A Process for Improving Energy Efficiency in Manufactured Homes

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US Environmental Protection Agency
1200 Pennsylvania Ave., N.W.
Washington, DC 20460

Prepared by
Manufactured Housing Research Alliance
2109 Broadway, Suite 200
New York , NY 10023

Manufactured Housing Research Alliance MHRA

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Brian Dean, ICF Consulting Group
Dean Gamble, ICF Consulting Group
Jay Hall, ICF Consulting Group
David Meisegeier, ICF Consulting Group

MHRA staff:

Emanuel Levy, Executive Director
Peyton Collie, Technical Editor
Francis Conlin, Technical Advisor
Jordan Dentz, Technical Editor
Deane Evans, FAIA, Technical Editor
Sandra Ho, Editorial Director

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INTRODUCTION

This report was developed for the manufactured housing industry and provides a methodology for designing, manufacturing, and installing energy efficient manufactured homes. A manufactured home is defined for the purposes of this report as a home built in a factory meeting the federal Manufactured Home Construction and Safety Standards.[1] The energy efficiency standards described in this report provide a consistent target level of energy efficiency for the manufactured housing industry to strive for. This target level represents a stretch beyond the current levels of energy efficiency typically achieved in manufactured homes, but at the same time should be achievable by most manufactured housing plants.

THE ENERGY EFFICIENCY TARGET

A manufactured home meets the energy efficiency target when it is at least 30% more energy efficient in its heating, cooling and water heating than a comparable home built to the 1993 Model Energy Code (MEC). This increased level of energy efficiency can be met using standard technologies and manufacturing practices by successfully integrating three key home components:

- An energy efficient building envelope (effective insulation, tight construction, advanced windows).
- Energy efficient air distribution (air-tight, well-insulated ducts).
- Energy efficient equipment (space heating, space cooling and hot water heating).

WHY SHOULD A PLANT PRODUCE ENERGY EFFICIENT HOMES?

There are at least four basic reasons why a plant should consider making the commitment to produce energy efficient homes.

1. Energy efficiency can be a powerful sales tool. It can differentiate a manufactured home design from its peers within the industry and from site-built homes in the same market.
2. Energy efficient homes have lower monthly operating costs, reducing a homeowner's monthly out-of-pocket expenses and potentially increasing the resale value of a home.
3. The efficiency measures built into an energy efficient manufactured home have residual benefits that increase customer satisfaction. These homes are typically more comfortable, durable, quiet and environmentally friendly than non-energy efficient homes-all potential benefits for home buyers and owners.
4. Since this efficiency target ties performance directly to a single standard, the Model Energy Code, meeting this energy efficient target offers another opportunity for a manufactured housing producer to demonstrate parity with or superiority to site-built competitors.

[1] The federal Manufactured Home Construction and Safety Standards regulations at 24 CFR 3280 are commonly referred to collectively as the HUD Code.

PRODUCING ENERGY EFFICIENT MANUFACTURED HOMES

Preparing a manufacturing plant to produce energy efficient homes typically requires a number of steps. Because the energy efficiency measures incorporated into new energy efficient manufactured homes will require changes to standard plant practices, a formal control and inspection system should be put in place to ensure consistent quality and performance of the homes. Following is a suggested series of actions that a plant may undertake to ensure a smooth transition to the production of energy efficient homes.

Step 1. Enlist an Energy Efficiency Specialist

A specialist should be enlisted to coordinate the plant's efforts to gear up to produce energy efficient homes. This individual may be a plant employee or an outside consultant. In either case, they should possess the following qualifications:

- Knowledge of manufactured housing design, construction and installation methods
- Building science and diagnostics expertise (e.g., is certified as a Home Energy Rating System (HERS) rater, licensed engineer or architect or experienced energy consultant)
- Capable of conducting duct leakage and building shell leakage testing, specifically, duct pressurization and blower door tests
- Energy efficiency training
- Document preparation and record keeping skills

Step 2. Design Homes to Meet the Energy Efficiency Target

The plant must create home designs that meet the energy efficiency target. Appendix A provides options and more detailed guidance for designing homes that meet the this target.

Since a duct leakage value is needed as part of the design process, it is recommended that the ducts be tested at this step to determine their level of leakage and their potential for improvement. The duct leakage measured in the plant can be used only to estimate whether the ducts will meet required leakage levels when homes are set up in the field. Field tests will be valuable aids in verifying this estimate. (See *Manufactured Housing Duct Systems: Guide to Best Practices*, published by the Manufactured Housing Research Alliance (MHRA), for guidance on constructing efficient duct systems.)

Step 3. Incorporate Energy Design Features into Quality Control and Inspection Procedures

Information about the energy efficiency features in the new home designs should be incorporated into the Design Approval Primary Inspection Agency (DAPIA)-approved packages, the plant Quality Control Manual and the Manufacturers' Installation Manual.

Step 4. Manufacture, Inspect and Test Homes in the Plant for Duct Tightness

As part of the implementation of the energy efficiency program, a plant should manufacture a series of test homes (three is typically sufficient) that meet the energy efficient duct system requirements. As these homes are manufactured, their ducts should be tested to determine the level of leakage.

Step 5. Develop a Site Installation Checklist

Although the vast majority of the work on a manufactured home is completed in the plant, a number of activities undertaken at the site affect the home's final energy efficiency level. Such activities include sealing the marriage line and installing the crossover duct on multi-section homes, installing the air conditioning equipment, and constructing the basement if there is one. If improperly installed, any one of these items may compromise the energy efficiency of the home and cause it to fail to meet target levels of efficiency. Because these items are not within the direct control of the plant, energy efficient manufactured homes should have a site installation checklist identifying items that are part of the energy efficiency package but installed and verified at the time of home installation. The Checklist should also be included in the Manufacturers' Installation Manual or be delivered to the retailer with all other pertinent paperwork that accompanies the home.

A sample site installation checklist is included in Appendix B.

Step 6. Install, Inspect and Test Sample Energy Efficient Homes in the Field

Sample energy efficient homes should be installed and tested in the field. The homes selected should be representative of the types of energy efficient homes the plant intends to build. Following each sample installation, a plant representative should verify that the items on the site installation checklist are completed.

The homes should then be tested in the field for duct and whole house air leakage to ensure that they meet the specified target levels. If a home fails either test, the plant should investigate the cause and determine if changes should be made to the manufacturing process.

Step 7. Incorporate Energy Efficient Practices into Routine Operations

Once the sample homes have been installed successfully, the plant must take steps to transfer the lessons learned from the process into its routine production, including the following:

- Instruct key plant personnel on the critical processes and procedures for creating and manufacturing new energy efficient homes, including any corrective actions undertaken during the installation of the sample homes.
- Review with the plant's third-party approval and inspection agencies, the unique energy efficiency features contained in the third-party approved design packages.
- Instruct set-up crews on how to correctly install and inspect energy efficient homes in the field and the need to complete the site installation checklist.

DESIGNING ENERGY EFFICIENT MANUFACTURED HOMES

The information in this section can be used to select the energy features for energy efficient manufactured homes.

A target energy efficiency level was established that is at least 30 percent more efficient than a comparable home built to the 1993 Model Energy Code (MEC) published by the International Code Council. The 30 percent refers not just to the thermal envelope but to the estimate of total energy use for space heating, space cooling and water heating.

A home may be designed to meet this target by incorporating pre-approved 'packages' of energy efficient features. Each of these packages is defined as a unique combination of building elements including building thermal envelope, specific duct arrangement (overhead or under floor) and maximum leakage level, space heating and cooling equipment efficiency and hot water heater efficiency. These elements taken together will produce predictable energy use characteristics for which a manufacturer may develop an energy efficient-specific third-party design package.

INCORPORATING ENERGY EFFICIENT 'PACKAGES'

Normally, estimating total energy use requires performing a computer analysis of each home design. However, to simplify the process, this appendix contains several pre-approved "packages" of energy features that meet or exceed the target requirements.

Finding the right package of energy measures for homes built to satisfy the HUD code is a two-step process as follows:

- Select the climate region where the home will be installed. Climate region information is provided on the map in Figure A-1. Detailed, county-by-county climate region information is provided on Table A-1.
- From the information on Table A-2, select from the packages of energy options provided for the selected climate region.

The notes below will aid in navigating through and interpreting the information provided on the map and tables in this section.

1. Select the climate region where the energy efficient homes will be sited

There are different requirements for each of the four regions. The regions are NOT the same as the thermal zones contained in the HUD Standards for manufactured homes, nor do the region boundaries coincide with state boundaries. A state may include more than one region.

The map in Figure A-1 provides a general idea of the area covered by each climate region and Table A-1 provides a more precise state-by-state index. In cases where a state has more than one climate region, Table A-1 provides the 'primary' region and lists counties in the other regions as 'exceptions.'

Select the region(s) that correspond to the home site(s). Where the destination of a home is not known prior to manufacture, and the plant's typical shipping radius covers more than one region, it may be advisable to select a package from the region with the more stringent envelope thermal requirements (Region 1 is the most stringent, Region 4 the least).

Table A-1 State-by-State Climate Region Index

State	Primary Region	Exception Counties				
Alabama	3	Region 4:	Baldwin	Coffee	Escambia	Lowndes	Perry
			Barbour	Conecuh	Geneva	Macon	Pike
			Bullock	Covington	Greene	Marengo	Russell
			Butler	Crenshaw	Hale	Mobile	Sumter
			Choctaw	Dale	Henry	Monroe	Washington
			Clarke	Dallas	Houston	Montgomery	Wilcox
Alaska	1	None					
Arizona	4	Region 2:	Apache	Coconino	Graham	Navajo	Santa Cruz
			Cochise	Gila	Greenlee	Pima	Yavapai
Arkansas	3	Region 4:	Ashley	Cleveland	Drew	Lincoln	Ouachita
			Bradley	Columbia	Hempstead	Little River	Pike
			Calhoun	Dallas	Howard	Miller	Sevier
			Chicot	Desha	Jefferson	Montgomery	Union
			Clark		Lafayette	Nevada	
California	3	Region 2:	Alpine	Lake	Nevada	Sierra	Yolo
			Butte	Lassen	Placer	Solano	Yuba
			Colusa	Modoc	Plumas	Sutter	
			Glenn	Mono	Shasta	Tehama	
		Region 4:	Imperial	Inyo	Riverside	San Bernardino	
Colorado	1	Region 2:	Baca	Custer	Kit Carson	Phillips	Washington
			Bent	El Paso	Lake	Prowers	Yuma
			Chaffee	Fremont	Las Animas	Pueblo	
			Cheyenne	Huerfano	Lincoln	Sedgwick	
			Crowley	Kiowa	Otero	Teller	
Connecticut	2	None					
Delaware	2	None					
Florida	4	None					
Georgia	4	Region 3:	Banks	Dawson	Habersham	Marion	Stephens
			Barrow	DeKalb	Hall	Meriwether	Talbot
			Bartow	Douglas	Haralson	Murray	Taylor
			Carroll	Elbert	Harris	Muscogee	Towns
			Catoosa	Fannin	Hart	Oconee	Troup
			Chattahoochee	Fayette	Heard	Oglethorpe	Union
			Chattooga	Floyd	Henry	Paulding	Upson
			Cherokee	Forsyth	Jackson	Pickens	Walker
			Clarke	Franklin	Lamar	Pike	Walton
			Clayton	Fulton	Lincoln	Polk	White
			Cobb	Gilmer	Lumpkin	Rabun	Whitfield
			Coweta	Gordon	Macon	Schley	Wilkes
			Dade	Gwinnett	Madison	Spalding	
Hawaii	4	None					
Idaho	1	Region 2:	Ada	Gooding	Lemhi	Minidoka	Payette
			Canyon	Jerome	Lincoln	Nez Perce	Washington
			Gem				
Illinois	2	None					

State	Primary Region	Exception Counties				
Indiana	2	None				
Iowa	2	Region 1:	Allamakee	Cherokee	Emmet	Kossuth	Pocahontas
			Black Hawk	Chickasaw	Fayette	Lyon	Sioux
			Bremer	Clay	Floyd	Mitchell	Winnebago
			Buchanan	Clayton	Franklin	O'Brien	Winneshiek
			Buena Vista	Delaware	Hancock	Osceola	Worth
			Butler	Dickinson	Howard	Palo Alto	Wright
			Cerro Gordo	Dubuque	Humboldt	Plymouth	
Kansas	2	None				
Kentucky	2	None				
Louisiana	4	None				
Maine	1	None				
Maryland	2	None				
Massachusetts	2	Region 1:	Berkshire	Franklin	Hampden	Hampshire	
Michigan	2	Region 1:	Alcona	Clare	Iosco	Mason	Ontonagon
			Alger	Crawford	Iron	Mecosta	Osceola
			Alpena	Delta	Isabella	Menominee	Oscoda
			Antrim	Dickinson	Kalkaska	Midland	Otsego
			Arenac	Emmet	Keweenaw	Missaukee	Presque Isle
			Baraga	Gladwin	Lake	Montcalm	Roscommon
			Bay	Gogebic	Leelanau	Montmorency	Saginaw
			Benzie	Grand Taverse	Luce	Muskegon	Sanilac
			Charlevoix	Gratiot	Mackinac	Newaygo	Schoolcraft
			Cheboygan	Houghton	Manistee	Oceana	Tuscola
			Chippewa	Huron	Marquette	Ogemaw	Wexford
Minnesota	1	None				
Mississippi	4	Region 3:	Alcorn	Grenada	Marshall	Prentiss	Tishomingo
			Benton	Itawamba	Panola	Tate	Union
			Calhoun	Lafayette	Pontotoc	Tippah	Yalobusha
			DeSoto	Lee			
Missouri	2	Region 3:	Butler	Mississippi	Pemiscot	Scott	Stoddard
			Duncan	New Madrid			
Montana	1	None				
Nebraska	2						
Nevada	4	Region 1:	Elko	Eureka	Lander	White Pine	
		Region 2:	Carson City	Esmeralda	Lyon	Nye	Storey
			Churchill	Humboldt	Mineral	Pershing	Washoe
			Douglas	Lincoln			
New Hampshire	1	None				
New Jersey	2	None				
New Mexico	2	Region 3:	Chaves	Dona Ana	Guadalupe	Lea	Otero
			DeBaca	Eddy	Hidalgo	Luna	

State	Primary Region	Exception Counties				
New York	2	Region 1:	Allegany	Cortland	Lewis	Otsego	Tioga
			Broome	Delaware	Livingston	Schoharie	Tompkins
			Cattaraugus	Essex	Madison	Schuyler	Warren
			Cayuga	Franklin	Montgomery	Seneca	Wyoming
			Chemung	Fulton	Oneida	St. Lawrence	Yates
			Chenango	Hamilton	Onondaga	Steuben	
			Clinton	Herkimer	Ontario	Sullivan	
North Carolina	3	Region 2:	Alleghany	Caldwell	Henderson	Mitchell	Transylvania
			Ashe	Cherokee	Jackson	Polk	Watauga
			Avery	Clay	McDowell	Rutherford	Wilkes
			Buncombe	Graham	Macon	Surry	Yadkin
			Burke	Haywood	Madison	Swain	Yancey
North Dakota	1	None					
Ohio	2	None					
Oklahoma	4	Region 2:	Beaver	Cimarron	Ellis	Harper	Texas
		Region 3:	Craig	Nowata	Ottawa	Rogers	Wagoner
			Delaware	Osage	Pawnee	Tulsa	Washington
			Mayes				
Oregon	2	Region 1:	Baker	Klamath	Union	Wallowa	
Pennsylvania	2	Region 1:	Bradford	Sullivan	Susquehanna	Tioga	Wyoming
Rhode Island	2	None					
South Carolina	3	Region 4:	Allendale	Berkeley	Colleton	Jasper	Orangeburg
			Bamberg	Calhoun	Dorchester	Lee	Richland
			Barnwell	Charleston	Hampton	Lexington	Sumter
			Beaufort	Clarendon			
South Dakota	1	Region 2:	Gregory	Mellette	Todd	Tripp	
Tennessee	3	Region 2:	Bledsoe	Franklin	Morgan	Putnum	Van Buren
			Coffee	Grundy	Overton	Scott	Warren
			Cumberland	Marion	Pickett	Sequatchie	White
			Fentress				
Texas	4	Region 3:	Andrews	Dallam	Hansford	Lubbock	Potter
			Armstrong	Dawson	Hartley	Lynn	Randall
			Bailey	Deaf Smith	Hemphill	Martin	Roberts
			Briscoe	Floyd	Hockley	Midland	Sherman
			Carson	Gaines	Howard	Moore	Swisher
			Castro	Glasscock	Hutchinson	Ochiltree	Terry
			Cochran	Gray	Lamb	Oldham	Yoakum
			Crosby	Hale	Lipscomb	Parmer	
Utah	2	Region 1:	Cache	Daggett	Morgan	Summit	Wasatch
			Carbon	Duchesne	Rich	Uintah	
		Region 4:	Washington				
Vermont	1	None					
Virginia	2	Region 3:	Accomack	Isle of Wight	Lancaster	Northumberland	Surry
			Charles City	James City	Mathews	Prince George	Sussex
			Essex	King and Queen	Middlesex	Richmond	Westmoreland
			Gloucester	King George	New Kent	Southampton	York
			Greensville	King William	Northampton	Stafford	

State	Primary Region	Exception Counties					
Washington	2	Region 1:	Chelan Ferry	Kittitas Okanogan	Pend Orielle Skamania	Spokane Stevens	Yakima
West Virginia	2	None					
Wisconsin	1	None					
Wyoming	1	None					

2. Select a design package (Table A-2)

For each climate region, several design packages are provided. The variety of packages gives the plant fairly wide latitude in deciding how to design an energy efficient home.

A package contains requirements for several features that must be used together to meet the energy efficiency target.

Table A-2 is divided into four sub-tables; one for each climate region. Each sub-table is divided into three sections, one each for 3%, 5% and 7% duct leakage. Each of these sections is further divided into two or three sections, one for each heating system type: gas/oil, heat pump and electric resistance if applicable. To use the table, first select the climate region where the home will be sited. Next, select the duct leakage level that the plant expects can be consistently reached and has been identified by testing. Then select the heating source, either the gas/oil heat, heat pump or the electric resistance section followed by the heating efficiency. Further, select the rows containing appropriate U_0 and, for Regions 3 and 4, the solar heat gain coefficient (SHGC) values.

The second and third columns from the right indicate the requirements for the type of thermostat and the hot water equipment efficiency.

All the packages are roughly equivalent in energy terms. That is, applied to the same home, all packages will result in approximately the same total energy use. Therefore, saving energy in one area (for example, by using tighter ducts or installing a programmable thermostat) will result in offsets elsewhere (for example, by allowing a higher U_0-value).

A more detailed description of the features on Table A-2 follows:

- **Maximum Duct Loss:** This refers to the amount of leakage from the air distribution ducts as measured with a "Duct Blaster" or similar diagnostic device. During plant qualification, the manufacturer will determine the target leakage rate and steps required to achieve that rate (e.g., duct sealing strategies).[2] The midrange leakage rate of 5% should be readily achievable with currently available duct design and sealing techniques. The duct leakage values on Table A-2 are measurements of air leakage to the outside when the ducts are depressurized to negative 25 pascals. The values are based on air handler airflow rates and approximately correlate to cubic feet per minute of leakage divided by the floor area of the home. When measured in the plant, only total duct leakage can be determined. It should be assumed that 50% of total measured duct leakage will leak to the outside after the home is set. This should then be confirmed when field tests are conducted and actual duct leakage to the outside can be measured.

[2] See *Manufactured Housing Duct Systems: Guide to Best Practices*, published by MHRA, for guidance on constructing efficient duct systems.

- **Minimum Heating Equipment Efficiency:** This refers to the equipment performance rating as certified by the Air-Conditioning and Refrigeration Institute (ARI) for electric heat pumps and by Gas Appliance Manufacturers Association (GAMA) for fossil fuel-burning furnaces (furnaces that burn natural gas, liquefied petroleum (LP gas) or fuel oil). Heat Pump certifications are published in the ARI Directory of Certified Unitary Products and referenced by manufacturer and equipment model number as it appears on the rating label on the equipment.

  The heating mode of heat pumps are rated in terms of Heating Seasonal Performance Factor (HSPF). Fossil fuel-burning furnace certifications are published by GAMA in the Consumers' Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment and referenced by manufacturer and equipment model number as it appears on the rating label on the equipment.

  Fossil fuel-burning furnaces are rated in terms of Annual Fuel Utilization Efficiency (AFUE).

- **Maximum U_0-value:** This refers to the ability of the home's envelope to resist heat flow and is calculated in the same manner as the U_0-value referred to in the HUD standards. U_0-value is an engineering concept that combines all types of interior and exterior thermal energy transfers into an overall thermal efficiency number that is used in combination with the overall area of the entire home's envelope. This value should be calculated in a manner that includes the walls, ceiling, floor, windows, doors, glass in doors, skylights, bay windows, ducts or any other envelope components that impact energy use.

- **Solar Heat Gain Coefficient (SHGC):** This refers to the ability of the window to block solar heat from entering the home. The higher the SHGC, the more solar heat is transmitted through the window. The SHGC requirement can be met in one of two ways:

  - All windows in the home meet the requirement based on the rated value.[3]
  - The area weighted average SHGC for all the windows meets the requirement (multiply each window area by its whole window SHGC, add the results together and divide by the total window area for the home).

  Center of glass and whole window SHGC values are available from window suppliers.

- **Minimum Hot Water Equipment Efficiency:** This refers to the efficiency rating of the hot water heater (WH). Hot water heaters are rated in terms of Energy Factor (EF). Different EF levels are provided for gas and for electric equipment. In some packages a high efficiency water heater is required. This is indicated by a checkmark in the "High Efficiency WH" column in Table A-2. The high efficiency WH requirement may be met in one of two ways:

  - an EF of at least 0.59 for gas or at least 0.91 for electric heaters.
  - a lower-rated heater wrapped with a minimum of R-5 insulation.[4]

  The minimum WH EF for all other packages is 0.56 for gas heaters and 0.88 for electric heaters.

- **Thermostat Type:** Programmable thermostats that can be automatically set back to lower temperatures in the heating season or set up to higher temperatures in the cooling season can generate significant energy savings. Use the rows marked Programmable if a programmable thermostat is specified for the home and Manually Operated if a non-programmable thermostat is used.

- **Minimum Cooling Equipment Efficiency:** This refers to the equipment rating as certified by ARI and published in the ARI Directory of Certified Unitary Products. Air conditioners and heat pumps in the cooling mode are rated in terms of Seasonal Energy Efficiency Ratio (SEER). All homes built in accordance with these guidelines must be equipped with cooling equipment rated not less than 12 SEER, except those electric resistance packages in climate zones 1 and 4 noted as 13 SEER. Homes without air conditioning are automatically considered to have the SEER level required for the package selected. While not a requirement, cooling equipment should be correctly sized.

[3] Analysis is based on the whole window value, but the center of glass value may also be used, as it will result in a more conservative package. For an explanation of whole window SHGC rating, see National Fenestration Rating Council Incorporated, *NFRC 200-2001: Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence* (Silver Spring, MD, November 2002).

[4] Check with the water heater manufacturer about restrictions on wrapping their water heater.

- **Heat Recovery Ventilator:** The electric resistance heating packages for Climate Region 1 require a heat recovery ventilator (HRV) to maintain a minimum of 0.35 air changes per hour (ACH), as these homes are required to have an extremely tight shell to retain the heat imparted to the indoor air by the furnace. A heat recovery ventilator (also called an air-to-air heat exchanger) is a ventilation system that consists of two separate air-handling systems-one collects and exhausts stale indoor air and the other draws in fresh outdoor air and distributes it throughout the home. At the core of an HRV is a heat transfer module. Both the exhaust and fresh air streams pass through this module and the heat from the exhaust air is used to pre-heat the fresh air stream. Only the heat is transferred; the two air streams remain physically separate. Typically, an HRV is able to recover 70-80 percent of the heat from the exhaust air and transfer it to the incoming air. This dramatically reduces the energy needed to heat fresh air to a comfortable temperature.

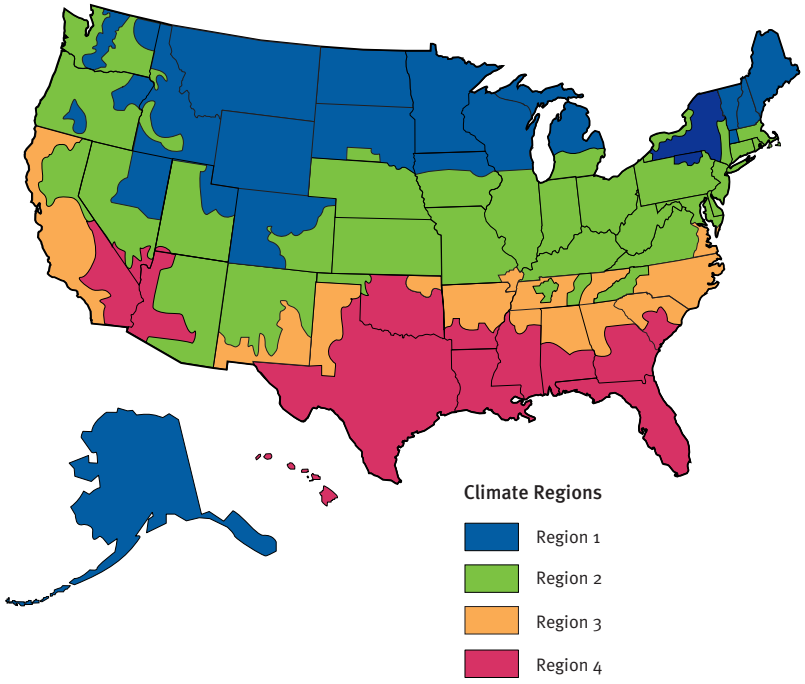
All homes must also meet the following requirements:

- **Minimum External Duct Insulation:** This refers to the rated insulation value (R-value) of materials used for insulating the exterior crossover duct.
  - Climate Regions 1 and 2: a minimum of **R-8** is required
  - Climate Regions 3 and 4: a minimum of **R-6** is required
- **Whole home leakage:** All homes shall have whole home leakage rates, calculated based on blower door measurements, which do not exceed 7.0 $ACH50$[5].
- **Basements:** All homes placed over basements must also meet the following requirements:

  Unconditioned basement: The basement is not intentionally heated, is not considered part of the living space and is separated from the living area. The walls of the interior stairwell are insulated to the same levels as the exterior walls. Doors to the basement are insulated and weather-stripped.

  Semi-conditioned and conditioned basements: Compliance can be demonstrated by insulating the basement walls to the following levels:
  - Climate Region 1: R-13
  - Climate Region 2: R-10
  - Climate Region 3: R-10
  - Climate Region 4: R-0

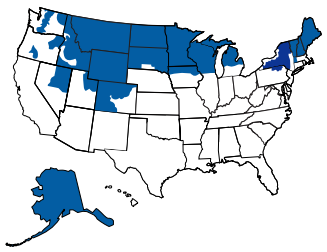
Figure A-1 Climate Region Map



[5] Electric resistance packages in Region 1 require a maximum shell leakage rate of 4.0 ACH_{50}.

Table A-2 **Energy Efficiency Packages**

CLIMATE REGION 1



Basic Requirements:

- Maximum shell leakage: 7.0 ACH_{50}
- Minimum cooling SEER: 12.0 (Electric resistance packages only: 13.0)
- Window SHGC: any
- Minimum duct insulation: R-8

Packages for homes with maximum 3% duct losses

Heating Type	Minimum Heating Efficiency	Maximum U_o-value	High Efficiency WH[6]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.054			1-1
		0.056		✓	1-2
		0.058	✓		1-3
	0.90 AFUE	0.060		✓	1-4
		0.063	✓	✓	1-5
Heat Pump	7.6 HSPF	0.052		✓	1-6
		0.053	✓	✓	1-7
Electric Resistance[7] (Forced Air)	1.0 EF	0.048		✓[8]	1-8
		0.050	✓	✓[8]	1-9

Packages for homes with maximum 5% duct losses

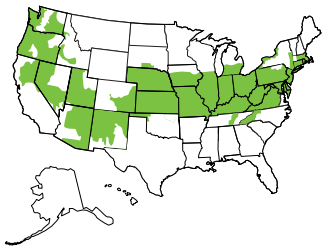
Heating Type	Minimum Heating Efficiency	Maximum U_o-value	High Efficiency WH[6]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.052			1-10
		0.054		✓	1-11
		0.056	✓	✓	1-12
	0.90 AFUE	0.058		✓	1-13
		0.061	✓	✓	1-14
Heat Pump	7.6 HSPF	0.050		✓	1-15
		0.051	✓	✓	1-16
	8.0 HSPF	0.052		✓	1-17
		0.053	✓	✓	1-18

[6] The high efficiency WH requirement may be met by using a 0.59 EF gas WH or a 0.91 EF electric WH or by wrapping a lower-rated WH with a minimum of R-5 insulation.

[7] Electric resistance packages in Region 1 require a maximum shell leakage rate of 4.0 ACH_{50} and a 70% efficient heat recovery ventilator to ensure that total ventilation rate is maintained at 0.35 ACH at all times. They also require a cooling SEER of 13.0.

[8] A programmable thermostat is required for a forced air all-electric heating system. Zone controls are required for baseboard electric resistance heating systems.

CLIMATE REGION 2



Basic Requirements:

- Maximum shell leakage: 7.0 ACH_{50}
- Minimum cooling SEER: 12.0
- Maximum window SHGC: 0.55
- Minimum duct insulation: R-8

Packages for homes with maximum 3% duct losses

Heating Type	Minimum Heating Efficiency	Maximum U_o-value	High Efficiency WH[9]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.061			2-1
		0.065		✓	2-2
		0.067	✓	✓	2-3
Heat Pump	7.2 HSPF	0.058			2-4
		0.059		✓	2-5
		0.061		✓	2-6
		0.063	✓	✓	2-7

Packages for homes with maximum 5% duct losses

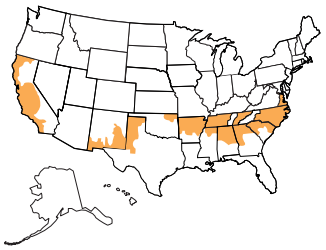
Heating Type	Minimum Heating Efficiency	Maximum U_o-value	High Efficiency WH[9]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.057			2-8
		0.061		✓	2-9
		0.063	✓	✓	2-10
	0.90 AFUE	0.063		✓	2-11
		0.065	✓	✓	2-12
Heat Pump	7.2 HSPF	0.056			2-13
		0.057		✓	2-14
		0.061	✓	✓	2-15
	7.6 HSPF	0.059		✓	2-16
		0.062	✓	✓	2-17
	8.0 HSPF	0.062		✓	2-18
		0.064	✓	✓	2-19

Packages for homes with maximum 7% duct losses

Heating Type	Minimum Heating Efficiency	Maximum U_o-value	High Efficiency WH[9]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.056			2-20
		0.060		✓	2-21
		0.062	✓	✓	2-22
	0.90 AFUE	0.062		✓	2-23
		0.064	✓	✓	2-24
Heat Pump	7.2 HSPF	0.054			2-25
		0.055		✓	2-26
		0.059	✓	✓	2-27

[9] The high efficiency WH requirement may be met by using a 0.59 EF gas WH or a 0.91 EF electric WH or by wrapping a lower-rated WH with a minimum of R-5 insulation.

CLIMATE REGION 3



Basic Requirements:

- Maximum shell leakage: 7.0 ACH_{50}
- Minimum cooling SEER: 12.0
- Minimum duct insulation: R-6

Packages for homes with maximum 3% duct losses

Heating Type	Minimum Heating Efficiency	Maximum U_o-value	Maximum Window SHGC	High Efficiency WH[10]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.075	0.50			3-1
		0.082	0.50		✓	3-2
		0.084	0.50	✓	✓	3-3
		0.084	0.40		✓	3-4
		0.086	0.40	✓	✓	3-5
Heat Pump	7.2 HSPF	0.071	0.50			3-6
		0.072	0.50		✓	3-7
		0.073	0.50	✓	✓	3-8
		0.074	0.40		✓	3-9
		0.075	0.40	✓	✓	3-10

Packages for homes with maximum 5% duct losses

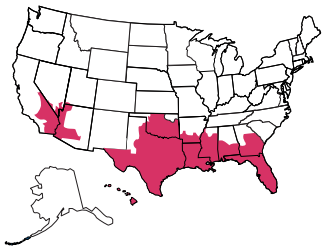
Heating Type	Minimum Heating Efficiency	Maximum U_o-value	Maximum Window SHGC	High Efficiency WH[10]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.073	0.50			3-11
		0.080	0.50		✓	3-12
		0.082	0.50	✓	✓	3-13
		0.082	0.40		✓	3-14
		0.084	0.40	✓	✓	3-15
Heat Pump	7.2 HSPF	0.070	0.50			3-16
		0.071	0.50		✓	3-17
		0.072	0.50	✓	✓	3-18
		0.072	0.40		✓	3-19
		0.073	0.40	✓	✓	3-20
	7.6 HSPF	0.074	0.50		✓	3-21
		0.075	0.50	✓	✓	3-22
		0.076	0.40	✓	✓	3-23
	8.0 HSPF	0.077	0.50		✓	3-24
		0.078	0.50	✓	✓	3-25
		0.079	0.40	✓	✓	3-26

Packages for homes with maximum 7% duct losses

Heating Type	Minimum Heating Efficiency	Maximum U_o-value	Maximum Window SHGC	High Efficiency WH[10]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.068	0.50			3-27
		0.075	0.50		✓	3-28
		0.077	0.50	✓	✓	3-29
		0.078	0.40		✓	3-30
		0.080	0.40	✓	✓	3-31
Heat Pump	7.2 HSPF	0.066	0.50			3-32
		0.067	0.50		✓	3-33
		0.068	0.50	✓	✓	3-34
		0.070	0.40		✓	3-35
		0.071	0.40	✓	✓	3-36

[10] The high efficiency WH requirement may be met by using a 0.59 EF gas WH or a 0.91 EF electric WH or by wrapping a lower-rated WH with a minimum of R-5 insulation.

CLIMATE REGION 4



Basic Requirements:

- Maximum shell leakage: 7.0 ACH_{50}
- Minimum cooling SEER: 12.0 (Electric resistance packages with maximum 5% duct loss: 13.0)
- Minimum duct insulation: R-6

Packages for homes with maximum 3% duct losses

Heating Type	Minimum Heating Efficiency	Maximum U_o-value	Maximum Window SHGC	High Efficiency WH[11]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.111	0.50			4-1
Heat Pump	7.2 HSPF	0.097	0.50			4-2
		0.104	0.50		✓	4-3
		0.108	0.50	✓	✓	4-4
Electric Resistance[12]	1.0 EF	0.074	0.40		✓[13]	4-5
		0.075	0.40	✓	✓[13]	4-6
Electric Resistance (Florida Only)[12]	1.0 EF	0.111	0.40		✓[13]	4-7
		0.114	0.40	✓	✓[13]	4-8

Packages for homes with maximum 5% duct losses

Heating Type	Minimum Heating Efficiency	Maximum U_o-value	Maximum Window SHGC	High Efficiency WH[11]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.102	0.50			4-9
		0.116	0.50		✓	4-10
Heat Pump	7.2 HSPF	0.093	0.50			4-11
		0.100	0.50		✓	4-12
		0.105	0.50	✓	✓	4-13
	7.6 HSPF	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
Electric Resistance[12]	1.0 EF	0.070	0.40		✓[13]	4-18
		0.071	0.40	✓	✓[13]	4-19
Electric Resistance (Florida Only)[12]	1.0 EF	0.116	0.40		✓[13]	4-20

Packages for homes with maximum 7% duct losses

Heating Type	Minimum Heating Efficiency	Maximum U_o-value	Maximum Window SHGC	High Efficiency WH[11]	Programmable Thermostat	Package Number
Gas/Oil Furnace	0.80 AFUE	0.092	0.50			4-21
		0.106	0.50		✓	4-22
		0.109	0.40		✓	4-23
		0.111	0.50	✓	✓	4-24
		0.115	0.40	✓	✓	4-25
Heat Pump	7.2 HSPF	0.086	0.50			4-26
		0.093	0.50		✓	4-27
		0.095	0.40		✓	4-28
		0.099	0.50	✓	✓	4-29
		0.101	0.40	✓	✓	4-30

[11] The high efficiency WH requirement may be met by using a 0.59 EF gas WH or a 0.91 EF electric WH or by wrapping a lower-rated WH with a minimum of R-5 insulation.

[12] These packages require a cooling SEER of 13.0.

[13] A programmable thermostat is required for a forced air all-electric heating system. Zone controls are required for baseboard electric resistance heating systems.

SAMPLE ENERGY EFFICIENT MANUFACTURED HOME SITE INSTALLATION CHECKLIST

Home manufacturer:_____ Plant location:_____

Home Serial Number:_____ Model number:_____

Home address:_____ City:_____ State:_____ County:_____

This home was manufactured as an energy efficient manufactured home. The items below are required to ensure that the home is installed in compliance with intended energy efficiency design.

The items on this checklist are to be completed by a representative of the home manufacturer. After completing the checklist, the manufacturer's representative shall sign the checklist and return the original copy to the manufacturer.

Marriage line seal
The marriage line areas must be filled with a non-porous insulating gasket creating a permanent air barrier. Verify that the following marriage line joints are gasketed:

- ❑ **Ceiling**
- ❑ **End walls**
- ❑ **Floor**

Acceptable gaskets can be one or two-part systems: "center-seal," "soft chink", "soft seal", foams, insulation wrapped in polyethylene, insulation covered by butyl or other long-life tape on one side.

Tears in bottom board material repaired
All tears in the bottom board material, including penetrations for utility lines and other hook-ups, are covered and sealed with a durable patch to prevent air leakage. (Foam sealant can be used to seal bolt and other small holes.) Verify that the following item is completed:

- ❑ **Bottom board is intact**

Crossover duct installation
For multi-section homes, the crossover ducts must be sealed with a permanent connection as per the manufacturer's Installation Manual. Identify that the following items are completed:

- ❑ **All crossover ducts have been installed and wrapped with insulation**
- ❑ **Crossover collar is secured with at least three screws and cannot rotate or move**
- ❑ **All crossover duct insulation is R-____**
- ❑ **Nylon or metal straps and saddles are used to support the crossover 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**
- ❑ **Crossover duct insulation is pushed into the floor cavity and sealed with tape or foam sealant at all bottom board penetrations**

Field Installed HVAC equipment

- ❑ **Cooling equipment efficiency meets or exceeds the following performance rating: SEER-_____**
- ❑ **Heating equipment efficiency meets or exceeds the following specification: HSPF-_____**

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 constructed in the same manner as an exterior wall with full insulation and a weatherstripped, insulated exterior door is installed.**
- ❑ **This home has a HEATED BASEMENT. The basement wall insulation level is a minimum of: R-_____**

Description of deficient installation and steps taken to correct the deficiency: _____

(Continue on back)

I have inspected this home and find that all site work complies with the above and all other relevant energy efficiency requirements.

Signature (Manufacturer's field representative) Print Name Date

I have checked this home's records against the address provided on this form and find that the home is located in the appropriate climate region.

Signature (Manufacturer's field representative) Print Name Date

(Continued from front)

Description of deficient installation and steps taken to correct the deficiency: