Florida Solar Energy Center

Creating Energy Independence Since 1975

Techniques To Incorporate In Your New Home or How to Star in the High Hurdles

Rob Vieira and Stephanie Thomas-Rees

Building America U.S. Department of Energy — Partnership for Improved Residential Construction — BA-PIRC

A Research Institute of the University of Central Florida

Proven Techniques

- Cool roof materials and radiant barriers
- Tight ductwork
- Locating ductwork in the conditioned space
- Sizing the AC properly
- Also:
  - Lighting
  - Tree Preservation
  - Marketing

Incorporate Cool Roofs

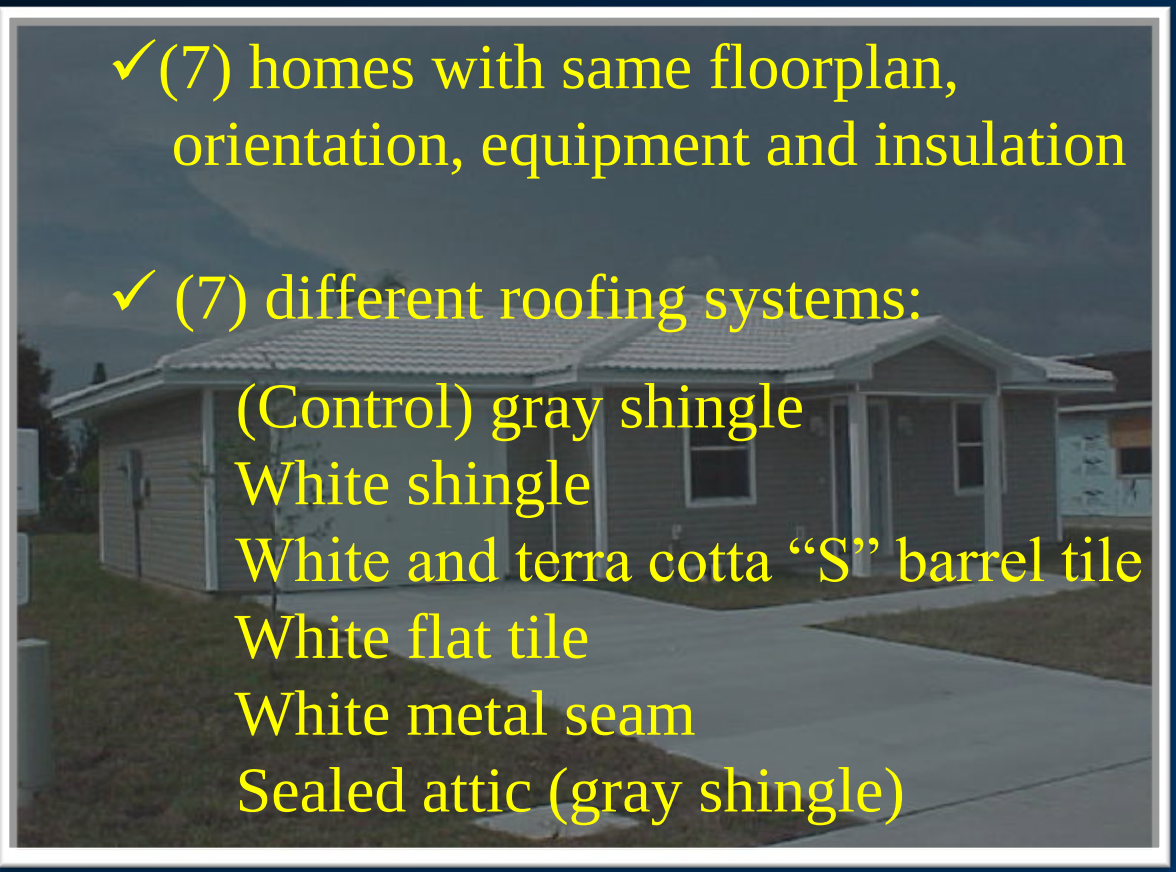
- White metal or tile reflective roofs
- Radiant barrier with other roof materials

Solar heat gain through the insulated ceiling and to the duct system can be responsible for 20 - 30% of the AC use. Choice of a white roof color can reduce the overall cooling load by 20% or more in new homes.

Roof Choices

Roof Materials--- Cool Roofs Study

Roof Materials--- Cool Roofs Study



- ✓(7) homes with same floorplan, orientation, equipment and insulation
- ✓ (7) different roofing systems:
  - (Control) gray shingle
  - White shingle
  - White and terra cotta “S” barrel tile
  - White flat tile
  - White metal seam
  - Sealed attic (gray shingle)

Roof Materials--- Cool Roofs Study

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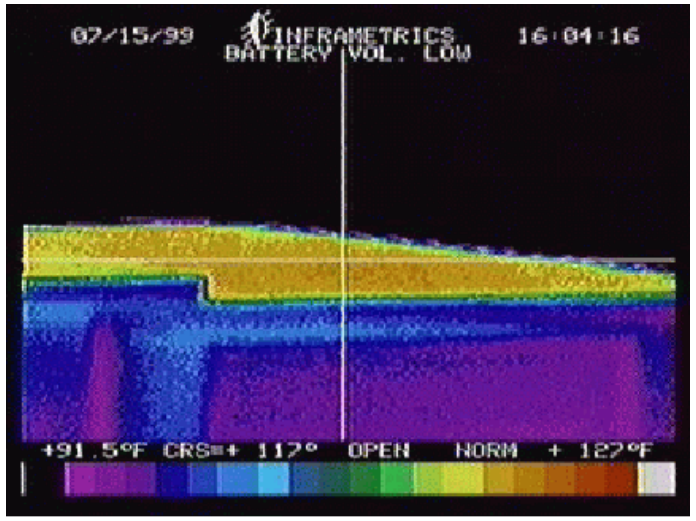
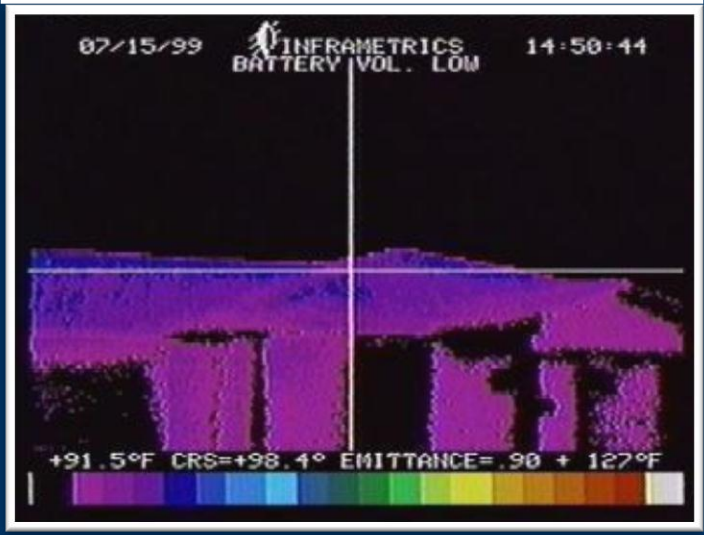
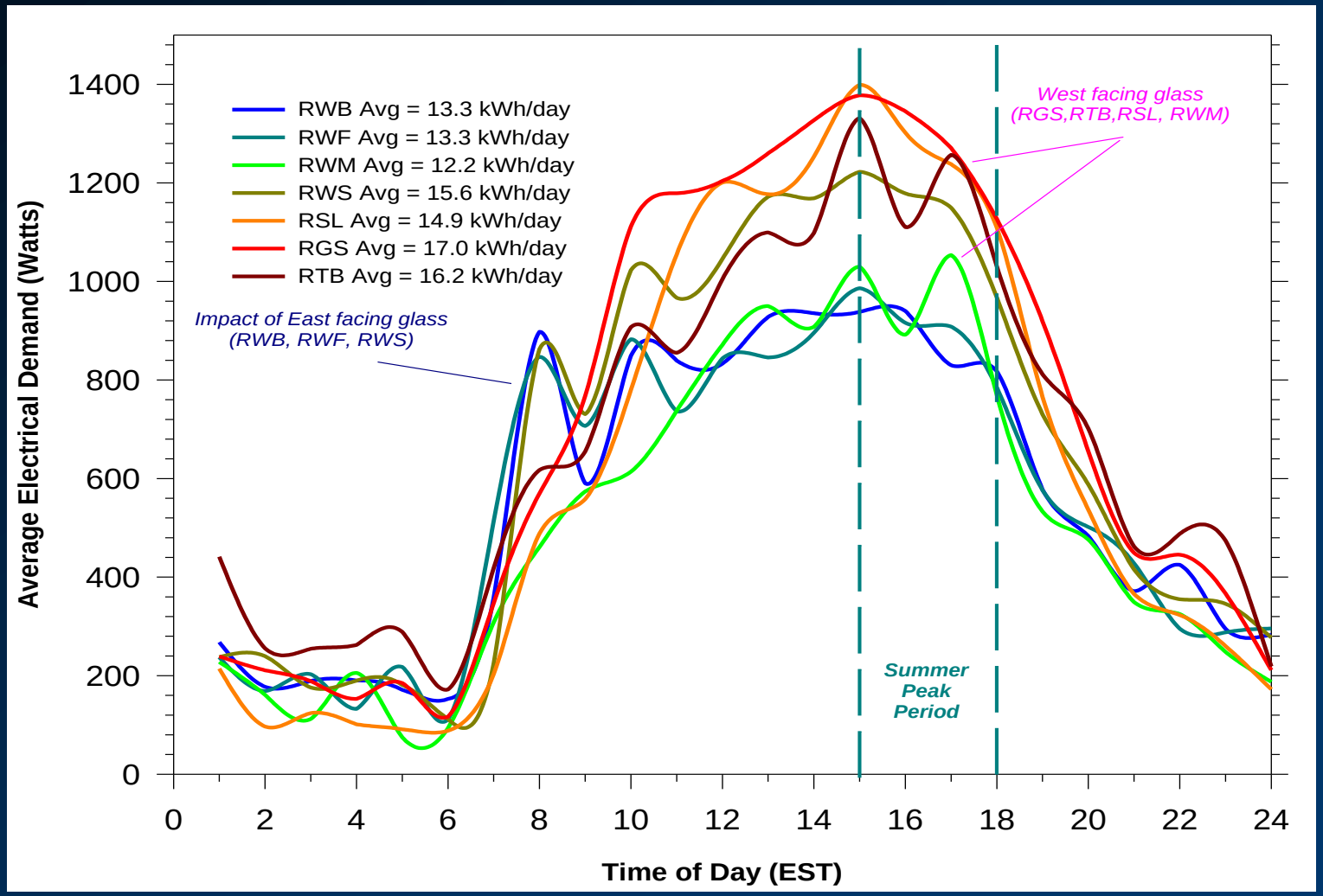
Roof Materials--- Cool Roofs Study





Roof Materials--- Cool Roofs Study

Avg. cooling over unoccupied period



Roof Materials--- Cool Roofs Study

Estimated Normalized Average Savings for 1770 Square Foot Home

	Cooling Savings	Peak Demand Reduction
RGS (Control, dark shingle):	--	--
RWS (White Shingle):	4%	17%
RSL (Sealed Attic, dark shingle):	9%	5%
RTB (Terra Cotta Barrel):	3%	13%
RWB (White Barrel Tile)	20%	32%
RWF (White Flat Tile)	17%	34%
RWM (White Metal)	23%	28%

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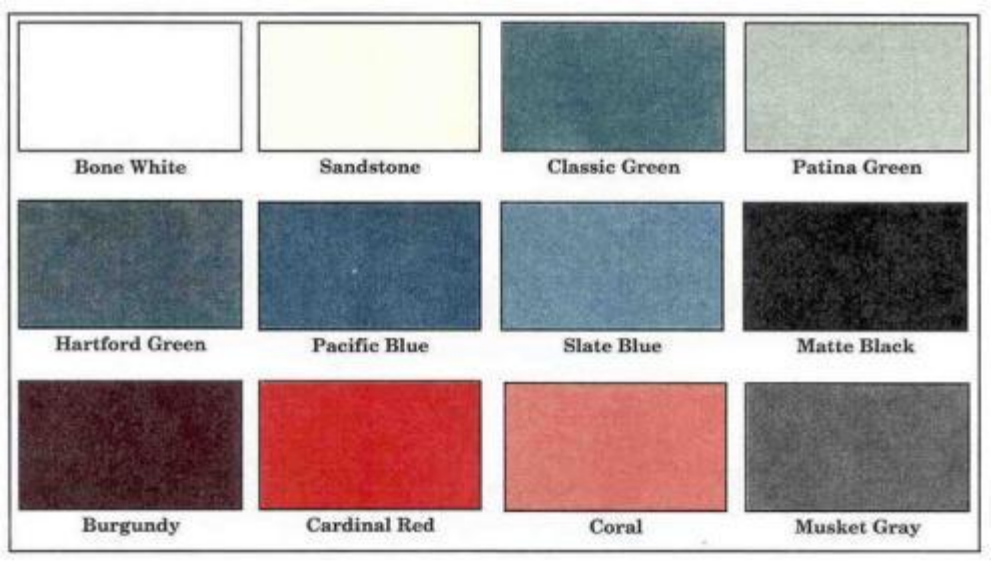
Solar Reflectances %

Specimen	
White	66
Sandstone	50
Classic Green	11
Patina Green	24
Hartford Green	9
Pacific Blue	18
Slate Blue	20
Matte Black	6
Burgundy	12
Cardinal Red	37
Coral	34
Musket Gray	13



Radiant Barrier Systems (RBS)

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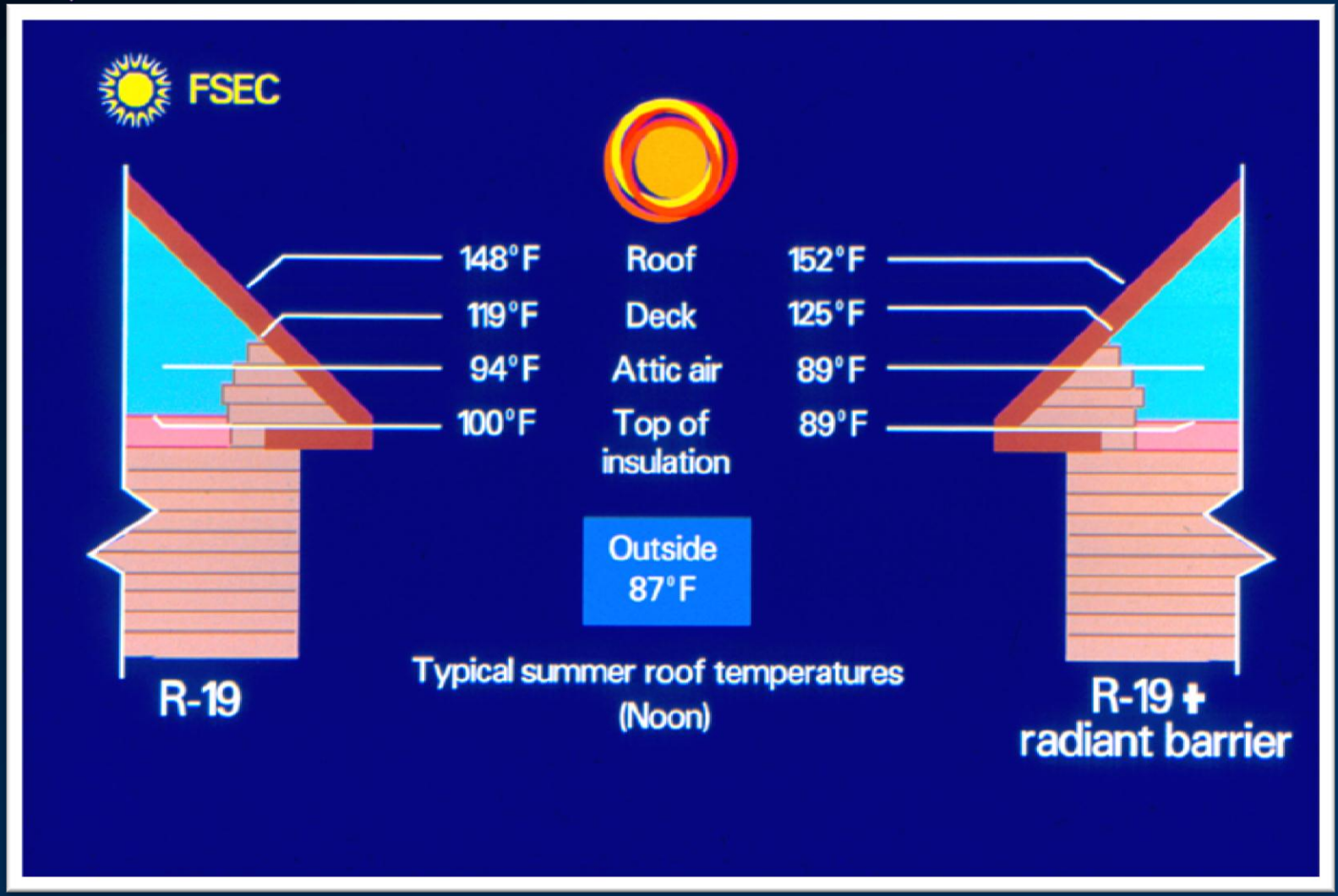
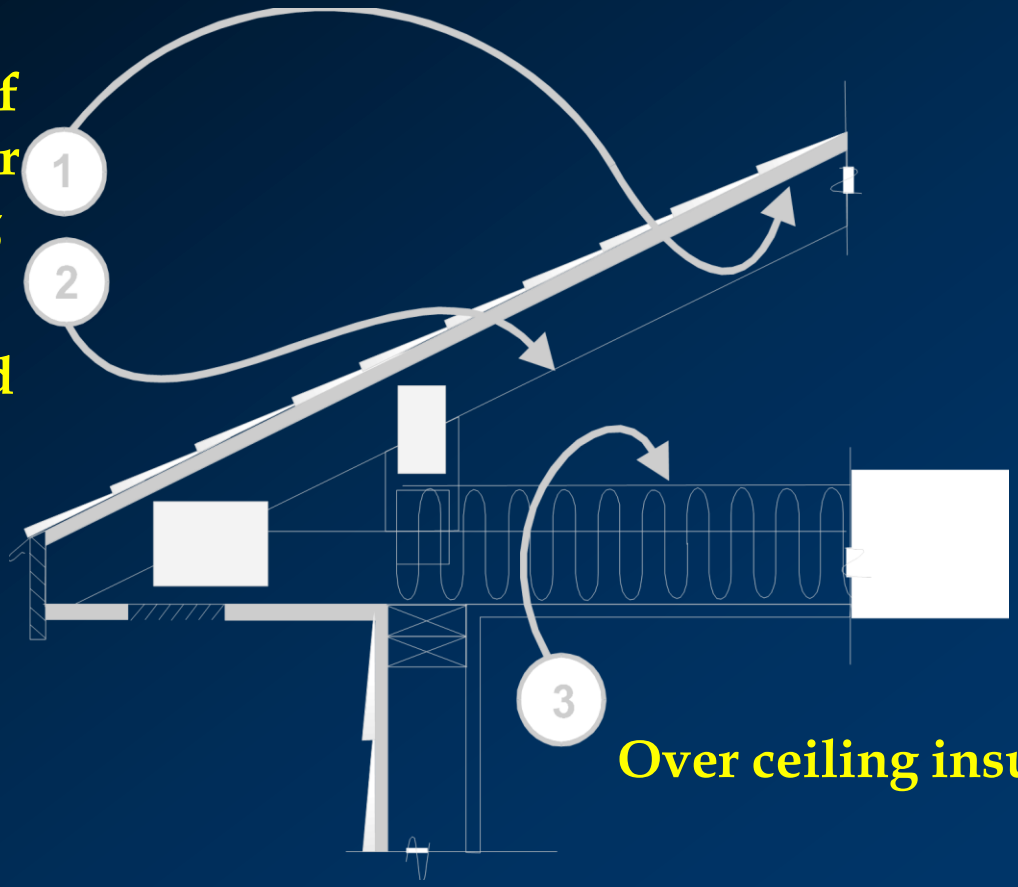


Radiant Barrier Systems (RBS)

Top side of truss under sheathing

Below bottom cord



Over ceiling insulation

Radiant Barrier Systems (RBS)

- Pre-applied to roof sheathing

GP thermostat.

TECHSHIELD RADIANT BARRIER

Ainsworth Engineered THERMASTRAND®

SOLARBORD. RADIANT BARRIER SHEATHING

Radiant Barrier Systems (RBS)

- Pre-apply it yourself

Photo from RadiantGUARD® Made in the USA

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RBS – Cool Roofs Study

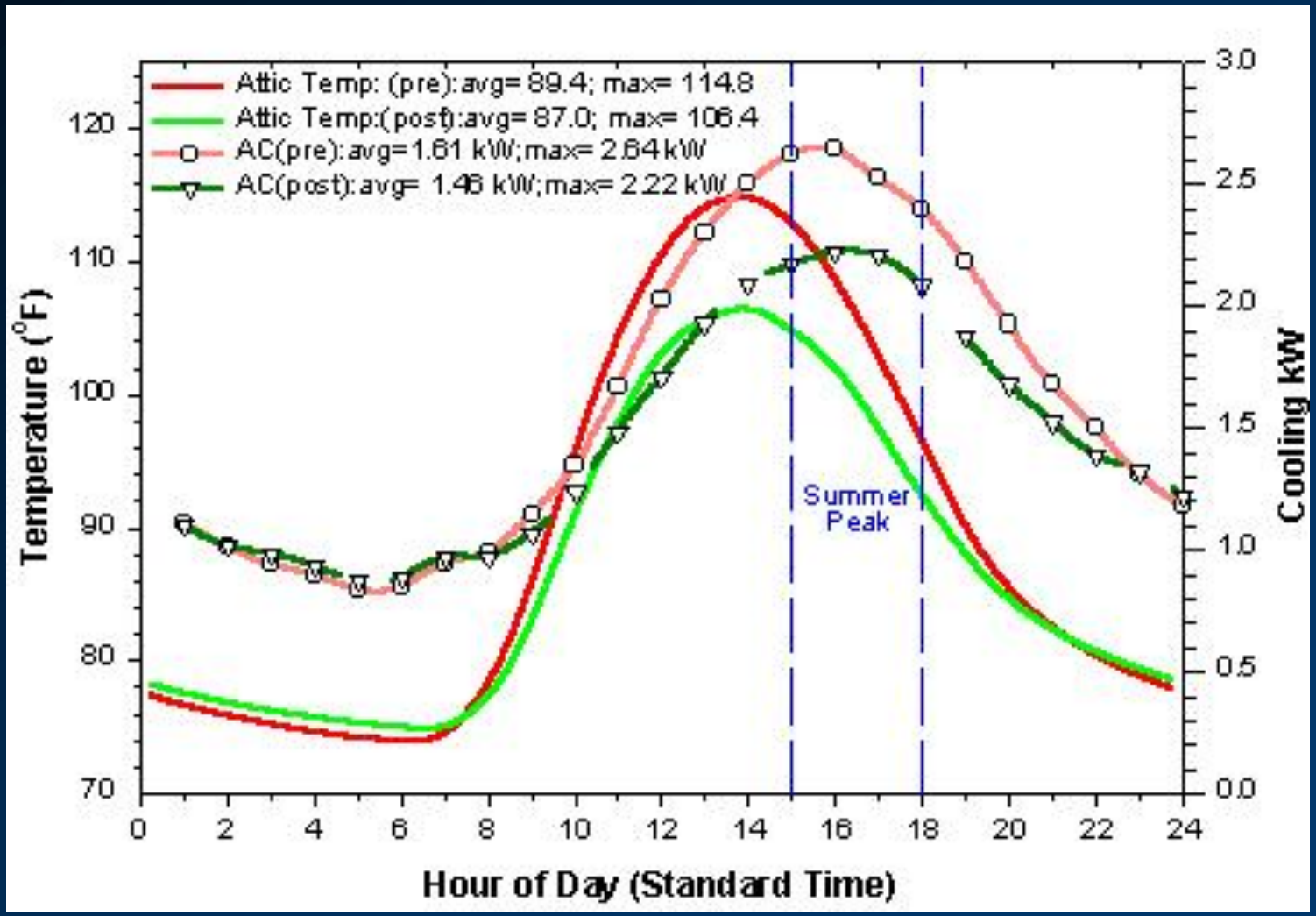
Before and after tests on 9 homes

Site #199 pre-retrofit

Site #199 post-retrofit

RBS – Cool Roofs Study

Results – 9% Savings



Put on a Cool Roof

- Hurdles
  - Aesthetic
  - Covenant and Deed Restrictions
  - First Cost
  - Who installs radiant barrier?
  - Proper installation
  - Shingle warranty

- Making the Leap
  - Look for materials with semi-reflective surfaces
  - Within the same material – no added first cost for color change
  - Radiant barrier material is as low as $\$0.10/ft^2$
  - If no insulating contractor for radiant barrier – use roof sheathing –install foil-side down to air space
  - Choose shingle that does not void warranty

Sealed & Tested Ductwork

- Duct leakage accounts for 10 to 20% of the heating and cooling bills
  - Leakage may occur in supply ducts, return ducts and paths, and air handler
  - Air handler leakage often around 5%
  - Seal ducts with mastic, not tape
  - Must test to verify ducts are sealed

Install and Seal the AH and Ducts Properly

Duct Leakage Research - 1990

- Florida
  - 50 all electric homes
  - 13% total building leakage in duct system
  - 17% savings
  - $200 cost
  - Typical: single story, slab on grade, duct board ducts in attic

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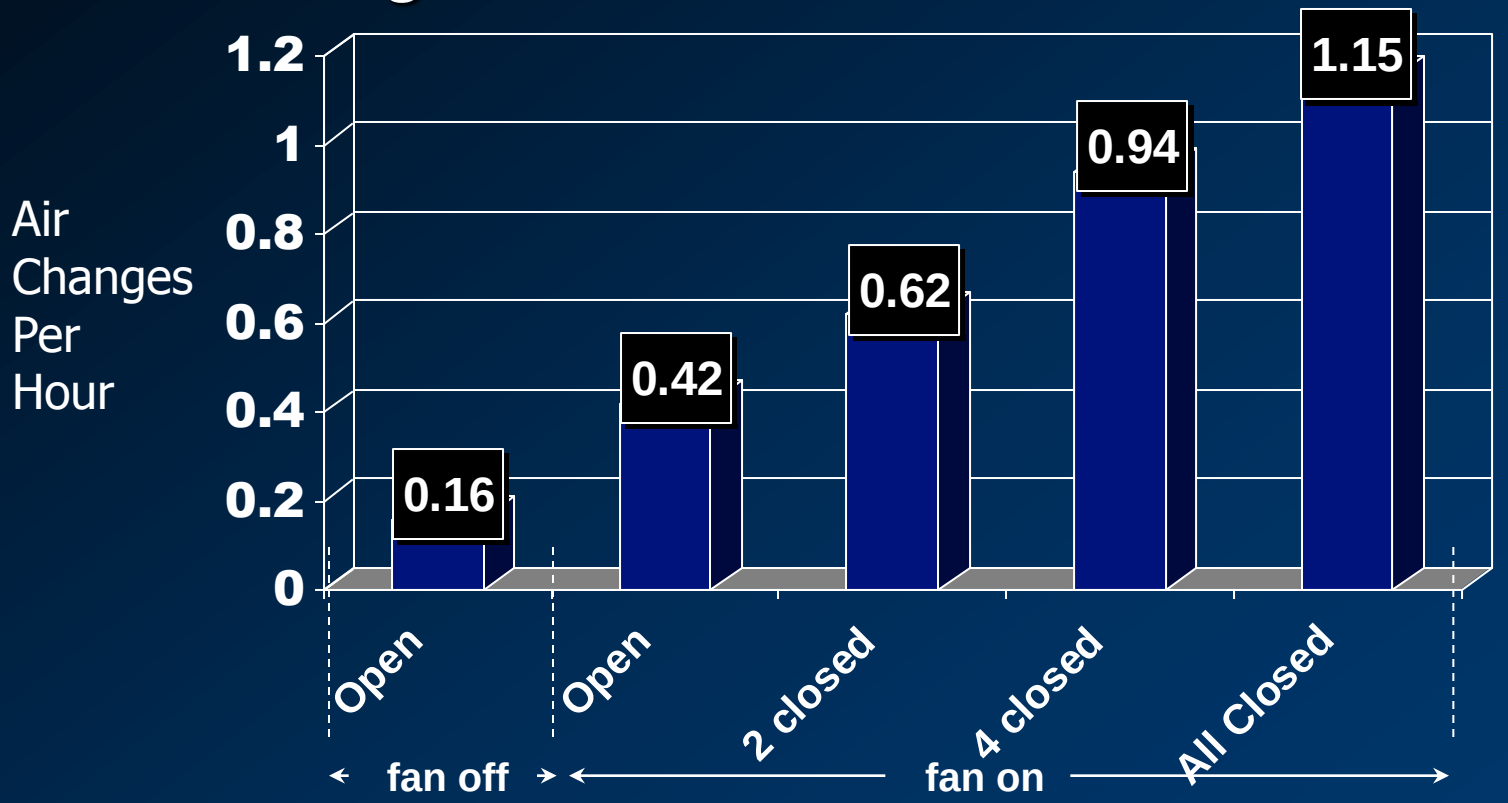
Install and Seal Ducts Properly

Closing interior doors when AHU fan on



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Install and Seal Ducts Properly

Don’t do this…

Install and Seal Ducts Properly

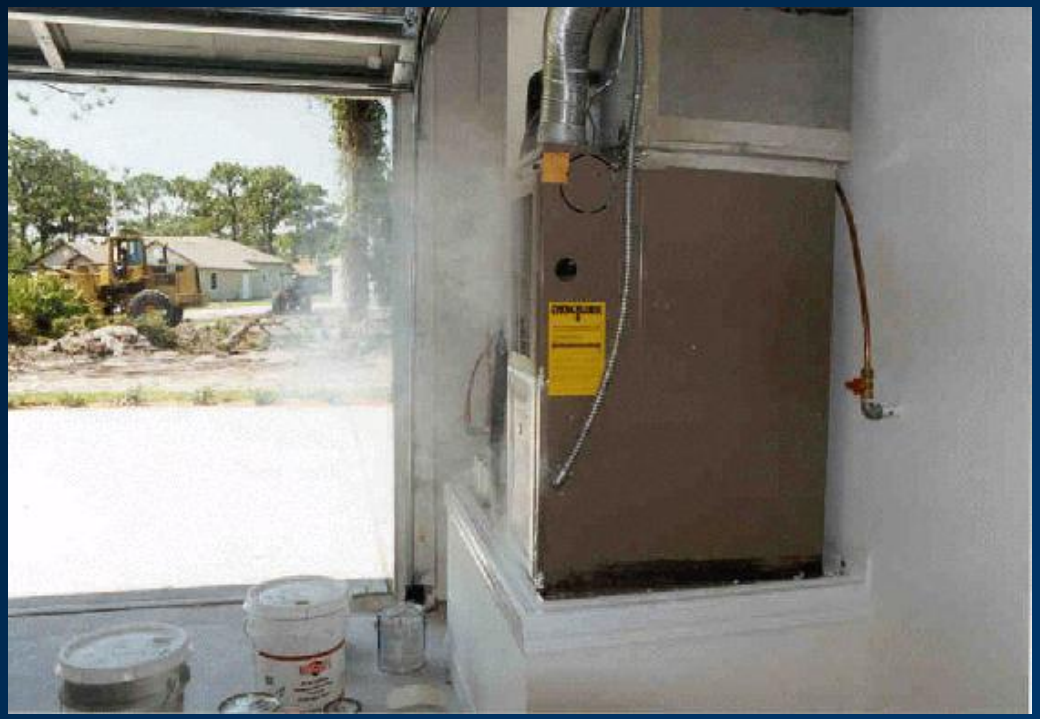
Or this…

Install and Seal Ducts Properly

Or this…

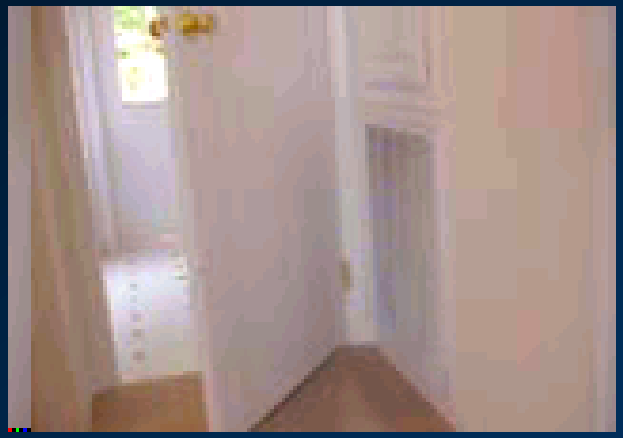
Install and Seal Ducts Properly

Or this…



Install and Seal Ducts Properly

And definitely don't do this…



- Utility room door that swings to the return grill.
- When the system turns on, the door is pulled to the grill.
- Perhaps this was designed as an automatic flow reducer to enhance dehumidification of the air conditioning unit? Not!

Install and Seal Ducts Properly

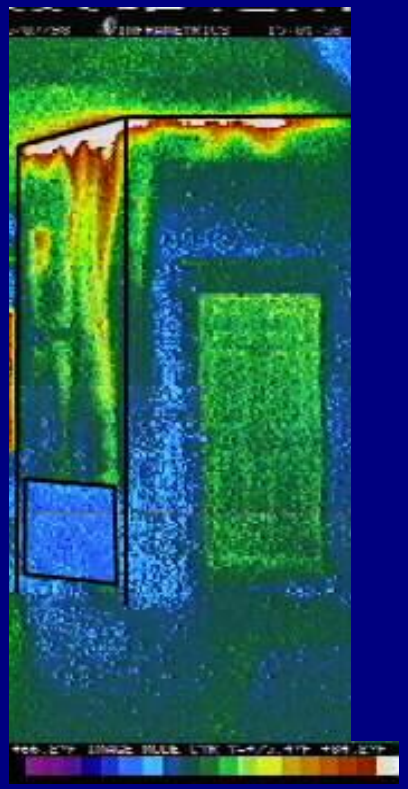
Or you may get this…

Install and Seal Ducts Properly

Or this…(way to avoid water shortages?)

Install and Seal Ducts Properly

Or this…



Install and Seal Ducts Properly

Causes of duct issues

- Use of sealing materials which are not durable over time
- 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
- Workmanship

Sealed and Tested Ducts

- Hurdles
  - Lack of knowledge
  - Contractor insists ducts are sealed already
  - First cost
  - Who can test the ducts?

- Making the Leap
  - One of the most cost-effective measures available
  - Specific measurable goal should be part of specification (e.g., **leakage to outside <5% of flow when tested at 25 pascal**)
  - In Florida there is energy code credit for meeting spec, and established energy raters
  - Provides comfort benefits, fewer callbacks, potential IAQ benefits

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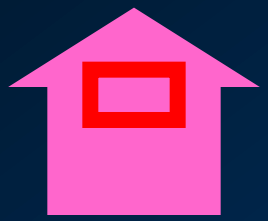
Interior Ducts

- Greatly reduces consequences of air leakage
- Duct conduction (heat loss or gain through ducts to attic or other non-conditioned location) is 5 to 15% of heating and cooling bill
- Involves starting in the design phase of a home and sealing duct space off from unconditioned space

Reduce the Impact of Ducts in Unconditioned Spaces

- Sealed and Insulated Ducts: continuous thermal barrier and sealed with mastic and mesh *including the return plenum*. Cool roof preferred.



- 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.

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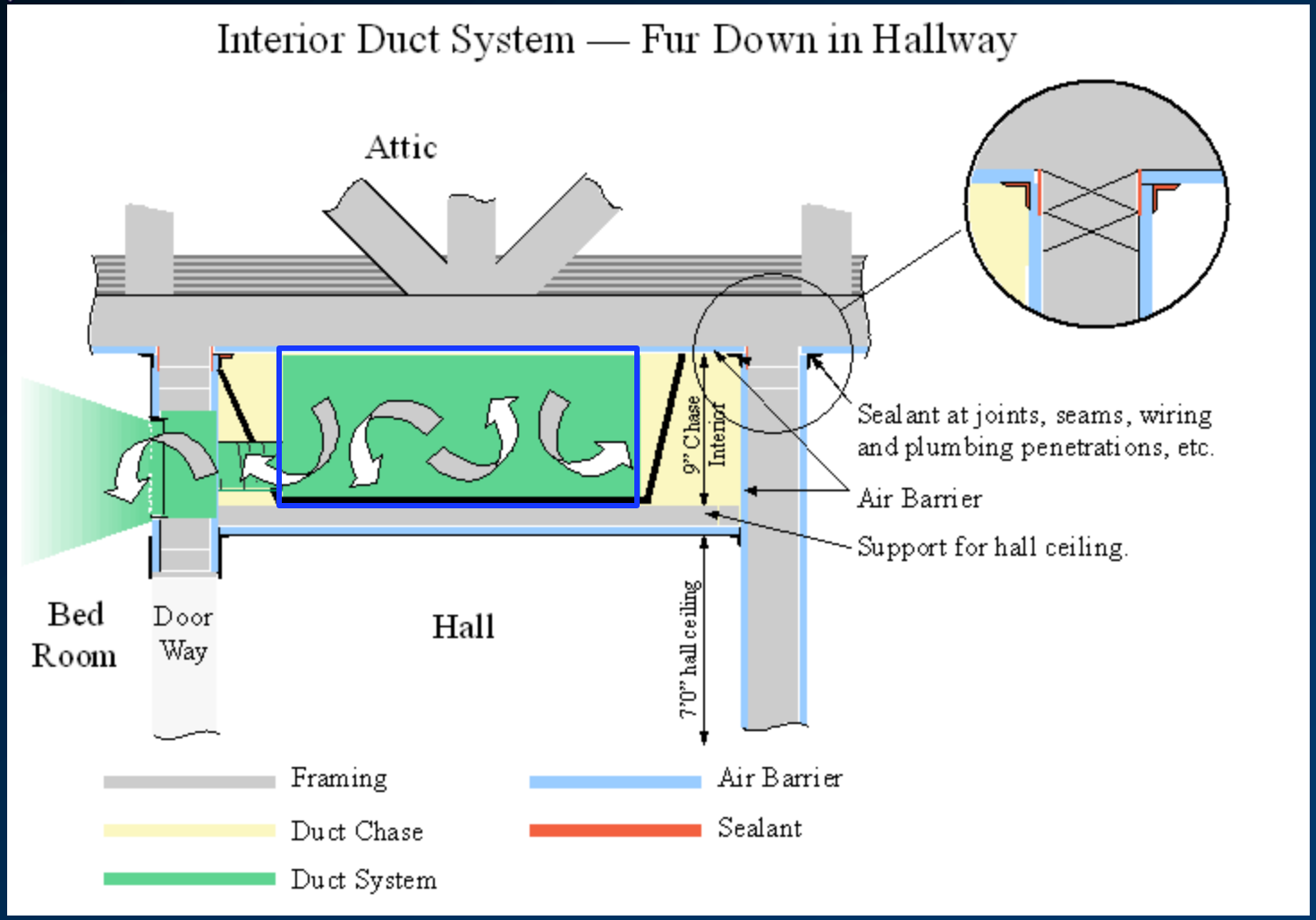
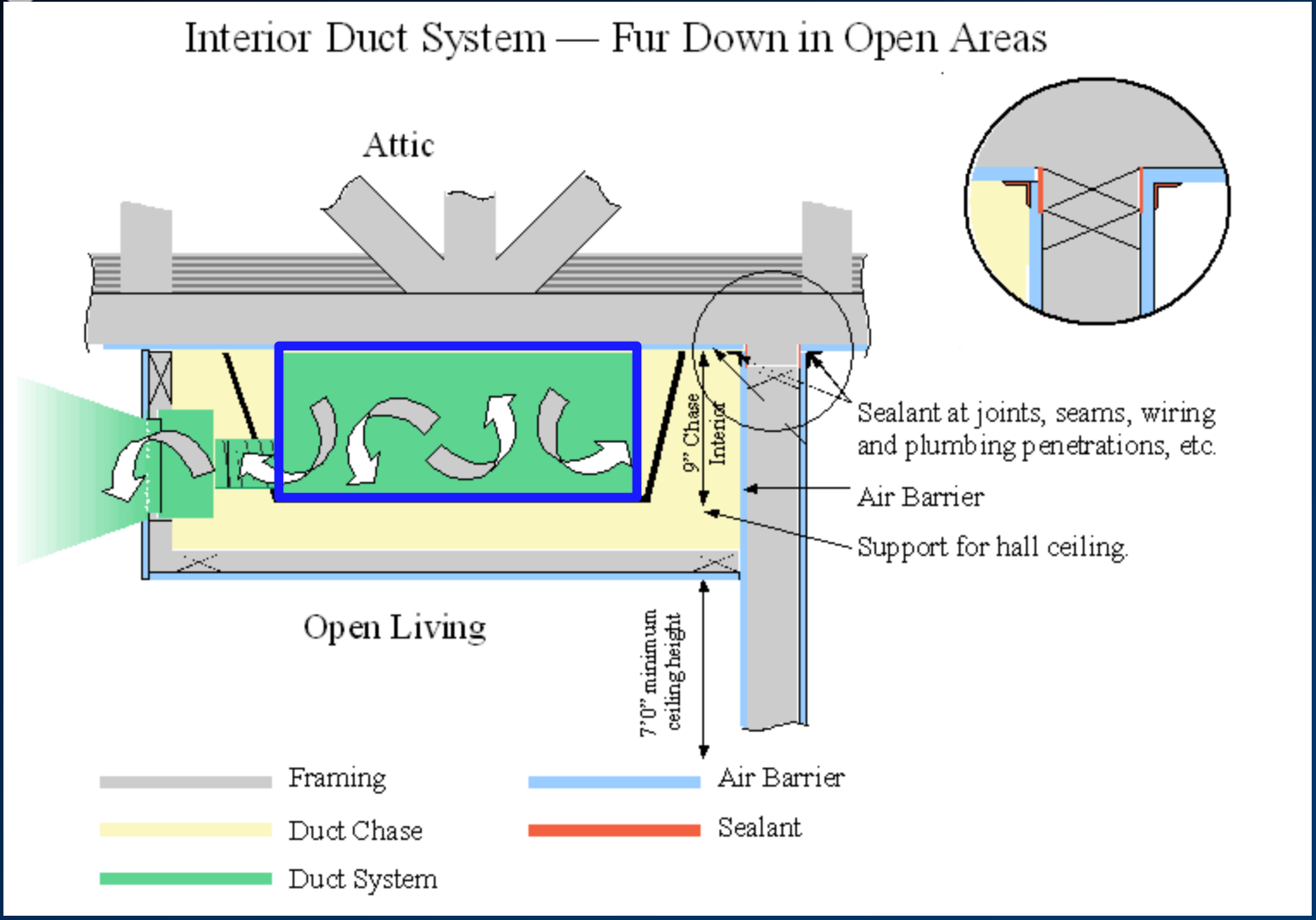
Interior Ducts - Schematic Design



Interior Duct Chase
Air Barrier in Place

Interior Duct Chase Details to Coordinate

Interior Ducts - Schematic Design



Savings and Ratings

- North Carolina Houses: 1014 sq ft
- 5 with Ducts in Crawl Space
  - Average loss of air 6.8% (68.9 CFM25out)
  - Annual Estimated Energy Cost = $1099
- Ducts in Conditioned Space with Qn = 4% (average)
  - Average loss of air 4% (40.64 CFM25out)
  - Annual Estimated Energy Cost = $1013
- Estimated Annual Savings = $86

Cost Effectiveness

- Example Economics from North Carolina Houses

$0	No incremental cost for duct installation
+$200	Drywall for miscellaneous air barriers
$0	Ceiling insulation will be thermal barrier
+$350	Labor + materials to install and seal air barrier
- $250	~1/2 ton reduction in heating/cooling
$300	**FIRST COST**

- Annual Savings = $86
- Simple payback $300/$80 = 3.75 years

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Interior Ducts – Case Study

NZEH #1 – Gainesville, FL

- 1700 sq.ft.
- RBS underneath with R-30 ceiling insulation
- Interior duct system
- SEER 19 air cooled 2 spd AC
- Fully condensing 95% furnace
- Windows: Low-e, vinyl frame, SHGC=0.28; U-factor <0.35.
- Doors: Insulated (R-5)
- Walls: Cellulose R-13 walls
- Slab-on-grade floors: 50% tile

Interior Ducts – Case Study

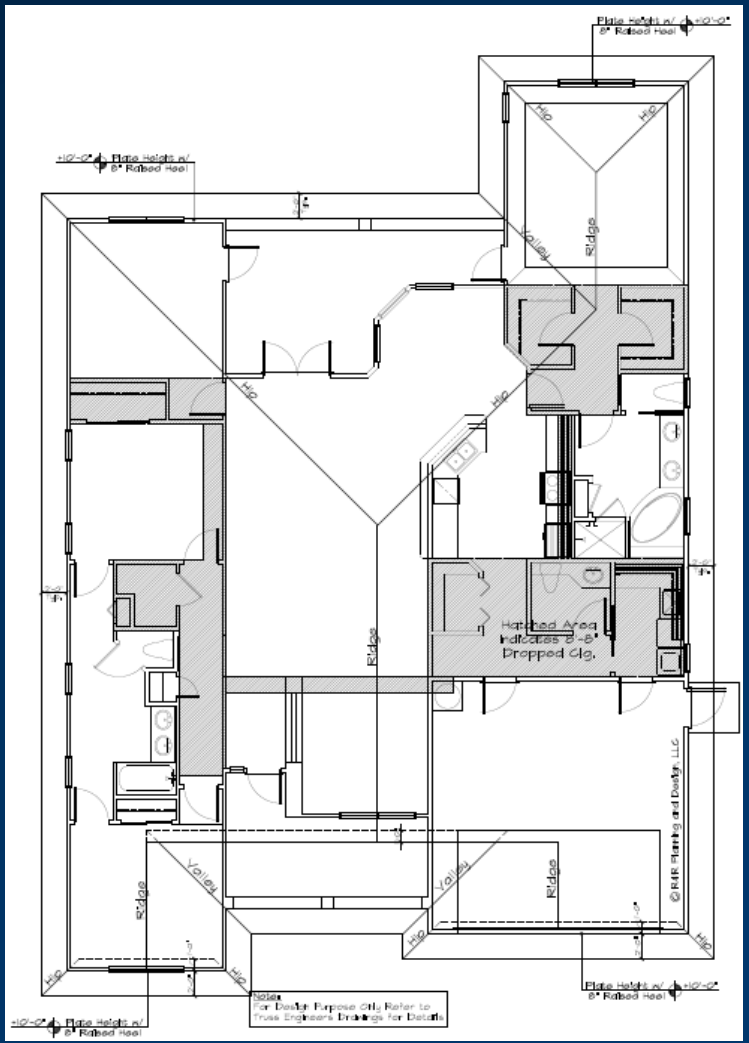
NZEH #1 – Gainesville, FL

Interior duct system showing roughed in ducts and framing details and finished interior detail

Interior Ducts – Case Study

ZEH #1 – Gainesville, FL

Design - Shaded areas denote areas where ceiling sheetrock is to be installed after the home is dried in.



Interior Ducts – Case Study

ZEH #1 – Gainesville, FL

IEQ & HVAC

- Penetrations & openings sealed to achieve 2.3 natural air changes under blower door testing at 50 Pa
- Ducts (sealed with mastic) & air handler in conditioned space
- Periodic site inspections & tested

- ACCA Manual D sized duct system, sealed with mastic at joints
- ACCA Manual J sized heating/cooling equipment
- 2.8 ton high efficiency, CFC/HCFC free refrigerant, heat pump (SEER 16, HSPF 9.5)

Foam gasket at ceiling/wall joints ensures airtightness

Ducts within conditioned space

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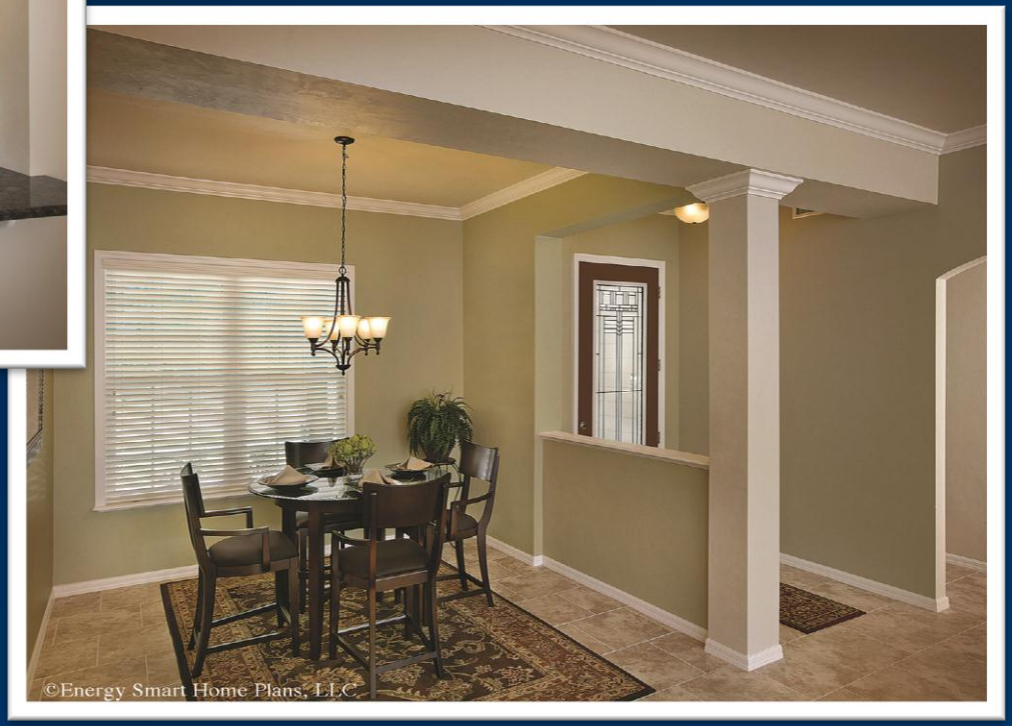
Interior Ducts – Case Study

ZEH #1 – Gainesville, FL



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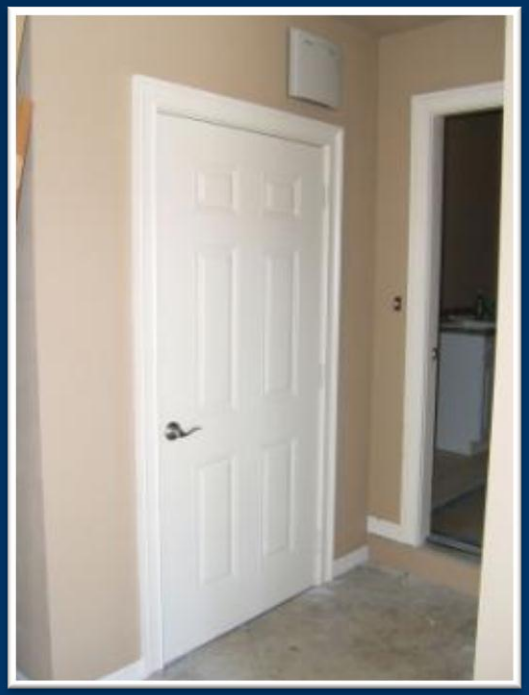
AHU in Conditioned Space Builder Benefits

- Results in ~15 sq. ft. More Conditioned Space
- ~$2,000 Added Appraised Value
- ~$500 In First Cost
- Net Profit to builder ~$1500!



Interior Ducts – Case Study

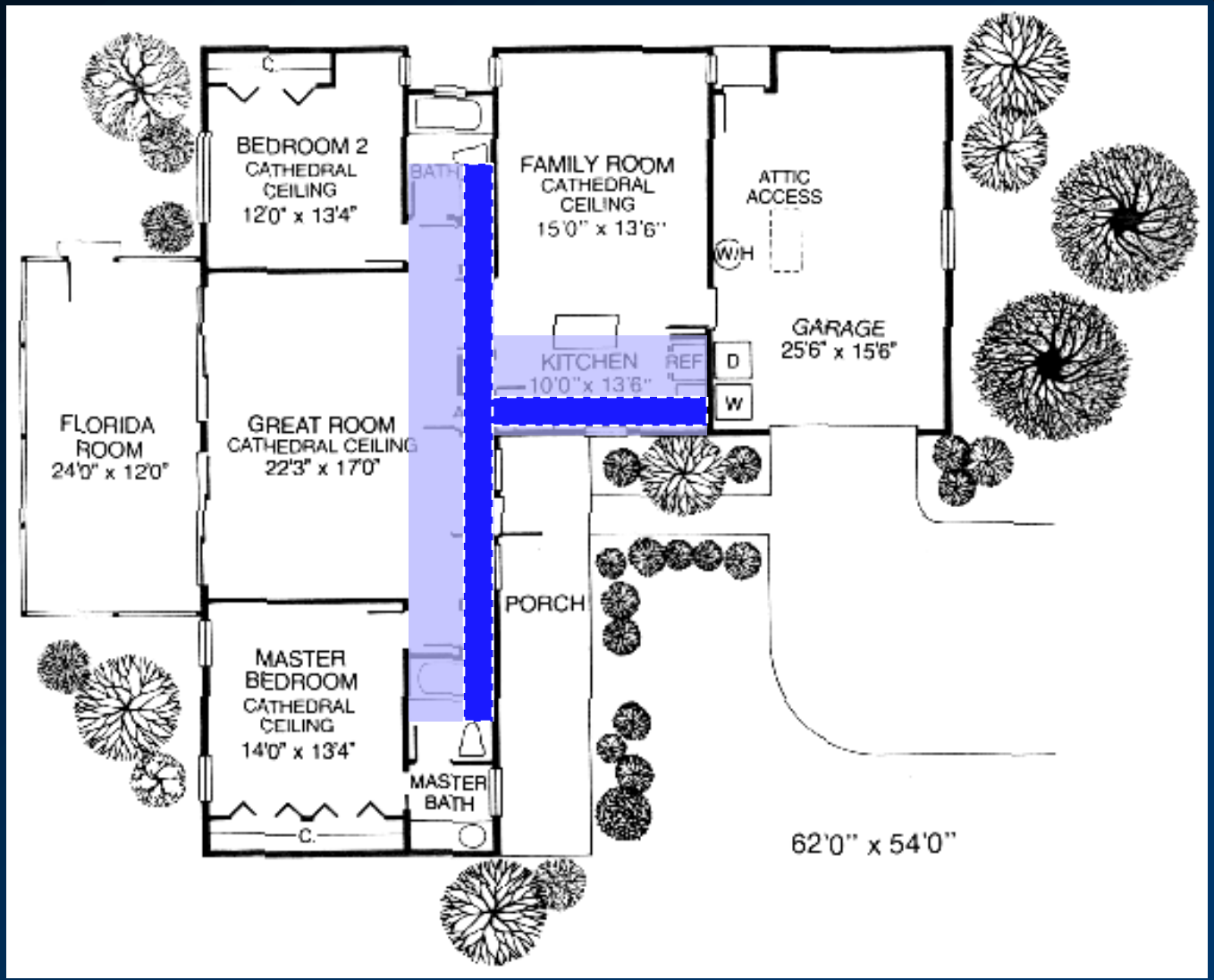
NZEH #1 – Gainesville, FL

Cost Analysis

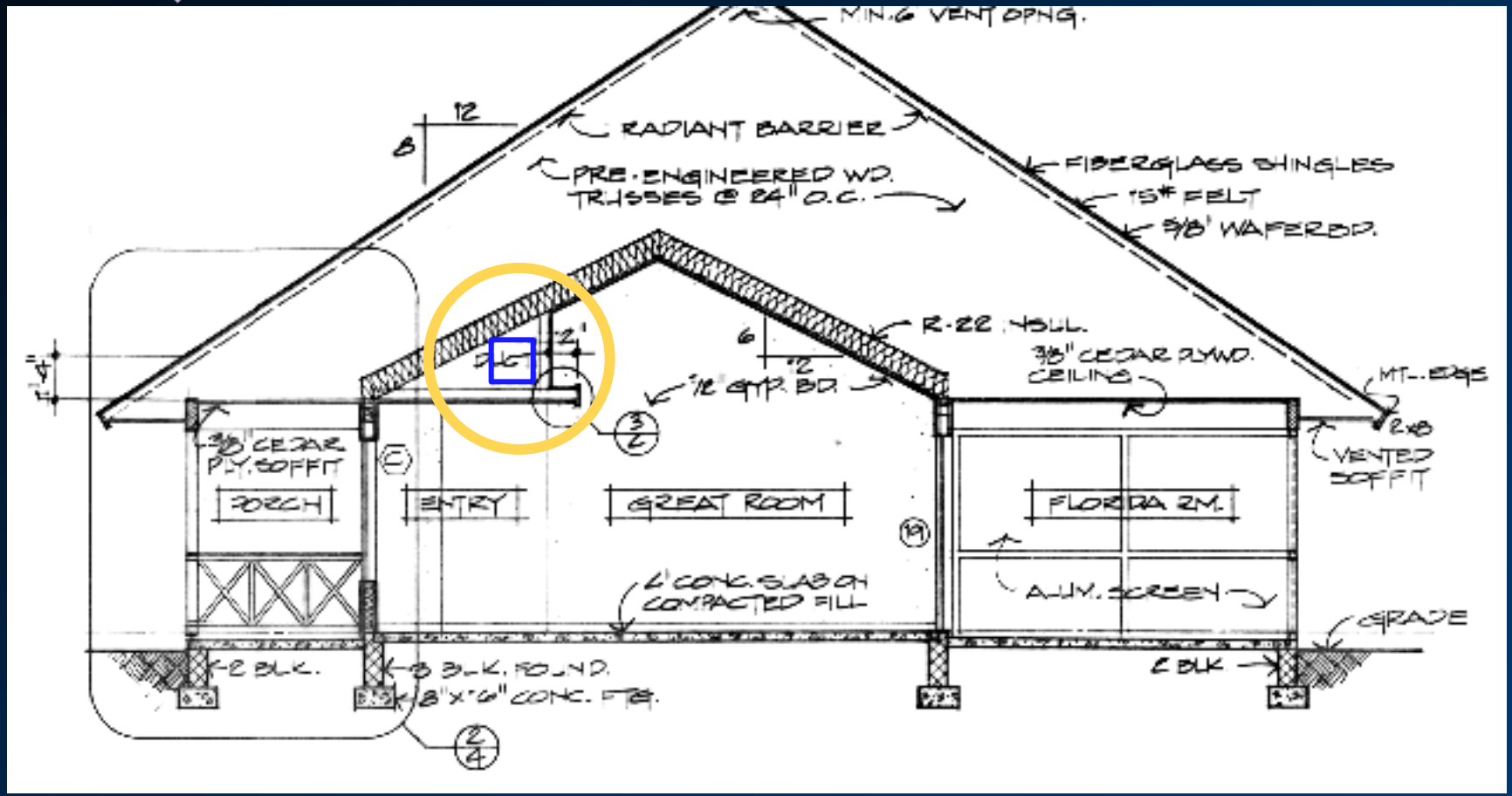
Note: Above costs were obtained from a local insulation contractor on 4/28/10

Duct location	Unvented Attic	Conditioned Space
Floor Area (sq.ft.)	2,250	2,250
House Volume (cu.ft.)	25,500	22,500
Roof Pitch	7/12	7/12
Heat Transfer Area (sq.ft.)	2,520	2,250
R-Value	21	38
Insulation Cost **($/sq.ft. of floorArea)**	$5,625 $2.50	$1,688 $0.75
DCS Cost ($) **($/sq.ft. of floor Area)**	**N/A** **N/A**	**$875** **$0.39**
Radiant Barrier Cost ($)	$0	$500
Total Cost ($) **($/sq.ft. of floor Area)**	**$5,625** **$2.50**	**$3,063** **$1.36**

Cathedral Duct Chase



Cathedral Duct Chase



Fur Up Chase in Truss Frame Attic

- Problems:
  - Platform Return
    - Not sealed from adjacent interior walls
  - Attic Fur-up
    - Holes from other trades
    - No connection to drywall ceiling
    - Missing insulation
    - Trade Coordination
      - Plumbing, electrical, alarm, and phone installers view chase as dropped ceiling
      - Drill holes for pipe and wiring and don't seal.

Fur Up Chase in Truss Frame Attic

- Solution:
  - Add blocking between bottom of chase wall and ceiling drywall
  - Spray foam on chase walls and top of AHU Closet
- Result:
  - 36% Reduction in CFM25out

Recommendations: Before Construction

- Design
  - Completely think through the construction during design
  - Make the path of the chase as simple as possible
  - Avoid miscellaneous framing under the trusses
  - Take advantage of space above cabinets and tops of closets
  - Do not locate supply registers above doors
  - Indicate the chase on at least the dimensional, mechanical, and framing plans
  - Provide a detailed section indicating materials and sealant locations

Recommendations: Before Construction

- Logistics
  - Have air barrier material on site when needed
  - Mark position of door framing on chase walls before framing out the bottom – allow for floor finish and chase structure
- Trade Coordination
  - Communicate the intent and location of the chase to all trades affected by the chase
  - Identify the chase on all plans

Recommendations: During Construction

- On-site Coordination of Trades
  - GC level supervision
  - Site Communication (color codes, symbols)
    - Post drawing of the detail for reference
    - Mark location of chase at the bottom plate
    - Mark supply registers on chase walls
  - Post M/E/P inspection “seal up”
  - He who drills it, seals it.

- Seal the top of the chase to the walls of the chase as if it were a ceiling to interior walls
- Avoid unducted returns - Seal non-ducted plenums with mastic
- Detailed design and construction guidelines available, contact:
  - Janet McIlvaine 321-638-1434 janet@fsec.ucf.edu
  - David Beal 321-638-1433 david@fsec.ucf.edu

Ducts in Conditioned Space

- Hurdles
  - Aesthetic
  - Ain't how we usually do it
  - Must take place at design stage
- Making the Leap
  - Good design will totally hide ductwork
  - Good planning required
  - Highly cost-effective

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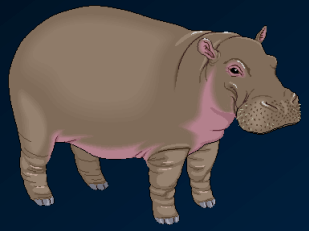
Correctly Size Single-Speed AC System

- Residential AC Systems are usually larger than needed
- Oversizing by 50% (e.g., a 3-ton unit where a 2-ton would be needed) results in about 10% greater energy use
- Shorter run times of larger systems leads to poor humidity removal
- *Multispeed compressor systems could be oversized*

Proper AC Sizing (Myths)



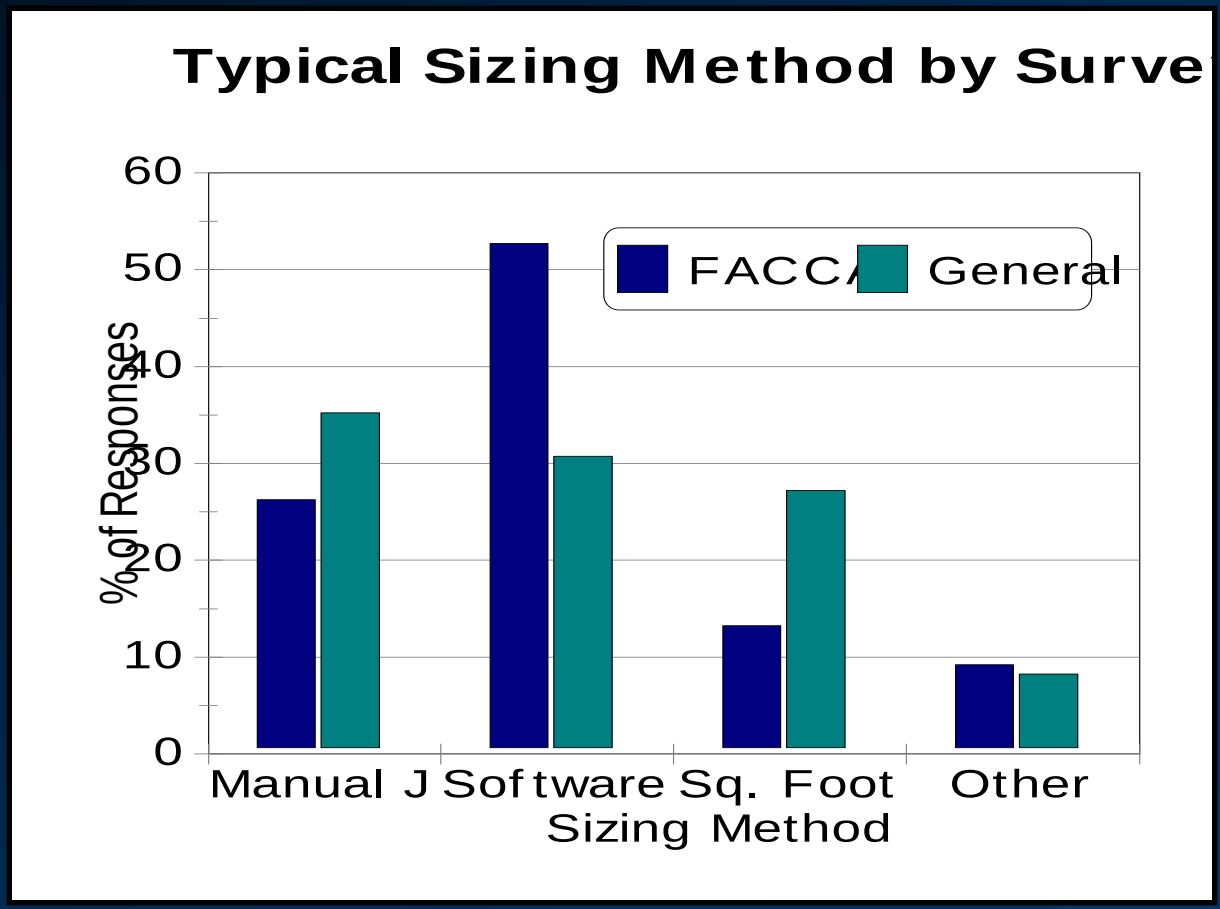
"Bigger is Better"

"Meanest Dog on the Block"

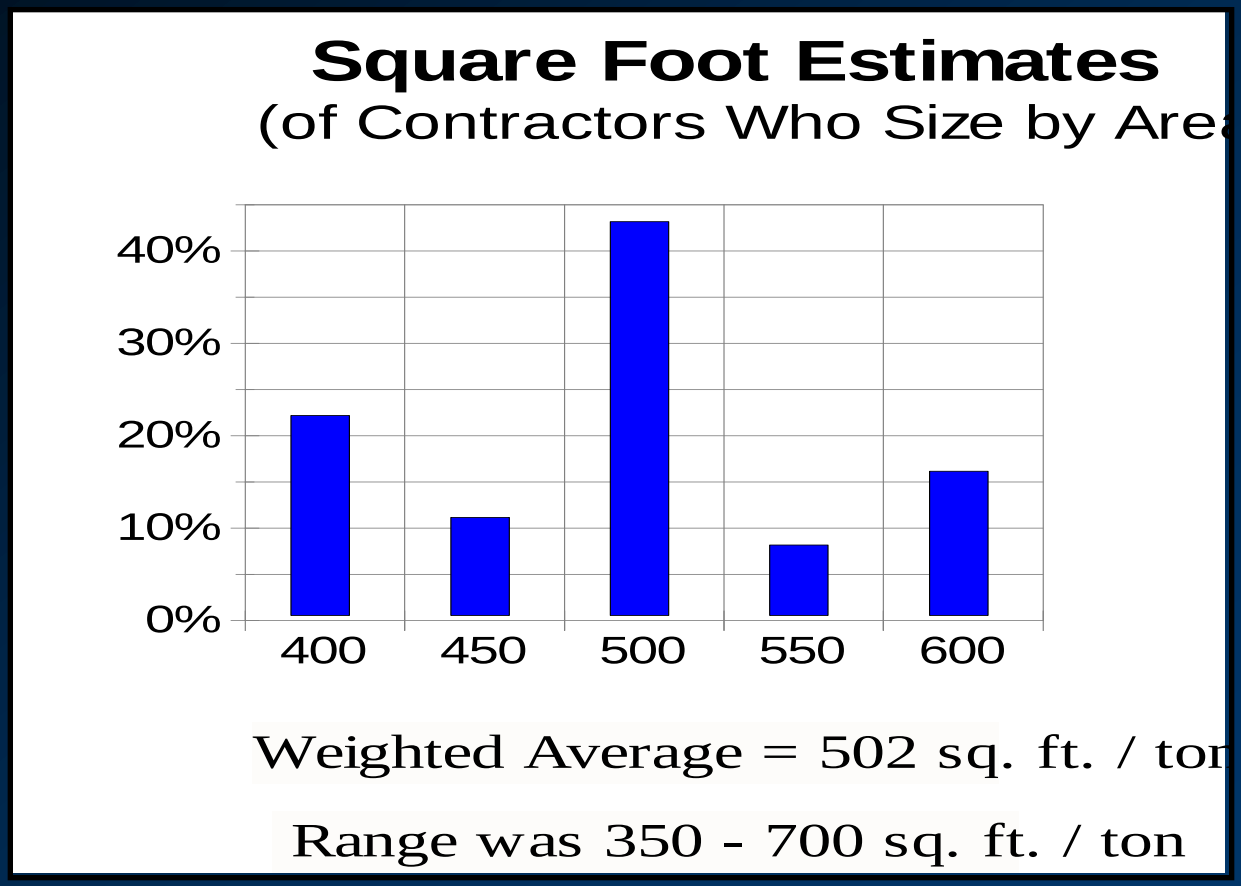
"Front Door Rule"

Source: Abrams (1986) AC Sizing Summary

Proper AC Sizing- Survey Methods



Proper AC Sizing- Survey Methods



Proper AC Sizing
FPL/FSEC Audit Study

- 386 new homes
- Complete audit to calculate Florida Energy Code and Manual J.
- Compared installed system size vs. calculated Manual J.
- Grouped homes by ratio of installed / calculated Manual J cooling capacity:
  < 1.0 1.0 – 1.2 > 1.2

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Proper AC Sizing
FPL/FSEC Audit Study

Approximately 50% were sized 1.2 times Manual J or greater.

Peak day cooling electrical load about 13% greater for sizing >120% Manual J

3.7% and 9.3% increase in cooling energy for systems sized 120% and 150% of Manual J respectively.

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Proper AC Sizing
FPL/FSEC Audit Study

Undersizing left some customers wanting

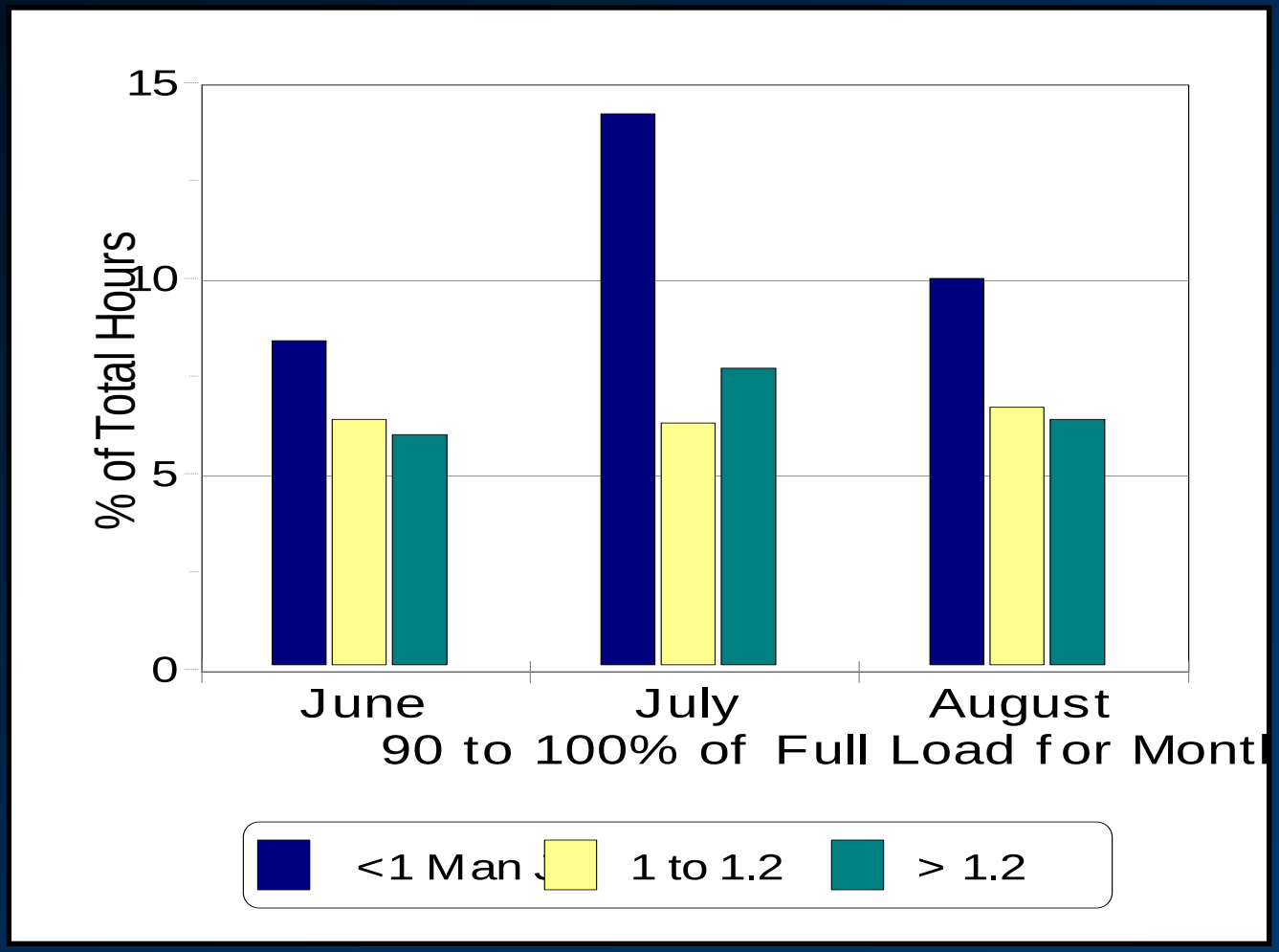
30% to 50% higher peak run time percentages for systems sized < 1.0x Manual J.

Proper AC Sizing
FPL/FSEC Audit Study

Oversizing provided no benefit

No significant diff. in peak run times for systems sized 1.0x to 1.2x Manual J and those > 1.2 times Manual J.

Proper AC Sizing
FPL/FSEC Audit Study



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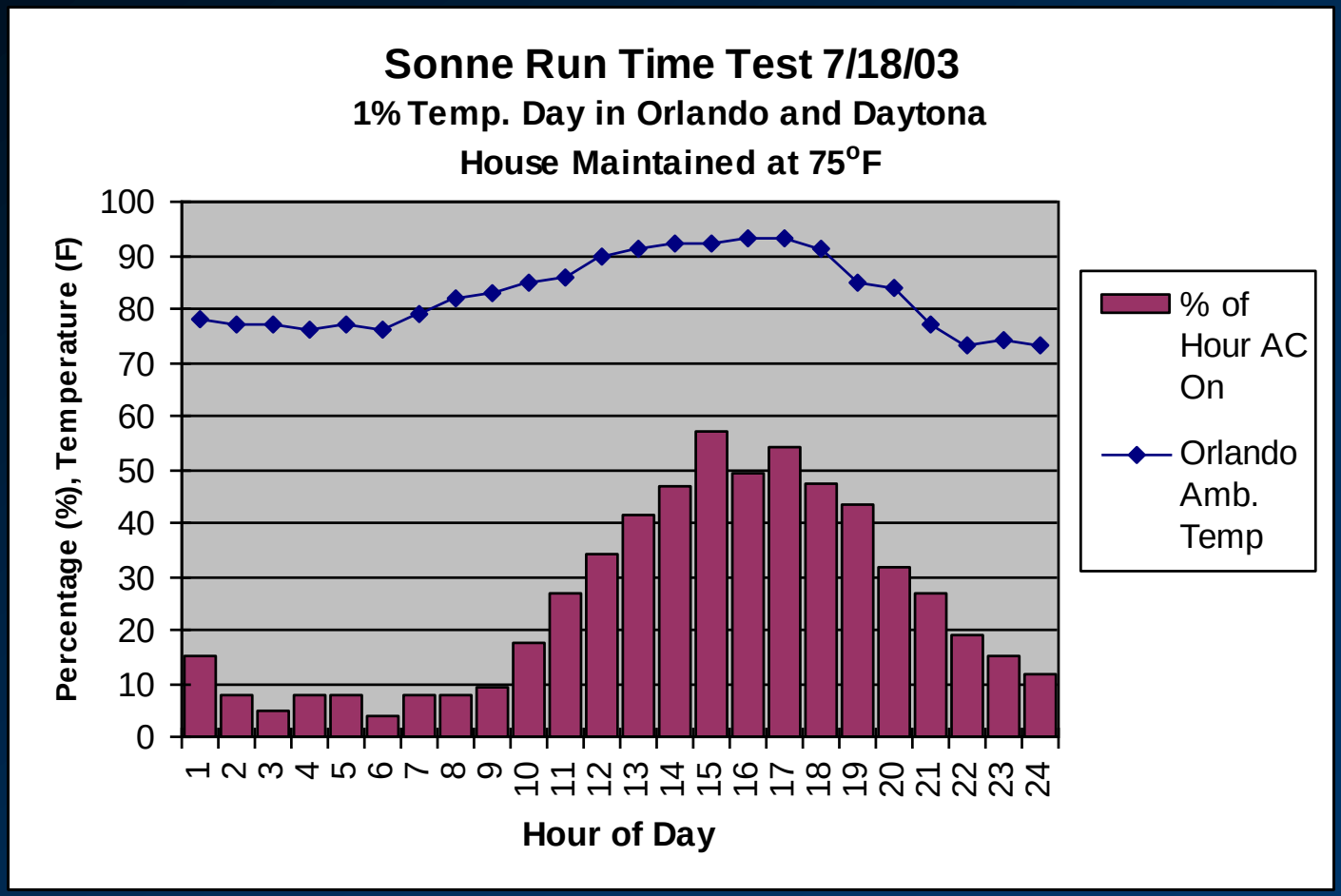
Proper AC Sizing
Manual J vs. Manual J

My Manual J Calculation:	33,700 Btuh
A Large AC Company:	
Modifying Design Conditions:	38,300 Btuh
No Internal Window Shading:	46,000 Btuh
100 CFM for Bathroom Fans:	52,500 Btuh
Rounding Up:	60,000 Btuh

Difference is approximately 180%
Manual J, or 2.2 tons capacity

Proper AC Sizing
Sonne Run Time Test



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Proper AC Sizing Case Study

The Lakeland PVRes House

Maintained 75ºF and provided better comfort than the control home that has a 4 ton AC …

…using a 2 ton system (1200 sq. ft. / ton)...

… during the summer of ’98!

home incorporated cool roof, interior sealed ducts, high efficiency lighting and AC and saved 78% of cooling energy use

Correctly Sized AC Systems

- Barriers
  - This is the way the HVAC contractor insists is correct
  - Thinking that bigger is better
  - Thinking that larger is safer

- Making the Leap
  - Sizing tools can be checked
  - Shop the job among contractors
  - Smaller saves money for builder and buyer
  - Smaller more likely to control humidity

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Compact Flourescent Lighting

- Barriers
  - Higher first cost
  - Do the bulbs fit the fixtures?
  - Bulb aesthetics
  - Color rendering

- Making the Leap
  - New bulb and fixture choices
  - Stick to reliable brands
  - Color rendering

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Preserving Shade Trees on Site

- Barriers
  - Not enough room
  - Takes too much time
  - Buyer may cut it anyway
  - I plant new trees

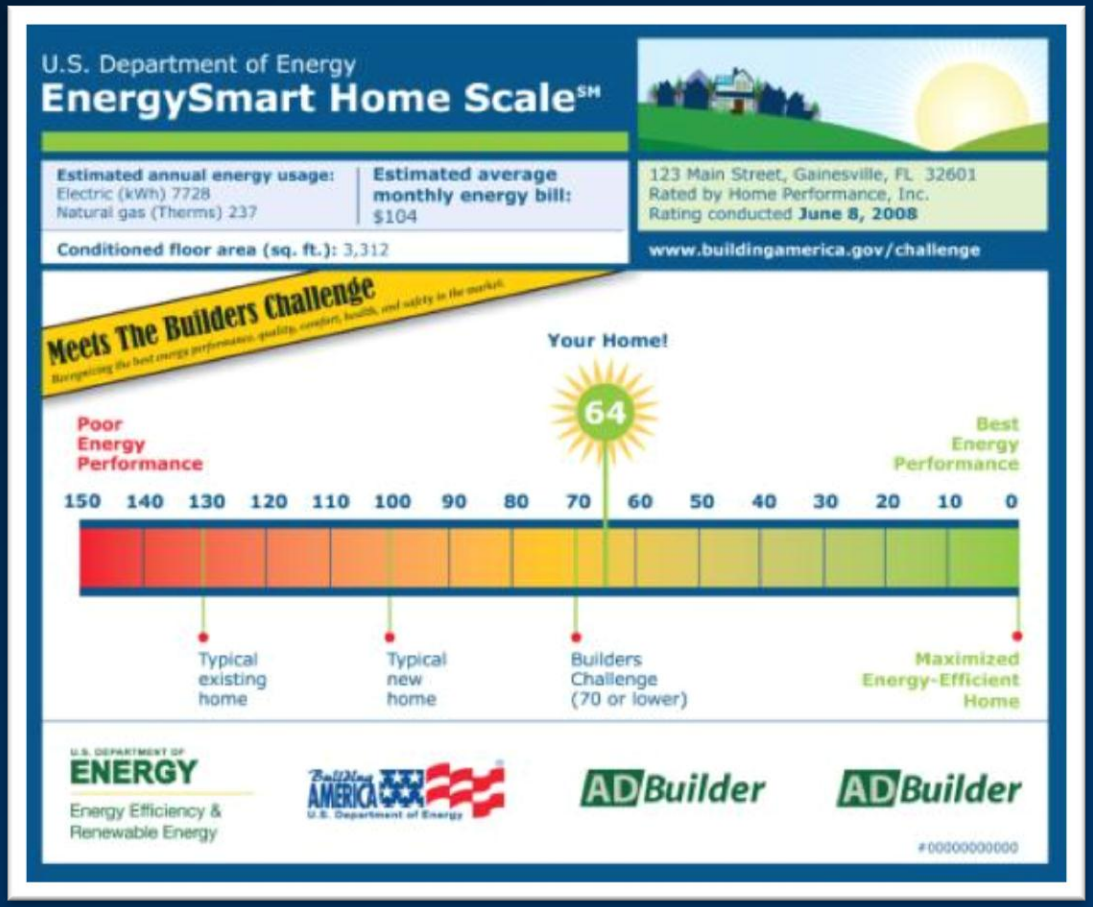
- Making the Leap
  - Seen great successes on 50’x50’ and multifamily lots
  - Time spent saving trees leads to time and money saved at landscaping time
  - May attract buyers to your home
  - Big profits available

Marketing

Now that you've built it, how do you sell it?

3 Ways to Sell High Performance Homes

1. Show Feature Has Benefit



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3 Ways to Sell High Performance Homes

1. Show Feature Has Benefit

What if this...

Allowed you to do more of this

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3 Ways to Sell High Performance Homes

1. Show Feature Has Benefit

What if this...

Allowed you to afford this

3 Ways to Sell High Performance Homes

1. Show Feature Has Benefit – Use creative names

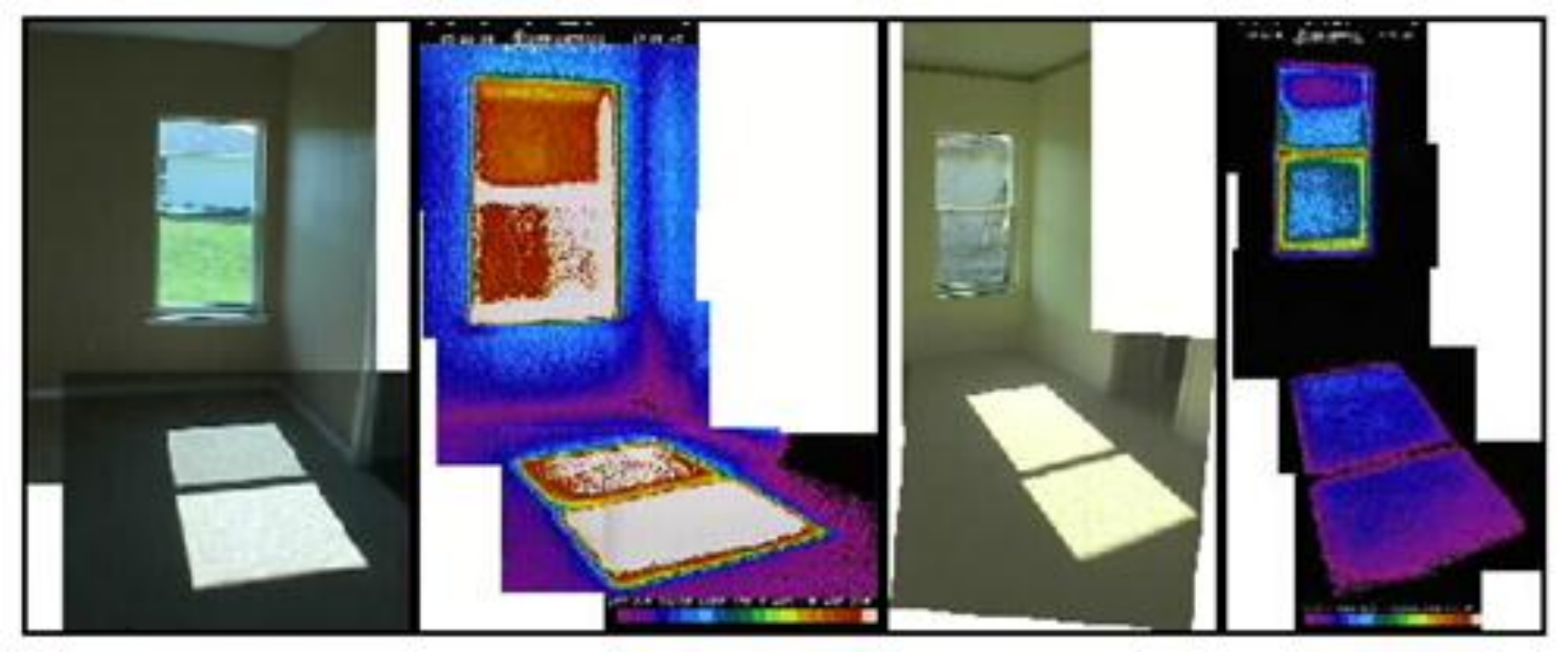
"Accoustimass - Wave-System"

vs

"Positive Pressure Ventilation System"

3 Ways to Sell High Performance Homes

1. Show Feature Has Benefit –Fear Tactic



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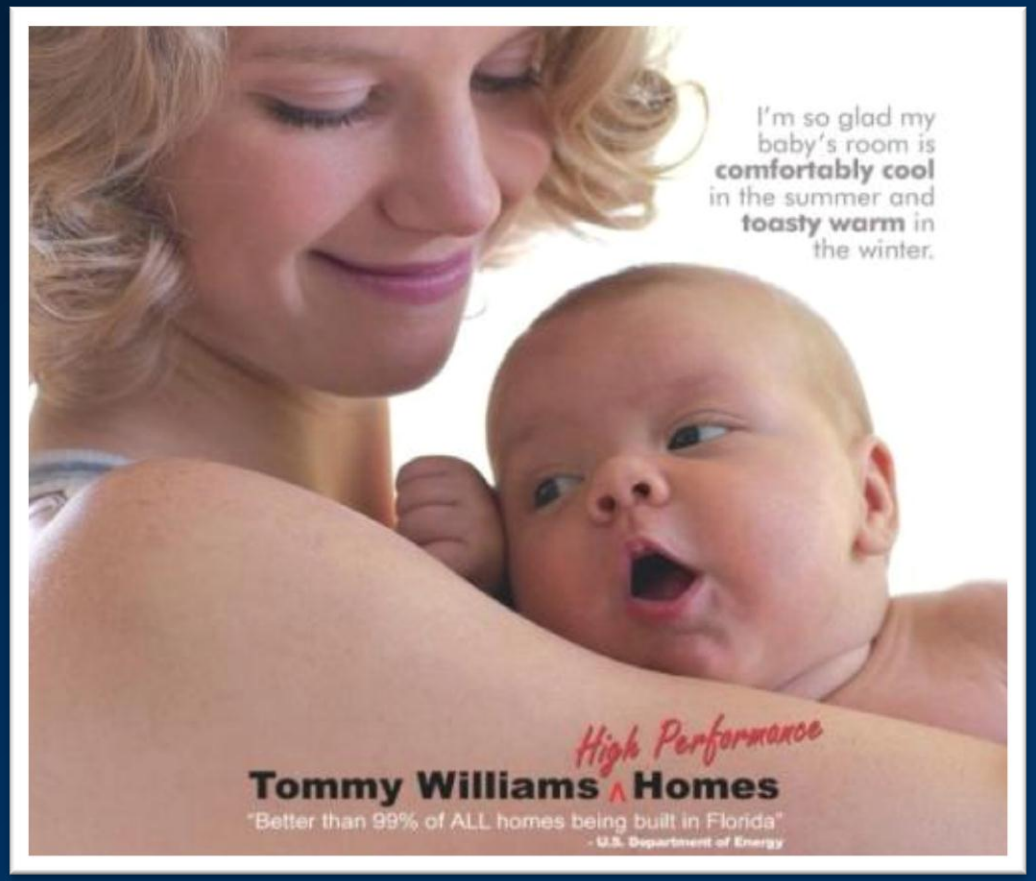
3 Ways to Sell High Performance Homes

1. Show Feature Has Benefit –Fear Tactic



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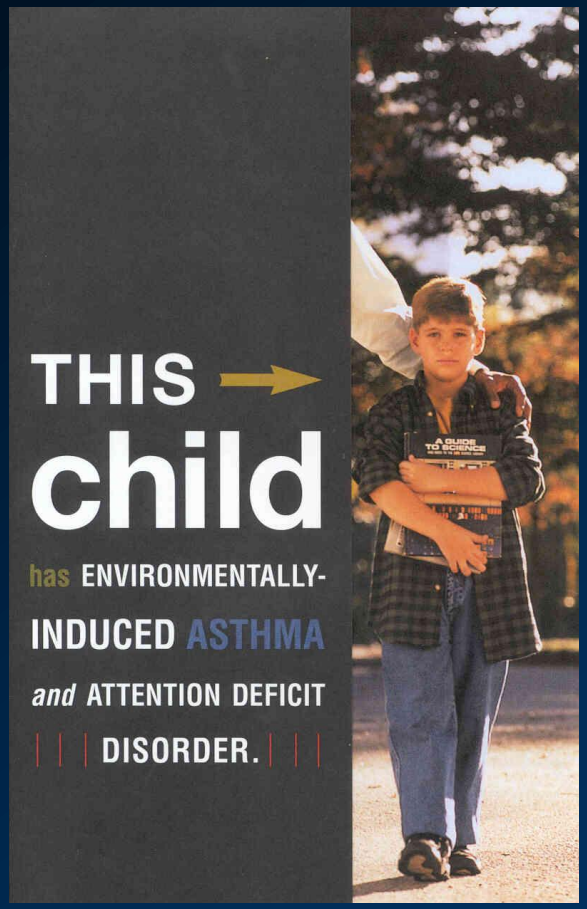
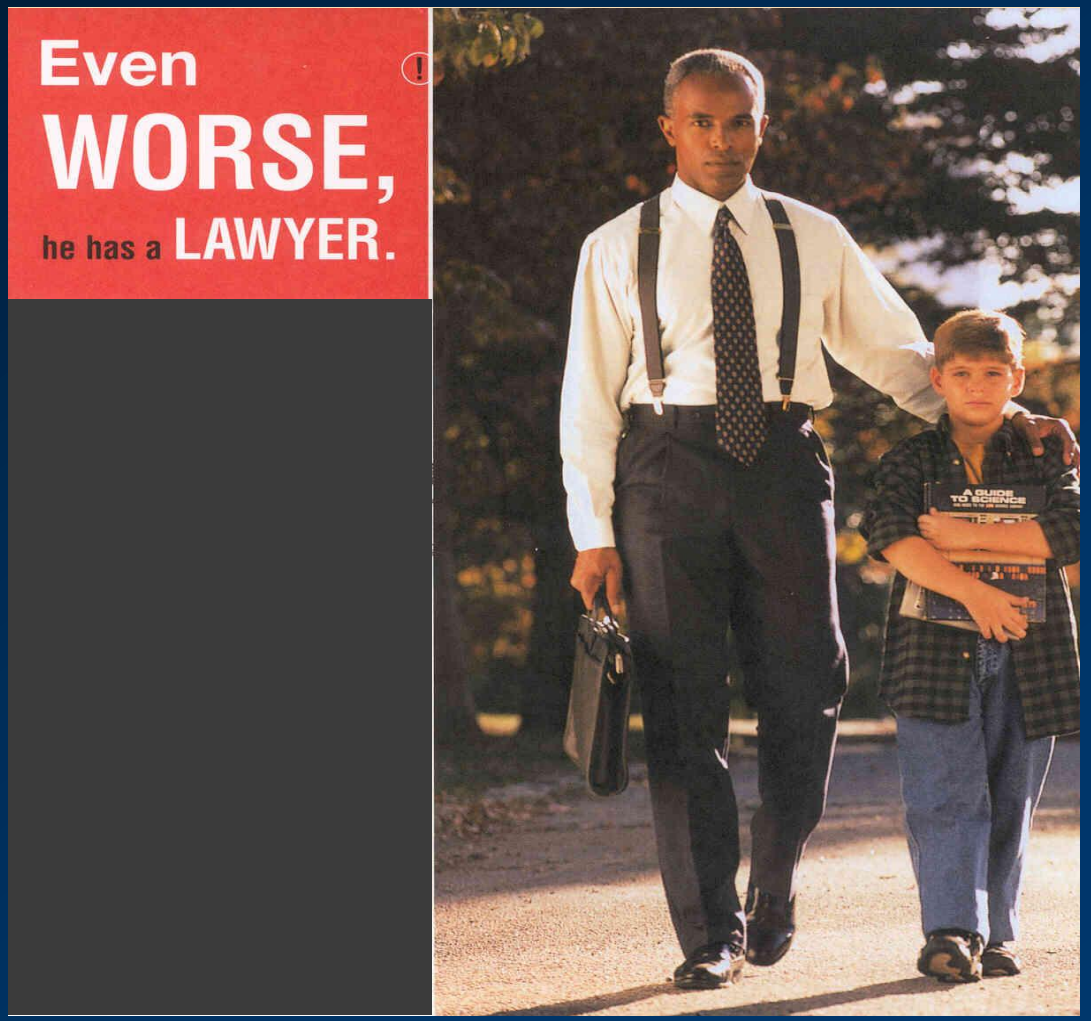
1. Show Feature Has Benefit –Fear Tactic





3 Ways to Sell High Performance Homes

2. See for yourself

Show & sell

Educate consumer

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3 Ways to Sell High Performance Homes

2. See for yourself – Open House

Model demonstrations

A chance to bond

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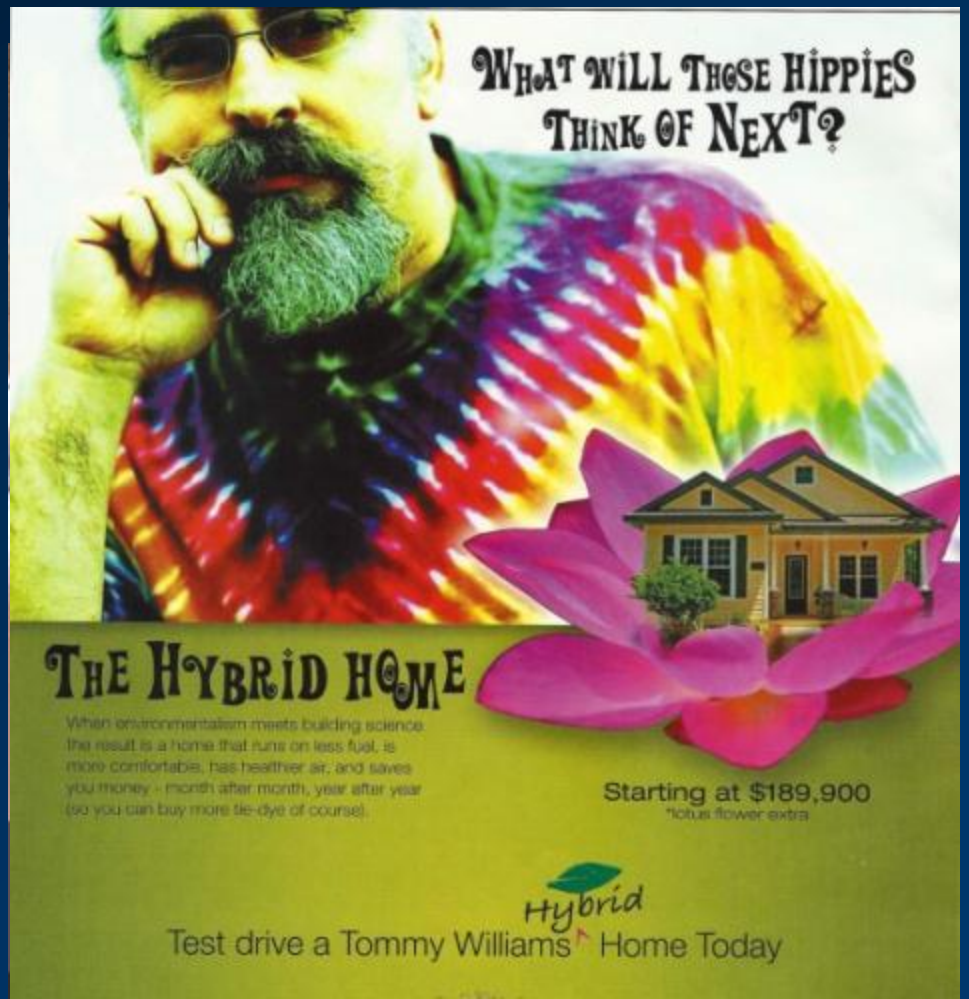
3 Ways to Sell High Performance Homes

2. See for yourself – Model

3 Ways to Sell High Performance Homes

3. Creative & Targeted Advertising



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3 Ways to Sell High Performance Homes

3. Creative & Targeted Advertising (and, sex appeal)

3 Ways to Sell High Performance Homes

3. (Advertising) Incentives – builder/utility/state/federal (both homeowner and builder)

3 Ways to Sell High Performance Homes

3. (Advertising) Branding

3 Ways to Sell High Performance Homes

RESULTS = SALES!!!

3 Ways to Sell High Performance Homes

Results = SALES over competition – +$/sq.ft (8%) & faster sales

Tommy Williams Homes Sales Data, Longleaf subdivision, both builders have 275 lots each. Gainesville, FL.

	TW	Competitor
Sales Price	$161/ sq. ft.	$148/ sq. ft.
12/06 – 5/08 sales	44 homes	22 homes

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3 Ways to Sell High Performance Homes

RESULTS = SALES!!!

Lifestyle Sales Data	
2007	45 homes
2008	26 homes
2009 *	50 homes

Decline

92% increase

*June 2010, pre-sold 8 Builders Challenge Homes in 4 months

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3 Ways to Sell High Performance Homes

Results = SALES = Happy Builder & Bragging Rights

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Thank You

- Rob Vieira and Stephanie Thomas-Rees
- www.fsec.ucf.edu
- Web site has publications and you can sign up for our quarterly buildings newsletter
- www.BuildingAmerica.gov

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