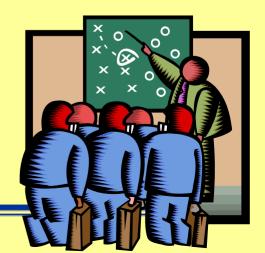








Manage the Water







INSIGHT INTO VARIOUS HUMIDITY SOURCES AND STRENGTHS



Bec Humidity: Sources & Strengths

- Moisture in buildings comes form only 5 general sources
 - Construction materials (just add water)
 - Interior activities (people)
 - Immediate surrounding exterior (water vapor)
 - > Above-grade environment (liquid water)
 - > Adjacent soils (what the building sits on or in)
- If properly constructed and operated, the largest single moisture source is from the people's respiration and perspiration, for a family of four, 10 – 13 pints per day.
 - Christian, J. 1994. Moisture sources. In: Moisture Control in Buildings, (ed) Treschel, H. ASTM manual series MNL 18. 485 p.

Where Does All That Water Come From?

 \mathbf{O}

- Total daily load can be as much as 42 pints/day first year of construction
 - People: respiration & perspiration
 - 0.03 to 0.6 pint/day depending on activity
 - Combustion (cooking, unvented fireplaces, etc.)
 - Natural gas: 1 gallon per 100K Btu input
 - LPG: 1 gallon per gallon burned (110K Btu input)
 - Activities
 - Cooking 2.1 pint/day
 - Cleaning (mopping) 0.03 pint/ sqft
 - Personal hygiene (incl. showers & baths) 1.3
 - Accoutrements
 - Plants 0.25 0.8 pint/day/plant
 - Aquariums (~5sqft surface) 0.3 pint/hour
 - Construction ("average" house)
 - First year: 21 pints/day Second year: 10 pints/day
 - Lumber 423 pints released
 - Concrete 146 pints / cubic yard
 - 5000 pints released



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Sec 3 Strategies To Minimize Risk

- Various strategies can be implemented to minimize the risk of moisture damage. The strategies fall into the following three groups:
 - Control of moisture entry,
 - Control of moisture accumulation, and
 - » Removal of moisture.
- These are best used in combination.



sec How To Begin

Drain the water Drain the water Drain the water

- Drain the site.
 - Urain the site.
 - Drain the building.
 - Drain the assembly.
 - Drain the opening.
 - Drain the component.
 - Drain the material.

Drainage is the key to rain/ground-water control In other words, drain everything.

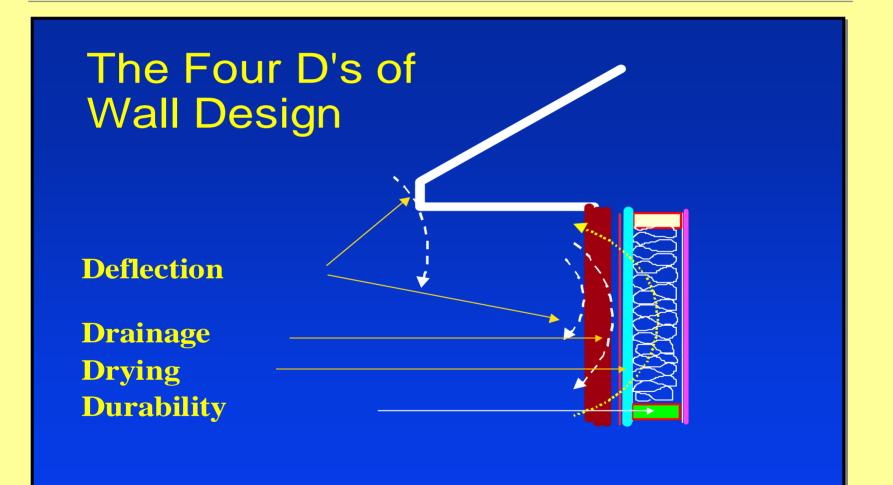




- If it gets wet let it dry.
- Make it tight—You cannot control air until you enclose air.
- Control the airflow direction by pressurizing (if it makes sense to do so).
- Ventilate and control humidity.

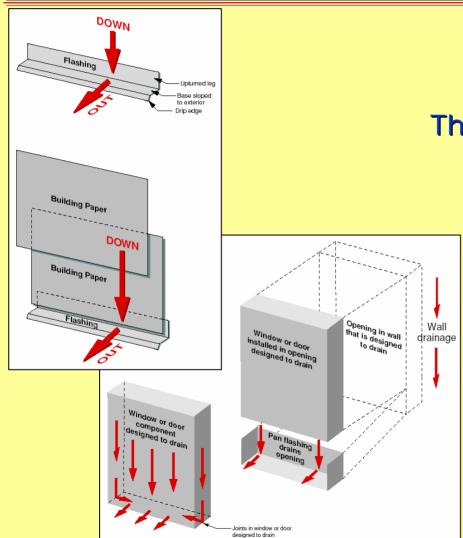






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fsec Drain the Water



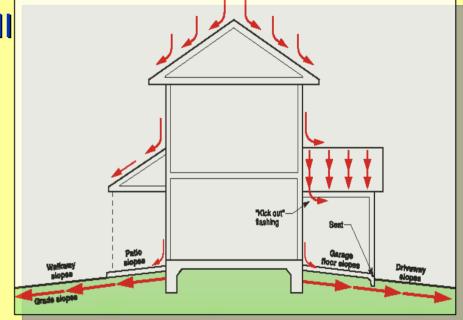
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The fundamental principle of water management is to shed water by layering materials in such a way that water is directed downwards and outwards out of the building or away from the building. The key to this fundamental principle is drainage.

From: EEBA Water Management Guide

See Slope Away From Building

- Kick-out flashings direct water away from walls at roof/wall intersections.
- Patios & decks lower than floors
- Grade lower than main floor
- Stoops and walkways lower than main floor
- Garage floor lower than main floor
- Driveway lower than garage floor

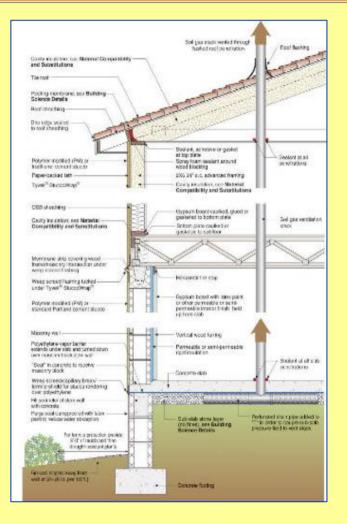


From: EEBA Water Management Guide

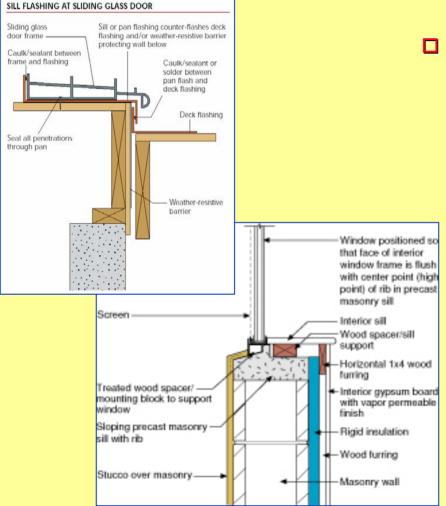


sec Building Water Barrier

Provide sections showing liquid water barrier continuity around the entire building including roofs, walls, windows, doors and **foundations**



See Component Water Barrier



Provide typical details for liquid water continuity at intersections between two or more building elements (e.g. windows-walls, skylight-roofs, roof-walls)





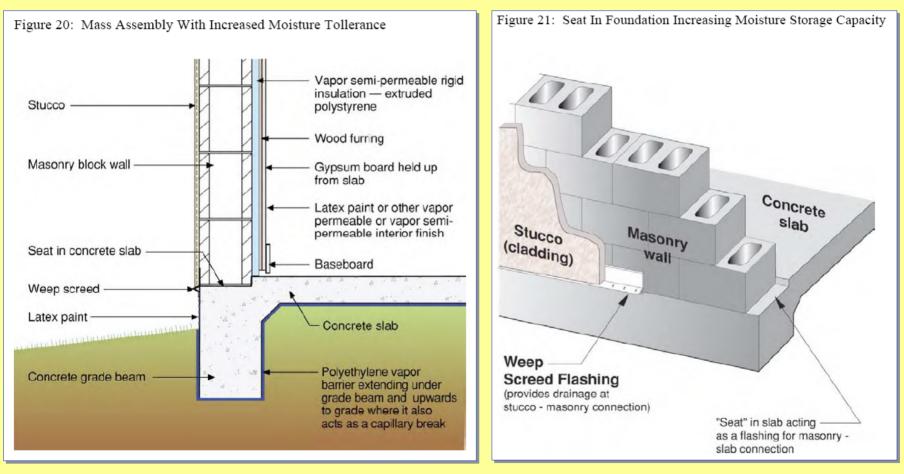






Rainwater Management Performance

Prepared for the Home Builders Association of Metro Orlando and the Florida Home Builders



www.buildingscience.com/resources/walls/rainwater_management.pdf



fsec



Photograph 62: Seat In Concrete Slab Foundation Increasing Moisture Storage Capacity





sec Flashing – Drain Away

CLOSE UP OF FLASHING DETAIL	
Asphalt-saturated felt underlayment turned up vertical walls approx. 3" to 4"	
Flashing placed just upslope from exposed edge of shingle – extends approx. 4" over underlying shingle and approx. 4" up vertical wall	
Approx. 2" head lap	
Wall cladding/siding serves as counter flashing and should overlap step flashing a min. of 2"	
Housewrap, felt, cladding, siding – maintain 2" above the roof surface –	
Place nails high, so nails are overlapped by the next upslope step flashing/	

Source: APA - The Engineered Wood Association











All the right pieces – just misplaced









Can we learn from these water vapor problems?



sec Why Were We There?

- Repeat repairs resulting in reoccurring reports of retrogressing
 - Going back again and again to repair a problem that just won't go away
 - Current Repair strategy
 - Replace damage material with same product
 - Look for water leaks
 - Blame customer in frustration







And yes, Martha, we can grow some really neat stuff...

1-01



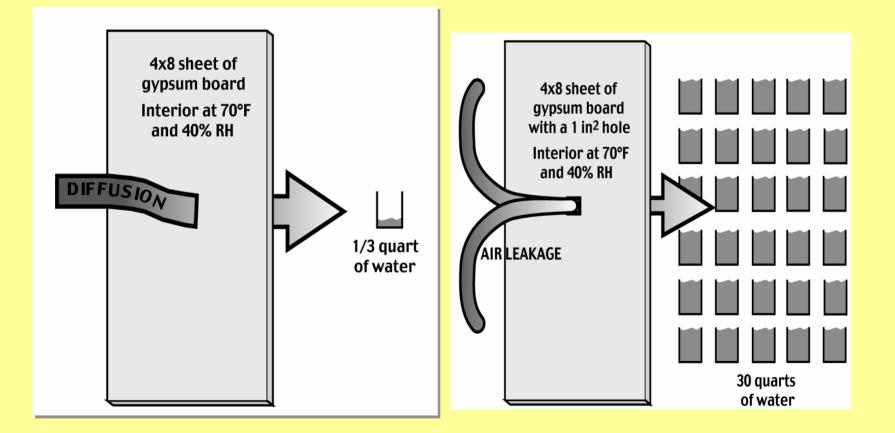
^{sec} Moisture - Air Transported

cubic foot of air per mile Air holds moisture and moves across a hole by a air pressure difference carrying the moisture with it.

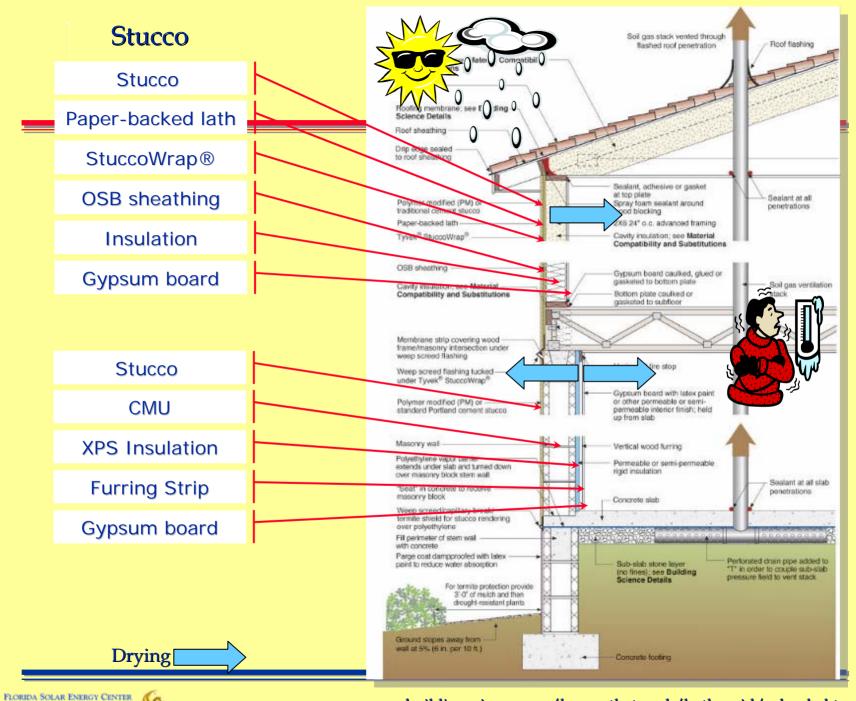
150 Pints of Water During cooling season in Orlando

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Compare Diffusion vs Air Transported

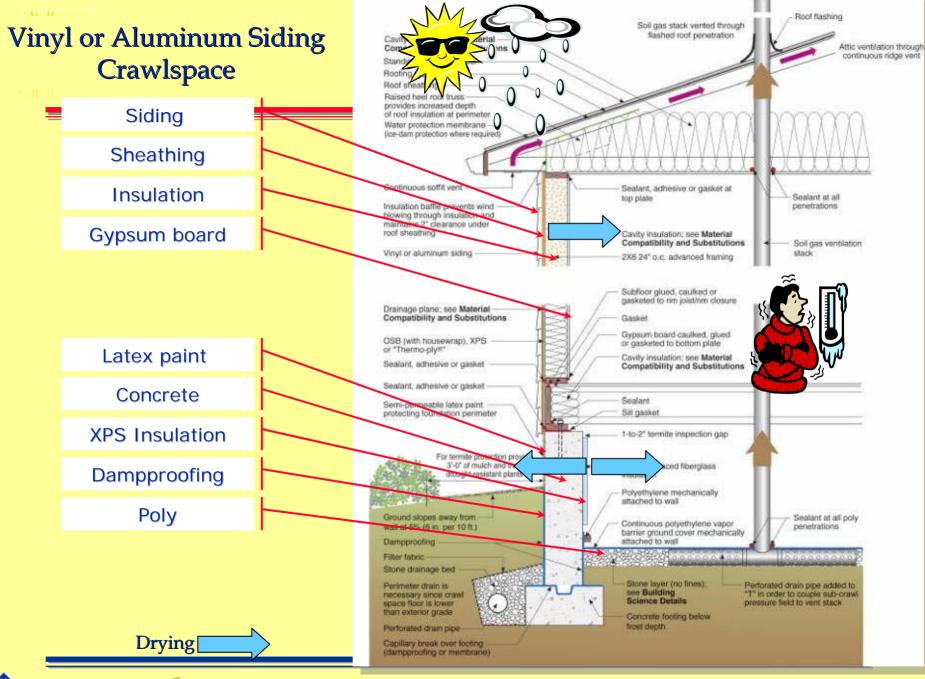


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Research Institute of the University of Central Flacids

www.buildingscience.com/housesthatwork/hothumid/orlando.htm



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www.buildingscience.com/housesthatwork/hothumid/montgomery.htm



"Elegant solutions elsewhere are complex failures here" Philip Fairey

"Minds are like parachutes, they only work if open." Thomas Dewar



"The way to discover the limits of the possible is to go beyond them into the impossible" Arthur C. Clarke

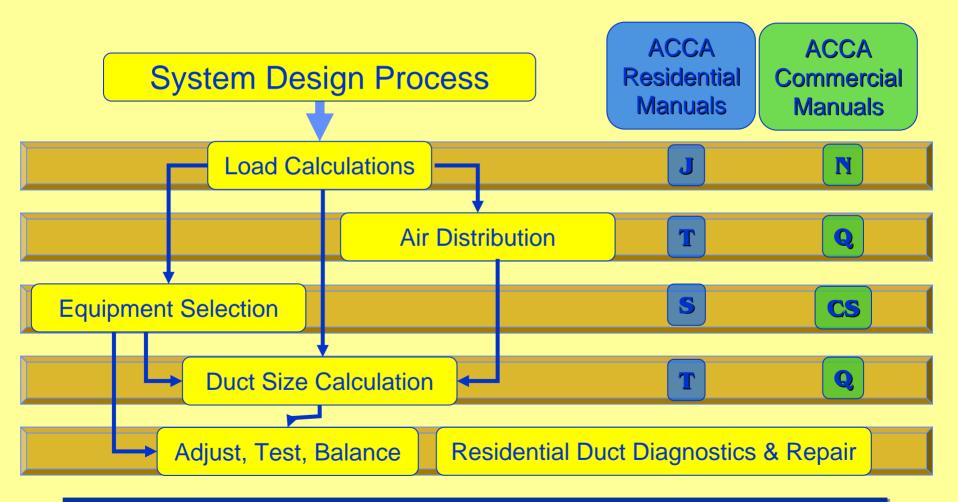


HVAC Equipment

Heating - Ventilating -Air Conditioning







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fsec Heating & Cooling Systems

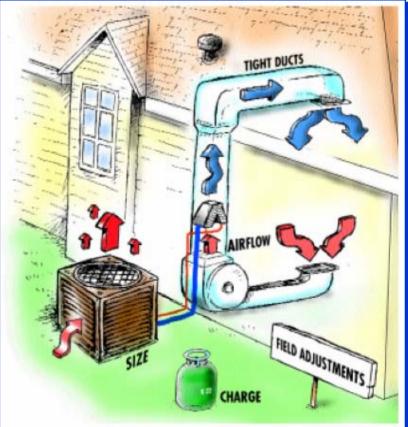
Design

- ACCA Manuals
 - Loads ducts equipment
 - BE Conservative!
- Duct design layout

Installation

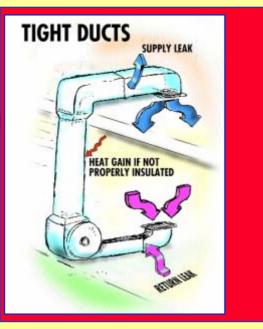
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- Right sized
- Sealed ducts
- Proper air flow
- Correct charge

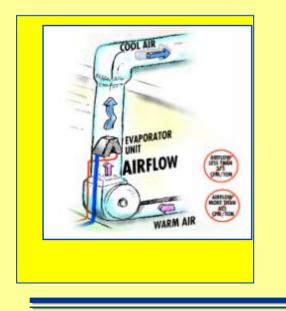


Graphic: Advanced Energy

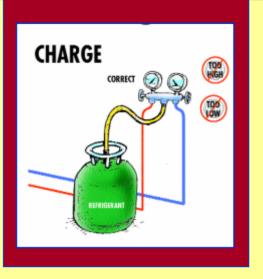




Lack of attention can lead to...







Short cycling
Comfort concerns
Noise
Sweating ductwork
High energy usage
Foreign object dispensing
Decreased equipment life
Mold

Sec Mechanical Ventilation

Spot or source

- Kitchens & bathrooms
- Whole house
 - Exhaust Supply
 - Balanced
 - Dilution only
 - Heat or Energy transfer

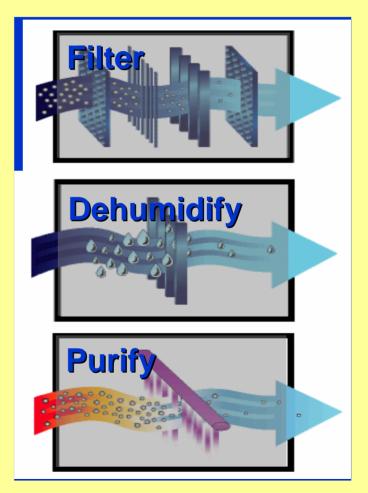






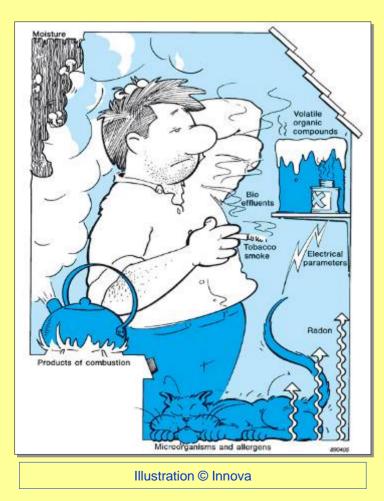


The purpose of a residential ventilation system is to control odors and contaminants and indoor levels of moisture. These goals must be achieved without causing discomfort to the occupants, without unduly increasing the operating cost of the house, and without adversely affecting the building envelope or the operation of other mechanical systems.





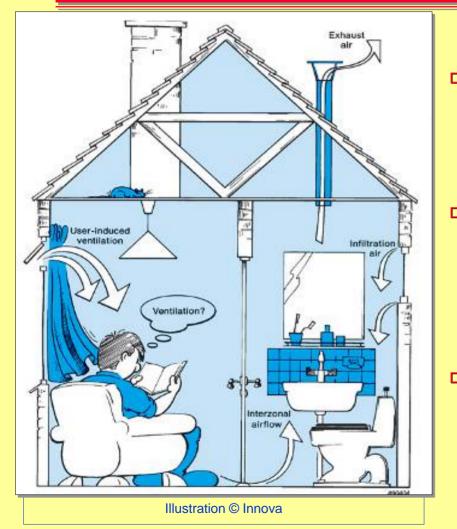
See Why do we need ventilation?



New building techniques have been developed in an effort to reduce energy consumption. Tighter buildings have resulted in poor indoor air quality caused by:

- > Tobacco smoke
- Fumes
- Dust
- VOC from glues, paints & materials
- Combustion products
- Moisture from cooking & washing
- Bioeffluents from people
- Micro-organisms, allergens
- Fibres
- Radon

fsec What is ventilation?



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 Ventilation is the process of supplying and removing air by natural or mechanical means to and from any space.

Natural ventilation:

> Uncontrolled air-leakage via cracks

Intended via windows, doors & vents

Mechanical ventilation:

> Air-conditioning system for control of the supply & exhaust airflow

fsec Dehumidifiers

- Basically a package air conditioner that has been optimized to moisture removal.
 - Waste heat discharged through the air stream
- Energy efficiency
 & waste heat may
 be a consideration



Typical 40-50 Pint Dehumidifier

fsec 100 Pint/day Dehumidifier w/Outside Air







Some Minimum Performance Testing





















Sec Rules of Building Performance

- Moisture moves from more to less
- Moisture move from warm to cold
- Heat flows from warm to cold
- CFM (air) out equals CFM (air) in
- Drain the rain



- Things always get wet let them dry
- Heat, air & moisture are one
- All the action happens at the surface
- Keep clients out of harms way



Get Back to Building Science Basics

We know...

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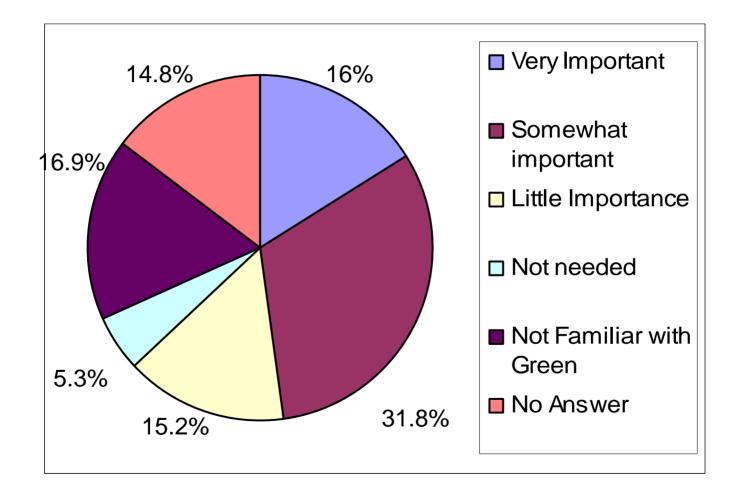
- what we did wrong in the past
- we need to have air tightness for durability
- bow to insulate for energy efficiency
- we need to look at whole building performance for whatever climate we build
- b that whatever materials we select to use, we can produce durable buildings.
- > that we need to do it right the first time





Energy Efficient Green Home Casa Verde by **WCI** Venetian Golf and River Club

WCI Homebuyer Survey 2005



Casa Verde Energy Efficient Features

- ICF exterior walls
- Icynene insulation
- Argon filled tinted windows
- Sealed air ducts
- Insulated exterior doors
- Sealed penetration points
- Energy Star appliances and fans
- CFL light bulbs
- Light color exterior
- Tile roof
- Solar tubes
- Programmable thermostat
- 15 SEER A/C
- Insulated hot water pipes









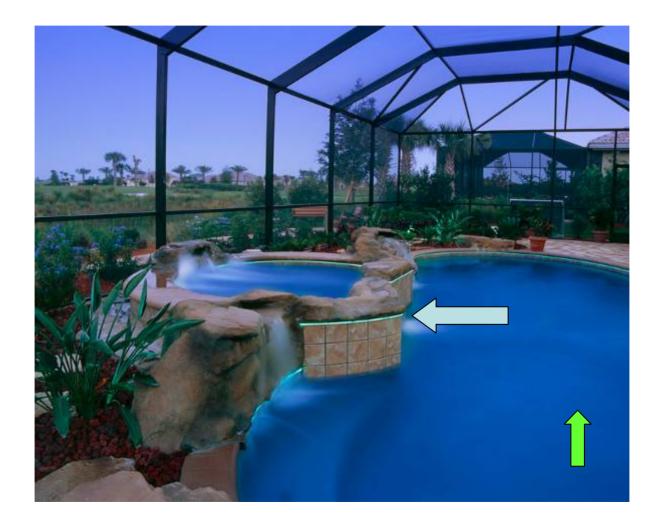
Energy efficient and green





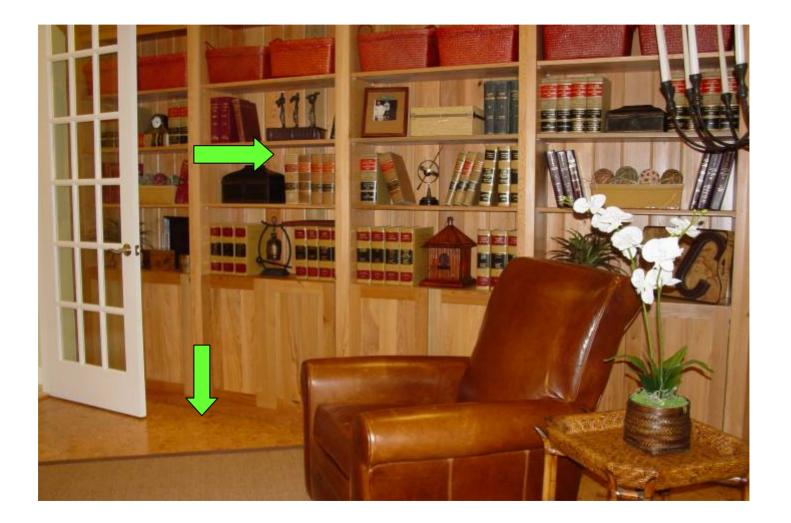












Composter & rain barrel



Casa Verde learning lab







Homebuyer interest?

- WCI Survey indicates that 48% of respondents are willing to spend up to \$10,000 on green home features
- 29.5% say they would spend between \$10,000 - \$15,000
- 8.1% say they would spend over \$20,000

Energy Efficient Green Home

Casa Verde by WCI Venetian Golf and River Club

High Performance Housing



South East Building Conference 2005



Orlando, Florida

Thursday, July 14th, 2005

Jay Fechtel, The Fechtel Company

Introduction





- The Fechtel Company Since 1988, employs eighteen people
- Design/Build custom homes in the Tampa, Florida area
- Homes are priced from \$1.2 to 4 million, seven to ten per year
- Have implemented high-performance housing techniques since 1999

What I'll Cover



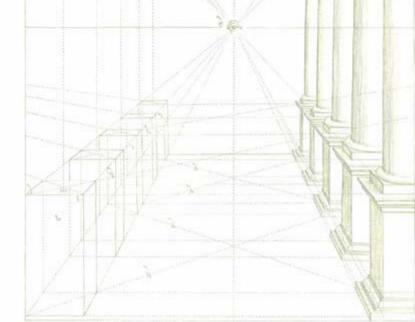
1. <u>Why</u> build high-performance housing?

2. <u>What</u> we do and <u>how</u> we do it – Building with all things considered



1. Happy Clients

- Durability and Comfort
- Time Spent In The Home
- The Golden Rule

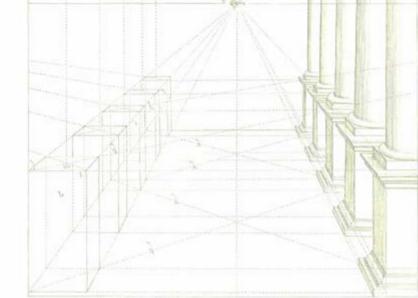






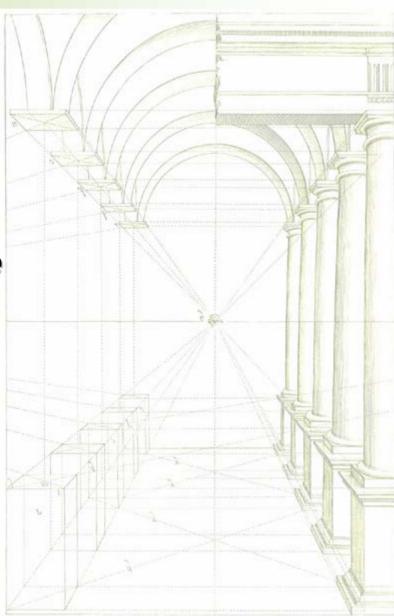
2. Innovation

- Product Differentiation
- In The Search Of Excellence





- 1. Happy Clients
- 2. Innovation
- 3. Good Marketing
 - Media Coverage





A DE LA D







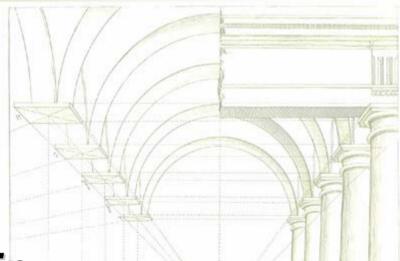
- 1. Happy Clients
- 2. Innovation
- 3. Good Marketing
 - Media Coverage
 - Awards







- 1. Happy Clients
- 2. Innovation
- 3. Good Marketing
- 4. Good Stewardship



- Philosophical: Resource Management
- Practical: Waste Not, Want Not



- 1. Happy Clients
- 2. Innovation
- 3. Good Marketing
- 4. Good Stewardship
- 5. Lowers Risk/Liability
 - Popular
 Legal
 Issues





- 1. Happy Clients
- 2. Innovation
- 3. Good Marketing
- 4. Good Stewardship
- 5. Lowers Risk/Liability
 - Popular Legal Issues
 - Eager Professionals
 - Personal Experience

Practical Application





Design & Systems Synergy

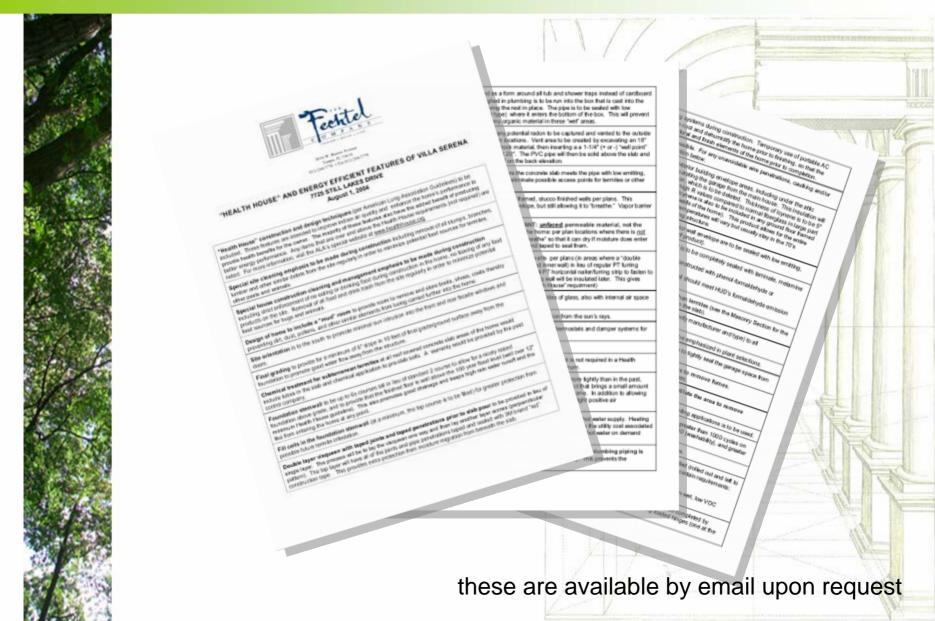




High-Performance Standards

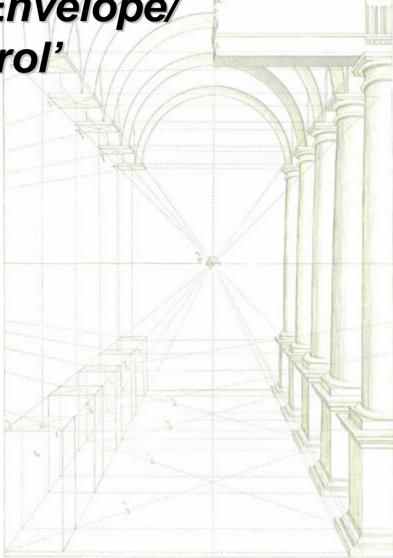
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1. Good 'Building Envelope/ Moisture Control' • Roofing





1. Good 'Building Envelope/ Moisture Control'

- Roofing
- Windows and Doors





1. Good 'Building Envelope/ **Moisture Control**

- Roofing
- Windows and Doors
- Balcony Decks





1. Good 'Building Envelope/ **Moisture Control**

- Roofing
- Windows and Doors
- Balcony Decks
- House Wrap







1. Good 'Building Envelope/ **Moisture Control'**

Insulation

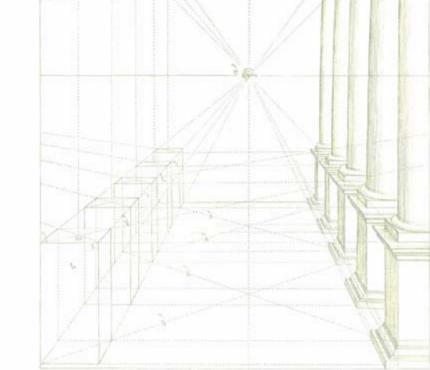






2. Indoor Air Control

Outside Air Makeup By Direct Vent







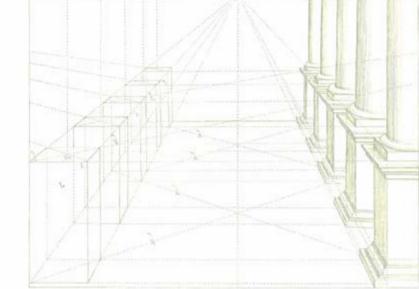
- Outside Air Makeup By Direct Vent
- Outside Air Makeup By Air-Purifying **Dehumidifier – Positive Pressure**







- Outside Air Makeup By Direct Vent
- Outside Air Makeup By Air-Purifying Dehumidifier
- Enhanced Air Filtration





3. Resource Efficient Systems

- Energy Efficient HVAC Systems
- Water-Conserving Appliances
- Tankless and Solar Water Heating or Heat Recovery With Gas Water Heating
- Smart Fan and HVAC Control
- Lighting and Home Control
- Reclaimed Material



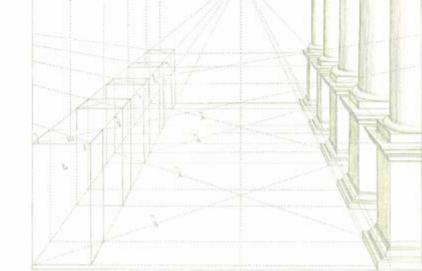
- 4. Site Planning
 - Passive Solar Siting
 - Work With The Site Trees, Etc.





4. Site Planning

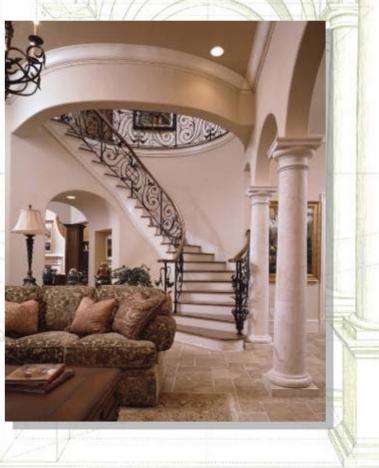
- Passive Solar Siting
- Work With The Site Trees, Etc.
- Landscape And Irrigation Design -**Xeriscape Principles**





Functional Sculpture







5. Aesthetic Sensitivity and Design

- Functional Sculpture
- High Performance Doesn't Mean Ugly





5. Aesthetic Sensitivity and Design

- Functional Sculpture
- High Performance Does Not Mean Ugly
- Good Design = Good Emotional And Physical Health
 - Mud Rooms
 - High-Traffic Spaces Should Not Irritate
 - Lines of Sight



Conclusion



Why Build High-Performance Housing?

- 1. Happy Clients
- 2. Innovation
- 3. Good Marketing
- 4. Good Stewardship
- 5. Lowers Risk/Liability

<u>What</u> We Do, <u>How</u> We Do It

- a.) Good Building Envelope/Moisture Prevention
- b.) Indoor Air Control
- c.) Resource Efficient Systems
- d.) Site Planning
- e.) Aesthetic Sensitivity and Design

High Performance Housing is Good Business!