ENERGY STAR FOR MANUFACTURED HOMES - HOW RATERS CAN WORK WITH MANUFACTURERS

2007 RESNET Building Performance Conference

"Taking It To The Next Level"

February 17 - 21, 2007
Sheraton San Diego Hotel & Marina
San Diego, CA

Neil Moyer

2 Types of Energy Star Homes

Modular

HUD Code

Factory-Built Homes

Manufactured Homes: These are homes built entirely in the factory under a federal building code administered by the U.S. Department of Housing and Urban Development (HUD).

Must meet all local codes

Modular Homes: These factory-built homes are built to the state, local or regional code where the home will be located. Modules are transported to the site and installed.

Panelized Homes: These are factory-built homes in which panels - a whole wall with windows, doors, wiring and outside siding - are transported to the site and assembled. The homes must meet state or local building codes where they are sited.

Pre-Cut Homes: This is the name for factory-built housing in which building materials are factory-cut to design specifications, transported to the site and assembled. Pre-cut homes include kit, log and dome homes. These homes must meet local, state or regional building codes.

Mobile Homes: This is the term used for factory-built homes produced prior to June 15, 1976, when the HUD Code went into effect. By 1970, these homes were built to voluntary industry standards that were eventually enforced by 45 of the 48 contiguous states.

2 Energy Star Programs

Modular

- EPA + RESNET (Home Energy Rater)
- 2006 HERS Index
- Prescriptive or Performance path

HUD-code

- EPA + QAP (MHRA or NEEM) (Rater / Plant Certifier)
- 1999 HERS Score
- Primarily Prescriptive (performance path available)

Energy Star Program Highlights

Modular

- *Thermal Bypass Checklist* (pre-drywall inspection)
- Tend toward performance path (rating software) with custom homes
- Performance testing
  - 100%

HUD-code

- Plant certification
  - Test homes in plant & field
  - Incorporate changes into DAPIA/QC/Install manuals
  - Site Installation Checklist
- Performance testing
  - random sample
- Energy Star = Tax Credit ($1,000/home)

BAIHP Assistance to Modular Factories

- Rating software and home design assistance
- In-plant ductblaster training and support
  - Spot-check of testing methods and equipment
  - Developed new pass/fail criteria
- New *Thermal Bypass Checklist* requirements
  - Integrity of installed insulation
  - Continuous air barrier

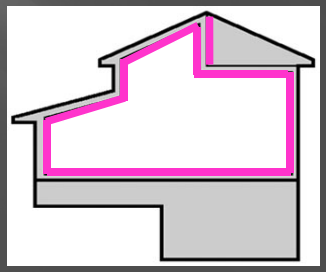


Image courtesy of Southface Energy Institute

Thermal Bypass Checklist

Bottom Plate Airseal

Interior wallboard omitted at shower (OK in zones 1-3)

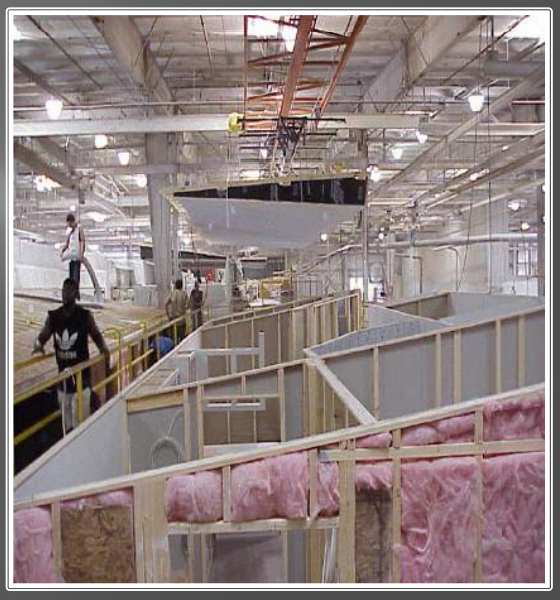
Insulation Compression

Active BAIHP Manufactured Housing Partners

- Palm Harbor Homes
- Homark Homes
- Southern Energy Homes
- Cavalier Homes

Mfg Housing- What is it?

Home built entirely in the factory under the Federal Manufactured Home Construction & Safety Standards (HUD Code) June 15, 1976.



Mfg Housing- What is it?

Single- or multi-section and are transported to the site & installed.

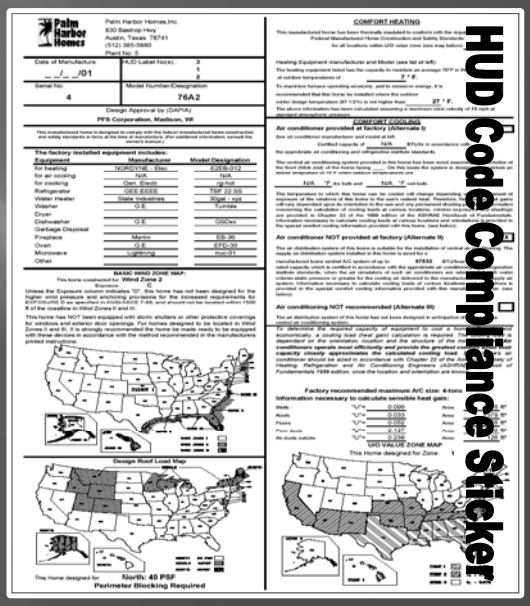
Mfg Housing- What is it?

Federal standards regulate:

- design & construction
- strength & durability
- transportability
- fire resistance
- energy efficiency
- quality

HUD Code sets performance standards:

- heating & air conditioning
- plumbing
- thermal
- electrical systems



Mfg Housing- Why Important?

According to MHI…

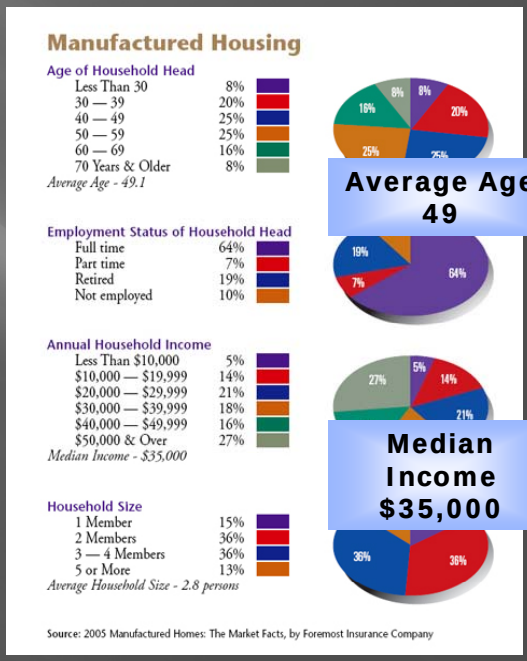
- HUD-code represented ~8% of all new single-family housing starts in 2005

Total shipments 2005

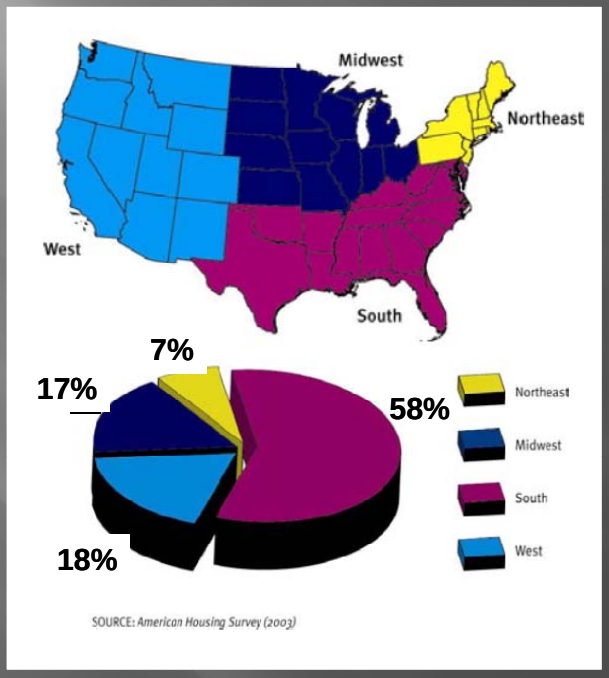
- 146,881 homes from ~200 manufacturing facilities
  - 65% multi-section
  - 35% single-section

Average $ (excluding land)

- Single-section $33,800
- Multi-section $68,600



Where are They Going…



www.baihp.org

The Partners, Plan, Progress…

- Partners
  - Manufacturers
    - Palm Harbor Homes, Fleetwood Homes, Southern Energy Homes, Cavalier Homes
  - Suppliers
    - Stylecrest, LaSalle Air Systems, Tamarack Technologies
- Plan
  - Diagnostics: moisture (and energy) problems
  - Monitoring: document improvements and/or energy savings
  - Partnership: change in the design and manufacture of air distribution & ventilation systems
  - Training: conducting seminars and other educational activities.
- Progress
  - No reported moisture problems! And some energy savings too.

The "Opportunity" of Moisture

Moisture were experienced by a number of manufactured homes in the hot, humid climate of the Southeast United States.

Solving moisture "concerns" is the highest research priority of the HUD code industry. According to the Manufactured Housing Research Alliance (MHRA).

The "Opportunities"

Repeat repairs resulting in recurring reports of retrogressing…

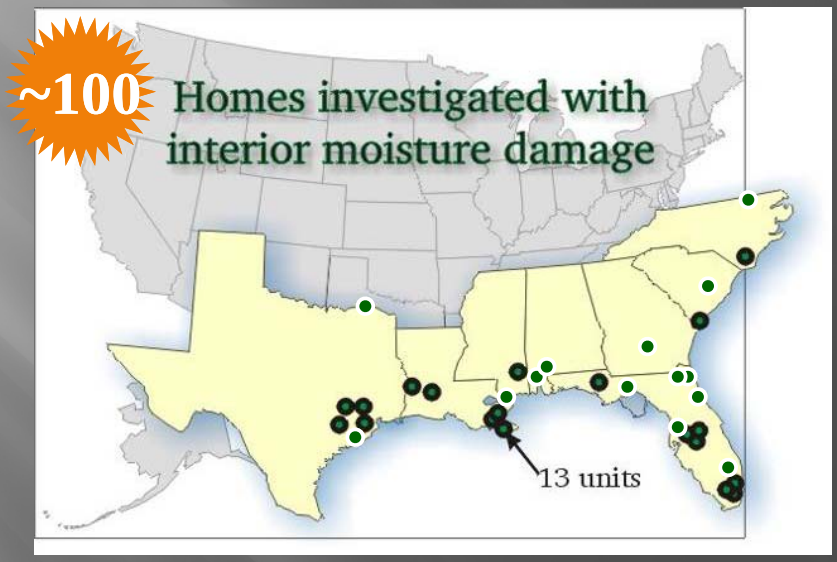
- Going back again & again to repair a problem that just will not go away
- Current repair strategy…
  - Replace damage product with same product
  - Look for water leaks (roof – plumbing)
  - Blame customer (in frustration)

Why Were We There?

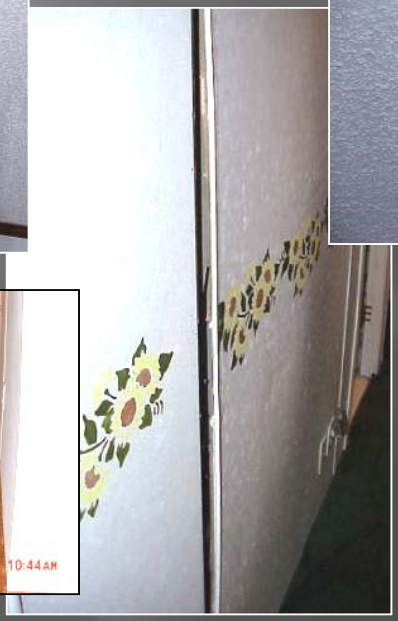
Unmitigated moisture problems

- **Provide some understanding of moisture dynamics**
- **Emphasis on air transported water vapor**
  - **Conditions**
  - **Drivers (or causes)**
  - **Possible fixes**

Where Investigated?



Opportunities: Envelope Integrity



- **Damage to…**
  - **Floors**
  - **Walls**
  - **Ceilings**

Opportunities: Biologicals

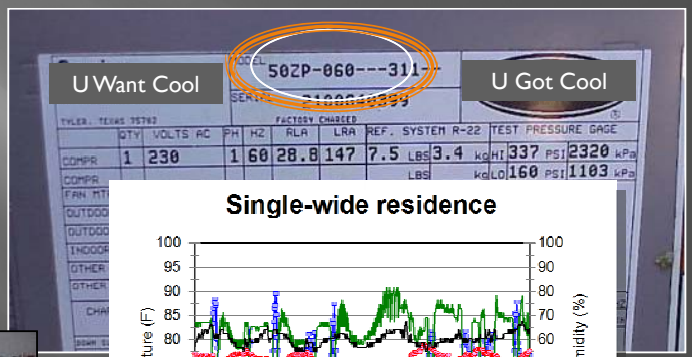
Biological growth

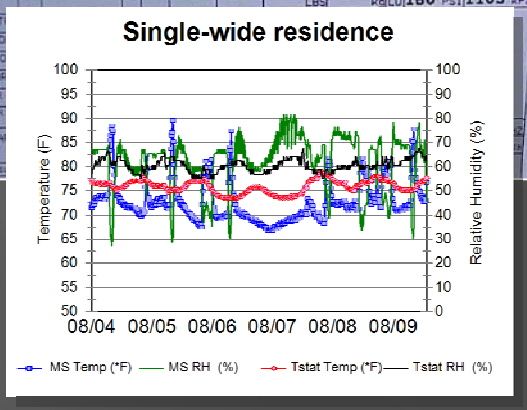
- Molds & Mildews

Opportunities: Comfort

Comfort complaints

- Cave syndrome
  "cold & damp"
- Swamp thing
  "warm & humid"

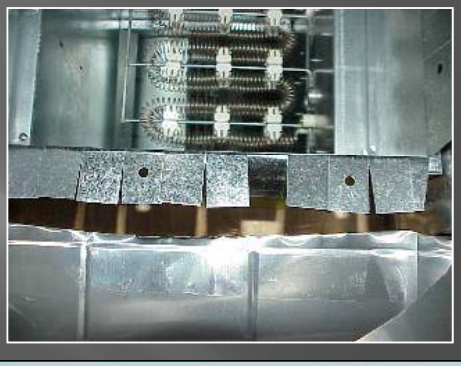


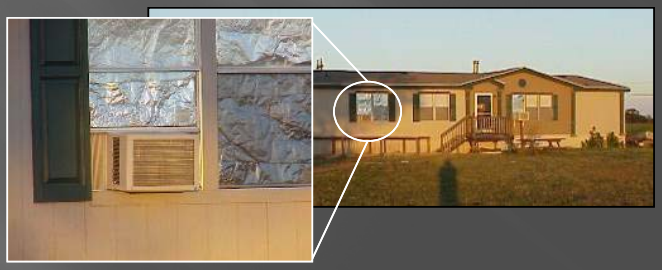


Opportunities: Energy

High energy bills

- Usually coupled with other problems
- House sold as energy efficient model





Opportunities for Research & Technical Assistance

- **Industry Identified Need**
  - Homes in Failure due to Moisture Problems
- **Commonality**
  - Located in Southeast (hot-humid)
  - At least one major repair attempt
  - Thermostat setting 68º – 75º F
  - Significant supply duct leakage
  - Vinyl wall or floor covering involved
  - Interior doors closed for extended periods
  - Belly board failure: numerous penetrations & tears
  - Ventilation systems usually not used

Presented paper: Moisture Problems in Manufactured Housing: Probable Causes and Cures. ASHRAE IAQ2001, San Francisco, CA, Nov 2001.

Air Distribution Dilemmas

"The Greatest Opportunity"

Unique Construction

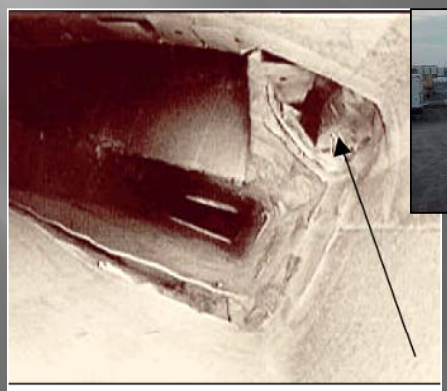
Field Installation problems

Model centers

Final Set-Ups

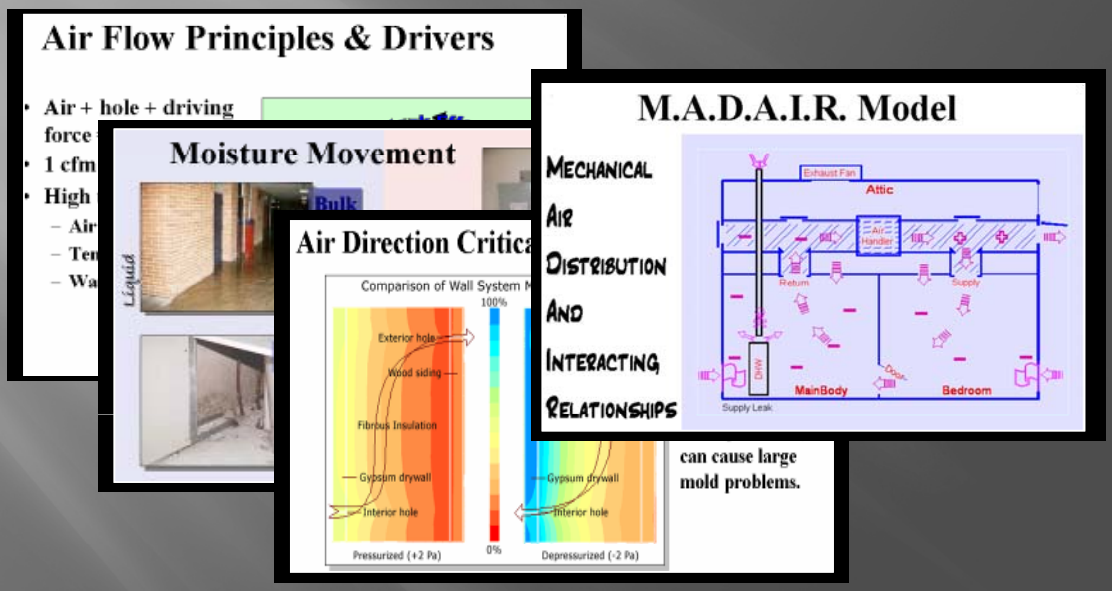
And The "13" in Louisiana…

	House wrt out
All fans off	-0.0 pa
Air handler (AHU) on & supply registers as found	-4.5 pa
AHU on & supply registers open	-2.5 pa
AHU on & all interior doors closed except hall	-4.5 pa
AHU on & all interior doors	-8.5 pa



View at plenum – note large hole

Providing Building Science Basics

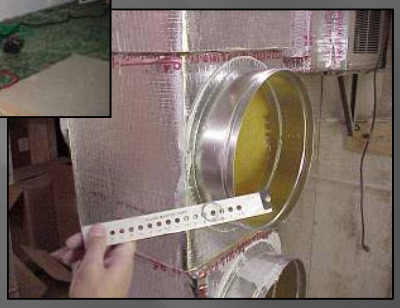


Training

Moisture Diagnostics & Duct Systems

- Fleetwood
- Palm Harbor
- Southern Energy

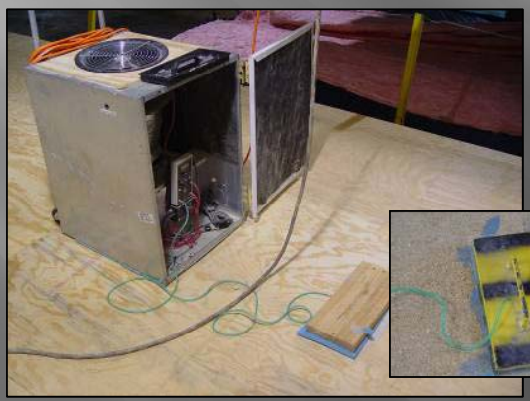
Sealed
-&-
Tested



Palm Harbor Homes

Target:
•< 30 cfm25/1000 sqft
•All factories

Sealed
-&-
Tested



SE homes
Southern Energy Homes

Target:
•< 30 cfm25/1000 sqft
•100% of floor systems
•All factories in Alabama

Mastic Sealed

Cavalier Homes, Inc.

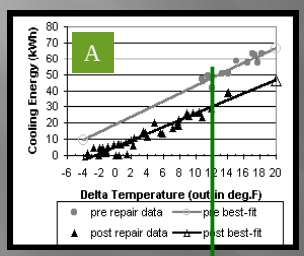
FLEETWOOD

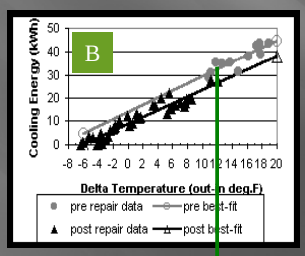
Target:
- Mastic used
- All factories

Duct Leakage Impacts

- Partners: Fleetwood, Stylecrest

House	Pre CFM25out	Post CFM25out	Pre airflow	Post airflow
A	167	31	1248	1355
B	114	23	1271	1421





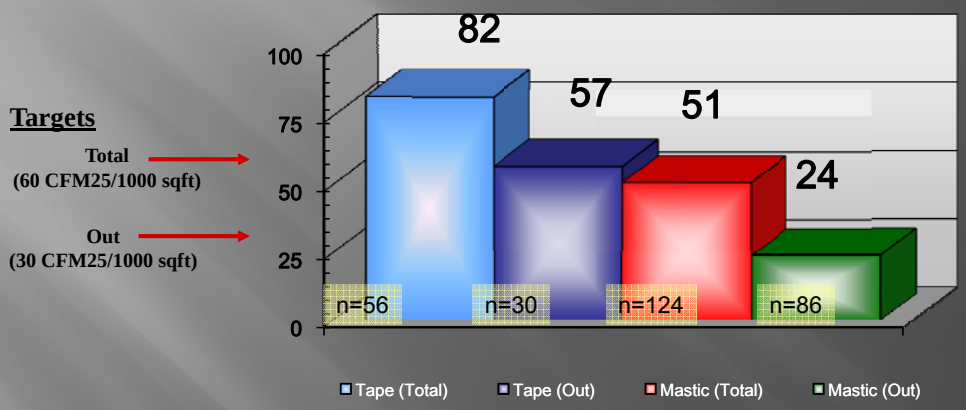
Cooling Energy vs. dT.

37 % savings

18 % savings

Presented paper: "Performance and Impact from Duct Repair and Ventilation Modifications of Two Newly Constructed Manufactured Houses Located in a Hot and Humid Climate", 13th Symposium on Improving Building Systems in Hot & Humid Climates, 2002, TX

BAIHP Duct Data Averages



Material & labor Costs / floor: < $8
(about $0.09 per squarefoot)

Presented paper: Achieving Airtight Ducts in Manufactured Housing. Symposium on Improving Building Systems in Hot and Humid Climates, Richardson, Texas, May 2004.

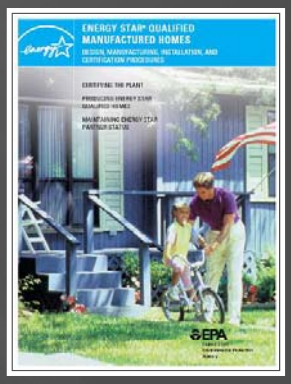
EnergyStar Manufactured Homes

- Factory Qualification
- Factory Demonstration
- Field Sampling

In 2001, EPA introduced the ENERGY STAR label for manufactured homes. Guidelines focus on certification of the HUD-code plant and award the ENERGY STAR label to any homes manufactured to prescriptive design requirements. Revised in 2003

How to participate in ENERGY STAR - Certifying the Plant

1-Hire a Manufactured Housing ENERGY STAR Certifier
2-Design Homes To Meet ENERGY STAR Requirements
3-Incorporate ENERGY STAR Design Features into Quality Control and Inspection Procedures
4-Manufacture, Inspect, & Test Duct Tightness in the Plant
5-Develop Site Installation Checklist
6-Install, Inspect, & Test a Minimum of 3 Homes in the Field
7-Incorporate ENERGY STAR Practices into Operations
8-Establish ENERGY STAR Information Manager Account
9-Submit ENERGY STAR Partnership Agreement



www.energystar.gov/ia/partners/downloads/manufactured_procedures.pdf

How to participate in ENERGY STAR - Certifying the Plant

1-Hire a Manufactured Housing ENERGY STAR Certifier

Capabilities and Qualifications

MANUFACTURED HOUSING DESIGN, CONSTRUCTION AND INSTALLATION METHODS
(Must check all boxes below)
- ❑ Working knowledge of the Federal Manufactured Home Construction and Safety Standards
- ❑ Working knowledge of the plant production processes
- ❑ Working knowledge of the DAPIA/IPIA oversight processes
- ❑ Knowledge of manufactured home design, construction, installation, material use, and fabrication techniques

BUILDING SCIENCE AND ENERGY EFFICIENCY EXPERIENCE
(Must check at least one box below)
- ❑ Certified Home Energy Rating System (HERS) rater or provider
- ❑ Licensed Engineer or Architect

(Must check all boxes below)
- ❑ Hands-on experience conducting duct and whole-house air leakage measurements in manufactured (HUD-code) homes
- ❑ Experience and training in the principles of building science
- ❑ Experience and training in energy efficiency construction practices

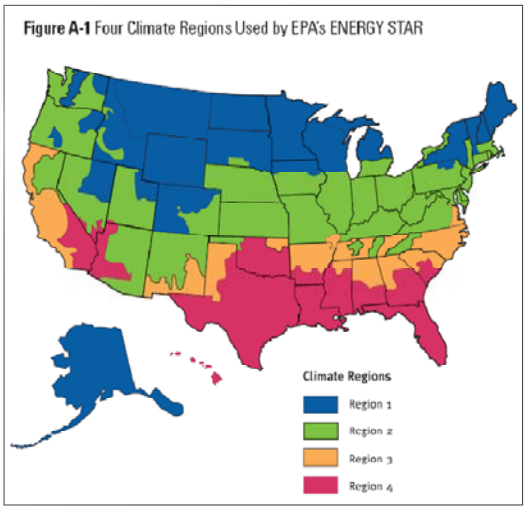
DOCUMENT PREPARATION AND RECORD KEEPING
(Must check all boxes below)
- ❑ Working knowledge of the HUD-required documentation for manufactured housing
- ❑ Capability to maintain computer records and communicate via email

How to participate in ENERGY STAR - Certifying the Plant

2-Design Homes To Meet ENERGY STAR Requirements

Finding the right package of energy measures is a two-step process

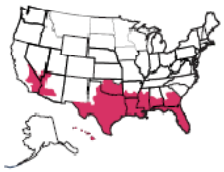
1. Select the climate region where the home will be installed.
2. Select from the packages of energy options provided for the chosen climate region.



Prescriptive Packages

Designing ENERGY STAR Qualified Homes

CLIMATE REGION 4



Basic Requirements:

- Maximum shell leakage: 7.0 ACH_{50}
- Minimum duct insulation: R-6

Packages for homes with maximum 3% duct losses:

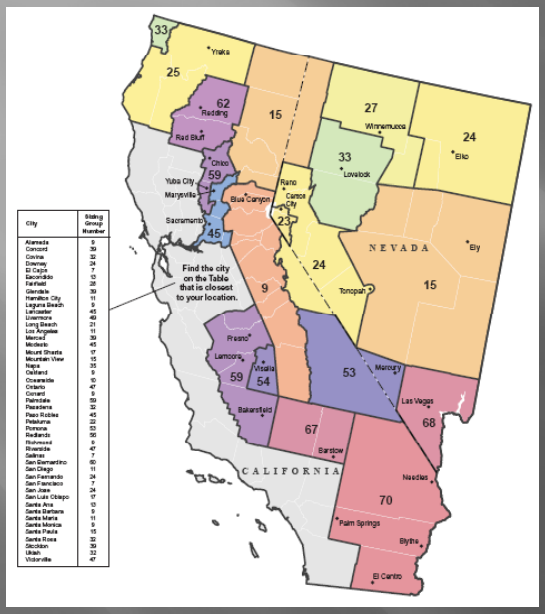
Heating Type	Minimum Heating Efficiency	Maximum Uo-value	Maximum Window SHGC	High Efficiency WH [17]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.111	0.50			4-1
Heat Pump	7.7 HSPF	0.097	0.50			4-2
		0.104	0.50		✓	4-3
		0.108	0.50	✓	✓	4-4
Electric Resistance [16]	1.0 EF	0.074	0.40		✓[18]	4-5
		0.075	0.40	✓	✓[18]	4-6
Electric Resistance (Florida Only)	1.0 EF	0.111	0.40		✓[18]	4-7
		0.114	0.40	✓	✓[18]	4-8

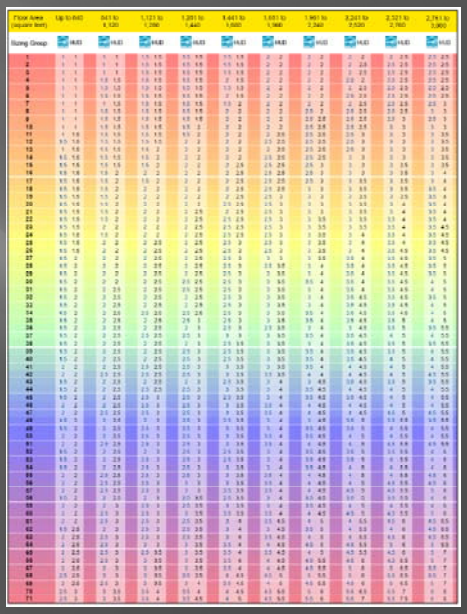
Packages for homes with maximum 5% duct losses:

Heating Type	Minimum Heating Efficiency	Maximum Uo-value	Maximum Window SHGC	High Efficiency WH [17]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.102	0.50			4-9
		0.116	0.50		✓	4-10
Heat Pump	7.7 HSPF	0.095	0.50			4-11
		0.102	0.50		✓	4-14
		0.106	0.50	✓	✓	4-15
	8.0 HSPF	0.104	0.50		✓	4-16
		0.108	0.50	✓	✓	4-17

http://mhrahome.org/media/energystar/es_guide3_h.pdf

Manufactured Home Cooling Equipment Sizing Guidelines





For ENERGY STAR® qualified manufactured homes and homes built to the HUD standards

www.mhrahome.org/media/sizing/guidelines.pdf

~or~ COMPUTER ANALYSIS TO CREATE ENERGY STAR DESIGNS

CALIFORNIA HOME ENERGY EFFICIENCY RATING SYSTEM

9400 Topanga Canyon Blvd., Suite 220
Chatsworth, CA 91311
818-407-1500 fax: 818-407-1188
Contact: Tom Hamilton
thamilton@cheers.org
www.cheers.org

ENERGY GAUGE USA

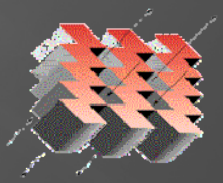
Florida Solar Energy Center
1679 Clearlake Road
Coca, FL 32922-5703
321-638-1492 fax: 407-638-1010
Contact: Tei Simmerman
engauge@fsec.ucf.edu
www.energygauge.com/USARes/default.htp

E-STAR COLORADO

1981 Blake Street
Denver, CO 80202-1272
303-297-7395 fax: 303-297-0948
Contact: Megan Edmunds
comments@e-star.com
www.e-star.com

REM/RATE

Architectural Energy Corporation
2540 Frontier Avenue, Suite 201
Boulder, CO 80301
303-444-4149 fax: 303-444-4304
Contact: Michael Holtz
AECinfor@archenergy.com
www.archenergy.com



TREAT

Taitem Engineering/Performance Systems Development
109 South Albany Street
Ithaca, NY 14850
607-277-1118
Contact: Ethan MacCormick
EmacCormick@PSDconsulting.com
www.psdconsulting.com/psd/treat.html

How to participate in ENERGY STAR - Certifying the Plant

3-Incorporate ENERGY STAR Design into QC & Inspection Procedures

- Information about the ENERGY STAR features in the new home designs must now be incorporated into the
  - **Design Approval Primary Inspection Agency (DAPIA)-approved packages,**
  - Plant **Quality Control Manual**, and the
  - **Manufacturers' Installation Manual.**

How to participate in ENERGY STAR - Certifying the Plant

4-Manufacture, Inspect, & Test Duct Tightness in the Plant

In-plant Duct Testing Incorporated into Production Line

The primary hurdle to certification is consistent production of tight duct systems.

Presented paper: Energy Star Manufactured Homes: The Plant Certification Process," Proceedings of ACEEE 2004 Summer Study, American Council for an Energy Efficient Economy, Washington, DC, August 2004

In-plant Duct Testing Methods Vary

New Duct Test Procedure

- Switched from analog to digital manometer
- Simple pass/fail test to meet 3% leakage target

DG3 DG700

DATE OF TEST_____
Pressure not to exceed "max pressure" in highlighted column for given box size
SERIAL NUMBER _____

CIRCLE FLOOR WIDTH AND CIRCLE ONE
WRITE ACTUAL PRESSURE IN "ACTUAL" COLUMN

UNIT A
UNIT B
UNIT C
UNIT D
UNIT E
UNIT F

Ring 3 Installed

Floor Area	Width	Length	Max Pressure	ACTUAL	Floor Area	Width	Length	Max Pressure	ACTU
311	13.333	23.33	2		350	15	23.33	3	
364	13.333	27.33	3		410	15	27.33	4	
600	13.33	45	8		660	15	44	10	
600	13.333	45	8		675	15	45	10	
613	13.333	46	8		690	15	46	11	
627	13.333	47	9		705	15	47	11	
640	13.333	48	9		720	15	48	12	
653	13.333	49	10		735	15	49	12	
667	13.333	50	10		750	15	50	13	
680	13.333	51	10		765	15	51	13	
693	13.333	52	11		780	15	52	14	
707	13.333	53	11		795	15	53	14	
720	13.333	54	12		810	15	54	15	
733	13.333	55	12		825	15	55	15	
747	13.333	56	13		840	15	56	16	
760	13.333	57	13		855	15	57	16	
773	13.333	58	13		870	15	58	17	
787	13.333	59	14		885	15	59	18	
800	13.333	60	14		900	15	60	18	
813	13.333	61	15		915	15	61	19	

How to participate in ENERGY STAR - Certifying the Plant

5-Develop Site Installation Checklist

ENERGY STAR CONSTRUCTION REQUIREMENTS

A. Marriage Line Seal
The marriage line areas must be filled with a continuous non-porous insulating gasket creating a permanent air barrier at joints
Acceptable gaskets can be one or two-part systems, including proprietary gaskets, foams, insulation wrapped in poly, and insul
other long-life tape on one side. In addition, there must be no visible signs of gaps or tears.

B. Tears in Bottom Board Material Repaired
All tears in the bottom board material must be covered and sealed with a durable, permanent patch to prevent air leakage. (Foa
bolt and other small holes.)

C. Exterior (Including Crossover) Duct Installation
For multi-section homes, the exterior ducts must be sealed with a permanent connection per the Manufacturer's Installation Ma
following items are completed:

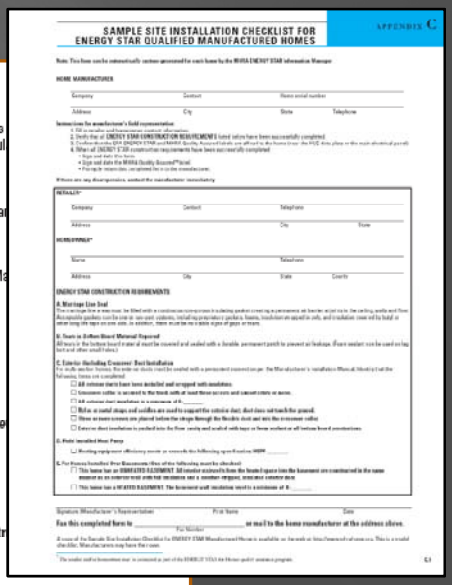
- ☐ All exterior ducts have been installed and wrapped with insulation.
- ☐ Crossover collar is secured to the trunk with at least three screws and cannot rotate or move.
- ☐ All exterior duct insulation is a minimum of R-_____.
- ☐ Nylon or metal straps and saddles are used to support the exterior duct duct does not touch the ground.
- ☐ Three or more screws are placed below the straps through the flexible duct and into the crossover collar.
- ☐ Exterior duct insulation is pushed into the floor cavity and sealed with tape or foam sealant at all bottom board pene

D. Field Installed Heat Pump

- ☐ Heating equipment efficiency meets or exceeds the following specification: HSPF-_____.

E. For Homes Installed Over Basements (One of the following must be checked)

- ☐ This home has an UNHEATED BASEMENT. All interior stairwells from the heated space into the basement are constr
  manner as an exterior wall with full insulation and a weather-stripped, insulated exterior door.
- ☐ This home has a HEATED BASEMENT. The basement wall insulation level is a minimum of: R- .


SAMPLE SITE INSTALLATION CHECKLIST FOR ENERGY STAR QUALIFIED MANUFACTURED HOMES

APPENDIX C

How to participate in ENERGY STAR - Certifying the Plant

6-Install, Inspect, & Test a Minimum of 3 Homes in the Field

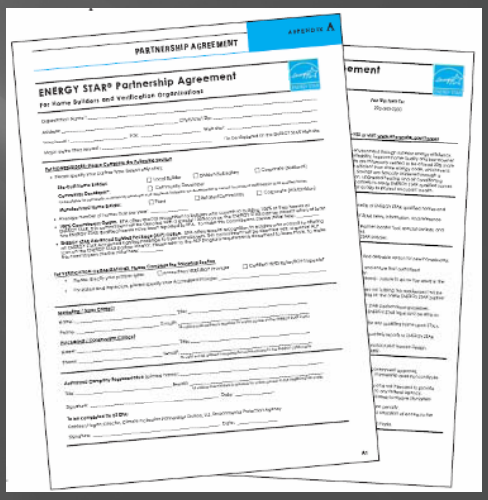
- ✓ Inspect the installation and certify that the items on the Site Installation Checklist have been completed successfully
- ✓ Certify that the duct pressurization tests measuring air leakage to the outside
- ✓ Certify the shell leakage tests.

How to participate in ENERGY STAR - Certifying the Plant

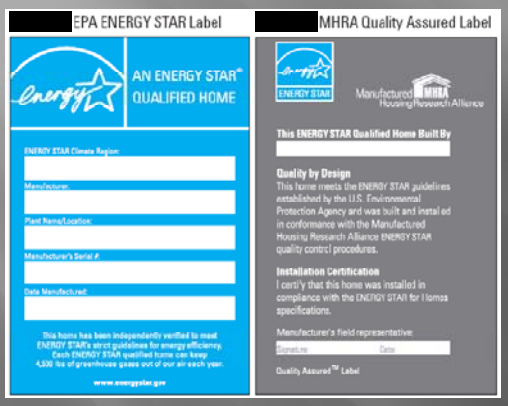
7-Incorporate ENERGY STAR Practices into Operations

8-Establish ENERGY STAR Information Manager Account

9-Submit ENERGY STAR Partnership Agreement



PRODUCING ENERGY STAR QUALIFIED HOMES



Manufacture and Inspect Homes in the Plant *[Plant Production Staff]*

Manufactures qualified homes in accordance with the designs created during the plant certification process.

Install and Inspect Homes in the Field *[Installer, Plant Rep]*

Plant representative (e.g., the factory field representative or retailer) uses the Site Installation Checklist developed during the plant certification process or custom-generated for each home by the MHRA ENERGY STAR Information Manager to monitor set-up.

Affix the ENERGY STAR Label and the Quality Assured Label *[Plant Representative or Plant Field Rep]*

Every qualified home must have an EPA-issued ENERGY STAR qualified home label and a Quality Assurance Provider label affixed to it.

Conduct Periodic Field Evaluations To Verify Performance *[Manufactured Housing ENERGY STAR Certifier]*

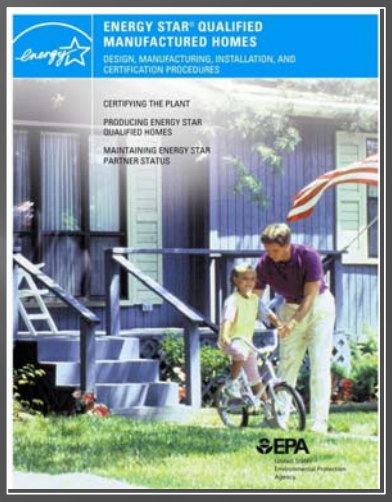
A plant must at all times retain an accredited ENERGY STAR Certifier responsible for conducting field evaluations on no less than 2 percent (2%) of its ENERGY STAR qualified homes sold and installed on a homeowner's site or a minimum of one home each calendar year, whichever is greater.

The Certifier's Role at a Glance
~ or ~
# What does a Rater do?

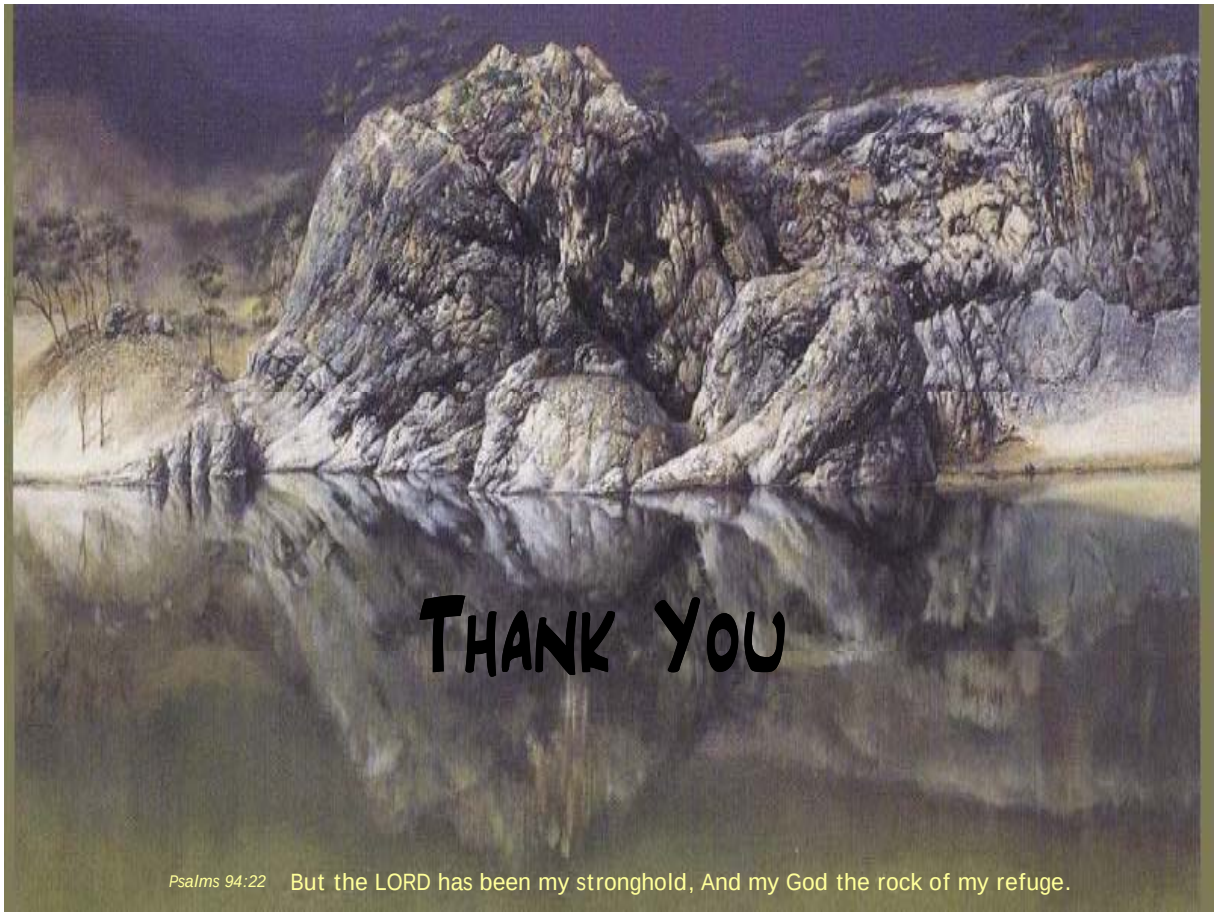
- ✓ Oversee the plant qualification process
- ✓ Train plant production staff in ENERGY STAR techniques
- ✓ Review and if acceptable, approve plant processes and the plant's ENERGY STAR-related documentation including ENERGY STAR home designs, ENERGY STAR Site Installation Checklist, Quality Control Manual and the Manufacturer's Installation Manual.
- ✓ Conduct quality control inspection and testing of a representative sample of completed homes
- ✓ Participate in and contribute to periodic meetings regarding program quality control and oversight.

Sources for Information

- *ENERGY STAR® Qualified Manufactured Homes: Guide for Retailers with Instructions for Installers and HVAC Contractors*



- **MHRA website: www.mhrahome.org**


Thank You
Psalms 94:22 But the LORD has been my stronghold, And my God the rock of my refuge.