RESNET PDS 301-01

Contents

RESNET Standard 301-CD02

Standard for the Calculation and Labeling of the Energy Performance of Low-Rise Residential Buildings using the HERS Index

Forward

1. Purpose. The provisions of this document are intended to establish national residential energy rating and labeling Standards, consistent with the provisions of the Energy Policy Act of 1992, which any provider of home energy ratings may follow to produce uniform energy ratings and energy performance labels for residential buildings.

2. Scope. This standard is applicable to all single family residences and to all multifamily residences three stories or less in height above ground excepting hotels and motels. This Standard is a companion to the RESNET *Mortgage Industry National Home Energy Rating Systems Standards*.

3. Definitions. The following terms and acronyms have specific meanings as used in this Standard. In the event that definitions given here differ from definitions given elsewhere, the definitions given here shall govern.[1]

ACCA – Air Conditioning Contractors of America, Inc.

Accreditation Categories (software tools) – Specific computer software tool functionalities that may be accredited by RESNET under the provisions of this Standard.

Accredited Software Rating Tool – A computerized procedure that is accredited by RESNET for the purpose of conducting home energy ratings and calculating the annual energy consumption, annual energy costs and a HERS Index for a home.

AFUE – Annual Fuel Utilization Efficiency; a measure of the efficiency of gas fired furnaces calculated as the furnace heating energy output divided by fuel energy input. AFUE does not include electrical energy for fans, pilot lights, or electronic ignition systems (see also EAE).

Air Source Heat Pump (ASHP) – Vapor compression heating and cooling equipment that uses the outdoor air as the heat source or sink for heat (see also Heat pump).

ASHP – see Air Source Heat Pump

ASHRAE – American Society or Heating, Refrigerating and Air Conditioning Engineers, Inc.

[1] Additional definitions and acronyms common to all aspects of Home Energy Rating Systems (HERS) may be found in Appendix B of the RESNET *Mortgage Industry National Home Energy Rating System Standards.*

ASTM – ASTM International, originally known as the American Society for Testing and Materials (ASTM)

Baseline Existing Home Model – The original energy features and standard operating conditions of an existing home that is (or will be) subjected to improvements through a home energy efficiency retrofit.

Bedroom – A room or space 70 square feet or greater, with egress window and closet, used or intended to be used for sleeping. A "den." "library," "home office" with a closet, egress window, and 70 square feet or greater or other similar rooms shall count as a bedroom, but living rooms and foyers shall not.

BESTEST – Building Energy Simulation Test (see also HERS BESTEST)

British thermal unit (Btu) – An energy unit equal to the amount of heat needed to raise one pound of water one degree Fahrenheit at a constant pressure of one atmosphere; equal to approximately 1055 joules.

Btu – see British thermal unit

Builder Name – The legal Company (or Corporation) designation of an Energy Smart Home Builder of a specific Home Plan that is registered as a Projected Worst-Case Rating.

Certified Rater – An individual who has become qualified to conduct home energy ratings through certification by a RESNET-accredited Rating Provider.

Certified Home Energy Rating – A home energy rating that has been accepted by the national RESNET Registry and assigned a Registration ID as conforming to all required standards for home energy ratings.

Certified Rater ID – The unique identifier, stored in the RESNET Registry database, which is assigned to a Certified Rater.

Coefficient of Performance (COP) –The ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system under designated operating conditions.

Community Name – The legal designation of the neighborhood or subdivision within a specific geographic location in which a Projected Worst-Case Rating is registered by the national RESNET Registry.

Conditioned floor area (CFA) – The finished floor area in square feet of a home that is conditioned by heating or cooling systems, measured in accordance with ANSI Standard Z765-2003 with exceptions as specified in Appendix A of the RESNET *Mortgage Industry National Home Energy Rating Systems Standards*.

Confirmed Rating – A Rating Type accomplished using data gathered from an on-site audit inspection and, if required, performance testing of the physical building and its installed systems and equipment.

COP – see Coefficient of Performance

CRRC – Cool Roof Rating Council

DAPIA – Design Approval Primary Inspection Agency. A third-party agency designated by the U.S. Department of Housing and Urban Development (HUD) to be responsible for evaluating manufactured home designs submitted to it by the manufacturer and for assuring that they conform to the HUD standards for manufactured homes.

Distribution System Efficiency (DSE) – A system efficiency factor, not included in manufacturer's equipment performance ratings for heating and cooling equipment, that adjusts for the energy losses associated with the delivery of energy from the equipment to the source of the load, such energy losses associated with heat transfer across duct or piping walls and air leakage to or from forced air distribution systems.

DOE – U.S. Department of Energy

DSE – see Distribution System Efficiency

EAE – see Electric Auxiliary Energy

EER – see Energy Efficiency Ratio

EF – see Energy Factor

Electric Auxiliary Energy (EAE) – The average annual auxiliary electrical energy consumption for a gas furnace or boiler in kilowatt-hours per year as published in the AHRI Consumer's Directory of Certified Efficiency Ratings.

Emittance – A measure of the ability of a surface to emit radiation, expressed as the ratio of the energy radiated within a specific spectral band by a surface to that radiated within that same specific spectral band by a blackbody at the same temperature.

Energy Efficiency Ratio (EER) – The ratio of net equipment cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions.

Energy Factor (EF) – A standardized measure of energy efficiency as determined under Department of Energy Regulations, 10 CFR 430.

Energy Policy Act of 1992 (EPAct 92) – An act of the U.S. Congress, passed in 1992, which required the development by the U.S. Department of Energy (DOE) of voluntary guidelines for Home Energy Rating Systems (HERS).

ENERGY STAR – A joint program of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) that encourages energy use reduction by providing ENERGY STAR labels to products and homes meeting the improved energy efficiency requirements of the program.

EPA – U.S. Environmental Protection Agency

EPAct 92 – see Energy Policy Act of 1992

Equivalent Electric Energy – The amount of electricity that would be produced from site fossil fuel uses when converted to electrical power using the Reference Electricity Production Efficiency.

Existing Home Retrofit – The set of energy efficiency improvements made to an existing home to improve its energy performance.

Fenestration – A glazed opening and its associated sash and framing that is installed into a building.

Framing Fraction (FF) – The fractional area of walls, ceilings, floors, roofs and other enclosure elements comprising the structural framing elements with respect to the total gross area of the component.

GSHP – see Ground Source Heat Pump

Gross Area – The area of a building enclosure component that includes the areas of the fenestration areas that are not normally included in the net area of the enclosure component (i.e. normally the simple area calculated as the overall length times the overall width of the enclosure component – such as a wall).

Ground Source Heat Pump (GSHP) – Vapor compression heating and cooling equipment that uses the ground (or ground water) as the heat source or sink for heat (see also Heat Pump).

Heat Pump - A vapor-compression refrigeration device that includes a reversing valve and optimized heat exchangers so that the direction of heat flow may be reversed in order to transfer heat from one location to another using the physical properties of an evaporating and condensing fluid known as a refrigerant. Most commonly, heat pumps draw heat from the air or from the ground moving the heat from a low temperature heat source to a higher temperature heat sink.

Heating Seasonal Performance Factor (HSPF) – A standardized measure of heat pump efficiency, based on the total heating output of a heat pump, in Btu, divided by the total electric energy input, in watt-hours, under test conditions specified by the Air Conditioning and Refrigeration Institute Standard 210/240.

HERS® – see Home Energy Rating System.[2]

HERS BESTEST – The Home Energy Ratings System Building Energy Simulation Test protocol published as NREL Report No. NREL/TP-472-7332

HERS Index – A numerical integer value that represents the relative energy use of a Rated Home as compared with the energy use of the HERS Reference Home and where an Index value of 100 represents the energy use of the HERS Reference Home and an Index value of 0 (zero) represents a home that uses zero net purchased energy.

HERS Reference Home – A hypothetical home configured in accordance with the specifications set forth in Section 4.2 of this Standard as the basis of comparison for the purpose of calculating the relative energy efficiency and HERS Index of a Rated Home.

Home Energy Rating System (HERS®) – The procedures, rules and guidelines by which Home Energy Ratings are conducted by accredited Providers (Home Energy Rating,

[2] HERS® is a registered U.S. Trademark of Residential Energy Services Network, Inc.

Software, Training, BOP, Sampling, Home Energy Survey), as specified in these Standards.

HSPF – see Heating Seasonal Performance Factor

HUD – U.S. Department of Housing and Urban Development

HVAC – Heating, Ventilating and Air Conditioning

IDR – Innovative Design Request

IECC – see International Energy Conservation Code

IECC Standard Reference Design – A hypothetical home configured in accordance with the specifications set forth in the International Energy Conservation Code (IECC) as the performance basis for achieving compliance with that code.

Improved Home Model – The energy features and standard operating conditions of a home after an Existing Home Retrofit has been accomplished to improve the energy performance of the home.

Infiltration – The inadvertent exchange of outdoor and indoor air through small cracks and penetrations in home enclosures driven by pressure differences between the indoor and outdoor environment.

Internal Gains – The heat gains within a home attributable to lights, people, and miscellaneous equipment.

International Energy Conservation Code (IECC) – The model code for building energy conservation as promulgated by the International Code Council.

IPIA – In-Plant Inspection Agency. A third-party agency designated by the U.S. Department of Housing and Urban Development (HUD) to ensure the construction quality of manufactured housing.

IRS – U.S. Internal Revenue Service

kWh – One thousand Watt-hours (see also Watt-hour); approximately equal to 3412 Btu.

Latent Energy – Energy associated with the amount of moisture vapor in the air. The term can refer to moisture vapor that is added to an indoor space by Internal Gains, a humidifier or by outdoor air introduced to the indoor space or to moisture vapor that is removed from an indoor space by air conditioning, ventilation or dehumidification. (see also Sensible Energy.)

MBtu – One million British thermal units (Btu)

Manual J – The procedures published by the Air Conditioning Contractors of America (ACCA) used to estimate the heating and air conditioning loads of homes.

MELs – Miscellaneous Electric Loads. Normally used to describe electrical energy uses that are not attributable to space heating, space cooling, hot water heating or well-defined

energy uses of specific appliances that have a large saturation in homes, such as refrigerators.

MEPR – Manufacturer's Equipment Performance Rating

Minimum Rated Features – The characteristics of the building elements which are the basis for the calculation of end use loads and energy consumption for the purpose of a home energy rating, and which are evaluated by Home Energy Raters in to order collect the data necessary to create a home energy rating using accredited simulation tools.

Mortgage Industry National Home Energy Rating Standards – National consensus Standards promulgated by RESNET that specify the methods, procedures and practices that shall be used by entities who purport to evaluate the energy performance of homes.

NAECA – National Appliance Energy Conservation Act

National Home Energy Performance Label Certificate – The uniform national label of a home's energy performance that is based upon a home energy rating and the HERS Index.

National RESNET Registry – A national database of Accredited Providers, Certified Raters and Certified Home Energy Ratings maintained by RESNET.

Natural Ventilation – The purposeful introduction of outdoor air into the home through open windows and doors with the specific purpose of improving indoor comfort without the use of HVAC equipment; as opposed to *Infiltration*, which is not purposeful and which occurs in much smaller quantities through cracks and enclosure penetrations rather than opened windows and doors.

New Home Tax Credit Reference – The hypothetical home model that is the basis of comparison for new homes seeking to qualify for the federal tax credit for highly efficient new homes. The New Home Tax Credit Reference has the same geometry and gross areas as the Qualifying Home with component and equipment efficiencies as prescribed by the U.S. Congress in the law(s) governing the Tax Credit.

NREL – National Renewable Energy Laboratory.

On-Site Power Production (OPP) – Electric power produced at the site of a Rated Home. OPP shall be the net electrical power production, such that it equals the gross electrical power production minus any purchased fossil fuel energy, converted to its Equivalent Electric Power, used to produce the on-site power.

Pascal (Pa) - The metric unit of pressure equaling 1 Newton per square meter.

Plan Name – The designation assigned by the Builder to a specific home plan and specification that may be constructed multiple times within a given Community.

Private Label – The customized presentation of the home energy performance label, approved by RESNET, that is specific to a particular RESNET Energy Smart Home Builder.

Projected Rating – A Rating Type performed prior to the construction of a new building or prior to implementation of energy-efficiency improvements to an existing building.

Projected Worst-Case Rating – A Rating Type that has been obtained using a RESNET-accredited HERS Rating Tool using input coming from a set of plans and specifications for the Minimum Rated Features of a home under the least favorable configuration, including orientation.

Proposed Design – The simulation input model, including all minimum energy features, for a home seeking compliance under the Simulated Performance Alternative of the International Energy Conservation Code.

Purchased Energy – The portion of the total energy requirement of a home purchased from a utility or other energy supplier.

Qualifying Home – The actual, as-built home seeking to qualify for the federal tax credit for highly efficient new homes that has been field-verified to assure that all minimum rated features of the home have been installed as specified.

Rating Provider – A RESNET-accredited entity responsible for the certification of Home Energy Raters working under its auspices and who is responsible for the quality assurance of such certified Raters and for the quality assurance of Home Energy Ratings produced by such Home Energy Raters in accordance with Section 600 of the *Mortgage Industry National Home Energy Rating System Standards*.

Rated Home – The specific real property that is evaluated using the home energy rating procedures specified by this Standard.

Rating Certification – The process by which Home Energy Rating quality assurance, as required by Section 900 of the *Mortgage Industry National Home Energy Rating System Standards*, is verified through the National RESNET Registry.

Rating Certification Form – The standard Home Energy Rating Label that is provided for in these Standards.

Rating Type – One of four different distinctions of home energy performance evaluation as provided by these Standards.

Reference Electricity Production Efficiency – Electric power production efficiency, including all production and distribution losses, of 40%, approximating the efficiency of a modern, high-efficiency, central power plant. The Reference Electricity Production Efficiency is to be used only to convert site fossil fuel energy uses to an Equivalent Electric Power for the sole purposes of providing home energy rating system credit for On-site Power Production.

Registration ID – The unique identification assigned to each Certified Home Energy Rating that is registered within the National RESNET Registry

Residual MELs – The miscellaneous energy uses within a Rated Home that are included in the energy use but are not explicitly accounted for as distinct end uses by the Minimum Rated Features of the home.

***RESNET* –** Residential Energy Services Network, Inc.

RESNET Energy Smart Builder – A home builder who has entered into a Memorandum of Understanding with RESNET to have their homes energy rated and to market their homes using the HERS Index.

***Revenue-Based Price* –** The electric, natural gas or other fuel rate that is calculated as the total units sold divided by the total revenues received.

***R-value* –** Thermal resistance value measured in h-ft^2-F/Btu.

Sampling - An application of the Home Energy Rating process whereby fewer than 100% of a builder's new homes are randomly inspected and tested in order to evaluate compliance with a set of threshold specifications.

***Sampled Rating* –** A Rating Type for which the field verification quality assurance procedures consist of a sampling protocol governed by Section 600 of the *Mortgage Industry National Home Energy Rating Systems Standards*.

Seasonal Energy Efficiency Ratio (SEER) – A standardized measure of air conditioner efficiency based on the total cooling output of an air conditioner in Btu/h, divided by the total electric energy input, in watt-hours, under test conditions specified by the Air Conditioning and Refrigeration Institute Standard 210/240.

***SEER* –** see Seasonal Energy Efficiency Ratio

***Sensible Energy* –** Energy associated with the amount of heat contained in the air, as contrasted with Latent Energy, which is energy associated with the amount of moisture vapor contained in the air.[3]

Shall - As used in this Standard, the word 'shall' means that the action specified is mandatory and must be accomplished by the responsible party.

***Software Tool* –** A RESNET-accredited computer program that has been shown to perform the functions for which it is accredited through a series of Software Verification Tests as prescribed by this Standard (see also Accredited Software Rating Tool).

***Software Verification Tests* –** A series of home energy computer simulation exercises designed to determine if computer simulation tools produce reliable and accurate results as compared against a set of criteria established by this Standard.

***Solar Absorptance* –** The ratio of the embodied energy of normal incident sunlight divided by the total of the reflected and transmitted energy associated with a given material.

***Specific Leakage Area (SLA)* –** The unitless ratio of the Equivalent Leakage Area (ELA) of a home enclosure divided by the Conditioned Floor Area (CFA) of the home, given in the same units of measure.

[3] The total energy contained in the air (also called enthalpy) is equal to the sum of the latent and the sensible energies contained in the air.

***Standing Technical Committee (or Technical Committee)* –** The group of individuals established by the RESNET Board of Directors to be responsible for maintaining the scientific aspects of RESNET Standards.

Threshold Specifications - A set of qualification criteria which are established based on worst-case Projected Ratings with consideration of all options, and in worst-case orientation, or a set of prescriptive specifications such as the ENERGY STAR® prescriptive path adopted by the U.S. Environmental Protection Agency.

***Therms* –** An energy unit equal to 100,000 British Thermal Units (Btu); usually used to measure the consumption of natural gas.

Typical Existing Home –A representation of existing U.S. housing stock that assumes standard operating conditions and which is assigned a HERS Index of 130 based on U.S. Department of Energy estimates.

***U-Factor* –** Coefficient of thermal transmittance (expressed as Btu/h-ft2-oF (W/m2-oC)) of a building envelope component or system, including indoor and outdoor air film transmission coefficients.

Watt – Energy flow rate equal to one joule per second; approximately equal to 3.412 Btu per hour.

Watt-Hour – A unit of energy equal to an energy flow rate of one watt for a duration of one hour or 3,600 joules; approximately equal to 3.412 Btu.

***Whole-House fan* –** A forced air system consisting of a fan or blower that exhausts relatively large quantities indoor air to the outdoor for the purpose of drawing outdoor air into a home through open windows and doors for the purpose of cooling the home.

***Worst-Case Rating* –** A Rating Type for which the minimum rated features of the home are configured to provide the poorest energy performance of the home (i.e. the largest HERS Index) when four ordinal home orientations and the least energy efficient minimum rated features for the specified home plan are considered by the Rating.

4. Home Energy Rating Calculation Procedures.

4.1. Determining the HERS Index. The HERS Index shall be a numerical integer value that is based on a linear scale constructed such that the HERS Reference Home has an Index value of 100 and a home that uses no net purchased energy has an Index value of 0 (zero). Each integer value on the scale shall represent a 1% change in the total energy use of the Rated Home relative to the total energy use of the Reference home. Except in states or territories whose laws or regulations require a specific alternative method, which shall control, equations 4.1-1 and 4.1-2 shall be used in a 2 step process to calculate the HERS Index for the Rated Home, as follows:

4.1.1. Calculating End Use Loads. Calculate the individual normalized Modified End Use Loads (nMEUL) for heating, cooling, and hot water using equation 4.1-1:

nMEUL = REUL * (nEC_x / EC_r) **(Eq 4.1-1)**

where:

nMEUL = normalized Modified End Use Loads (for heating, cooling, or hot water) as computed using accredited simulation tools.

REUL = Reference Home End Use Loads (for heating, cooling or hot water) as computed using accredited simulation tools.

nEC_x = normalized Energy Consumption for Rated Home's end uses (for heating, including auxiliary electric consumption, cooling or hot water) as computed using accredited simulation tools.

EC_r = estimated Energy Consumption for Reference Home's end uses (for heating, including auxiliary electric consumption, cooling or hot water) as computed using accredited simulation tools.

and where:

nEC_x = (a* EEC_x – b)*(EC_x * EC_r * DSE_r) / (EEC_x * REUL) **(Eq 4.1-1a)**

where:

EC_x = estimated Energy Consumption for the Rated Home's end uses (for heating, including auxiliary electric consumption, cooling or hot water) as computed using accredited simulation tools.

EEC_x = Equipment Efficiency Coefficient for the Rated Home's equipment, such that EEC_x equals the energy consumption per unit load in like units as the load, and as derived from the Manufacturer's Equipment Performance Rating (MEPR) such that EEC_x equals 1.0 / MEPR for AFUE, COP or EF ratings, or such that EEC_x equals 3.413 / MEPR for HSPF, EER or SEER ratings.

DSE_r = REUL/EC_r * EEC_r
For simplified system performance methods, DSE_r equals 0.80 for heating and cooling systems and 1.00 for hot water systems [see Table 4.2.2(1)]. However, for detailed modeling of heating and cooling systems, DSE_r may be less than 0.80 as a result of part load performance degradation, coil air flow degradation, improper system charge and auxiliary resistance heating for heat pumps. Except as otherwise provided by these Standards, where detailed systems modeling is employed, it must be applied equally to both the Reference and the Rated Homes.

EEC_r = Equipment Efficiency Coefficient for the Reference Home's equipment, such that EEC_r equals the energy consumption per unit load in like units as the load, and as derived from the Manufacturer's Equipment Performance Rating (MEPR) such that EEC_r equals 1.0 / MEPR for AFUE, COP or EF ratings, or such that EEC_r equals 3.413 / MEPR for HSPF, EER or SEER ratings and where the coefficients 'a' and 'b' are as defined by Table 4.2.1(1) below:

Table 4.2.1(1) Coefficients 'a' and 'b'

Fuel type and End Use	a	b
Electric space heating	2.2561	0
Fossil fuel* space heating	1.0943	0.4030
Biomass space heating	0.8850	0.4047
Electric air conditioning	3.8090	0

Table 4.2.1(1) Coefficients 'a' and 'b'

Fuel type and End Use	a	b
Electric water heating	0.9200	0
Fossil fuel* water heating	1.1877	1.0130

*Such as natural gas, liquid propane gas, fuel oil

4.1.2. Calculating the HERS Index. Determine the HERS Index using equation 4.1-2:

HERS Index = PEfrac * (TnML / TRL) * 100 (Eq 4.1-2)

where:

TnML = $nMEUL_{HEAT} + nMEUL_{COOL} + nMEUL_{HW} + EUL_{LA}$ (MBtu/yr).

TRL = $REUL_{HEAT} + REUL_{COOL} + REUL_{HW} + REUL_{LA}$ (MBtu/yr).

and where:

EUL_{LA} = Rated Home end use loads for lighting, appliances and MELs as defined by Section 4.2.2.5.2, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293 or (therms/yr)/10, as appropriate.

$REUL_{LA}$ = Reference Home end use loads for lighting, appliances and MELs as defined by Section 4.2.2.5.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293 or (therms/yr)/10, as appropriate.

and where:

PEfrac = (TEU - OPP) / TEU

TEU = Total energy use of the Rated Home including all rated and non-rated energy features where all fossil fuel site energy uses are converted to Equivalent Electric Energy by multiplying them by the Reference Electricity Production Efficiency of 40%

OPP = On-Site Power Production as defined by Section 5.1.1.5 of this Standard.

4.2. HERS Reference Home and Rated Home Configuration

4.2.1. General Requirements. Except as specified by this Section, the HERS Reference Home and the Rated Home shall be configured and analyzed using identical methods and techniques.

4.2.2. Residence Specifications. The HERS Reference Home and Rated Home shall be configured and analyzed as specified by Table 4.2.2(1).

Table 4.2.2(1) Specifications for the HERS Reference and Rated Homes

Building Component	HERS Reference Home	Rated Home
Above-grade walls:	Type: wood frame	Same as Rated Home
	Gross area: same as Rated Home	Same as Rated Home
	U-Factor: from Table 4.2.2(2)	Same as Rated Home
	Solar absorptance = 0.75	Same as Rated Home

Table 4.2.2(1) Specifications for the HERS Reference and Rated Homes

Building Component	HERS Reference Home	Rated Home
	Emittance = 0.90	Same as Rated Home
Conditioned Basement walls:	Type: same as Rated Home Gross area: same as Rated Home U-Factor: from Table 4.2.2(2) with the insulation layer on the interior side of walls	Same as Rated Home Same as Rated Home Same as Rated Home
Floors over unconditioned spaces:	Type: wood frame Gross area: same as Rated Home U-Factor: from Table 4.2.2(2)	Same as Rated Home Same as Rated Home Same as Rated Home
Ceilings:	Type: wood frame Gross area: same as Rated Home U-Factor: from Table 4.2.2(2)	Same as Rated Home Same as Rated Home Same as Rated Home
Roofs:	Type: composition shingle on wood sheathing Gross area: same as Rated Home Solar absorptance = 0.75 Emittance = 0.90	Same as Rated Home Same as Rated Home Values from Table 4.2.2(4) shall be used to determine solar absorptance except where test data are provided for roof surface in accordance with ASTM methods C-1549, E-1918, or CRRC Method # 1. Emittance values provided by the roofing manufacturer in accordance with ASTM C-1371 shall be used when available. In cases where the appropriate data are not known, same as the Reference Home.
Attics:	Type: vented with aperture = 1ft^2 per 300 ft^2 ceiling area	Same as Rated Home
Foundations:	Type: same as Rated Home Gross Area: same as Rated Home U-Factor / R-value: from Table 4.2.2(2)	Same as Rated Home Same as Rated Home Same as Rated Home
Crawlspaces:	Type: vented with net free vent aperture = 1ft^2 per 150 ft^2 of crawlspace floor area. U-factor: from Table 4.2.2(2) for floors over unconditioned spaces.	Same as the Rated Home, but not less net free ventilation area than the Reference Home unless an approved ground cover in accordance with IRC 408.1 is used, in which case, the same net free ventilation area as the Rated Home down to a

Table 4.2.2(1) Specifications for the HERS Reference and Rated Homes

Building Component	HERS Reference Home	Rated Home
		minimum net free vent area of 1ft^2 per 1,500 ft^2 of crawlspace floor area.
		Same as Rated Home
Doors:	Area: 40 ft^2	Same as Rated Home
	Orientation: North	Same as Rated Home
	U-factor: same as fenestration from Table 4.2.2(2)	Same as Rated Home
Glazing: [a]	Total area [b] =18% of conditioned floor area	Same as Rated Home
	Orientation: equally distributed to four (4) cardinal compass orientations (N,E,S,&W)	Same as Rated Home
	U-factor: from Table 4.2.2(2)	Same as Rated Home
	SHGC: from Table 4.2.2(2)	Same as Rated Home
	Interior shade coefficient: Summer = 0.70 Winter = 0.85	Same as HERS Reference Home [c]
	External shading: none	Same as Rated Home
Skylights	None	Same as Rated Home
Thermally isolated sunrooms	None	Same as Rated Home
Air exchange rate	Specific Leakage Area (SLA) [d] = 0.00036 (assuming no energy recovery)	For residences that are not tested, the same as the HERS Reference Home For residences without mechanical ventilation systems that are tested in accordance with ASHRAE Standard 119, Section 5.1, the measured air exchange rate [e] but not less than 0.30 ach For residences with mechanical ventilation systems that are tested in accordance with ASHRAE Standard 119, Section 5.1, the measured air exchange rate [e] combined with the mechanical ventilation rate,[f] which shall not be less than 0.01 x CFA + 7.5 x (Nbr+1) cfm
Mechanical ventilation:	None, except where a mechanical	Same as Rated Home

Table 4.2.2(1) Specifications for the HERS Reference and Rated Homes

Building Component	HERS Reference Home	Rated Home
	ventilation system is specified by the Rated Home, in which case: Annual vent fan energy use: kWh/yr = 0.03942*CFA + 29.565*(N_{br}+1) (per dwelling unit) where: CFA = conditioned floor area N_{br} = number of bedrooms	Same as Rated Home
Internal gains:	As specified by Table 4.2.2(3)	Same as HERS Reference Home, except as provided by Section 4.2.1.7.2
Internal mass:	An internal mass for furniture and contents of 8 pounds per square foot of floor area	Same as HERS Reference Home, plus any additional mass specifically designed as a Thermal Storage Element [g] but not integral to the building envelope or structure
Structural mass:	For masonry floor slabs, 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air For masonry basement walls, same as Rated Home, but with insulation required by Table 4.2.2(2) located on the interior side of the walls For other walls, for ceilings, floors, and interior walls, wood frame construction	Same as Rated Home Same as Rated Home Same as Rated Home
Heating systems [h],[i]	Fuel type: same as Rated Home Efficiencies: Electric: air source heat pump in accordance with Table 4.2.2(1a) Non-electric furnaces: natural gas furnace in accordance with Table 4.2.2(1a) Non-electric boilers: natural gas boiler in accordance with Table 4.2.2(1a) Capacity: sized in accordance with Section 4.5.1.4 of this	Same as Rated Home [i] Same as Rated Home Same as Rated Home Same as Rated Home Same as Rated Home

Table 4.2.2(1) Specifications for the HERS Reference and Rated Homes

Building Component	HERS Reference Home	Rated Home
	Standard.	
Cooling systems [h],[k]	Fuel type: Electric Efficiency: in accordance with Table 4.2.2(1a) Capacity: sized in accordance with Section 4.5.1.4 of this Standard.	Same as Rated Home [k] Same as Rated Home Same as Rated Home
Service water heating systems [h] [m]	Fuel type: same as Rated Home Efficiency Electric: EF = 0.97 - (0.00132 * store gal) Fossil fuel: EF = 0.67 - (0.0019 * store gal) Use (gal/day): $30*N_{du} + 10*N_{br}$ where N_{du} = number of dwelling units Tank temperature: 120 F	Same as Rated Home [m] Same as Rated Home Same as Rated Home Same as Rated Home Same as HERS Reference Home Same as HERS Reference Home
Thermal distribution systems:	A thermal distribution system efficiency (DSE) of 0.80 shall be applied to both the heating and cooling system efficiencies.	As specified by Table 4.2.2(4), except when tested in accordance with ASHRAE Standard 152-2004[n], and then either calculated through hourly simulation or calculated in accordance with ASHRAE Standard 152-2004
Thermostat	Type: manual Temperature setpoints: cooling temperature set point = 78 F; heating temperature set point = 68 F	Type: Same as Rated Home Temperature setpoints: same as the HERS Reference Home, except as required by Section 4.2.1.1

Table 4.2.2(1) Notes:

(a) Glazing shall be defined as sunlight-transmitting fenestration, including the area of sash, curbing or other framing elements, that enclose conditioned space. Glazing includes the area of sunlight-transmitting fenestration assemblies in walls bounding conditioned basements. For doors where the sunlight-transmitting opening is less than 50% of the door area, the glazing area is the sunlight transmitting opening area shall be used. For all other doors, the glazing area is the rough frame opening area for the door, including the door and the frame.

(b) For homes with conditioned basements and for multi-family attached homes the following formula shall be used to determine total window area:

AF = 0.18 x CFA x FA x F

where:
AF = Total fenestration area
CFA = Total floor area of directly conditioned space
FA = (Above-grade thermal boundary gross wall area) / (above-grade boundary wall area + 0.5 x below-grade boundary wall area)
F = 1- 0.44* (Common Wall Area) / (above-grade thermal boundary wall area + common wall area)

and where:
Thermal boundary wall is any wall that separates conditioned space from unconditioned space or ambient conditions
Above-grade thermal boundary wall is any portion of a thermal boundary wall not in contact with soil.
Below-grade boundary wall is any portion of a thermal boundary wall in soil contact
Common wall is the total wall area of walls adjacent to another conditioned living unit, not including foundation walls.

(c) For fenestrations facing within 15 degrees of due south that are directly coupled to thermal storage mass, the winter interior shade coefficient shall be permitted to increase to 0.95 in the Rated Home.

(d) Where Leakage Area (L) is defined in accordance with Section 5.1 of ASHRAE Standard 119 and where SLA = L / CFA (where L and CFA are in the same units). Either hourly calculations using the procedures given in the 2001 ASHRAE Handbook of Fundamentals, Chapter 26, page 26.21, equation 40 (Sherman-Grimsrud model) or calculations yielding equivalent results shall be used to determine the energy loads resulting from air exchange.

(e) Tested envelope leakage shall be determined and documented by a Certified Rater using the on-site inspection protocol as specified in Appendix A, *Mortgage Industry National Home Energy Rating Systems Standards* under "Blower Door Test." Either hourly calculations using the procedures given in the 2001 ASHRAE Handbook of Fundamentals, Chapter 26, page 26.21, equation 40 (Sherman-Grimsrud model) or calculations yielding equivalent results shall be used to determine the energy loads resulting from air exchange.

(f) The combined air exchange rate for infiltration and mechanical ventilation shall be determined in accordance with equation 43 of 2001 ASHRAE Handbook of Fundamentals page 26.24 in combination with the" Whole-house Ventilation" provisions of 2001 ASHRAE Handbook of Fundamentals, page 26.19 for intermittent mechanical ventilation.

(g) Thermal storage element shall mean a component not normally part of the floors, walls, or ceilings that is part of a passive solar system, and that provides thermal storage such as enclosed water columns, rock beds, or phase change containers. A thermal storage element must be in the same room as fenestration that faces within 15 degrees of due south, or must be connected to such a room with pipes or ducts that allow the element to be actively charged.

(h) For a Rated Home with multiple heating, cooling, or water heating systems using different fuel types, the applicable system capacities and fuel types shall be weighted in accordance with the loads distribution (as calculated by accepted engineering practice for that equipment and fuel type) of the subject multiple systems. For the HERS Reference Home, the prevailing federal minimum efficiency shall be assumed except that the efficiencies given in Table 4.2.2(1a) below will be assumed when:

1) A type of device not covered by NAECA is found in the Rated Home;

2) The Rated Home is heated by electricity using a device other than an air source heat pump; or

3) The Rated Home does not contain one or more of the required HVAC equipment systems.

Table 4.2.2(1a). Default HERS Reference Home Heating and Cooling Equipment Efficiencies (i) (k) (m) (n)

Rated Home Fuel	Function	Reference Home Device
Electric	Heating	7.7 HSPF air source heat pump
Non-electric warm air furnace or space heater	Heating	78% AFUE gas furnace
Non-electric boiler	Heating	80% AFUE gas boiler
Any type	Cooling	13 SEER electric air conditioner
Biomass System (o)	Heating	63% Efficiency

Table 4.2.2(1a) Notes:

(i) For a Rated Home without a proposed heating system, a heating system with the prevailing federal minimum efficiency shall be assumed for both the HERS Reference Home and Rated Home. For electric heating systems, the prevailing federal minimum efficiency air-source heat pump shall be selected.

(k) For a Rated Home without a proposed cooling system, an electric air conditioner with the prevailing federal minimum efficiency shall be assumed for both the HERS Reference Home and the Rated Home.

(m) For a Rated Home with a non-storage type water heater, a 40-gallon storage-type water heater with the prevailing federal minimum efficiency and with the same fuel as the proposed water heater shall be assumed for the HERS Reference Home. For a Rated Home without a proposed water heater, a 40-gallon storage-type water heater with the

prevailing federal minimum efficiency with the same fuel as the predominant heating fuel type shall be assumed for both the Rated and HERS Reference Homes.

(n) Tested duct leakage shall be determined and documented by a Certified Rater using the on-site inspection protocol as specified in Appendix A under "Air leakage (ducts)".

(o) Biomass fuel systems should not be included in ratings when they are considered "supplemental systems", i.e. where an automatic system, sized to meet the load of the house exists. Biomass systems should only be included in the rating in those situations where the automatic heating system is not large enough to meet the load of the house, and a biomass fuel system is in place to meet the balance of the load, or where there is only a biomass fuel system in place. In the situation where there are two systems that together meet the load, the biomass system shall be assigned only that part of the load that cannot be met by the automatic system.

Table 4.2.2(2). Component Heat Transfer Characteristics for HERS Reference Home [a]

Climate Zone [b]	Fenestration and Opaque Door U-Factor	Glazed Fenestration Assembly SHGC	Ceiling U-Factor	Frame Wall U-Factor	Floor Over Unconditioned Space U-Factor	Basement Wall U-Factor [c]	Slab-on-Grade [d,e] R-Value & Depth
1	1.20	0.40	0.035	0.082	0.064	0.360	0
2	0.75	0.40	0.035	0.082	0.064	0.360	0
3	0.65	0.40	0.035	0.082	0.047	0.360	0
4 except Marine	0.40	0.55	0.030	0.082	0.047	0.059	10, 2 ft.
5 and Marine 4	0.35	0.55	0.030	0.060	0.033	0.059	10, 2 ft.
6	0.35	0.55	0.026	0.060	0.033	0.059	10, 4 ft.
7 and 8	0.35	0.55	0.026	0.057	0.033	0.059	10, 4 ft.

Notes:
(a) Non-fenestration U-Factors shall be obtained from measurement, calculation, or an approved source.
(b) Climates zones shall be as specified by the 2004 Supplement to the International Energy Conservation Code.
(c) For basements where the conditioned space boundary comprises the basement walls.
(d) R-5 shall be added to the required R-value for slabs with embedded heating.
(e) Insulation shall extend downward from the top of the slab vertically to the depth indicated.

Table 4.2.2(3). Internal Gains for HERS Reference Homes [a]

End Use / Component	Sensible Gains (Btu/day)			Latent Gains (Btu/day)		
	a	b	c	a	b	c

End Use / Component	Sensible Gains (Btu/day)			Latent Gains (Btu/day)		
	a	b	c	a	b	c
Residual MELs		7.27			0.38	
Interior lighting	4,253	7.48				
Refrigerator	5,955		168			
TVs	3,861		645			
Range/Oven (elec) (b)	2,228		262	248		29
Range/Oven (gas) (b)	4,086		488	1,037		124
Clothes Dryer (elec) (b)	661		188	73		21
Clothes Dryer (gas) (b)	738		209	91		26
Dish Washer	219		87	219		87
Clothes Washer	95		26	11		3
Gen water use	-1227		-409	1,245		415
Occupants (c)			3716			2,884

Notes for Table 4.2.2(3)

(a) Table values are coefficients for the following general equation:
Gains = a + b*CFA + c*Nbr
where CFA = Conditioned Floor Area and Nbr = Number of bedrooms.

(b) For Rated Homes with electric appliance use (elec) values and for Rated homes with natural gas-fired appliance use (gas) values

(c) Software tools shall use either the occupant gains provided above or similar temperature dependent values generated by the software where the number of occupants equals the number of bedrooms and occupants are present in the home 16.5 hours per day.

Table 4.2.2(4). Default Distribution System Efficiencies for Inspected Systems (a)

Distribution System Configuration and Condition:	Forced Air Systems	Hydronic Systems (b)
Distribution system components located in unconditioned space	0.80	0.95
Distribution systems entirely located in conditioned space (c)	0.88	1.00
Proposed "reduced leakage" with entire air distribution system located in the conditioned space (d)	0.96	
Proposed "reduced leakage" air distribution system with components located in the unconditioned space(d)	0.88	
"Ductless" systems (e)	1.00	

Table 4.2.2(4) Notes:

(a) Default values given by this table are for distribution systems as rated, which meet minimum IECC 2000 requirements for duct system insulation.

(b) Hydronic Systems shall mean those systems that distribute heating and cooling energy directly to individual spaces using liquids pumped through closed loop piping and that do not depend on ducted, forced air flows to maintain space temperatures.

(c) Entire system in conditioned space shall mean that no component of the distribution system, including the air handler unit or boiler, is located outside of the conditioned space boundary.

(d) Proposed "reduced leakage" shall mean substantially leak free to be leakage of not greater than 3 cfm to outdoors per 100 square feet of conditioned floor area and not greater than 9 cfm total air leakage per 100 square feet of conditioned floor area at a pressure differential of 25 Pascal across the entire system, including the manufacturer's air handler enclosure. Total air leakage of not greater than 3 cfm per 100 square feet of conditioned floor area at a pressure difference of 25 Pascal across the entire system, including the manufacturer's air handler enclosure, shall be deemed to meet this requirement without measurement of air leakage to outdoors. This rated condition shall be specified as the required performance in the construction documents and requires confirmation through field-testing of installed systems as documented by a Certified Rater.

(e) Ductless systems may have forced airflow across a coil but shall not have any ducted airflows external to the manufacturer's air handler enclosure.

Table 4.2.2(5). Default Solar Absorptance for Various Roofing Surfaces

Roof Materials	Absorptance
White Composition Shingles	0.80
White Tile (including concrete)	0.60
White Metal	0.50
All others	0.92

4.2.2.1. All enclosure elements shall use framing fractions that are consistent with and representative of reality. Default enclosure framing fractions are provided by Table 4.2.2(6).

Table 4.2.2(6) Default Framing Fractions for Enclosure Elements

Enclosure Element	Frame Spacing (in o.c.)	Default Frame Fraction (% area)
Walls (standard):		
@16" o.c.	16	23%
@24" o.c.	24	20%
Walls (advanced):		
@16" o.c.	16	19%
@24" o.c.	24	16%
Structural.Insulated.Panels	48	10%
Floors (standard):		
@16" o.c.	16	13%
@24" o.c.	24	10%
Floors (advanced):		
@16" o.c.	16	11%

Table 4.2.2(6) Default Framing Fractions for Enclosure Elements

Enclosure Element	Frame Spacing (in o.c.)	Default Frame Fraction (% area)
@24" o.c.	24	8%
Ceilings (standard trusses):		
@16" o.c.	16	14%
@24" o.c.	24	11%
Ceilings (advanced trusses – "raised heel"):		
@16" o.c.	16	10%
@24" o.c.	24	7%
Ceilings (conventional framing):		
@16" o.c.	16	13%
@24" o.c.	24	9%

4.2.2.2. Insulation Inspections: All enclosure elements for the Rated Home shall have their insulation assessed in accordance with this Standard. Installed cavity insulation shall be rated as Grade I, II, or III in accordance with the on-site inspection procedures of Appendix A, *Mortgage Industry National Home Energy Rating Systems Standard*.

4.2.2.2.1. The HERS Reference Home enclosure elements shall be modeled assuming Grade I insulation. Default values for Rated Home insulation that is not inspected according to the procedures of Appendix A, *Mortgage Industry National Home Energy Rating Systems Standards* shall be in accordance with the requirements of Grade III as given in Section 4.2.2.2.2 and shall be recorded as "not inspected" in the rating information.

Exceptions:

(a) Modular and manufactured housing using IPIA (In-Plant Inspection Agent) inspections may be substituted for the HERS inspection. However, housing manufacturer shall include RESNET insulation inspection details and requirements in their "DAPIA" (Design Approval Primary Inspection Agency) packages submitted to HUD which are used by IPIA's for their factory inspections.

(b) Structural Insulated Panels (SIP's), Insulated Concrete Forms (ICF's), and other similar insulated manufactured assemblies. Note that manufacturer's claims of "equivalent" R-values based on reduced air leakage or other secondary effects may not be used; only the thermal resistance values for the actual materials as found in ASHRAE Handbook of Fundamentals may be used.

(c) A RESNET-approved, third-party audited installer certification program may be substituted under the conditions specified in the RESNET approval process.

4.2.2.2.2. Insulation Assessment: Insulated surfaces categorized as "Grade I" shall be modeled such that the insulation R-value within the cavity is considered at its measured (for loose fill) or labeled value, including other adjustments such as

compression, and cavity fill versus continuous, for the insulated surface area (not including framing or other structural materials which shall be accounted for separately). Insulated surfaces categorized as "Grade II" shall be modeled such that there is no insulation R-value for 2% of the insulated surface area and its measured or labeled value, including other adjustments such as compression and cavity fill versus continuous, for the remainder of the insulated surface area (not including framing or other structural materials). Insulated surfaces categorized as "Grade III" shall be modeled such that there is no insulation R-value for 5% of the insulated surface area and its measured or labeled value, including other adjustments such as compression and cavity fill versus continuous, for the remainder of the insulated surface area (not including framing or other structural materials). Other building materials, including framing, sheathing, and air films shall be assigned aged or settled -values according to ASHRAE Fundamentals. In addition, the following accepted conventions shall be used in modeling Rated Home insulation enclosures:

4.2.2.2.3. Insulation that does not cover framing members shall not be modeled as if it covers the framing. Insulated surfaces that have continuous insulation (i.e. rigid foam, fibrous batts, loose fill, or sprayed insulation) covering the framing members shall be assessed and modeled according to Section 4.2.2.2 and combined with the cavity insulation, framing and other materials to determine the overall assembly R-value.

4.2.2.2.4. Compression: for modeling purposes, the base R-value of fibrous insulation that is compressed to less than its full rated thickness in a completely enclosed cavity shall be assessed according to the manufacturer's documentation; in the absence of such documentation, use R-value correction factor (CF) for Compressed Batt or Blanket from Manual J, 8th edition Table A5-1, Section 7-d.

4.2.2.2.5. Where large areas of insulation that is missing, or has a different R-value from the rest of an assembly exist, these areas shall be modeled with the appropriate R-value and assembly description separately from the rest of the assembly. Insulation R-values may not be averaged according to coverage area. For example, if 50 square feet of a wall area has no cavity fill insulation at all, that 50 square feet shall be recorded as a separate building component with no cavity insulation, but with the existing structural components.

4.2.2.2.6. Steel framing in insulated assemblies: calculations for the overall thermal properties of steel-framed walls, ceilings and floors shall be based on the “Zone Method” from 2009 ASHRAE Handbook of Fundamentals (p 27.5); or equivalent.

4.2.2.3. Renewable energy systems, using solar, wind or other renewable energy sources, which offset the energy consumption requirements of the Rated Home, shall not be included in the Reference Home.

4.2.2.4. For non-electric warm furnaces and non-electric boilers, the values in Table 4.2.2.4(1) shall be used for electric auxiliary energy (EAE) in the Reference Home.

Table 4.2.2.4(1) Electric Auxiliary Energy for Fossil Fuel Heating Systems

System Type	EAE
Oil boiler	330
Gas boiler	170
Oil furnace	439 + 5.5*Capacity (kBtu/h)
Gas furnace	149 + 10.3*Capacity (kBtu/h)

4.2.2.5. Lighting, Appliances and Miscellaneous Electric Loads (MELs)

4.2.2.5.1. HERS Reference Home. Lighting, appliance and miscellaneous electric loads in the HERS Reference Home shall be determined in accordance with the values provided in Table 4.2.2.5(1) and Table 4.2.2.5(2), as appropriate, and equation 4.2-1:

kWh (or therms) per year = a + b*CFA + c*Nbr (Eq 4.2-1)

where:

'a', 'b', and 'c' are values provided in Table 4.2.2.5.1(1) and Table 4.2.2.5.1(2)

CFA = conditioned floor area

Nbr = number of bedrooms

4.2.2.5.1.1. Electric Reference Homes. Where the Rated Home has electric appliances, the HERS Reference Home lighting, appliance and miscellaneous loads shall be determined in accordance with the values given in Tables 4.1.2.5(1).

Table 4.2.2.5(1) Lighting, Appliance and Miscellaneous Electric Loads (kWh/yr) in electric HERS Reference Homes

End Use Component[(a)]	Equation Coefficients		
	a	b	c
Residual MELs		0.91	
Interior lighting	455	0.80	
Exterior lighting	100	0.05	
Refrigerator	637		18
Televisions	413		69
Range/Oven	331		39
Clothes Dryer	524		149
Dish Washer	78		31
Clothes Washer	38		10

Table 4.2.2.5(1) Notes:

(a) For homes with garages, an additional 100 kWh per year shall be added to the HERS Reference home for garage lighting.

4.2.2.5.1.2. Reference Homes with Natural Gas Appliances. Where the Rated Home is equipped with natural gas cooking or clothes drying appliances, the Reference Home cooking and clothes drying loads defined above in Table 4.2.2.5(1) shall be replaced by the natural gas and electric appliance loads provided below in Table 4.2.2.5(2), as applicable.

Table 4.2.2.5(2) Natural Gas Appliance Loads (therms/yr) for HERS Reference Homes with gas appliances

End Use Component[(a)]	Equation Coefficients		
	a	b	c
Range/Oven (therms)	22.6		2.7
Range/Oven (kWh)	22.6		2.7
Clothes Dryer (therms)	18.8		5.3
Clothes Dryer (kWh)	41		11.7

Table 4.2.2.5(2) Notes:

(a) Both the natural gas and the electric components shall be included in determining the HERS Reference Home annual energy use for the above appliances.

4.2.2.5.1.3. Garage Lighting. Where the Rated Home includes an enclosed garage, 100 kWh/yr shall be added to the energy use of the Reference Home to account for garage lighting.

4.2.2.5.1.4. Mechanical Ventilation. Where mechanical ventilation is provided in the Rated home, $REUL_{LA}$ shall be modified for the Reference Home by adding [0.03942*CFA + 29.565*(N_{br}+1)] kWh/yr for ventilation fan operation, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

4.2.2.5.1.5. Ceiling Fans. Where ceiling fans are included in the Rated Home they shall also be included in the Reference Home in accordance with the provisions of Section 4.2.2.5.2.11 of this Standard.

4.2.2.5.2. Rated Homes. For Rated homes, the following procedures shall be used to determine lighting, appliance and residual miscellaneous electric load energy consumption.

4.2.2.5.2.1. Residual MELs. Residual miscellaneous electric loads in the Rated Home shall be the same as in the HERS Reference Home and shall be calculated as 0.91*CFA, where CFA is the conditioned floor area.

4.2.2.5.2.2. Interior Lighting. Interior lighting in the Rated home is calculated using equation 4.2-2:

$$\mathbf{kWh/yr = 0.8*[(4 - 3*qFF_{IL})/3.7]*(445 + 0.8*CFA) + 0.2*(455 + 0.8*CFA)} \quad \textbf{(Eq 4.2-2)}$$

where:

CFA = Conditioned floor area

qFF_{IL} = the ratio of the Qualifying interior Light Fixtures to all interior light fixtures in Qualifying interior Light Fixture Locations.

For rating purposes, the Rated Home shall not have qFF_{IL} less than 0.10 (10%).[4]

For the purpose of adjusting the annual interior lighting energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{IL}, which shall be calculated as the annual interior lighting energy use derived by the procedures in this section minus the annual interior lighting energy use derived for the HERS Reference Home in Section 4.2.2.5.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

For Interior lighting, internal gains in the Rated home shall be modified by 100% of the interior lighting ΔEUL_{IL} converted to Btu/day as follows: $\Delta EUL_{IL} * 10^6 / 365$.

4.2.2.5.2.3. Exterior Lighting. Exterior lighting in the Rated home shall be determined using equation 4.2-3:

$$\mathbf{kWh/yr = (100 + 0.05*CFA)*(1-FF_{EL}) + 0.25*(100 + 0 .05*CFA)*FF_{EL}} \quad \textbf{(Eq 4.2-3)}$$

where

CFA = Conditioned floor area

FF_{EL} = Fraction of exterior fixtures that are Qualifying Light Fixtures

For the purpose of adjusting the annual exterior lighting energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{EL}, which shall be calculated as the annual exterior lighting energy use derived by the procedures in this section minus the annual exterior lighting energy use derived for the HERS Reference Home in Section 4.2.2.5.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

Internal gains in the Rated Home shall not be modified as a result of reductions in exterior lighting energy use.

4.2.2.5.2.4. Garage Lighting. For Rated homes with garages, garage lighting in the Rated home shall be determined using equation 4.2-4:

$$\mathbf{kWh = 100*(1-FF_{GL}) + 25*FF_{GL}} \quad \textbf{(Eq 4.2-4)}$$

where:

FF_{GL} = Fraction of garage fixtures that are Qualifying Light Fixtures

[4] Informative Note: When qFF_{IL} = 0.10 (10%), the above equation reduces to the standard interior lighting equation of: kWh/yr = 455 + 0.8*CFA.

For the purpose of adjusting the annual garage lighting energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{GL}, which shall be calculated as the annual garage lighting energy use derived by the procedures in this section minus the annual garage lighting energy use derived for the HERS Reference Home in Section 4.2.2.5.1 (i.e. 100 kWh/yr), converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

Internal gains in the Rated Home shall not be modified as a result of reductions in garage lighting energy use.

4.2.2.5.2.5. Refrigerators. Refrigerator energy use for the Rated Home shall be determined from either Refrigerator Energy Guide Labels or from age-based defaults provided in Table 4.2.2.5.2.5(1).

Table 4.2.2.5.2.5(1) Age-based Refrigerator Defaults

Refrigerator/Freezer Type	Annual kWh Equation
Single-door refrigerator only	(13.5*AV + 299)*VR
Single-door refrigerator/freezer	(13.5*AV + 299)*VR
Refrigerator with top freezer	(16.0*AV + 355)*VR
with TDI	(17.6*AV + 391)*VR
Refrigerator with side-by-side freezer	(11.8*AV + 501)*VR
with TDI	(16.3*AV + 527)*VR
Refrigerator with bottom freezer	(16.6*AV + 367)*VR
Upright freezer only manual defrost	(10.3*AV + 264)*VR
Upright freezer only auto defrost	(14.0*AV + 391)*VR
Chest freezer only	(11.0*AV + 160)*VR
where: AV = Adjusted Volume = (refrigerator compartment volume) + 1.63*(freezer compartment volume) TDI = Through the door ice VR = Vintage Ratio from Table 4.2.2.5.2.5(2)	

Table 4.2.2.5.2.5(2) Age-based Vintage Ratios

Refrigerator Vintage	Vintage Ratio
1980 or before	2.50
1981-1984	1.82
1985-1988	1.64
1989-1990	1.39
1991-1993	1.30
1994-2000	1.00
2001 forward	0.77

For the purposes of determining adjusted volume (AV), the following defaults may be used:

Table 4.2.2.5.2.5(3) Default Adjusted Volume Equations

Model Type	Default Equation
Single door refrigerator only	AV = 1.00 * nominal volume
Single door refrigerator/freezer	AV = 1.01 * nominal volume
Bottom Freezer	AV = 1.19 * nominal volume
Top Freezer	AV = 1.16 * nominal volume
Side by Side	AV = 1.24 * nominal volume
Freezer only	AV = 1.73 * nominal volume

For the purpose of adjusting the annual refrigerator energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{FRIG}, which shall be calculated as the annual refrigerator energy use derived by the procedures in this section minus the annual refrigerator energy use derived for the HERS Reference Home in Section 4.2.2.5.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

For refrigerator energy use, internal gains in the Rated home shall be modified by 100% of the refrigerator ΔEUL_{FRIG} converted to Btu/day as follows: $\Delta EUL_{FRIG} * 10^6 / 365$. Internal gains shall not be modified for refrigerators located in unconditioned spaces (e.g. unconditioned garages, etc.)

4.2.2.5.2.6. Televisions. Television energy use in the Rated Home shall be the same as television energy use in the HERS Reference Home and shall be calculated as TVkWh/yr = 413 + 69*Nbr, where Nbr is the number of bedrooms in the Rated Home.

4.2.2.5.2.7. Range/Oven. Range/Oven (cooking) energy use for the Rated Home shall be determined as follows:

1) For electric cooking:
   kWh/yr = BEF * OEF * (331 + 39*Nbr) **(Eq 4.2-5a)**
2) For natural gas cooking:
   Therms/yr = OEF*(22.6 + 2.7*Nbr) **(Eq 4.2-5b)**
   plus:
   kWh/yr = 22.6 + 2.7*Nbr **(Eq 4.2-5c)**

where:
BEF= Burner Energy Factor = 0.91 for induction ranges and 1.0 otherwise.
OEF = Oven Energy Factor = 0.95 for convection types and 1.0 otherwise
Nbr = Number of bedrooms

For the purpose of adjusting the annual Range/Oven energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{RO}, which shall be calculated as the annual Range/Oven energy use derived by the procedures in this section minus the annual Range/Oven energy use derived for the HERS Reference Home in Section 4.2.2.5.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 or (therms/yr) / 10, whichever is applicable.

For Range/Oven energy use, internal gains in the Rated Home shall be modified by 80% of the Range/Oven ΔEUL_{RO} converted to Btu/day as follows: $\Delta EUL_{RO} * 10^6 / 365$. Of this total amount, internal gains shall be apportioned as follows, depending on fuel type:

a) For electric Range/Ovens, 90% sensible internal gains and 10% latent internal gains
b) For gas Range/Ovens, 80% sensible internal gains and 20% latent internal gains.

4.2.2.5.2.8. Clothes Dryers. Clothes Dryer energy use for the Rated Home shall be determined by the following equation.

kWh/yr = 12.5*(164+46.5*Nbr)*FU/EFdry*(CAPw/MEF - LER/392)/(0.2184*(CAPw*4.08+0.24)) **(Eq 4.2-6)**

where:

Nbr = Number of bedrooms in home

FU = Field Utilization factor =1.18 for timer controls **or** 1.04 for moisture sensing

EFdry = Efficiency Factor of clothes dryer (lbs dry clothes/kWh) from the CEC database [5] or use following electric clothes dryer default: 3.01

CAPw = Capacity of clothes washer (ft^3) from the manufacturer's data or the CEC database **or** the EPA Energy Star website [6] **or** use default of 2.874 ft^3

MEF[7] = Modified Energy Factor of clothes washer from Energy Guide Label **or** use default of 0.817

LER = Labeled Energy Rating of clothes washer (kWh/yr) from Energy Guide Label **or** use default of 704

For natural gas clothes dryers the following equations shall be used:

Therms/yr = (result of Eq. 4.2-6)*3412*(1-0.07) *(3.01/EFdry-g)/100000 **(Eq 4.2-7a)**

kWh/yr = (result of Eq. 4.2-6)*0.07*(3.01/EFdry-g) **(Eq 4.2-7b)**

where:

EFdry-g = Efficiency Factor for gas clothes dryer from the CEC database[1] or use the following gas clothes dryer default: 2.67.

For the purpose of adjusting the annual Clothes Dryer energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{CD}, which shall be calculated as the annual Clothes Dryer energy use derived by the procedures in

[5] http://www.energy.ca.gov/appliances/database/excel_based_files/

[6] http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

[7] This value must be determined from the energy rating for clothes washer as it determines the amount of moisture remaining in the clothes after the washer cycle is completed.

this section minus the annual Clothes Dryer energy use derived for the HERS Reference Home in Section 4.2.2.5.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 or (therms/yr) / 10, whichever is applicable.

For Clothes Dryer energy use, total internal gains in the Rated Home shall be modified by 15% of the Clothes Dryer ΔEUL_{CD} converted to Btu/day as follows: $\Delta EUL_{CD} * 10^6 / 365$. Of this total amount, 90% shall be apportioned to sensible internal gains and 10% to latent internal gains. Internal gains shall not be modified for Clothes Dryers located in unconditioned spaces (e.g. unconditioned garages, etc.)

4.2.2.5.2.9. Dishwashers. Dishwasher energy use for the Rated Home shall be determined using the following equation.

kWh/yr = [(86.3 + 47.73/EF)/215]*dWcpy **(Eq 4.2-8a)**

where:

EF = Labeled dishwasher energy factor

or

EF = 215/(labeled kWh/year)

dWcpy = (88.4 + 34.9*Nbr)*12/dWcap

where:

dWcap = Dishwasher place setting capacity; Default = 12 settings for standard sized dishwashers and 8 place settings for compact dishwashers

And the change (Δ) in daily hot water use (GPD – gallons per day) for dishwashers shall be calculated as follows:[8]

ΔGPD_{DW} = [(88.4+34.9*Nbr)*8.16 - (88.4+34.9*Nbr) *12/dWcap*(4.6415*(1/EF) - 1.9295)]/365 **(Eq 4.2-8b)**

For the purpose of adjusting the annual Dishwasher energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{DW}, which shall be calculated as the annual Dishwasher energy use derived by the procedures in this section minus the annual Clothes Dishwasher energy use derived for the HERS Reference Home in Section 4.2.2.5.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 or (therms/yr) / 10, whichever is applicable.

For the purpose of adjusting the daily hot water use for calculating the rating, the daily hot water use change shall be 'ΔGPD_{DW}' as calculated above.

For Dishwasher energy use, total internal gains in the Rated Home shall be modified by 60% of the Dishwasher ΔEUL_{DW} converted to Btu/day as follows: $\Delta EUL_{DW} * 10^6 / 365$. Of this total amount, 50% shall be apportioned to sensible internal gains and 50% to latent internal gains.

[8] http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_dishwasher.xls

4.2.2.5.2.10. Clothes Washers. Clothes Washer annual energy use and daily hot water use for the Rated Home shall be determined as follows.

Annual energy use shall be calculated using the following equation:

kWh/yr = ((LER/392)-((LER*($/kWh)-AGC)/(21.9825*($/kWh) - ($/therm))/392)*21.9825)*ACY **(Eq 4.2-9a)**

where:

LER = Label Energy Rating (kWh/yr) from Energy Guide Label

$/kWh = Electric Rate from Energy Guide Label

AGC = Annual Gas Cost from Energy Guide Label

$/therm = Gas Rate from Energy Guide Label

ACY = Adjusted Cycles per Year

and where:

ACY = NCY * ((3.0*2.08+1.59)/(CAPw*2.08+1.59))

where:

NCY = (3.0/2.847) * (164 + Nbr*45.6)

CAPw = washer capacity in cubic feet from the manufacturer's data or the CEC database[9] **or** the EPA Energy Star website [10] **or** use default of 2.874 ft^3

And daily hot water use shall be calculated as follows:

DHWgpd = 60 * therms/cyc * ACY / 365 **(Eq 4.2-9b)**

where:

therms/cyc = (LER * $/kWh - AGC) / (21.9825 * $/kWh - $/therm) / 392

For the purpose of adjusting the annual Clothes Washer energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{CW}, which shall be calculated as the annual Clothes Washer energy use derived by the procedures in this section minus the annual Clothes Washer energy use derived for the HERS Reference Home in Section 4.2.2.5.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 **or** (therms/yr) / 10, whichever is applicable.

For the purpose of adjusting the daily hot water use for calculating the rating, the daily hot water use change shall be calculated as the daily hot water use derived by the procedures in this section minus 3.97 gallons per day for the reference standard clothes washer.

For Clothes Washer energy use, total internal gains in the Rated Home shall be modified by 30% of the Clothes Washer ΔEUL_{CW} converted to Btu/day as follows: $\Delta EUL_{CW} * 10^6 / 365$. Of this total amount, 90% shall be apportioned to sensible internal gains and 10% to latent internal gains. Internal gains shall not be

[9] http://www.energy.ca.gov/appliances/database/excel_based_files/

[10] http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

modified for Clothes Washers located in unconditioned spaces (e.g. unconditioned garages, etc.)

Rating and label data on clothes washer may be found at the following web sites:

EPA: www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers
CEC:
www.energy.ca.gov/appliances/database/excel_based_files/Clothes_Washers/

4.2.2.5.2.11. Ceiling Fans. If ceiling fans are included in the Rated home, they shall also be included in the Reference home. The number of bedrooms plus one (Nbr+1) ceiling fans shall be assumed in both the Reference Home and the Rated Home. A daily ceiling fan operating schedule equal to 10.5 full-load hours shall be assumed in both the Reference Home and the Rated Home during periods when ceiling fans are operational. Ceiling fans shall be assumed to operate only during the cooling season, which may be estimated to be all months with an average temperature greater than 63 ^{o}F. The cooling thermostat (but not the heating thermostat) shall be set up by 0.5 ^{o}F in both the Reference and Rated Home during periods when ceiling fans are assumed to operate.

The Reference Home shall use number of bedrooms plus one (Nbr+1) Standard Ceiling Fans of 42.6 watts each. The Rated Home shall use the Labeled Ceiling Fan Standardized Watts (LCFSW), also multiplied by number of bedrooms plus one (Nbr+1) fans to obtain total ceiling fan wattage for the Rated Home. The Rated Home LCFSW shall be calculated as follows:

LCFSW = (3000cfm) / (cfm/watt as labeled at medium speed) (Eq 4.2-10)

Where installed ceiling fans in the Rated Home have different values of LCFSW, the average LCFSW shall be used for calculating ceiling fan energy use in the Rated Home.

During periods of fan operation, the fan wattage, at 100% internal gain fraction, shall be added to internal gains for both the Reference and Rated Homes. In addition, annual ceiling fan energy use, in MBtu/yr [(kWh/yr)/293], for both the Rated and Reference homes shall be added to the lighting and appliance end use loads (EUL_{LA} and $REUL_{LA}$, as appropriate) as specified by Equation 5.2-2, Section 5.2 of this Standard.

4.2.2.5.2.12. Mechanical Ventilation System Fans. If ventilation fans are present in the Rated Home, EUL_{LA} shall be adjusted by adding total annual kWh energy consumption of the ventilation system in the Rated Home, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293.

4.2.2.6. If the Rated Home includes On-site Power Production, the Purchased Energy Fraction for the Rated Home (see Section 5.2) shall be used to determine the impact of the On-site Power Production on the HERS Index.

4.3. Operating Condition Assumptions. All HERS providers shall estimate the annual purchased energy consumption for heating, cooling and hot water for both the Rated Home and the Reference Home using the following assumptions–

4.3.1. Programmable Thermostats. Where programmable offsets are available in the Rated Home, 2 ^{o}F temperature control point offsets with an 11 p.m. to 5:59 a.m. schedule for heating and a 9 a.m. to 2:59 p.m. schedule for cooling, and with no offsets assumed for the Reference Home;

4.3.2. Local Climate. The climatologically most representative TMY or equivalent climate data, which may be interpolated between climate sites if interpolation is established or approved by the accrediting body and consistent for all HERS providers operating within a state;

4.3.3. HVAC Sizing. Manufacturer's Equipment Performance Ratings (e.g., HSPF, SEER, AFUE) shall be corrected for local climate conditions and mis-sizing of equipment. To determine equipment mis-sizing, the heating and cooling loads shall be calculated in accordance with ACCA Manual J, Eighth Edition, ASHRAE 2009 Handbook of Fundamentals, or an equivalent computation procedure, using the following assumptions:

4.3.3.1. HERS Reference Home:

4.3.3.1.1. Indoor temperatures shall be 75 F for cooling and 70 F for heating.

4.3.3.1.2. Outdoor temperatures shall be the 99.0% and 1.0% design temperatures as published in the ASHRAE Handbook of Fundamentals for the city where the home is located or the most representative city for which design temperature data are available.

4.3.3.1.3. Infiltration rate in air changes per hour (ach) shall be:

(a) For summer: 1.2 * nL * W
(b) For winter: 1.6 * nL * W
(c) Where: nL = 0.48
(d) W = Weather factor from W Tables in ASHRAE Standard 136

4.3.3.1.4. Mechanical ventilation shall be zero.

4.3.3.1.5. All windows shall have blinds/draperies that are positioned in a manner that gives an Internal Shade Coefficient (ISC) of 0.70 in the summer and an ISC of 0.85 in the winter. These values are represented in ACCA Manual J Eighth Edition as "dark closed blinds" in the summer and "dark, fully drawn roller shades" in the winter.

4.3.3.1.6. Internal heat gains shall be 1,600 Btu/hr sensible for appliances plus 230 Btu/hr sensible and 200 Btu/hr latent per occupant, with the number of occupants equal to the number of bedrooms plus one.

4.3.3.1.7. Heat pump equipment shall be sized to equal the larger of the heating and cooling season calculations in accordance with these procedures.

4.3.3.1.8. Systems shall be smaller than the size calculated using this procedure plus 100 Btu/hr.

4.3.3.2. Rated Home:

4.3.3.2.1. Indoor temperatures shall be 75 F for cooling and 70 F for heating.

4.3.3.2.2. Outdoor temperatures shall be the 99.0% and 1.0% design temperatures as published in the ASHRAE Handbook of Fundamentals for the city where the home is located or the most representative city for which design temperature data are available.

4.3.3.2.3. Infiltration rate shall be either the measured envelope leakage area converted to equivalent natural air changes per hour (ach,nat) or the default value derived above for the Reference Home modified as follows:

(a) For summer: either 1.2 * ach,nat or 1.2 * nL * W
(b) For winter: either 1.6 * ach,nat or 1.6 * nL * W
(c) Where: nL = 0.48
(d) W = Weather factor from W Tables in ASHRAE Standard 136

4.3.3.2.4. Mechanical ventilation shall only be included for systems that are controlled to run every hour or every time the HVAC system operates. Standard bathroom and kitchen ventilation may not be considered as ventilation for sizing purposes.

4.3.3.2.5. Combined infiltration and ventilation may not be less than the ventilation rates required by ASHRAE Standard 62.2-2004, nor greater than nL * W * 1.2 in summer and nL * W * 1.6 in winter.

4.3.3.2.6. Windows shall include observed blinds/draperies. For new homes, all windows shall assume blinds/draperies that are positioned in a manner that gives an Internal Shade Coefficient (ISC) of 0.70 in the summer and an ISC of 0.85 in the winter. (These values are represented in ACCA Manual J Eighth Edition as "dark closed blinds" in the summer and "dark fully drawn roller shades" in the winter.)

4.3.3.2.7. Internal heat gains shall be 1,600 Btu/hr sensible plus 230 Btu/hr sensible and 200 Btu/hr latent per occupant, with the number of occupants equal to the number of bedrooms plus one.

4.3.3.2.8. Heat pump equipment shall be sized to equal the larger of the heating and cooling season calculations in accordance with these procedures.

4.3.3.2.9. To the degree that the installed equipment for the Rated Home exceeds properly sized equipment in accordance with the above procedures, the manufacturer's equipment performance rating shall be reduced accordingly.

4.3.4. Air Source Heat Pumps. For heat pumps and air conditioners where a detailed, hourly HVAC simulation is used to separately model the compressor and evaporator energy (including part-load performance), the back-up heating energy, the distribution fan or blower energy and crank case heating energy, the Manufacturer's Equipment Performance Rating (HSPF and SEER) shall be modified as follows to represent the performance of the compressor and evaporator components alone: HSPF, corr = HSPF, mfg / 0.582 and SEER, corr = SEER, mfg / 0.941. The energy uses of all components (i.e. compressor and distribution fan/blower; and crank case heater) shall then be added together to obtain the total energy uses for heating and cooling.

4.3.5. Ground Source Heat Pumps. For ground-loop and ground-water heat pumps, the Auxiliary Electric Consumption shall be determined as follows:

GSHP Auxiliary Electric Consumption (kWh/yr) = $GSHP_{pump}$ + $GSHP_{fan}$

where:

$GSHP_{pump}$ in watts is the observed pump nameplate data (Volts *Amps) for all hours of heat pump operation. Amps may be taken from nameplate as Run Load Amps (RLA) or Full Load Amps (FLA). Alternatively, pumping energy that is measured on-site with a watt-hour meter, or using measured V*A may be substituted. Such measured pumping energy may be further adjusted for on-site measured duty cycle during heat pump operation, when pumping is intermittent during continuous heat pump operation.

$GSHP_{fan}$: If ducts are attached to the system to deliver heating or cooling, the external fan energy in watts, $GSHP_{fan}$ = (air flow in CFM * 0.5 watts per CFM), shall be added for all hours of heat pump operation. The air flow in CFM shall be (360 * rated cooling Btu/h / 12,000), where 360 is the air flow in CFM per ton (12 kBtu/h) of capacity.

4.3.6. Natural Ventilation. Natural ventilation shall be assumed in both the Reference and Rated Homes during hours when natural ventilation will reduce annual cooling energy use.

4.3.7. Whole House Fans. When a whole-house fan is present in the Rated Home, it shall operate during hours of favorable outdoor conditions, and no whole-house fan shall be assumed in the Reference Home. The fan energy associated with the whole-house fan shall be included in the normalized Energy Consumption for the Rated Home's cooling end-use (nEC_x).

4.4. Minimum Rated Features. All HERS providers shall calculate the estimated annual purchased energy consumption for heating, cooling, water heating and lighting and appliances set forth in Section 4.2 of this Standard using the energy loss and gain associated with the minimum rated features as set forth in Table 4.4.2(1).

4.4.1. Data Sources. If data for the minimum rated features set forth in Section 4.4.1.1 of this Standard cannot be obtained by observation or without destructive disassembly of the home, default values shall be used. The default values are determined from the following sources listed in the preferential order of use:

(a) For manufactured homes, available manufacturer's data:
(b) Current and historical local building practices; or
(c) Current and historical local building codes.

4.4.2. Standard Features.

4.4.2.1. The envelope thermal characteristics of building elements 1 through 7 set forth in Table 4.4.2(1) are determined by site observation.

4.4.2.2. The determination of air leakage and duct leakage values set forth as building elements 10 and 11 in Table 4.4.2(1) are determined by data collected on site using the following procedures listed in preferential order of use:

4.4.2.2.1. Current on-site diagnostic tests conducted in accordance with the requirements set forth in Table 4.2.2(1); or

4.4.2.2.2. Observations of the condition of the building and duct system made by a Certified Rater. Based on these observations, values from Tables 4.1.2(3) shall be used.

4.4.2.3. The energy efficiency of the mechanical equipment set forth as building elements 12 through 14 in Table 4.4.2(1) is determined by data collected on site using the following sources listed in preferential order of use:

(a) Current on-site diagnostic test data as corrected using the following equation:

Eff,rated = Eff,listed * Es,measured / Es,listed
where:
Eff,rated = annual efficiency to use as input to the rating
Eff,listed = listed annual efficiency by manufacturer or directory
Es,measured = measured steady state efficiency of system
Es,listed = manufacturer's listed steady state efficiency, under the same operating conditions found during measurement

(b) Name plate data;
(c) Manufacturer's data sheet; or
(d) Equipment directories.

4.4.2.4. When information on the energy efficiency of mechanical equipment cannot be determined from the sources listed in paragraph 4.3.1.2 of this Standard, the values set forth in Tables 4.4.2(2); 4.4.2(3); 4.4.2(4) and 4.4.2(5) shall be used.

Table 4.4.2(1) Minimum Rated Features

Building element	Minimum Rated Feature
1. Floor/Foundation Assembly	Construction type (slab-on-grade, crawl space; basement), insulation value (edge, under slab, cavity, sheathing), framing material and on-center spacing, insulation installation (Grade I, II, or III), vented or unvented (crawl space), capacitance (if slab or basement receives appreciable solar gain).
2. Walls	Construction type, insulation value (cavity, sheathing), framing material and on-center spacing insulation installation (Grade I, II, or III) capacitance, color (light, medium, or dark).
3. Roof/Ceiling Assembly	Construction type, insulation value (cavity, sheathing), framing material and on-center spacing insulation installation (Grade I, II, or III), framing covered by insulation or exposed, roof color (light, medium, or dark).
4. Rim Joist	Insulation value (cavity, sheathing).
5. Doors	Construction type, insulation value.
6. Windows	Construction type, orientation, U-value (of complete assembly), solar heat gain coefficient, shading.
7. Skylights	Construction type, orientation, tilt, U-value (of complete assembly), heat gain coefficient, shading.
8. Passive Solar System (Direct Gain system)	Solar type, collector type and area, orientation, tilt efficiency, storage tank size, pipe insulation value.
9. Solar Domestic Hot Water Equipment	System type, collector type and area, orientation, tilt, efficiency, storage tank size, pipe insulation value.
10. Air Leakage	Air leakage measurement type (default estimate, blower door test, tracer gas test), volume of conditioned space.
11. Distribution System	System type, location, insulation value (duct and pipe), air leakage measurement type (default estimate, duct pressurization).
12. Heating Equipment	Equipment type, location, efficiency (AFUE, HSPF), auxiliary electric (Eae); power consumption of ground fluid circulating pump(s) for ground-loop and ground-water heat pumps.
13. Cooling Equipment	Equipment type, location, efficiency (SEER, COP).
14. Domestic Hot Water Equipment	Equipment type, location, energy factor or seasonal efficiency, extra tank insulation value, pipe insulation value.
15. Control Systems	Thermostat type.
16. Light fixtures	Number of qualifying and non-qualifying light fixtures in qualifying locations (i.e. kitchens, dining rooms, living rooms, family rooms/dens, bathrooms, hallways, stairways, entrances, bedrooms, garage, utility rooms, home offices, and all outdoor fixtures mounted on a building or pole (excluding landscape lighting)).

Table 4.4.2(1) Minimum Rated Features

Building element	Minimum Rated Feature
17. Refrigerator(s)	Total annual energy consumption (kWh) for all units from: California Energy Commission: Appliance Database at http://www.energy.ca.gov/appliances/appliance/index.html or Association of Home Appliance Manufacturers (AHAM) directories
18. Dishwasher(s)	Energy factor (cycles/kWh) for all units from: the Federal Trade Commission's " Dishwasher Energy Data" posted at http://www.ftc.gov/bcp/conline/edcams/eande/appliances/data/2004/dwasher/brand.htm
19. Ceiling Fans	Labeled cfm, Watts and cfm/Watt at medium fan speed from EPA ENERGY STAR ceiling fan label.
20. Mechanical Ventilation System(s)	Equipment type, daily run hours, measured flow rate, and wattage (may be listed in the Certified Home Ventilating Products Directory available from the Heating and Ventilation Institute (HVI). If air handler fan is used as ventilation fan, record air handler fan wattage from either field measurements or manufacturer's product data. Air handler fan wattage is the product of multiplying voltage by amperes.
21. On-site Power Generation	Total annual kWh generation and total site fuel used in the production of on-site power generation as derived from manufacturer's performance ratings.

Table 4.4.2(2) Default Solid Fuel Combustion Seasonal Efficiencies for Space Heating

Type	Location	Seasonal Efficiency	Notes
EPA-Listed Stove, Furnace, or Boiler	Conditioned space	Contained in the EPA publication "Certified Wood Heaters" and posted at http://www.epa.gov/compliance/resources/publications/monitoring/programs/woodstoves/certifiedwood.pdf	
EPA-Listed Stove, Furnace or Boiler	Unconditioned space	0.85 of EPA listing	
EPA Stove – Not Listed	Conditioned space	60%	For stoves with documented EPA compliance, but not found on EPA's Web site list of certified stoves
EPA Stove – Not	Unconditioned	50%	For stoves with

Table 4.4.2(2) Default Solid Fuel Combustion Seasonal Efficiencies for Space Heating

Type	Location	Seasonal Efficiency	Notes
Listed	space		documented EPA compliance, but not found on EPA's Web site list of certified stoves
EPA-Listed Stove Insert	Enclosed, such as in fireplace	Subtract 10% from listed seasonal efficiency	
Non-EPA Stove	Conditioned space	50%	Not tested or listed by EPA
Non-EPA Stove	Unconditioned space	40%	Not tested or listed by EPA
Biomass Fuel Furnace or Boiler with Distribution System	Conditioned space	50%	Not tested or listed by EPA Distribution system efficiency shall also be considered
Biomass Fuel Furnace or Boiler with Distribution System	Unconditioned space	40%	Not tested or listed by EPA Distribution system efficiency shall also be considered
Biomass Fuel Furnace or Boiler with Distribution System	Outside	30%	Not tested or listed by EPA Distribution system efficiency shall also be considered
Solid Fuel Furnace or Boiler – Independently Tested	Central with ducted or hydronic distribution	0.85 of tested listing	Only permitted with documentation of independent testing lab documentation Distribution system efficiency shall also be considered

Table 4.4.2(3) Default Values for Mechanical System Efficiency (Age-based)*

Mechanical Systems	Units	Pre-1960	1960-1969	1970-1974	1975-1983	1984-1987	1988-1991	1992--2005	2006-present
Heating:									
Gas Furnace	AFUE	0.72	0.72	0.72	0.72	0.72	0.76	0.78	0.78
Gas Boiler	AFUE	0.60	0.60	0.65	0.65	0.70	0.77	0.80	0.80
Oil Furnace or Boiler	AFUE	0.60	0.65	0.72	0.75	0.80	0.80	0.80	0.80

Table 4.4.2(3) Default Values for Mechanical System Efficiency (Age-based)*

Mechanical Systems	Units	Pre-1960	1960-1969	1970-1974	1975-1983	1984-1987	1988-1991	1992--2005	2006-present
Air-Source Heat Pump	HSPF	6.5	6.5	6.5	6.5	6.5	6.80	6.80	7.7
Ground-Water Geothermal Heat pump	COP	2.70	2.70	2.70	3.00	3.10	3.20	3.50	3.6
Ground-Coupled Geothermal Heat Pump	COP	2.30	2.30	2.30	2.50	2.60	2.70	3.00	3.1
Cooling:									
Air-Source Heat Pump	SEER	9.0	9.0	9.0	9.0	9.0	9.40	10.0	13.0
Ground-Water Geothermal Heat Pump	EER	10.00	10.00	10.00	13.00	13.00	14.00	16.0	16.2
Ground-Coupled Geothermal Heat Pump	EER	8.00	8.00	8.00	11.00	11.00	12.00	14.0	13.4
Central Air Conditioner	SEER	9.0	9.0	9.0	9.0	9.0	9.40	10.0	13.0
Room Air Conditioner	EER	8.0	8.0	8.0	8.0	8.0	8.10	8.5	8.5
Water Heating:									
Storage Gas	EF	0.50	0.50	0.50	0.50	0.55	0.56	0.56	0.59
Storage Oil	EF	0.47	0.47	0.47	0.48	0.49	0.54	0.56	0.51
Storage Electric	EF	0.86	0.86	0.86	0.86	0.86	0.87	0.88	0.92

*** Exception:** Where the labeled equipment efficiency exists for the specific piece of existing equipment, the labeled efficiency shall be used in lieu of these minimum input constraints.

TABLE 4.4.2(4) Default Values for Mechanical System Efficiency (not Age-based)*

	Units	Rating
Heating:		
Gas Wall Heater (Gravity)	AFUE	0.72
Gas Floor Furnace	AFUE	0.72
Gas Water Heater (Space Heating).	AFUE	0.75
Electric Furnace	HSPF	3.413
Electric Radiant	HSPF	3.413
Heat Pump Water Heater (Space)	HSPF	5.11

TABLE 4.4.2(4) Default Values for Mechanical System Efficiency (not Age-based)*

	Units	Rating
Electric Water Heater (Space)	HSPF	2.73
Cooling:		
Electric Evaporative Cooling	EER	30
Gas Absorption Cooler	COP	0.40
Water Heating:		
Heat Pump	COP	2.00
Instantaneous Electric	EF	0.87
Instantaneous Gas	EF	0.75
Solar (Use SRCC Adjustment Procedures)	EF	2.00

* Exception: Where the labeled equipment efficiency exists for the specific piece of existing equipment, the labeled efficiency shall be used in lieu of these minimum input constraints.

Table 4.4.2(5) Default EAE Values

System Type	EAE
Oil boiler	330
Gas boiler	170
Oil furnace	439 + 5.5 * Capacity (kBtu/h)
Gas furnace	149 + 10.3 * Capacity (kBtu/h)

4.4.3. Additional Features. Any HERS provider may base annual purchased energy consumption estimates for the Rated Home on additional features if the Rating Provider's energy analysis tool is capable of doing so.

4.5. Existing Home Retrofit Savings. Energy savings for existing home retrofits shall be determined by comparing a Baseline Existing Home with an Improved Home in accordance with the provisions of this section.

4.5.1. Baseline Existing Home. The Baseline Existing Home Model for the purposes of determining the energy savings of an existing home retrofit shall be the original configuration of the existing home, including the full complement of lighting, appliances and residual miscellaneous energy use as specified by Tables 4.2.2.5(1) and 4.2.2.5(2). The energy use of these end uses in the Baseline Existing Home shall be based on the original home configuration following the provision of Section 4.2.2.5.2.

4.5.1.1. Where multiple appliances of the same type exist in the original configuration of the existing home, the same number of those appliance types shall be included in the Baseline Existing Home model.

4.5.1.2. Where a standard appliance as defined by Tables 4.2.2.5(1) and 4.2.2.5(2) does not exist in the original configuration of the existing home, the standard default energy use and internal gains as specified by Table 4.2.2(3) for that appliance shall be included in the Baseline Existing Home model.

4.5.2. Improved Home. The Improved Home model for the purpose of determining the energy savings of an existing home retrofit shall be the existing home's configuration including all energy improvements to the original home and including the full complement of lighting, appliances and residual miscellaneous energy use contained in the home after all energy improvements have been implemented.

4.5.2.1. Where an appliance has been upgraded but the existing appliance is not removed from the existing home property, both the new and existing appliance shall be included in the Improved Home model.[11]

4.5.2.2. Where a standard appliance as defined by Tables 4.2.2.5(1) and 4.2.2.5(2) does not exist in the improved configuration of the existing home, the standard default energy use and internal gains as specified by Table 4.2.2(3) for that appliance shall be included in the Improved Home model.

4.5.2.3. Improvements in lighting and appliance energy use in the Improved Home model shall be calculated in accordance with Section 4.2.2.5.2.

4.5.3. Standard Operating Conditions

4.5.3.1. Both the Baseline Existing Home and Improved Home shall be configured and modeled in accordance with the Rated Home specifications of Table 4.2.2(1) except that the Baseline Home shall not violate the input constraints specified in Table 4.5.3(1) below.

Table 4.5.3(1) Baseline Existing Home Input Constraints

Equipment Constraints*	Minimum Value
Forced-air furnace, AFUE	72%
Hot water / steam boiler, AFUE	60%
Heat Pump, HSPF	6.5
Heat Pump, SEER	9.0
Central air conditioner, SEER	9.0
Room air conditioner, EER	8.0
Gas-fired storage water heater, EF	0.50
Oil-fired storage water heater, EF	0.45
Electric storage water heater, EF	0.86
Enclosure Constraints (including air film conductances)	Maximum U-factor
Wood-frame wall	0.222

[11] For example, if a refrigerator is upgraded to a more efficient model and the original refrigerator is kept on property for potential use as a second refrigerator; both refrigerators shall be included in the Improved Home energy model.

Masonry wall	0.250
Wood-frame ceiling with attic (interior to attic space)	0.286
Unfinished roof	0.400
Wood-frame floor	0.222
Single-pane window, wood frame	0.714
Single-pane window, metal frame	0.833

*** Exception:** Where the labeled equipment efficiency exists for the specific piece of existing equipment, the labeled efficiency shall be used in lieu of these minimum input constraints.

4.5.3.2. Air Distribution Systems

4.5.3.2.1. In cases where the air distribution system leakage is not measured in the original Baseline Existing Home, the ducts shall be modeled in the spaces in which they are located and the air distribution system leakage to outdoors at 25 Pascal pressure difference shall be modeled in both the Baseline Existing Home and the Improved Home as 0.10 times the conditioned floor area of the home split equally between the supply and return side of the air distribution system with the leakage distributed evenly across the duct system.

Exception: If the air handler unit and a minimum of 75% of its duct system are entirely inside the conditioned space boundary, the air distribution system leakage to outdoors at 25 Pascal pressure difference shall be modeled in both the Baseline Existing Home and the Improved Home as 0.05 times the conditioned floor area of the home split equally between the supply and return side of the air distribution system with the leakage distributed evenly across the duct system.

4.5.3.2.2. In cases where the air distribution system leakage is measured:

4.5.3.2.2.1. For the Baseline Existing Home, the ducts shall be modeled in the spaces in which they are located and the air distribution system leakage to outdoors at 25 Pascal pressure difference shall be modeled as the lesser of the measured air distribution system leakage to outdoors at 25 Pascal pressure difference in the original Baseline Existing Home or 0.24 times the conditioned floor area of the home, either split evenly between the supply and return side of the air distribution system or as measured separately with the leakage distributed evenly across the duct system.

4.5.3.2.2.2. For the Improved Home, the ducts shall be modeled in the spaces in which they are located and the air distribution system leakage to outdoors at 25 Pascal pressure difference shall be set equal to the measured air distribution system leakage to outdoors at 25 Pascal pressure difference in the Improved Home, either split evenly between the supply or return side of the air distribution system or as measured separately with the leakage distributed evenly across the duct system.

4.5.3.3. Both the Baseline Existing Home and the Improved Home shall be subjected to the operating conditions specified by Section 4.3.1.4.2.

4.5.4. Energy Savings Calculation

4.5.4.1. Energy units used in the calculation of energy savings shall be units of Equivalent Electric Energy using the Reference Electricity Production Efficiency for fossil fuels. Equivalent electric energy use shall be calculated using Equation 4.5-1.

$$kWh_{eq} = kWh_{elec} + \frac{Btu_{fossil}{}^{*}0.40}{3412} \quad \textbf{(Eq 4.5-1)}$$

4.5.4.2. Energy savings shall be calculated as the difference between the whole-house projected equivalent electric energy use of the Baseline Existing Home and the whole-house projected equivalent electric energy use of the Improved Home.

4.5.4.3. The energy savings percentage of the retrofit shall be calculated as the whole-house equivalent electric energy savings as determined by Section 4.5.4.2 above divided by the whole-house equivalent electric energy use of the Baseline Existing Home.

4.6. Economic Cost Effectiveness. If ratings are conducted to evaluate energy saving improvements to the home for the purpose of an energy improvement loan or energy efficient mortgage, indicators of economic cost effectiveness shall use present value costs and benefits, which shall be calculated as follows:

$$\mathbf{LCC_E = P1*(1^{st}\ Year\ Energy\ Costs)} \quad \textbf{(Eq 4.6-1)}$$

$$\mathbf{LCC_I = P2*(1^{st}\ Cost\ of\ Improvements)} \quad \textbf{(Eq 4.6-2)}$$

where:
LCC_E = Present Value Life Cycle Cost of Energy
LCC_I = Present Value Life Cycle Cost of Improvements
P1 = Ratio of Life Cycle energy costs to the 1^{st} year energy costs
P2 = Ratio of Life Cycle Improvement costs to the first cost of improvements

Present value life cycle energy cost savings shall be calculated as follows:

$$\mathbf{LCC_S = LCC_{E,b} - LCC_{E,i}} \quad \textbf{(Eq 4.6-3)}$$

where:
LCC_S = Present Value Life Cycle Energy Cost Savings
$LCC_{E,b}$ = Present Value LCC of energy for **baseline** home configuration
$LCC_{E,i}$ = Present Value LCC of energy for **improved** home configuration

Standard economic cost effectiveness indicators shall be calculated as follows:

$$\mathbf{SIR = (LCC_S) / (LCC_I)} \quad \textbf{(Eq 4.6-4)}$$

$$\mathbf{NPV = LCC_S - LCC_I} \quad \textbf{(Eq 4.6-5)}$$

where:
SIR = Present Value Savings to Investment Ratio
NPV = Net Present Value of Improvements

4.6.1. Calculation of Ratio Parameters. The ratios represented by parameters P1 and P2 shall be calculated in accordance with the following methodology[12]:

P1 = 1/(DR-ER)*(1-((1+ER)/(1+DR))^nAP) **(Eq 4.6-6a)**

or if DR = ER then

P1 = nAP / (1+DR) **(Eq 4.6-6b)**

where:
P1 = Ratio of Present Value Life Cycle Energy Costs to the 1st year Energy Costs
DR = Discount Rate as prescribed in Section 4.6.2
ER = Energy Inflation Rate as prescribed in Section 4.6.2
nAP = number of years in Analysis Period as prescribed in Section 4.6.2

$P2 = DnPmt + P2_A + P2_B + P2_C - P2_D$ **(Eq 4.6-7)**

where:
P2 = Ratio of Life Cycle Improvement costs to the first cost of improvements
DnPmt = Mortgage down payment rate as prescribed in Section 4.6.2
$P2_A$ = Mortgage cost parameter
$P2_B$ = Operation & Maintenance cost parameter
$P2_C$ = Replacement cost parameter
$P2_D$ = Salvage value cost parameter

$P2_A = (1-DnPmt)*(PWFd/PWFi)$ **(Eq 4.6-8a)**

where:
PWFd = Present Worth Factor for the discount rate = 1/DR*(1-(1/(1+DR)^nAP))
PWFi = Present Worth Factor for the mortgage rate = 1/MR*(1-(1/(1+MR)^nMP))
DR = Discount Rate as prescribed in Section 4.6.2
MR = Mortgage interest Rate as prescribed in Section 4.6.2
nAP = number of years of the Analysis Period as prescribed in Section 4.6.2
nMP = number of years of the Mortgage Period

$P2_B = MFrac*PWinf$ **(Eq 4.6-8b)**

where:
MFrac = annual O&M costs as a fraction of first cost of improvements[13]

[12] Duffie, J.A. and W.A. Beckman, 1980. *Solar Engineering of Thermal Processes*, pp. 381-406, John Wylie & Sons, Inc., New York, NY.

[13] The maintenance fraction includes all incremental costs over and above the operating and maintenance cost of the "standard" measure. Where components of a system have various lifetimes, the longest lifetime may be used and the components with shorter lifetimes may be included as a maintenance cost at the present value of their future maintenance cost. The maintenance fraction may also be used to represent the degradation in

PWinf = ratio of present worth discount rate to present worth general inflation rate
= 1/(DR-GR)*(1-(((1+GR)/(1+DR))^nAP))
or if DR = GR then
= nAP/(1+DR)
GR = General Inflation Rate as prescribed in Section 4.6.2

$P2_C$ = Sum {1/((1+(DR-GR))^(Life*i))} for i=1, n **(Eq 4.6-8c)**

where:
i = the i^{th} replacement of the improvement
Life = the expected service life of the improvement

$P2_D$ = RLFrac / ((1+DR)^nAP) **(Eq 4.6-8d)**

where:
RLFrac = Remaining Life Fraction following the end of the analysis period

4.6.2. Determination of Standard Economic Inputs. The following standard economic input values shall be determined by RESNET in accordance with this Section each January using the latest available specified data and published on the RESNET website.

a) General Inflation Rate (GR)
b) Discount Rate (DR)
c) Mortgage Interest Rate (MR)
d) Down Payment Rate (DnPmt)
e) Energy Inflation Rate (ER)

The economic parameter values used in the cost effectiveness calculations specified in Section 4.6.1 shall be determined as follows:

4.6.2.1. General Inflation Rate (GR) shall be the greater of the 5-year and the 10-year Annual Compound Rate (ACR) of change in the Consumer Price Index for Urban Dwellers (CPI-U) as reported by the U.S. Bureau of Labor Statistics,[14] where ACR shall be calculated as follows:

ACR = ((endVal)/(startVal))^(1.0/((endYr)-(startYr)))-1.0 **(Eq 4.6-9)**

where:
ACR = Annual Compound Rate of change
endVal = Value of parameter at end of period
startVal = Value of parameter at start of period
endYr = Year number at end of period
startYr = Year number at start of period

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performance of a given system. For example, photovoltaic (PV) systems have a performance degradation of about 0.5% per year and this value can be added to the maintenance fraction for PV systems to accurately represent this phenomenon in this cost calculation procedure.

[14] http://www.bls.gov/CPI/#tables

4.6.2.2. Discount Rate (DR) shall be equal to the General Inflation Rate plus 2%.

4.6.2.3. Mortgage Interest Rate (MR) shall be defaulted to the greater of the 5-year and the 10-year average of simple interest rate for fixed rate, 30-year mortgages computed from the Primary Mortgage Market Survey (PMMS) as reported by Freddie Mac unless the mortgage interest rate is specified by a program or mortgage lender, in which case the specified mortgage interest rate shall be used. The mortgage interest rate used in the cost effectiveness calculation shall be disclosed in reporting results.

4.6.2.4. Down Payment Rate (DnPmt) shall be defaulted to 10% of 1st cost of improvements unless the down payment rate is specified by a program or mortgage lender, in which case the specified down payment rate shall be used. The down payment rate used in the cost effectiveness calculation shall be disclosed in reporting results.

4.6.2.5. Energy Inflation Rate (ER) shall be the greater of the 5-year and the 10-year Annual Compound Rate (ACR) of change in the Bureau of Labor Statistics, Table 3A, Housing, Fuels and Utilities, Household Energy Index[15] as calculated using Equation 4.6-9.

4.6.2.6. Mortgage Period (nMP) shall be defaulted to 30 years unless a mortgage finance period is specified by a program or mortgage lender, in which case the specified mortgage period shall be used. The mortgage period used in the cost effectiveness calculation shall be disclosed in reporting results.

4.6.2.7. Analysis Period (nAP) shall be 30 years.

4.6.2.8. Remaining Life Fraction (RLFrac) shall be calculated as follows:

RLFrac = (nAP/Life) – (Integer (nAP/Life)) **(Eq 4.6-10)**

or if Life > nAP

RLFrac = (Life-nAP) / nAP

where:

Life = useful service life of the improvement(s)

4.6.2.9. Improvement Costs. The improvement cost for Energy Conservation Measures (ECMs) shall be included on the Economic Cost Effectiveness Report.

4.6.2.9.1. For New Homes the improvement costs shall be the full installed cost of the improvement(s) less the full installed cost of the minimum standard or code option less any financial incentives that accrue to the home purchaser.

4.6.2.9.2. For Existing Homes the improvement costs shall be the full installed cost of the improvement(s) less any financial incentives that accrue to the home purchaser.

[15] http://www.bls.gov/cpi/cpi_dr.htm

4.6.2.10. Measure Lifetimes. The ECM service life shall be included on the Economic Cost Effectiveness Report. Annex X of this standard provides informative guidelines for service lifetimes of a number of general categories of ECMs.

5. Certification and Labeling.

5.1. Rating Requirements.

5.1.1. General. To determine the Rating for a home, all Rating Providers shall –

5.1.1.1. If rating an existing home, visit the home to collect the data needed to calculate the rating;

5.1.1.2. If rating a new, to-be-built home, follow the procedures set forth in Section 4.7 and 4.8 of these Standards to collect the data needed to calculate the rating;

5.1.1.3. Use the collected data to estimate the annual purchased energy consumption for heating, cooling and water heating, lighting and appliances for both the Rated Home and the Reference Home as defined in Section 4.4 of these Standards.

5.1.1.4. If the Rated Home includes On-site Power Production (OPP), then OPP shall be calculated as the gross electric power produced minus the Equivalent Electric Power of any purchased fuels used to produce the electric power. The HERS Reference Home shall not include On-site Power Production.

For example, assume 1000 kWh (3413 kBtu or 3.413 MBtu) of gross electrical power is produced using 60 therms (6 MBtu) of natural gas to operate a high-efficiency fuel cell system. Using these assumptions, OPP = 3.413 MBtu - (6 MBtu * 0.4) = 1.0 MBtu.

5.1.1.5. Estimates completed by all HERS providers under Sections 5.1.1.3, 5.1.1.4 and 5.1.1.5 of this Standard must be–

5.1.1.5.1. Conducted using the standard operating assumptions established in Section 4.2 of these Standards.

5.1.1.5.2. Based on the minimum rated features set forth in Section 4.3 of these Standards.

5.1.1.5.3. Conducted using rating tools that have been certified for accuracy in accordance with Section 6 of this Standard.

5.1.1.6. All Rating providers shall compare the estimates provided under Section 5.1.1 of this Standard to determine the energy rating of the home and, if applicable, the energy rating of the home with proposed conservation measures and On-site Power Production installed.

5.1.2. Savings Estimates.

5.1.2.1. Energy Cost Savings. If energy cost savings for the Rated Home are calculated, they shall be calculated using the following procedures.

5.1.2.1.1. Energy Prices. Energy costs for all homes shall be calculated using revenue-based energy price rate data published annually by RESNET as derived from the U.S. Department of Energy (DOE) Energy Information Administration (EIA).

5.1.2.1.2. Energy Cost Savings. Estimated energy cost saving estimates for Rated Homes shall be calculated as follows –

5.1.2.1.2.1. HERS Reference Home energy costs shall be determined by fuel type by applying the energy prices determined in accordance with Section 5.1.2.1.1 to the individual fuel types of the HERS Reference Home.

5.1.2.1.2.2. Rated Home energy costs shall be determined by fuel type by applying the same energy prices data used for the HERS Reference Home in Section 5.1.2.1.2.1 above.

5.1.2.1.2.3. For Confirmed, Sampled and Projected Ratings, estimated energy cost savings shall be calculated as follows –

5.1.2.1.2.3.1. Estimated energy cost savings with respect to the HERS Reference Home shall be determined as the difference between the energy costs of the HERS Reference Home and the energy costs of the Rated Home.

5.1.2.1.2.3.2. Estimated energy cost savings with respect to the Typical Existing Home shall be determined as follows –

5.1.2.1.2.3.2.1. For each fuel type, multiply the HERS Reference Home costs by 1.3 to determine the Typical Existing Home energy costs by fuel type.

5.1.2.1.2.3.2.2. Estimated energy cost savings with respect to the Typical Existing Home shall be the difference between the energy costs of the Typical Existing Home and the energy costs of the Rated Home.

5.1.2.2. Pollution Emission Savings. If pollution emission savings for the Rated Home are calculated, they shall be calculated using the following Procedures.

5.1.2.2.1. Pollution Emissions. Pollution emissions for all homes shall be calculated using the following procedures.

5.1.2.2.1.1. For electricity use, pollution emission shall be calculated using the statewide average emission rates provided by the Environmental Protection Agency's most recent eGrid database[16] for electricity generation.

5.1.2.2.1.2. For fossil fuel use, pollution emissions shall be calculated using the emission factors given in Table 5.1.2(1) below.

Table 5.1.2(1) National Average Emission Factors for Household Fuels[17]

Fuel Type	Units	MBtu per Unit	CO2 lb/MBtu	NOx lb/MBtu	SO2 lb/MBtu
Natural Gas	Therm	0.1000	117.6	93.0	0.0000
Fuel Oil #2	Gallon	0.1385	159.4	127.8	0.5066
LPG*	Gallon	0.0915	136.4	153.4	0.0163

* Liquid petroleum gas

5.1.2.2.2. Pollution Emission Savings. Estimated pollution emission savings for Rated Homes shall be calculated as follows –

5.1.2.2.2.1. HERS Reference Home pollution emissions shall be determined by fuel type by applying the pollution emissions determined in accordance with Section 5.1.2.2.1 to the individual fuel types of the HERS Reference Home.

5.1.2.2.2.2. Rated Home pollution emissions shall be determined by fuel type by applying the same pollution emission data used for the HERS Reference Home in Section 5.1.2.2.2.1 above.

5.1.2.2.2.3. For Confirmed, Sampled and Projected Ratings, estimated pollution emission savings shall be calculated as follows –

5.1.2.2.2.3.1. Estimated pollution emission savings with respect to the HERS Reference Home shall be the difference between the pollution emissions of the HERS Reference Home and the pollution emissions of the Rated Home.

5.1.2.2.2.3.2. Estimated pollution emission savings with respect to the Typical Existing Home shall be determined as follows –

5.1.2.2.2.3.2.1. For each fuel type, multiply the HERS Reference Home pollution emissions by 1.3 to determine the Typical Existing Home pollution emissions by fuel type.

5.1.2.2.2.3.2.2. Estimated pollution emission savings with respect to the Typical Existing Home shall be the difference between the pollution

[16] Available online: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
[17] Developed from the U.S. DOE National Impact Analysis AHAM2 report (appendix 15A) http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/aham2_dfr_app-15a_environmentalemissionfactors_2011-04-13.pdf

emissions of the Typical Existing Home and the pollution emissions of the Rated Home.

5.1.3. Reports. All reports generated by RESNET-accredited software rating tools shall, at a minimum, contain the following information:

5.1.3.1. The property location, including city, state, zip code and either the street address or the Community Name and Plan Name for the Rating

5.1.3.2. The name of the certified Rater conducting the rating;

5.1.3.3. The name of the Rating Provider under whose auspices the Rater is certified;

5.1.3.4. The date the Rating was conducted;

5.1.3.5. The name of the software rating tool (including version number) used to determine the Rating; and

5.1.3.6. The following statement in no less than 10 point font, "The Home Energy Rating Standard Disclosure for this home is available from the Rating Provider." At a minimum, this statement shall also include the Rating Provider's mailing address and phone number.

5.1.4. Rating Types. This Standard addresses three Rating Types as follows.

5.1.4.1. Confirmed Rating. All confirmed ratings shall be for individual real properties where all Minimum Rated Features of the Rated Home are verified in the field through inspection and testing in accordance with the minimum requirements of Section 4.4 of this Standard.

5.1.4.1.1. All Confirmed Ratings shall be subject to the Quality Assurance requirements of Section 900 of the RESNET *Mortgage Industry National Home Energy Rating Systems Standard*.

5.1.4.1.2. All Confirmed Ratings shall use the field-verified Minimum Rated Feature characteristics of the Rated Home as input to the accredited software rating tool that generates the Home Energy Rating.

5.1.4.1.3. All Confirmed Ratings shall be submitted to the National RESNET Registry (see Section 5.3) for certification.

5.1.4.1.4. Following registration of Confirmed Ratings, the results of the Rating shall be certified in accordance with Section 5.2 of the Standard.

5.1.4.2. Sampled Rating. Sampled Ratings are a sub-type of Confirmed Ratings whereby field verification of the Minimum Rated Features is accomplished through

sampling procedures in accordance with Section 600 of the RESNET *Mortgage Industry National Home Energy Rating Systems Standard*.

5.1.4.2.1. All Sampled Ratings shall be subjected to the Quality Assurance requirements of Section 900 of the RESNET *Mortgage Industry National Home Energy Rating Systems Standard*.

5.1.4.2.2. All Sampled Ratings shall use the projected Minimum Rated Feature characteristics of the Sampled Home Plan as input to the accredited software rating tool that generates a Worst-Case Home Energy Rating for the Sampled Home Plan.

5.1.4.2.3. All Sampled Ratings shall report the HERS Index that comports with the Worst-Case Home Energy Rating for the Sampled Home Plan.

5.1.4.2.4. All Sampled Ratings shall be submitted to the National RESNET Registry (see Section 5.3) for certification.

5.1.4.2.5. Following registration of Sampled Ratings, the results of the Rating shall be certified in accordance with Section 5.2 of this Standard.

5.1.4.3. Projected Ratings. Projected Ratings are determined based on architectural drawings with material, mechanical and electrical specifications for new home plans, or based on a site audit for existing homes that are to be improved, subject to the following provisions.[18]

5.1.4.3.1. Projected Ratings shall use either the envelope leakage rate specified as the required performance by the construction documents, the site-measured envelope leakage rate, or a default value as specified for the Reference home in Table 4.2.2(1).

5.1.4.3.2. Projected Ratings shall use either the distribution system efficiency specified as the required performance by the construction documents, the site-measured distribution system efficiency, or a default distribution system efficiency value from Table 4.2.2(1); and

5.1.4.3.3. Projected Ratings shall use the planned location and orientation of the proposed home, or if the proposed orientation is unknown, calculate ratings for the home facing each of the four cardinal directions, north, south, east and west, using the largest HERS Index score for the Rating.

5.1.4.3.4. Projected Rating Reports shall contain the following text in no less than 14 point font at the top of the first page of the report: "Projected Rating Based on Plans – Field Confirmation Required."

5.1.4.3.5. Projected Ratings shall not be accepted by the RESNET Registry for Rating Certification.

[18] Projected Ratings are intended primarily for use in the home design process, for plan review where building codes use Ratings as a compliance mechanism and in programs requiring threshold design compliance.

5.1.4.3.6. Projected Ratings shall not use the same or similar Rating Report formats provided by Section 5.2 of this Standard for Certified Ratings.

5.1.4.3.7. Upon completion of construction and field verification of the proposed specifications for all Minimum Rated Features of the Rated Home in accordance with Section 4.3.1 of this Standard (e.g. on-site visual inspections, on-site diagnostic test results or default values for envelope air leakage and distributions system efficiencies), and entry of either the field verified rated features or the threshold specification for a Worst-Case Analysis into an accredited rating tool, a projected Rating for the home shall become a Confirmed Rating for the home.

5.2. National Home Energy Performance Label Certifications. Home Energy Ratings shall be certified through submission of the Rating results to the national RESNET Registry of Rated homes in accordance with the provisions of Section 6 of these Standards. Three Rating Types shall be certified and labeled in accordance with this Section, as follows.

5.2.1. Confirmed Ratings.

5.2.1.1. All Confirmed Ratings shall be labeled using Rating Certification Form 5.2-1 provided by RESNET.

5.2.1.2. In addition to the Rating information required by Section 5.1.3 of this Standard, Rating Certification Form 5.2-1 shall include the following mandatory information –

5.2.1.2.1. The HERS Index for the Rated Home;

5.2.1.2.2. The RESNET Registration ID for the Rated Home;

5.2.1.2.3. The total estimated annual purchased energy consumption by fuel type for space heating, space cooling, domestic hot water, and lighting and appliance energy uses for the Rated Home; and

5.2.1.2.4. The total estimated annual energy cost by fuel type for space heating, space cooling, domestic hot water, and lighting and appliance energy uses for the Rated Home.

5.2.1.3. In addition to the information in Section 5.2.1.2, Rating Certification Form 5.2-1 may include the following additional information –

5.2.1.3.1. The total estimated annual purchased energy consumption by fuel type for space heating, space cooling, domestic hot water, and lighting and appliance energy uses for the HERS Reference Home and

5.2.1.3.2. The total estimated annual energy cost by fuel type for space heating, space cooling, domestic hot water, and lighting and appliance energy uses for the HERS Reference Home.

5.2.1.3.3. The estimated annual energy cost and emission savings as compared to the home with a HERS Index of 100 (reference home).

5.2.1.3.4. The estimated annual energy cost and emission savings as compared to the home with a HERS Index of 130 (typical existing home).

5.2.2. Sampled Ratings.

5.2.2.1. All Sampled Ratings shall be labeled using Rating Certification Form 5.2-2 provided by RESNET.

5.2.2.2. In addition to the Rating information required by Section 5.1.3 of this Standard, Rating Certification Form 5.2-2 shall include the following mandatory information –

5.2.2.2.1. The HERS Index for the Sampled Home as computed for the worst-case threshold specification. Every home plan within a given sample set shall be assigned the same HERS Index as determined by the threshold specification for that floor plan;

5.2.2.2.2. The Builder Name for the Sampled Home;

5.2.2.2.3. The Plan Name for the Sampled Home;

5.2.2.2.4. The RESNET Registration ID for the Sampled Home;

5.2.2.2.5. The total estimated annual purchased energy consumption by fuel type for space heating, space cooling, domestic hot water, and lighting and appliance energy uses for the Sampled Home as computed for the worst-case threshold specification;

5.2.2.2.6. The total estimated annual energy cost by fuel type for space heating, space cooling, domestic hot water, and lighting and appliance energy uses for the Sampled Home as computed for the worst-case threshold specification;

5.2.2.2.7. The following statement in a font size of 10 point or greater: "This home has been certified using a sampling protocol in accordance with Chapter 6 of the RESNET *Mortgage Industry National Home Energy Rating Standards* (see http://www.resnet.us/standards/mortgage/)."

5.2.2.3. In addition to the information in Section 5.2.2.2, Rating Certification Form 5.2-2 may include the following additional information –

5.2.2.3.1. The total estimated annual purchased energy consumption by fuel type for space heating, space cooling, domestic hot water, and lighting and appliance energy uses for the HERS Reference Home.

5.2.2.3.2. The total estimated annual energy cost by fuel type for space heating, space cooling, domestic hot water, and lighting and appliance energy uses for the HERS Reference Home.

5.2.2.3.3. The estimated annual energy cost and emission savings as compared to the home with a HERS Index of 100 (reference home).

5.2.2.3.4. The estimated annual energy cost and emission savings as compared to the home with a HERS Index of 130 (typical existing home).

5.3. National RESNET Registry. RESNET shall maintain a national registry of Certified Home Energy Ratings.

5.3.1. Minimum Requirements. At a minimum, the National RESNET Registry shall include:

5.3.1.1. The Rated Home characteristics, including but not limited to the following:

a) Physical location of the home, including street address, city, state and zip code
b) IECC climate zone of the home
c) Certified Rater ID
d) Accredited Rating Provider ID
e) Date of the Rating
f) Status of the Rated Home (new or existing)
g) Rating Type for the home (confirmed or sampled)
h) Home Type (single-family, duplex, low-rise Multi-family, high-rise Multi-family)
i) Conditioned area of the home
j) Number of bedrooms in the home
k) The name and version number of the accredited software rating tool that created the Rating

5.3.1.2. The Rating results, including but not limited to the following:

a) Registration ID (provided by the Registry)
b) HERS Index
c) Annual Rated Home energy end uses for heating, cooling, hot water and lighting and appliance energy end uses by fuel type
d) Annual Rated Home energy costs for heating, cooling, hot water and lighting and appliance energy end uses by fuel type
e) Annual Rated Home on-site power production
f) Energy prices used to calculate costs by fuel type
g) Annual total cost to operate the Rated home
h) Annual Rated Home normalized Modified End Use Loads
i) Annual HERS Reference Home End Use Loads
j) Annual HERS Reference Home energy end uses for heating, cooling, hot water and lighting and appliance energy end uses by fuel type

k) Annual HERS Reference Home energy costs for heating, cooling, hot water and lighting and appliance energy end uses by fuel type

5.3.1.3. An executable copy of the building input file used by the accredited software rating tool to generate the Home Energy Rating.

5.3.2. Provider Responsibilities. All accredited Rating Providers shall assure that the following minimum responsibilities are duly discharged by their Providership:

5.3.2.1. All Home Energy Ratings conducted by their certified Raters are submitted to the RESNET Registry.

5.3.2.2. All Quality Assurance controls that are required by RESNET Standards are met or exceeded for Home Energy Ratings that are submitted to the RESNET Registry.

5.3.2.3. Rated Home Registration ID provided by the RESNET Registry is prominently displayed on all Rating Certifications.

5.4. Innovative Design Requests.

5.4.1. Petition. HERS providers can petition RESNET for adjustment to the HERS Index for a Rated Home with features or technologies not addressed by approved software tools and/or this Standard. Innovative Design Requests (IDRs) to RESNET shall include, at a minimum, the following:

5.4.1.1. A Rating generated from approved rating software tool for Rated Home without feature(s) that cannot be modeled in the software tool.

5.4.1.2. Written description of feature(s) not included in Rating generated from software.

5.4.1.3. Manufacturer's technical and/or performance specifications for feature(s) not included in the Rating generated from the approved software tool.

5.4.1.4. Estimated energy impact. Calculations or simulation results estimating the energy impact of feature(s) not included in the Rating generated from an approved software tool and documentation to support the calculation methodology and/or describe the modeling approach used.

5.4.1.5. Estimated adjustment to HERS Index. Calculations shall follow procedures of Sections 4.1 and 4.2.

5.4.2. Review. Upon review of an IDR, RESNET Standing Technical Committee shall request additional supporting documentation for further consideration or provide a recommendation with justification to the Board as follows: a) is approved, b) is denied, or c) is approved with modifications. The RESNET Board of Directors shall accept or reject the

recommendation of Technical Committee or request further information from the Technical Committee.

5.4.3. Approval. IDRs shall be approved on a case by case basis. RESNET shall assign a unique identifier to each IDR and maintain a database of IDRs. If RESNET approves the IDR, the HERS provider may issue a supplemental report that adjusts the HERS Index as approved.

6. Software Tool Accreditation. All software tools seeking accreditation by RESNET shall comply with the requirements prescribed by this section.

6.1. Accreditation Categories. Software tools shall be accredited in one or more of the following accreditation categories:

6.1.1. HERS Software Tools. This software accreditation category shall apply to all software used for Home Energy Ratings. Calculation procedures used to comply with this Standard shall be computer-based software rating tools capable of calculating the annual energy consumption and HERS Index of all building elements that differ between the HERS Reference Home and the Rated Home and shall include the following capabilities:

6.1.1.1. Compliance with the rating provisions of Sections 4 and 5 of this Standard.

6.1.1.2. Computer generation of HERS Index in accordance with the provisions of Section 5.2 of this Standard.

6.1.1.3. Automated computer generation of the HERS Reference Home using only the input for the Rated Home. The software tool shall not allow the user to directly modify the building component characteristics of the HERS Reference Home.

6.1.1.4. Calculation of whole-building, single-zone sizing for the heating and cooling equipment in the HERS Reference Home in accordance with Section 4.3.3 of this Standard.

6.1.1.5. Calculations that account for the indoor and outdoor temperature dependencies and the part-load performance of heating, ventilating, and air conditioning equipment based on climate and equipment sizing.

6.1.2. New Home Tax Credit Software Tools. This software tool accreditation category shall apply to all software used to qualify new homes for the Federal tax credit for highly efficient new homes. Calculation procedures used to comply with this Standard shall be computer-based software tools capable of calculating the annual energy consumption of all building elements that differ between the Tax Credit Reference Home and the Qualifying Home and shall include the following capabilities:

6.1.2.1. Compliance with all provisions of the IRS Notice pertaining to qualification for the Federal Tax Credit

6.1.2.2. Automated computer generation of the Tax Credit Reference Home using only the input for the Qualifying Home. The software tool shall not allow the user to directly modify the building component characteristics of the Tax Credit Reference Home.

6.1.2.3. HVAC system sizing and annual purchased energy consumption calculations in accordance with sections 4.3 and 4.4 of this Standard.

6.1.2.4. Computer generation of all verification reports required by the IRS Notice pertaining to qualification for the Federal Tax Credit.

6.1.3. Existing Home Software Tools. This software tool accreditation category shall apply to software used to certify the energy savings for existing home retrofits qualifying for Federal tax credits for existing home improvements.

6.1.3.1. Compliance with all provisions of the IRS Notice pertaining to qualification for the federal Tax Credit.

6.1.3.2. HVAC system sizing and annual purchased energy consumption calculations in accordance with sections 4.3 and 4.4 of this Standard.

6.1.3.3. Computer generation of all verification reports required by the IRS Notice pertaining to qualification for the Federal Tax Credit.

6.1.4. IECC Compliance Software Tools. This software tool accreditation category shall apply to software used to comply with the International Energy Conservation Code Simulated Performance Alternative.

6.1.4.1. Compliance with all minimum and mandatory provisions of the subject IECC code.

6.1.4.2. HVAC system sizing and annual purchased energy consumption calculations in accordance with sections 4.3 and 4.4 of this standard.

6.1.4.3. Computer generation of all code inspection and verification reports required by the subject IECC code.

6.2. Application for Accreditation. Software providers shall submit a completed application form, as provided by RESNET, along with the following supporting materials.

6.2.1. Software Manual. All software tools applying for RESNET accreditation shall provide a user's manual, which may be in the form of an on-board software help system, sufficient for users to fully understand the proper and improper use of the software tool.

6.2.2. Test Results. The required software verification test results shall be submitted on spreadsheet forms provided by RESNET.

6.2.3. Test Inputs. Electronic copies of the input files used to generate the test results shall be submitted in the format used by the software to run the simulations.

6.2.4. Test Outputs. Electronic copies of the output files from which the results are tabulated shall be submitted in the format output by the software.

6.2.5. Functioning Software. A functioning copy of the software tool used to generate the results shall be submitted with each application for accreditation.

6.3. Verification Tests. Software verification tests shall be required for each software tool accreditation category as specified by Table 1.2(1) and described below.

Table 6.2(1) Accreditation Test Suite Requirements

Required Test Suites as a Function of Software Accreditation Category	HERS Software Tool	New Home Tax Credit Software Tool	Existing Home Software Tool	IECC Compliance Software Tool
HERS Reference Home AutoGen	X			
New Home Tax Credit Reference AutoGen		X		
2006 IECC Standard Design AutoGen				X
ASHRAE Standard 140, Class II, Tier 1 Tests	X	X	X	X
RESNET L125A BESTEST			X	
RESNET HVAC Tests	X	X	X	X
RESNET DSE Tests	X	X	X	X
RESNET DHW Tests	X		X	X
HERS Method Tests	X			
New Home Tax Credit Method		X		

6.3.1. HERS Reference Home AutoGen Tests. These tests verify the ability of the software tool to automatically generate the HERS Reference Home given only the characteristics of the Rated Home. See normative Annex A for the test cases and for the established acceptance criteria for this auto-generation test suite.

6.3.2. New Home Tax Credit Reference Home AutoGen. These tests verify the ability of the software tool to automatically generate the New Home Tax Credit Reference given only the characteristics of the Qualifying Home. See normative Annex B for the test cases and for the established acceptance criteria for this auto-generation test suite.

6.3.3. 2006 IECC Standard Design AutoGen Tests. These tests verify the ability of the software tool to automatically generate the 2006 IECC Standard Reference Design given

only the characteristics of the Proposed Design. See normative Annex C for the test cases and for the established acceptance criteria for this auto-generation test suite.

6.3.4. ANSI/ASHRAE Standard 140, Class II, Tier 1 Tests. ASHRAE Standard 140, Class II Tests were developed from the HERS BESTEST[19] for testing the accuracy of simulation software for predicting building loads. The ANSI/ASHRAE Standard 140, Class II, Tier 1 test procedure has been adopted by RESNET and is a requirement for all software programs to be accredited. The acceptance criteria for this test suite are as specified in Tables 4-1 and 4-2 of the original HERS BESTEST document "Home Energy Rating System Building Energy Simulation Test (HERS BESTEST) – Volume 2, Tier 1 Test Reference Results" by R. Judkoff and J. Neymark, as published by the National Renewable Energy Laboratory, Golden, Colorado, Report No. NREL/TP-472-7332b, November 1995. This document may be found online at: http://www.nrel.gov/docs/legosti/fy96/7332b.pdf

6.3.5. RESNET L125A BESTEST. These tests measure the accuracy with which software tools calculate the difference between a base case and a case where two improvements that impact one another are combined. This test case is a combination of HERS BESTEST cases L120A and L130A and has been named case L125A. See normative Annex D for the specifications for the test cases and for the established acceptance criteria for this test suite.

6.3.6. RESNET HVAC Tests. RESNET has developed a series of tests that test the consistency with which software tools treat HVAC equipment; including furnaces, air conditioners, and air source heat pumps. See normative Annex E for the test cases and for the established acceptance criteria for this test suite.

6.3.7. RESNET DSE Tests. Duct Distribution System Efficiency Tests – These tests measure the accuracy with which software tools calculate air distribution system losses. ASHRAE Standard 152 results are used as the basis for the test suite acceptance criteria. See normative Annex F for the test cases and for the established acceptance criteria for this test suite.

6.3.8. RESNET DHW Tests. Service Hot Water System Tests – These tests measure the accuracy with which software tools calculate the hot water use in dwellings as a function of the entering water temperature, the daily hot water use and the labeled efficiency of the service hot water system. See normative Annex G for the test cases and for the established acceptance criteria for this test suite.

6.3.9. HERS Method Tests. These tests verify that software tools can accurately calculate the HERS Index that is used as the numerical indicator of the relative performance for a home. See normative Annex H for the test cases and for the established acceptance criteria for this test suite.

6.3.10. New Home Tax Credit Method Tests. These tests verify that software tools can accurately calculate relative performance for New Home Tax Credit Qualification. See

[19] R. Judkoff and J. Neymark, 1995, "Home Energy Rating System Building Energy Simulation Test (HERS BESTEST), Volume 1, Report No. NREL/TP-472-7332a, National Renewable Energy Laboratory, Golden, Colorado. (online at: http://www.nrel.gov/docs/legosti/fy96/7332a.pdf)

normative Annex I for the test cases and for the established acceptance criteria for this test suite.

6.4. Software Re-Certification. Rating tools accredited under this Standard must be retested and re-certified if a new version of the tool is released that includes changes to the engineering algorithms.

7. Normative Reference Documents.

ASHRAE *Handbook of Fundamentals*, 2009. American Society of Heating Refrigerating and Air Conditioning Engineers, Atlanta, GA.

ANSI/ASHRAE Standard 140-2011, "Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs." American Society of Heating, Refrigerating, and Air Conditioning Engineers, Atlanta, GA, 2012.

RESNET, *Mortgage Industry National Home Energy Rating Systems Standards*, 2006. Residential Energy Services Network, Oceanside, CA.

ASTM, C-1549-09, "Standard Test Method for Determining Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer," ASTM International, West Conshohocken, PA.

ASTM, E-1918-06, "Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field." ASTM International, West Conshohocken, PA.

CRRC-1, 2008. "Method #1: Standard Practice for Measuring Solar Reflectance of a Flat, Opaque, and Heterogeneous Surface Using a Portable Solar Reflectometer." Cool Roof Rating Council, Oakland, CA.

ASHRAE, Standard 119 (RA 2004), "Air Leakage Performance for Detached Single-Family Residential Buildings." American Society for Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA.

ASHRAE, Standard 152-04, "Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distributions Systems." American Society for Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA.

AACA, "Manual J Residential Load Calculation," 8th Edition. Air Conditioning Contractors of America, Arlington, VA.

EPA, eGrid2010, Version 1.1, U.S. Environmental Protection Agency, Washington, DC. Database online at http://www.epa.gov/cleanenergy/energy-resources/egrid/

Annex A – HERS Reference Home Auto-Generation Tests

(Normative)

This normative Annex contains the Reference Home auto-generation test suite for HERS rating tools. The test cases in this proposed test suite are designed to verify that software tools automatically generate accurate Reference Homes given only the building information from the Rated home.

1. Minimum Reporting Requirements

Software tools applying for verification shall provide evidence that their software meets the requirements of this test suite. The software tool provider or software vendor is responsible for producing the documentation needed to show that the software has been verified through this test suite. In some cases, the data needed to verify accuracy is of no interest or value to the end-user of the software, but in any case, the software tool must generate it. At a minimum, software tools applying for accreditation must report the following values for the Reference Home:

1. Areas and overall U-factors (or R-values in the case of slab-on-grade construction) for all building components, including ceilings, walls, floors, windows (by orientation) and doors.
2. Overall solar-heat gain coefficient ($SHGC_o$)[20] of the windows during heating.
3. Overall solar-heat gain coefficient ($SHGC_o$) of the windows during cooling.
4. Wall solar absorptance and infrared emittance
5. Roof solar absorptance and infrared emittance
6. Sensible internal gains to the home (Btu/day)
7. Latent internal gains to the home (Btu/day)
8. Specific leakage area (SLA) for the building, by zone or as SLA_o[21], as appropriate
9. Attic net free ventilation area (ft^2)
10. Crawlspace net free ventilation area (ft^2), if appropriate
11. Exposed masonry floor area and carpet and pad R-value, if appropriate
12. Heating system labeled ratings, including AFUE, COP, or HSPF, as appropriate.
13. Cooling system labeled ratings, including SEER or EER, as appropriate.
14. Thermostat schedule for heating and cooling
15. Air Distribution System Efficiency (DSE)
16. Mechanical ventilation kWh/yr, if appropriate

Software tools must have the ability to recreate or store the test case Reference Homes as if they were Rated Homes such that they also can be simulated and evaluated as Rated Homes.

1.1. Auto-generation Test Descriptions

[20] The overall solar heat gain coefficient ($SHGC_o$) of a fenestration is defined as the solar heat gain coefficient (SHGC) of the fenestration product taken in combination with the interior shade fraction for the fenestration.

[21] SLA_o is the floor-area weighted specific leakage area of a home where the different building zones (e.g. basement and living zones) have different specific leakage areas.

Test Case1. HERS BESTEST case L100 building configured as specified in the HERS BESTEST procedures, located in Baltimore, MD, including a total of 3 bedrooms and the following mechanical equipment: gas furnace with AFUE = 82% and central air conditioning with SEER = 11.0 with all electric lighting and appliances.

Test Case 2. HERS BESTEST case L100 configured on an un-vented crawlspace with R-7 crawlspace wall insulation, located in Dallas, TX, including a total of 3 bedrooms and the following mechanical equipment: electric heat pump with HSPF = 7.5 and SEER = 12.0 with natural gas range/oven and natural gas clothes dryer. All other appliances and lighting are electric.

Test Case 3. HERS BESTEST case L304 in Miami, configured as specified in the HERS BESTEST procedures, located in Miami, FL, including a total of 2 bedrooms and the following mechanical equipment: electric strip heating with COP = 1.0 and central air conditioner with SEER = 15.0 with all electric lighting and appliances.

Test Case 4. HERS BESTEST case L324 configured as specified as in the HERS BESTEST procedures, located in Colorado Springs, CO, including a total of 4 bedrooms and the following mechanical equipment: gas furnace with AFUE = 95% and no air conditioning with natural gas range/oven. All other lighting and appliances are electric.

Test Case 5. Recreate or store the Reference Homes created in Tests 1 through 4 as Rated Homes and simulate and evaluate them.

1.2. Acceptance Criteria

1.2.1. Test Cases 1 – 4

For test cases 1 through 4 the values contained in Table A-1 shall be used as the acceptance criteria for software tool accreditation. For Reference Home building components marked by an asterisk (*), the acceptance criteria may include a range equal to ± 0.05% of the listed value. For all other Reference Home components the listed value is exact.

Table A-1 Acceptance Criteria for Test Cases 1 – 4

Reference Home Building Component	Test 1	Test 2	Test 3	Test 4
Above-grade walls (U_o)	0.082	0.082	0.082	0.060
Above-grade wall solar absorptance (α)	0.75	0.75	0.75	0.75
Above-grade wall infrared emittance (ε)	0.90	0.90	0.90	0.90
Basement walls (U_o)	n/a	n/a	n/a	0.059
Above-grade floors (U_o)	0.047	0.047	n/a	n/a
Slab insulation R-Value	n/a	n/a	0	0
Ceilings (U_o)	0.030	0.035	0.035	0.030
Roof solar absorptance (α)	0.75	0.75	0.75	0.75

Reference Home Building Component	Test 1	Test 2	Test 3	Test 4
Roof infrared emittance (ε)	0.90	0.90	0.90	0.90
Attic vent area* (ft^2)	5.13	5.13	5.13	5.13
Crawlspace vent area* (ft^2)	n/a	10.26	n/a	n/a
Exposed masonry floor area * (ft^2)	n/a	n/a	307.8	307.8
Carpet & pad R-Value	n/a	n/a	2.0	2.0
Door Area (ft^2)	40	40	40	40
Door U-Factor	0.40	0.65	1.20	0.35
North window area* (ft^2)	69.26	69.26	69.26	102.63
South window area* (ft^2)	69.26	69.26	69.26	102.63
East window area* (ft^2)	69.26	69.26	69.26	102.63
West window area* (ft^2)	69.26	69.26	69.26	102.63
Window U-Factor	0.40	0.65	1.20	0.35
Window $SHGC_o$ (heating)	0.4675	0.34	0.34	0.4675
Window $SHGC_o$ (cooling)	0.385	0.28	0.28	0.385
SLA_o (ft^2/ft^2)	0.00036	0.00036	0.00036	0.00036
Sensible Internal gains* (Btu/day)	52,797	55,473	48,114	82,944
Latent Internal gains* (Btu/day)	12,700	13,806	9,262	17,896
Labeled heating system rating and efficiency	AFUE = 78%	HSPF = 7.7	HSPF = 7.7	AFUE = 78%
Labeled cooling system rating and efficiency	SEER = 13.0	SEER = 13.0	SEER = 13.0	SEER = 13.0
Air Distribution System Efficiency	0.80	0.80	0.80	0.80
Thermostat Type	Manual	Manual	Manual	Manual
Heating thermostat settings	68 F (all hours)	68 F (all hours)	68 F (all hours)	68 F (all hours)
Cooling thermostat settings	78 F (all hours)	78 F (all hours)	78 F (all hours)	78 F (all hours)

4.2.4 Test Case 5

Test case 5 requires that each of the Reference Homes for test cases 1-4 be stored or recreated in the software tool as a Rated Home and simulated as any other rated home would be simulated. If the resulting Rated Home is correctly configured to be identical to its appropriate Reference Home, rating calculations arising from normal operation of the software tool should produce virtually identical scoring criteria for both the Reference Home and the Rated Home for this round of tests. For test case 5, the modified loads e-Ratio shall be calculated separately from the simulation results, as follows:

e-Ratio = (Total normalized Modified Loads) / (Total Reference Loads)

Acceptance criteria for these calculations shall be ± 0.5% of 1.00. Thus, for each of the preceding test cases (1-4), the e-Ratio resulting from these software tool simulations and the subsequent e-Ratio calculations shall be greater than or equal to 0.995 **and** less than or equal to 1.005.

Annex B – New Home Tax Credit Reference Auto-Generation Tests
(Normative)

This software tool verification test suite and rule set standard consists of four sections: Section 1 provides standards for the certification of software tools used for tax credit qualification; Section 2 specifies the method by which energy savings are determined; and Section 3 (the "rule set") provides standards for the Tax Credit Reference and Qualifying Home configurations; and Section 4 provides the test specifications and acceptance criteria for the New Home Reference Auto-Generation Tests.

1. Software Tools for Tax Incentive Qualification.

1.1. Minimum software tool capabilities. Calculation procedures used to qualify homes for tax incentives shall be computer-based software tools capable of calculating the annual energy consumption of all building elements that differ between the Reference Home and the Qualifying Home and shall include the following minimum capabilities:

1. Computer generation of the Reference Home using only the input for the Qualifying Home. The calculation procedure shall not allow the user to directly modify the building component characteristics of the Reference Home.
2. Calculation of whole-building, single-zone sizing for the heating and cooling equipment in the Reference Home in accordance with ASHRAE *Handbook of Fundamentals* or equivalent computational procedures.
3. Calculations that account for the indoor and outdoor temperature dependencies and the part load performance of heating, ventilating and air conditioning equipment based on climate and equipment sizing.
4. Listing of each of the Qualifying Home component characteristics determined by the analysis to provide qualification along with their respective performance rating (e.g. R-Value, U-Factor, SHGC, HSPF, AFUE, SEER, EF, etc.).

1.2. Minimum reporting requirements. Tax incentive qualification software tools shall generate reports that, at a minimum, document the following information:

1. Address of the Qualifying Home;
2. Documentation of all building component characteristics of the Qualifying Home . Such documentation shall also give the estimated annual energy consumption for heating and cooling for both the Reference Home and the Qualifying Home;
3. Name and signature of individual certified to complete the qualification report;
4. Name and version of the certified tax credit qualification software tool used to perform the qualification analysis.

1.3. Software tool certification. Tools approved by RESNET shall be based on verification for certification using the following software test suites and acceptance criteria:

1.3.1. HERS BESTEST, Tier 1 Tests. This test suite determines the ability of software tools to predict building heating and cooling loads. Verification criteria shall be as

specified by Tables 4-1, 4-2 and 4-4 of "Home Energy Rating System Building Energy Simulation Test (HERS BESTEST) – Volume 2, Tier 1 and Tier 2 Test Reference Results" by R. Judkoff and J. Neymark, as published by the National Renewable Energy Laboratory, Golden, Colorado, Report No. NREL/TP-472-7332, November 1995.[22]

1.3.2. Reference Home Auto-generation Tests. This test suite determines the ability of software tools to automatically generate the tax credit Reference Home. Verification criteria shall be as specified in Appendix B of this publication.

1.3.3. RESNET HVAC Tests. This test suite determines the ability of software tools to account for indoor and outdoor temperature dependencies and the part load performance of heating, ventilating and air conditioning equipment based on climate. Verification criteria shall be as specified in Appendix C of this publication.

1.3.4. Distribution System Efficiency (DSE) Tests. This test suite determines the ability of software tools to account for air distribution system losses. Verification criteria shall be as specified in Appendix D of this publication.

2. Computation of Energy Savings

2.1. The energy loads for heating and cooling in the Qualifying Home shall be normalized to account for the differences in improvement potential that exist across equipment types using the following formula:[23]

nMEUL = REUL * (nEC_x /EC_r)

where:

nMEUL = normalized Modified End Use Loads (for heating or cooling) as computed using accredited simulation tools.
REUL = Reference Home End Use Loads (for heating or cooling) as computed using accredited simulation tools.
EC_r = estimated Energy Consumption for Reference Home's end uses (for heating, including auxiliary electric consumption, or cooling) as computed using accredited simulation tools.

and where:

nEC_x = (a* EEC_x – b)*(EC_x * EC_r * DSE_r) / (EEC_x * REUL)

where:

[22] HERS BESTEST has been adopted by RESNET as a test suite requirement for all rating software tools that are accredited by RESNET.

[23] Source: Fairey, P., J. Tait, D. Goldstein, D. Tracey, M. Holtz, and R. Judkoff, "The HERS Rating Method and the Derivation of the Normalized Modified Loads Method." Research Report No. FSEC-RR-54-00, Florida Solar Energy Center, Cocoa, FL, October 11, 2000. Available online at: http://www.fsec.ucf.edu/bldg/pubs/hers_meth/

nEC_x = normalized Energy Consumption for Qualifying Home's end uses (for heating, including auxiliary electric consumption, or cooling) as computed using accredited simulation tools.

EC_r = estimated Energy Consumption for Reference Home's end uses (for heating, including auxiliary electric consumption, or cooling) as computed using accredited simulation tools.

EC_x = estimated Energy Consumption for the Qualifying Home's end uses (for heating, including auxiliary electric consumption, or cooling) as computed using accredited simulation tools.

EEC_x = Equipment Efficiency Coefficient for the Qualifying Home's equipment, such that

EEC_x equals the energy consumption per unit load in like units as the load, and as derived from the Manufacturer's Equipment Performance Rating (MEPR) such that

EEC_x equals 1.0 / MEPR for AFUE or COP ratings, or such that
EEC_x equals 3.413 / MEPR for HSPF, EER or SEER ratings.

DSE_r = REUL/EC_r * EEC_r

For simplified system performance methods, DSE_r equals 0.80 for heating and cooling systems. However, for detailed modeling of heating and cooling systems, DSE_r may be less than 0.80 as a result of part load performance degradation, coil air flow degradation, improper system charge and auxiliary resistance heating for heat pumps. Except as otherwise provided by these Standards, where detailed systems modeling is employed, it must be applied equally to both the Reference and the Qualifying Homes.

EEC_r = Equipment Efficiency Coefficient for the Reference Home's equipment, such that EEC_r equals the energy consumption per unit load in like units as the load, and as derived from the Manufacturer's Equipment Performance Rating (MEPR) such that

EEC_r equals 1.0 / MEPR for AFUE or COP ratings, or such that
EEC_r equals 3.413 / MEPR for HSPF, EER or SEER ratings.

REUL = Reference Home End Use Loads (for heating or cooling) as computed using accredited simulation tools.

and where the coefficients 'a' and 'b' are as defined by Table 2.1 below:

Table 2.1. Coefficients 'a' and 'b'

Fuel type and End Use	a	b
Electric space heating	2.2561	0
Fossil fuel* space heating	1.0943	0.4030
Biomass space heating	0.8850	0.4047
Electric air conditioning	3.8090	0
Electric water heating	0.9200	0
Fossil fuel* water heating	1.1877	1.0130

*Such as natural gas, LP, fuel oil

2.2. Following normalization of the heating and cooling energy consumptions for the Qualifying Home as specified in section 2.1 above, the Reference Home's total reference end use loads for heating and cooling (REULtot) shall be compared with the Qualifying Home's total normalized modified end use loads for heating and cooling (nMEULtot) using the following formula to determine the % Energy Reduction:

% Energy Reduction = [(REULtot – nMEULtot) / (REULtot)] * 100

3. Rule Set for Configuration of the Reference Home and Qualifying Homes

3.1. General. Except as specified by this Section, the Reference Home and Qualifying Home shall be configured and analyzed using identical methods and techniques.
3.2. Residence Specifications. The Reference Home and Qualifying Home shall be configured and analyzed as specified by Table 3.2(1).

Table 3.2(1) Specifications for the Reference and Qualifying Homes

Building Component	Reference Home	Qualifying Home
Above-grade walls:	Type: wood frame Gross area: same as Qualifying Home U-Factor: from Table 3.2(2) Solar absorptance = 0.75 Emittance = 0.90	Same as Qualifying Home Same as Qualifying Home Same as Qualifying Home Same as Qualifying Home Same as Qualifying Home
Conditioned basement walls:	Type: same as Qualifying Home Gross area: same as Qualifying Home U-Factor: from Table 3.2(2) with the insulation layer on the interior side of walls	Same as Qualifying Home Same as Qualifying Home Same as Qualifying Home
Floors over unconditioned spaces:	Type: wood frame Gross area: same as Qualifying Home U-Factor: from Table 3.2(2)	Same as Qualifying Home Same as Qualifying Home Same as Qualifying Home
Crawlspaces:	Type: vented with net free vent aperture = $1ft^2$ per 150 ft^2 of crawlspace floor area.	Same as the Qualifying Home, but not less net free ventilation area than the Reference Home unless an approved ground cover in accordance with IRC 408.1 is used, in which case, the same net free ventilation area as the Qualifying Home down to a minimum net free vent area of $1ft^2$ per 1,500 ft^2 of crawlspace floor area.

Table 3.2(1) Specifications for the Reference and Qualifying Homes

Building Component	Reference Home	Qualifying Home
	U-factor: from Table 3.2(2) for floors over unconditioned spaces	Same as Qualifying Home
Ceilings:	Type: wood frame Gross area: same as Qualifying Home U-Factor: from Table 3.2(2)	Same as Qualifying Home Same as Qualifying Home Same as Qualifying Home
Roofs:	Type: composition shingle on wood sheathing Gross area: same as Qualifying Home Solar absorptance = 0.75 Emittance = 0.90	Same as Qualifying Home Same as Qualifying Home Values from Table 3.3 shall be used to determine solar absorptance except where test data is provided for roof surface in accordance with ASTM methods C-1549, E-1918, or CRRC Method # 1. In cases where the appropriate data is not known, the default for a standard dark shingle (0.92) shall be assumed. Same as Qualifying Home
Attics:	Type: vented with aperture = 1ft^2 per 300 ft^2 ceiling area	Same as Qualifying Home
Foundations:	Type: same as Qualifying Home Gross Area: same as Qualifying Home U-Factor / R-value: from Table 3.2(2)	Same as Qualifying Home Same as Qualifying Home Same as Qualifying Home
Doors:	Area: 40 ft^2 Orientation: North U-factor: same as fenestration from Table 3.2(2)	Same as Qualifying Home Same as Qualifying Home Same as Qualifying Home
Glazing: [(a)]	Total area [(b)] =18% of conditioned floor area Orientation: equally distributed to four (4) cardinal compass orientations (N,E,S,&W) U-factor: from Table 3.2(2) SHGC: from Table 3.2(2) Interior shade coefficient: Summer = 0.70 Winter = 0.85	Same as Qualifying Home Same as Qualifying Home Same as Qualifying Home Same as Qualifying Home Same as Reference Home [(c)]

Table 3.2(1) Specifications for the Reference and Qualifying Homes

Building Component	Reference Home	Qualifying Home
	External shading: none	Same as Qualifying Home
Skylights	None	Same as Qualifying Home
Thermally isolated sunrooms	None	Same as Qualifying Home
Air exchange rate	Specific Leakage Area (SLA) [(d)] = 0.00048 (assuming no energy recovery)	For residences that are not tested, the same as the Reference Home For residences without mechanical ventilation systems that are tested in accordance with ASHRAE Standard 119, Section 5.1, the measured air exchange rate [(e)] but not less than 0.35 ach For residences with mechanical ventilation systems that are tested in accordance with ASHRAE Standard 119, Section 5.1, the measured air exchange rate [(e)] combined with the mechanical ventilation rate,[(f)] which shall not be less than 0.01 x CFA + 7.5 x (Nbr+1) cfm.
Mechanical ventilation:	None, except where a mechanical ventilation system is specified by the Qualifying Home, in which case: Annual vent fan energy use: kWh/yr = 0.03942*CFA + 29.565*(N_{br}+1) (per dwelling unit) where: CFA = conditioned floor area N_{br} = number of bedrooms	Same as Qualifying Home Same as Qualifying Home
Internal gains:	As specified by Table 3.2(4)	Same as Reference Home, except as provided by Section 303.4.1.7.2, RESNET Standards
Internal mass:	An internal mass for furniture and contents of 8 pounds per square foot of floor area	Same as Reference Home, plus any additional mass specifically designed as a

Table 3.2(1) Specifications for the Reference and Qualifying Homes

Building Component	Reference Home	Qualifying Home
		Thermal Storage Element [g] but not integral to the building envelope or structure
Structural mass:	For masonry floor slabs, 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air	Same as Qualifying Home
	For masonry basement walls, same as Qualifying Home, but with insulation required by Table 3.2(2) located on the interior side of the walls	Same as Qualifying Home
	For other walls, for ceilings, floors, and interior walls, wood frame construction	Same as Qualifying Home
Heating systems [h],[i]	Fuel type: same as Qualifying Home	Same as Qualifying Home [i]
	Efficiencies:	
	Electric: air source heat pump with prevailing federal minimum efficiency	Same as Qualifying Home
	Non-electric furnaces: natural gas furnace with prevailing federal minimum efficiency	Same as Qualifying Home
	Non-electric boilers: natural gas boiler with prevailing federal minimum efficiency	Same as Qualifying Home
	Capacity: sized in accordance with Section 303.5.1.5, RESNET Standards (2005).	Same as Qualifying Home
Cooling systems [h],[k]	Fuel type: Electric	Same as Qualifying Home [k]
	Efficiency: in accordance with prevailing federal minimum standards	Same as Qualifying Home
	Capacity: sized in accordance with Section 303.5.1.5, RESNET Standards (2005).	Same as Qualifying Home
Thermal distribution systems:	A thermal distribution system efficiency (DSE) of 0.80 shall be applied to both the heating and cooling system efficiencies.	As specified by Table 3.2(3), except when tested in accordance with ASHRAE Standard 152-2004[m], and then either calculated through hourly simulation or calculated in accordance

Table 3.2(1) Specifications for the Reference and Qualifying Homes

Building Component	Reference Home	Qualifying Home
		with ASHRAE Standard 152-2004
Thermostat	Type: manual Temperature setpoints: cooling temperature set point = 78 F; heating temperature set point = 68 F	Type: Same as Qualifying Home Temperature setpoints: same as the Reference Home, except as provided by Section 303.5.1.2, RESNET Standards (2006)

Table 3.2(1) Notes:

(a) Glazing shall be defined as sunlight-transmitting fenestration, including the area of sash, curbing or other framing elements, that enclose conditioned space. Glazing includes the area of sunlight-transmitting fenestration assemblies in walls bounding conditioned basements. For doors where the sunlight-transmitting opening is less than 50% of the door area, the glazing area is the sunlight transmitting opening area shall be used. For all other doors, the glazing area is the rough frame opening area for the door, including the door and the frame.

(b) For homes with conditioned basements and for multi-family attached homes the following formula shall be used to determine total window area:

$A_F = 0.18 \times A_{FL} \times F_A \times F$

where:

A_F = Total fenestration area

A_{FL} = Total floor area of directly conditioned space

F_A = (Above-grade thermal boundary gross wall area) / (above-grade boundary wall area + 0.5 x below-grade boundary wall area)

F = (Above-grade thermal boundary wall area) / (above-grade thermal boundary wall area + common wall area) or 0.56, whichever is greater

and where:

Thermal boundary wall is any wall that separates conditioned space from unconditioned space or ambient conditions

Above-grade thermal boundary wall is any portion of a thermal boundary wall not in contact with soil

Below-grade boundary wall is any portion of a thermal boundary wall in soil contact

Common wall is the total wall area of walls adjacent to another conditioned living unit, not including foundation walls.

(c) For fenestrations facing within 15 degrees of due south that are directly coupled to thermal storage mass, the winter interior shade coefficient shall be permitted to increase to 0.95 in the Qualifying Home.

(d) Where Leakage Area (L) is defined in accordance with Section 5.1 of ASHRAE Standard 119 and where SLA = L / CFA (where L and CFA are in the same units). Either hourly calculations using the procedures given in the 2001 *ASHRAE Handbook of Fundamentals*, Chapter 26, page 26.21, equation 40 (Sherman-Grimsrud model) or calculations yielding equivalent results shall be used to determine the energy loads resulting from air exchange.

(e) Tested envelope leakage shall be determined and documented by a Certified Rater using the on-site inspection protocol as specified in Appendix A under "Blower Door Test." Either hourly calculations using the procedures given in the 2001 *ASHRAE Handbook of Fundamentals*, Chapter 26, page 26.21, equation 40 (Sherman-Grimsrud model) or calculations yielding equivalent results shall be used to determine the energy loads resulting from air exchange.

(f) The combined air exchange rate for infiltration and mechanical ventilation shall be determined in accordance with equation 43 of 2001 *ASHRAE Handbook of Fundamentals* page 26.24 in combination with the" Whole-house Ventilation" provisions of 2001 *ASHRAE Handbook of Fundamentals,* page 26.19 for intermittent mechanical ventilation.

(g) Thermal storage element shall mean a component not normally part of the floors, walls, or ceilings that is part of a passive solar system, and that provides thermal storage such as enclosed water columns, rock beds, or phase change containers. A thermal storage element must be in the same room as fenestration that faces within 15 degrees of due south, or must be connected to such a room with pipes or ducts that allow the element to be actively charged.

(h) For a Qualifying Home with multiple heating, cooling, or water heating systems using different fuel types, the applicable system capacities and fuel types shall be weighted in accordance with the loads distribution (as calculated by accepted engineering practice for that equipment and fuel type) of the subject multiple systems. For the Reference Home, the prevailing federal minimum efficiency shall be assumed except that the efficiencies given in Table 3.2(1)(a) below will be assumed when:

1) A type of device not covered by NAECA is found in the Qualifying Home;
2) The Qualifying Home is heated by electricity using a device other than an air source heat pump; or
3) The Qualifying Home does not contain one or more of the required HVAC equipment systems.

Table 3.2(1)(a). Default Reference Home Heating and Cooling Equipment Efficiencies (i) (k) (m) (n)

Qualifying Home Fuel	Function	Reference Home Device
Electric	Heating	7.7 HSPF air source heat pump
Non-electric warm air furnace or space heater	Heating	78% AFUE gas furnace
Non-electric boiler	Heating	80% AFUE gas boiler
Any type	Cooling	13 SEER electric air conditioner

(i) For a Qualifying Home without a proposed heating system, a heating system with the prevailing federal minimum efficiency shall be assumed for both the Reference Home and Qualifying Home. For electric heating systems, the prevailing federal minimum efficiency air-source heat pump shall be selected.

(k) For a Qualifying Home without a proposed cooling system, an electric air conditioner with the prevailing federal minimum efficiency shall be assumed for both the Reference Home and the Qualifying Home.

(m) Tested duct leakage shall be determined and documented by a Certified Rater using the on-site inspection protocol specified by the 2006 Mortgage Industry National Home Energy Rating Standards, Appendix A under "Air leakage (ducts)".

Table 3.2(2). Component Heat Transfer Characteristics for Reference Home [a]

Climate Zone [b]	Fenestration and Opaque Door U-Factor	Glazed Fenestration Assembly SHGC	Ceiling U-Factor	Frame Wall U-Factor	Floor Over Unconditioned Space U-Factor	Basement Wall U-Factor [c]	Slab-on-Grade [d, e] R-Value & Depth
1	1.20	0.40	0.035	0.082	0.064	0.360	0
2	0.75	0.40	0.035	0.082	0.064	0.360	0
3	0.65	0.40	0.035	0.082	0.047	0.360	0
4 except Marine	0.40	0.55	0.030	0.082	0.047	0.059	10, 2 ft.
5 and Marine 4	0.35	0.55	0.030	0.060	0.033	0.059	10, 2 ft.
6	0.35	0.55	0.026	0.060	0.033	0.059	10, 4 ft.
7 and 8	0.35	0.55	0.026	0.057	0.033	0.059	10, 4 ft.

Table 3.2(2) Notes:

(a) Non-fenestration U-Factors shall be obtained from measurement, calculation, or an approved source.

(b) Climates zones shall be as specified by the 2004 Supplement to the International Energy Conservation Code.

(c) For basements where the conditioned space boundary comprises the basement walls.

(d) R-5 shall be added to the required R-value for slabs with embedded heating.

(e) Insulation shall extend downward from the top of the slab vertically to the depth indicated.

Table 3.2(3) Default Distribution System Efficiencies for Inspected Systems [a]

Distribution System Configuration and Condition:	**Forced Air Systems**	**Hydronic Systems** [b]
Distribution system components located in unconditioned space	0.80	0.95
Distribution systems entirely located in conditioned space [c]	0.88	1.00
Proposed "reduced leakage" with entire air distribution system located in the conditioned space [d]	0.96	

Table 3.2(3) Default Distribution System Efficiencies for Inspected Systems [a]

Distribution System Configuration and Condition:	**Forced Air Systems**	**Hydronic Systems [b]**
Proposed "reduced leakage" air distribution system with components located in the unconditioned space	0.88	
"Ductless" systems [e]	1.00	

Table 3.2(3) Notes:

(a) Default values given by this table are for distribution systems as rated, which meet minimum IECC 2000 requirements for duct system insulation.

(b) Hydronic Systems shall mean those systems that distribute heating and cooling energy directly to individual spaces using liquids pumped through closed loop piping and that do not depend on ducted, forced air flows to maintain space temperatures.

(c) Entire system in conditioned space shall mean that no component of the distribution system, including the air handler unit or boiler, is located outside of the conditioned space boundary.

(d) Proposed "reduced leakage" shall mean substantially leak free to be leakage of not greater than 3 cfm to outdoors per 100 square feet of conditioned floor area and not greater than 9 cfm total air leakage per 100 square feet of conditioned floor area at a pressure differential of 25 Pascal across the entire system, including the manufacturer's air handler enclosure. Total air leakage of not greater than 3 cfm per 100 square feet of conditioned floor area at a pressure difference of 25 Pascal across the entire system, including the manufacturer's air handler enclosure, shall be deemed to meet this requirement without measurement of air leakage to outdoors. This rated condition shall be specified as the required performance in the construction documents and requires confirmation through field-testing of installed systems as documented by a Certified Rater.

(e) Ductless systems may have forced airflow across a coil but shall not have any ducted airflows external to the manufacturer's air handler enclosure.

Table 3.2(4). Internal Gains for HERS Reference Homes [a]

End Use / Component	**Sensible Gains (Btu/day)**			**Latent Gains (Btu/day)**		
	a	**b**	**c**	**a**	**b**	**c**
Residual MELs		7.27			0.38	
Interior lighting	4,253	7.48				
Refrigerator	5,955		168			
TVs	3,861		645			
Range/Oven (elec) [b]	2,228		262	248		29
Range/Oven (gas) [b]	3,934		470	1,020		122
Clothes Dryer (elec) [b]	661		188	73		21
Clothes Dryer (gas) [b]	685		194	85		24
Dish Washer	219		87	219		87
Clothes Washer	95		26	11		3
Gen water use	-1227		-409	1,245		415
Occupants [c]			3716			2,884

Notes for Table 3.2(4)

(a) Table values are coefficients for the following general equation:
Gains = a + b*CFA + c*Nbr
where CFA = Conditioned Floor Area and Nbr = Number of bedrooms.
(b) For Rated Homes with electric appliance use (elec) values and for Rated homes with natural gas-fired appliance use (gas) values
(c) Software tools shall use either the occupant gains provided above or similar temperature dependent values generated by the software where number of occupants equals the number of bedrooms and occupants are present in the home for 16.5 hours per day.

Table 3.3 Default Solar Absorptance for Various Roofing Surfaces[24]

Roof Materials	Absorptance	Roof Materials	Absorptance
Composition Shingles		Wood Shingles	
Dark	0.92	Dark	0.90
Medium	0.85	Medium	0.80
Light	0.75		
		Concrete/Cement	
Tile/Slate		Dark	0.90
Dark	0.90	Medium	0.75
Medium	0.75	Light	0.60
Terra cotta	0.65	White	0.30
Light	0.60		
White	0.30	Membrane	
		Dark	0.90
Metal		Medium	0.75
Dark	0.90	Light	0.60
Medium	0.75	White	0.30
Galvanized, unfinished	0.70		
Light	0.60	Built-Up (gravel surface)	
Galvalum, unfinished	0.35	Dark	0.92
White	0.30	Medium	0.85
		Light	0.75

4. New Home Tax Credit Reference Auto Generation Tests

The New Home Tax Credit Reference auto-generation test suite is one of four minimum test suites required for software tools used for new home tax incentive qualification. The test cases in this test suite are designed to verify that software tools automatically generate accurate Reference Homes given only the building information for the Qualifying home.

4.1. Reporting

[24] Source: Parker, D S, J E R McIlvaine, S F Barkaszi, D J Beal and M T Anello (2000). Laboratory Testing of the Reflectance Properties of Roofing Material. FSEC-CR670-00. Florida Solar Energy Center, Cocoa, FL. Available online at: http://www.fsec.ucf.edu/bldg/pubs/cr670/

Software tools applying for verification shall provide evidence that their software meets the requirements of this test suite. The software tool provider or software vendor is responsible for producing the documentation needed to show that the software has been verified through this test suite. In some cases, the data needed to verify accuracy is of no interest or value to the end-user of the software, but in any case, the software tool must generate it.

4.2. Minimum Requirements

At a minimum, software tools applying for accreditation must report the following values for the Reference Home:

1. Areas and overall U-factors (or R-values in the case of slab-on-grade construction) for all building components, including ceilings, walls, floors, windows (by orientation) and doors.
2. Overall solar-heat gain coefficient ($SHGC_o$)[25] of the windows during heating.
3. Overall solar-heat gain coefficient ($SHGC_o$) of the windows during cooling.
4. Wall solar absorptance and infrared emittance
5. Roof solar absorptance and infrared emittance
6. Total internal gains to the home (Btu/day)
7. Specific leakage area (SLA) for the building, by zone or as SLA_o[26], as appropriate
8. Attic net free ventilation area (ft^2)
9. Crawlspace net free ventilation area (ft^2), if appropriate
10. Exposed masonry floor area and carpet and pad R-value, if appropriate
11. Heating system labeled ratings, including AFUE, COP, or HSPF, as appropriate.
12. Cooling system labeled ratings, including SEER or EER, as appropriate.
13. Thermostat schedule for heating and cooling
14. Air Distribution System Efficiency (DSE).
15. Mechanical ventilation kWh/yr, if appropriate

Software tools must have the ability to recreate or store the test case Reference Homes as if they were Qualifying Homes such that they also can be simulated and evaluated as Qualifying Homes.

4.3. Tax Credit Reference Auto-generation Test Suite

Test Case1. HERS BESTEST case L100 building configured as specified in the HERS BESTEST procedures, located in Baltimore, MD, including a total of 3 bedrooms and the following mechanical equipment: gas furnace with AFUE = 82% and central air conditioning with SEER = 11.0; a gas range, oven and clothes dryer; all other appliances are electric.

[25] The overall solar heat gain coefficient ($SHGC_o$) of a fenestration is defined as the solar heat gain coefficient (SHGC) of the fenestration product taken in combination with the interior shade fraction for the fenestration.

[26] SLA_o is the floor-area weighted specific leakage area of a home where the different building zones (e.g. basement and living zones) have different specific leakage areas.

Test Case 2. HERS BESTEST case L100 configured on an un-vented crawlspace with R-7 crawlspace wall insulation, located in Dallas, TX, including a total of 3 bedrooms and the following mechanical equipment: electric heat pump with HSPF = 7.5 and SEER = 12.0; all appliances are electric.

Test Case 3. HERS BESTEST case L304 in Miami, configured as specified in the HERS BESTEST procedures, located in Miami, FL, including a total of 2 bedrooms and the following mechanical equipment: electric strip heating with COP = 1.0 and central air conditioner with SEER = 15.0; all appliances are electric.

Test Case 4. HERS BESTEST case L324 configured as specified as in the HERS BESTEST procedures, located in Colorado Springs, CO, including a total of 4 bedrooms and the following mechanical equipment: gas furnace with AFUE = 95% and no air conditioning; a gas range, oven and clothes dryer; all other appliances are electric.

Test Case 5. Recreate or store the Reference Homes created in Tests 1 through 4 as Qualifying Homes and simulate and evaluate them.

4.4. Verification Criteria

Test Cases 1 – 4. For test cases 1 through 4 the values contained in Table B-1 shall be used as the verification criteria for software tool accreditation. For Reference Home building components marked by an asterisk (*), the verification criteria may include a range equal to ± 0.05% of the listed value. For all other Reference Home components the listed value is exact.

Table B-1 Verification Criteria for Test Cases 1 – 4

Reference Home Building Component	Test 1	Test 2	Test 3	Test 4
Above-grade walls (U_o)	0.082	0.082	0.082	0.060
Above-grade wall solar absorptance (α)	0.75	0.75	0.75	0.75
Above-grade wall infrared emittance (ε)	0.90	0.90	0.90	0.90
Basement walls (U_o)	n/a	n/a	n/a	0.059
Above-grade floors (U_o)	0.047	0.047	n/a	n/a
Slab insulation R-Value	n/a	n/a	0	0
Ceilings (U_o)	0.030	0.035	0.035	0.030
Roof solar absorptance (α)	0.75	0.75	0.75	0.75
Roof infrared emittance (ε)	0.90	0.90	0.90	0.90
Attic vent area* (ft^2)	5.13	5.13	5.13	5.13
Crawlspace vent area* (ft^2)	n/a	10.26	n/a	n/a
Exposed masonry floor area * (ft^2)	n/a	n/a	307.8	307.8
Carpet & pad R-Value	n/a	n/a	2.0	2.0
Door Area (ft^2)	40	40	40	40

Reference Home Building Component	**Test 1**	**Test 2**	**Test 3**	**Test 4**
Door U-Factor	0.40	0.65	1.20	0.35
North window area* (ft^2)	69.26	69.26	69.26	102.63
South window area* (ft^2)	69.26	69.26	69.26	102.63
East window area* (ft^2)	69.26	69.26	69.26	102.63
West window area* (ft^2)	69.26	69.26	69.26	102.63
Window U-Factor	0.40	0.65	1.20	0.35
Window $SHGC_o$ (heating)	0.4675	0.34	0.34	0.4675
Window $SHGC_o$ (cooling)	0.385	0.28	0.28	0.385
SLA_o* (ft^2/ft^2)	0.00048	0.00048	0.00048	0.00048
Sensible Internal gains* (Btu/day)	55,166	52,794	48,111	82,764
Latent Internal gains* (Btu/day)	13,770	12,698	9,259	17,890
Labeled heating system rating and efficiency	AFUE = 78%	HSPF = 7.7	HSPF = 7.7	AFUE = 78%
Labeled cooling system rating and efficiency	SEER = 13.0	SEER = 13.0	SEER = 13.0	SEER = 13.0
Air Distribution System Efficiency	0.80	0.80	0.80	0.80
Thermostat Type	Manual	Manual	Manual	Manual
Heating thermostat settings	68 F (all hours)	68 F (all hours)	68 F (all hours)	68 F (all hours)
Cooling thermostat settings	78 F (all hours)	78 F (all hours)	78 F (all hours)	78 F (all hours)

Test Case 5. Test case 5 requires that each of the Reference Homes for test cases 1-4 be stored or recreated in the software tool as a Qualifying Home and simulated as any other qualifying home would be simulated. If the resulting Qualifying home is correctly configured to be identical to its appropriate Reference Home, energy use calculations arising from normal operation of the software tool should produce virtually identical energy use for both the Reference Home and the Qualifying Home for this round of tests. For test case 5, the energy use e-Ratio shall be calculated separately from the simulation results for heating and cooling, as follows:

e-Ratio = (Qualifying Home energy use) / (Reference Home Energy Use)

Verification criteria for these calculations shall be ± 0.5% of 1.00. Thus, for each of the preceding test cases (1-4), the e-Ratio resulting from these software tool simulations and the subsequent e-Ratio calculations shall be greater than or equal to 0.995 **and** less than or equal to 1.005.

Annex C – 2006 IECC Standard Design Auto-Generation Tests

(Normative)

This normative Annex contains the Reference Home auto-generation test suite for 2006 IECC performance compliance tools. The test cases in this proposed test suite are designed to verify that software tools automatically generate accurate Standard Reference Designs given only the building information from the Proposed Homes.

1. Minimum Reporting Requirements

Software tools applying for verification shall provide evidence that their software meets the requirements of this test suite. The software tool provider or software vendor is responsible for producing the documentation needed to show that the software has been verified through this test suite. In some cases, the data needed to verify accuracy is of no interest or value to the end-user of the software, but in any case, the software tool must generate it. At a minimum, software tools applying for accreditation must report the following values for the Reference Home:

1. Areas and overall U-factors (or R-values in the case of slab-on-grade construction) for all building components, including ceilings, walls, floors, windows (by orientation) and doors.
2. Overall solar-heat gain coefficient ($SHGC_o$)[27] of the windows during heating.
3. Overall solar-heat gain coefficient ($SHGC_o$) of the windows during cooling.
4. Wall solar absorptance and infrared emittance
5. Roof solar absorptance and infrared emittance
6. Total internal gains to the home (Btu/day)
7. Specific leakage area (SLA) for the building, by zone or as SLA_o[28], as appropriate
8. Attic net free ventilation area (ft^2)
9. Crawlspace net free ventilation area (ft^2), if appropriate
10. Exposed masonry floor area and carpet and pad R-value, if appropriate
11. Heating system labeled ratings, including AFUE, COP, or HSPF, as appropriate.
12. Cooling system labeled ratings, including SEER or EER, as appropriate.
13. Thermostat schedule for heating and cooling
14. Air distribution system characteristics, including locations of all supply and return ducts and the air handler units, supply and return duct R-values, and supply and return duct air leakage values (in cfm_{25}).[29]
15. Mechanical ventilation kWh/yr, if appropriate

[27] The overall solar heat gain coefficient ($SHGC_o$) of a fenestration is defined as the solar heat gain coefficient (SHGC) of the fenestration product taken in combination with the interior shade fraction for the fenestration.

[28] SLA_o is the floor-area weighted specific leakage area of a home where the different building zones (e.g. basement and living zones) have different specific leakage areas.

[29] cfm_{25} = cubic feet per minute of air leakage to outdoors at a pressure difference between the duct interior and outdoors of 25 Pa.

Software tools must have the ability to recreate or store the test case Standard Reference Designs as if they were Proposed Homes such that they also can be simulated and evaluated as the Proposed Homes.

2. Auto-generation Test Case Descriptions

Test Case1. HERS BESTEST case L100 building configured as specified in the HERS BESTEST procedures, located in Baltimore, MD, including a total of 3 bedrooms and the following mechanical equipment: gas furnace with AFUE = 82% and central air conditioning with SEER = 11.0.

Test Case 2. HERS BESTEST case L100 configured on an un-vented crawlspace with R-7 crawlspace wall insulation, located in Dallas, TX, including a total of 3 bedrooms and the following mechanical equipment: electric heat pump with HSPF = 7.5 and SEER = 12.0.

Test Case 3. HERS BESTEST case L304 in Miami, configured as specified in the HERS BESTEST procedures, located in Miami, FL, including a total of 2 bedrooms and the following mechanical equipment: electric strip heating with COP = 1.0 and central air conditioner with SEER = 15.0.

Test Case 4. HERS BESTEST case L324 configured as specified as in the HERS BESTEST procedures, located in Colorado Springs, CO, including a total of 4 bedrooms and the following mechanical equipment: gas furnace with AFUE = 95% and no air conditioning.

Test Case 5. Recreate or store the Reference Homes created in Tests 1 through 4 as Rated Homes and simulate and evaluate them.

2.1. Acceptance Criteria

Test Cases 1 – 4.

For test cases 1 through 4 the values contained in Table C-1 shall be used as the acceptance criteria for software tool accreditation. For Standard Reference Design building components marked by an asterisk (*), the acceptance criteria may include a range equal to ± 0.05% of the listed value. For all other Reference Home components the listed values are exact.

Table C-1 Acceptance Criteria for Test Cases 1 – 4

Reference Home Building Component	Test 1	Test 2	Test 3	Test 4
Above-grade walls (U_o)	0.082	0.082	0.082	0.060
Above-grade wall solar absorptance (α)	0.75	0.75	0.75	0.75
Above-grade wall infrared emittance (ε)	0.90	0.90	0.90	0.90
Basement walls (U_o)	n/a	n/a	n/a	0.059
Above-grade floors (U_o)	0.047	0.047	n/a	n/a
Slab insulation R-Value	n/a	n/a	0	0

Reference Home Building Component	**Test 1**	**Test 2**	**Test 3**	**Test 4**
Ceilings (U_o)	0.030	0.035	0.035	0.030
Roof solar absorptance (α)	0.75	0.75	0.75	0.75
Roof infrared emittance (ε)	0.90	0.90	0.90	0.90
Attic vent area* (ft^2)	5.13	5.13	5.13	5.13
Crawlspace vent area* (ft^2)	n/a	10.26	n/a	n/a
Exposed masonry floor area * (ft^2)	n/a	n/a	307.8	307.8
Carpet & pad R-Value	n/a	n/a	2.0	2.0
Door Area (ft^2)	40	40	40	40
Door U-Factor	0.40	0.65	1.20	0.35
North window area* (ft^2)	67.50	67.50	67.50	67.50
South window area* (ft^2)	67.50	67.50	67.50	67.50
East window area* (ft^2)	67.50	67.50	67.50	67.50
West window area* (ft^2)	67.50	67.50	67.50	67.50
Window U-Factor	0.40	0.65	1.20	0.35
Window $SHGC_o$ (heating)	0.34	0.34	0.34	0.34
Window $SHGC_o$ (cooling)	0.28	0.28	0.28	0.28
SLA_o (ft^2/ft^2)	0.00036	0.00036	0.00036	0.00036
Internal gains* (Btu/day)	66,840	66,840	62,736	107,572
Labeled heating system efficiency rating	AFUE = 78%	HSPF = 7.7	HSPF = 7.7	AFUE = 78%
Labeled cooling system efficiency rating	SEER = 13.0	SEER = 13.0	SEER = 13.0	SEER = 13.0
Air Distribution System Efficiency	0.80	0.80	0.80	0.80
Thermostat Type	Manual	Manual	Manual	Manual
Heating thermostat settings	68 F (all hours)	68 F (all hours)	68 F (all hours)	68 F (all hours)
Cooling thermostat settings	78 F (all hours)	78 F (all hours)	78 F (all hours)	78 F (all hours)

2.2. Test Case 5.

Test case 5 requires that each of the Standard Reference Design for test cases 1-4 be stored or recreated in the software tool as Proposed Homes and simulated as any other rated home would be simulated. If the resulting Proposed Home is correctly configured to be identical to its appropriate Standard Reference Design, code compliance calculations arising from normal operation of the software tool should produce virtually identical scoring criteria for both the Standard Reference Design and the Proposed Home for this round of tests. For test case 5, the energy use e-Ratio shall be calculated separately from the simulation results for heating and cooling, as follows:

e-Ratio = (Proposed Home energy use) / (Standard Reference Design energy use)

Acceptance criteria for these calculations shall be ± 0.5% of 1.00. Thus, for each of the preceding test cases (1-4), the e-Ratio resulting from these software tool simulations and the subsequent e-Ratio calculations shall be greater than or equal to 0.995 **and** less than or equal to 1.005.

Annex D – RESNET L125A BESTEST

(Normative)

Test Case L125A is developed as an additional HERS BESTEST case to examine potential interactions between home alterations that interact with one another in a way that causes their combined impact on energy use to be different than the sum of their individual impacts on energy use. HERS BESTEST Case L120A examines the impact of adding additional ceiling and wall insulation to the L100A Case (baseline) and Case L130A examines the impact of adding high performance windows to the L100A Case. This Case, named L125A combines test Case L120A and Case L130A to examine the impact of adding both sets of improvements to the L100A Case.

1. Test Case L125A Specifications. [30]

Case L125A is **exactly the same as Case L100A**, except that

- An extra layer of R-38 batt insulation has been added to the ceiling, and exterior walls have 2x6 24" O.C. framing and R-18 batt insulation with R-7.2 polyisocyanurate exterior board insulation; and

- All single-pane windows are replaced with double-pane low-emissivity (low-e) windows with wood frames and insulated spacers.

2. Acceptance Criteria for Test Case L125A

Acceptance criteria for Test Case L125A are developed in the same manner as for all other HERS BESTEST cases (as detailed in Appendix H of the User's Manual referenced above) except that for this test the criteria are developed from six software tools that are currently used in the marketplace as follows:

- *EnergyGauge® USA* by Florida Solar Energy Center
- *EnergyInsights* by Appogee Interactive
- *OptiMiser* by Energy Logic
- *Rem/Rate* by Architectural Energy Corporation
- *EnergyMeasure ™ Home* by Conservation Services Group
- *TREAT* by PSD Consulting

Results from these six simulation tools were used to determine the acceptance criteria both for Test Case L125A and for the difference between Test Case L100A and Test Case L125A. Table D-1 presents the software results along with the acceptance criteria range for Test Case L125A and Table D-2 presents the difference results along with acceptance criteria range for the L100A Case minus the L125A Case.

[30] Users are advised to consult the following reference for details: Judkoff, R. and J. Neymark, November 1995. "Home Energy Rating System Building Energy Simulation Test (HERS BESTEST) – Volumes 1, Tier 1 and Tier 2 Tests User's Manual." National Renewable Energy Laboratory, Golden, Colorado, Report No. NREL/TP-472-7332.

Table D-1. Absolute Results for Case L125A

Heating Results (L125A)		**Cooling Results (L125A)**	
Software Tool	Annual MBtu	Software Tool	Annual MBtu
Tool A	33.72	Tool A	36.07
Tool B	35.31	Tool B	32.11
Tool C	35.58	Tool C	32.60
Tool D	35.62	Tool D	34.31
Tool E	34.21	Tool E	35.47
Tool F	37.40	Tool F	33.40
Mean	35.31	Mean	33.99
StDev	1.29	StDev	1.58
90% CI	1.16	90% CI	1.42
+ Range	**41.40**	**+ Range**	**40.07**
-Range	**29.72**	**-Range**	**28.11**

Table D-2. Difference Results for Case L100A - L125A

Heating Results (L100A-L125A)		**Cooling Results (L100A-L125A)**	
Software Tool	Annual MBtu	Software Tool	Annual MBtu
Tool A	33.70	Tool A	23.96
Tool B	34.09	Tool B	22.89
Tool C	25.30	Tool C	21.15
Tool D	25.66	Tool D	21.40
Tool E	32.53	Tool E	23.08
Tool F	32.50	Tool F	22.10
Mean	30.63	Mean	22.43
StDev	4.04	StDev	1.07
90% CI	3.64	90% CI	0.97
+ Range	**38.09**	**+ Range**	**27.96**
-Range	**21.30**	**-Range**	**17.15**

Annex E – RESNET HVAC Tests
(Normative)

Tools must be capable of generating HVAC results using system type and efficiency as inputs. Additional efficiency information is allowable, but must not be required to operate the tool. Tools must also account for duct leakage, duct insulation levels and the presence of a programmable thermostat.

1. System Types

System types that must be supported by all tools:

1. Compressor based air conditioning system
2. Oil, propane or natural gas forced air furnaces
3. Electric resistance forced air furnaces
4. Air source heat pump

Optional system types that may be supported include:

1. Evaporative cooling, direct, indirect or IDEC
2. Ground or water source heat pumps
3. Multiple fossil fuel systems which utilize fuel for backup heating and an electric air or ground source heat pump for primary heating. An example of this would be an electric air source heat pump with a fossil fuel furnace as a supplement or backup.
4. Radiant heating systems including but not limited to hot water radiant floor systems, baseboard systems and ceiling cable systems.
5. Hydronic systems.
6. Combo systems in which the system supplies both domestic hot water and space heating.
7. Active solar space heating systems

Capability tests do not currently exist for the optional system types listed above. The following table lists the efficiency metrics that are reported by manufacturers and must be used for each system type.

HVAC Equipment Type	Heating Efficiency Metric	Cooling Efficiency Metric	Comments:
Gas or Fuel Furnaces	AFUE		Includes wall furnaces, floor furnaces and central forced air furnaces.
Electric Resistance Furnace	COP		Use COP of 1.0, an HSPF of 3.413 may be equivalent and acceptable for some tools.
Air Source Heat Pump <65 kBtu/h	HSPF	SEER	
Air Cooled Central Air Conditioner <65 kBtu/h		SEER	

Air Cooled Window Air Conditioner		EER	PTAC units are included in this category

2. Detailed Default Inputs

Where tools use detailed modeling capabilities for HVAC simulation like DOE-2, the following values should be used as default values in the simulation tool to achieve the best results.

Default Values for use with Detailed HVAC Simulation Tools

DOE-2 Keyword:	Description (units)	Value
HEATING-EIR	Heat Pump Energy Input Ratio compressor only, (1/cop)	0.582*(1/(HSPF/3.413))
COOLING-EIR	Air Conditioner Energy Input Ratio compressor only, (1/cop)	0.941*(1/(SEER/3.413))
DEFROST-TYPE	Defrost method for outdoor unit, (Reverse cycle)	REVERSE-CYCLE
DEFROST-CTRL	Defrost control method, (Timed)	TIMED
DEFROST-T (F)	Temperature below which defrost controls are activated, (^{o}F)	40^o
CRANKCASE-HEAT	Refrigerant crankcase heater power, (kW)	0.05
CRANK-MAX-T	Temperature above which crankcase heat is deactivated, (^{o}F)	50^o
MIN-HP-T (F)	Minimum temperature at which compressor operates, (^{o}F)	0^o
MAX-HP-SUPP-T	Temperature above which auxiliary strip heat is not available, (^{o}F)	50^o
MAX-SUPPLY-T (heating, heat pump)	Maximum heat pump leaving air temperature from heating coil, (^{o}F)	105^o
MAX-SUPPLY-T (heating, natural gas furnace)	Maximum gas furnace leaving air temperature from heating coil, (^{o}F)	120^o
FURNACE-AUX	Natural gas furnace pilot light energy consumption, (Btu/h)	100
MIN-SUPPLY-T (cooling)	Minimum cooling leaving air temperature from cooling coil, (^{o}F)	55^o
SUPPLY-KW	Indoor unit standard blower fan power, (kW/cfm)	0.0005

DOE-2 Keyword:	Description (units)	Value
SUPPLY-DELTA-T	Air temperature rise due to fan heat, standard fan, (^{o}F)	1.580
SUPPLY-KW	Indoor unit standard blower fan power, high efficiency fan, (kW/cfm)	0.000375
SUPPLY-DELTA-T	Air temperature rise associated due to fan heat, high efficiency fan, (^{o}F)	1.185
COIL-BF	Coil bypass factor, (dimensionless)	0.241
Other parameters:		
Part load performance curves	Compressor part load performance curves	Henderson, et.al.[31]
Heating system size	Installed heat pump size, (kBtu/h)	Determined by Manual J (specified)
Coil airflow	Indoor unit air flow, (cfm)	30 cfm/(kBtu/h)
Cooling system size	Installed air conditioner size, (kBtu/h)	Determined by Manual J (specified)

3. List of Tests

The following test suites represent tests that tools must pass to be accredited. All tests are to be performed using the L100 building case described by the HERS BESTEST procedures.[32]

For each test case, interim acceptance criteria are provided. These interim criteria are based on preliminary reference results from 5 tools, which are capable of detailed hourly building simulation and HVAC modeling computations (e.g. DOE-2). The criteria are established for interim purposes as the 90% confidence interval for the 5 preliminary sets of reference results. In order to pass a specific test, tools must predict percentage energy use changes for the specified heating and/or cooling system tests that falls between the upper and lower acceptance criteria for that test.

Tools that do not model the performance of HVAC equipment in detail must provide for climate adjusted equipment performance factors in order to fall within the acceptance criteria for these tests. Methods of adjusting the manufacturer's nameplate ratings to account for climate dependent performance have been reported.[33]

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[31] Henderson, H.I., D.S. Parker and Y.J. Huang, 2000. "Improving DOE-2's RESYS Routine: User Defined Functions to Provide More Accurate Part Load Energy Use and Humidity Predictions," Proceedings of 2000 Summer Study on Energy Efficiency in Buildings, Vol. 1, p. 113, American Council for an Energy-Efficient Economy, 1001 Connecticut Avenue, Washington, DC.

[32] Judkoff, R. and J. Neymark, 1995. "Home Energy Rating System Building Energy Simulation Test (HERS BESTEST)," Vol. 1 and 2, Report No. NREL/TP-472-7332, National Renewable Energy Laboratory, Golden, Colorado 80401-3393. (Also available online at http://www.nrel.gov/publications/.)

[33] Fairey, P., D.S. Parker, B. Wilcox and M. Lombardi, "Climate Impacts on Heating Seasonal Performance Factor (HSPF) and Seasonal Energy Efficiency Ratio (SEER) for Air Source Heat Pumps." ASHRAE

3.1. Test Suite 1 – Air conditioning systems: Test to ensure that there is the proper differential electrical cooling energy consumption by cooling systems when the efficiency is varied between SEER 10 and a higher efficiency unit, taken to be SEER 13. For the purposes of this test assume zero duct leakage and all ducts and air handlers are in conditioned space.

Air Conditioning System Test Specifications

Test #	System Type	Capacity	Location	Efficiency
HVAC1a	Air cooled air conditioner	38.3 kBtu/h	Las Vegas, NV	SEER = 10
HVAC1b	Air cooled air conditioner	38.3 kBtu/h	Las Vegas, NV	SEER = 13

Interim Air Conditioning System Acceptance Criteria

Test #	Mfg. Equip Performance Rating (MEPR) Change	Low Acceptance Criteria	High Acceptance Criteria
HVAC1a	Base case	---	---
HVAC1b	-23.1%	-20.0%	-18.4%

3.2. Test Suite 2 – Heating Systems: Test to ensure that there is differential heating energy consumed by heating systems when the efficiency is varied between a code minimum heating and a higher efficiency unit. The tests will be carried out for both electric and non-electric heating systems. For the purposes of this test assume zero duct leakage and all ducts and air handlers in conditioned space.

Gas Heating System Test Specifications

Test #	System Type	Capacity	Location	Efficiency
HVAC2a	Gas Furnace	56.1 kBtu/h	Colorado Springs, CO	AFUE = 78%
HVAC2b	Gas Furnace	56.1 kBtu/h	Colorado Springs, CO	AFUE = 90%

Gas Heating System Acceptance Criteria

Test #	Mfg. Equip Performance Rating (MEPR) Change	Low Acceptance Criteria	High Acceptance Criteria
HVAC2a	Base case	---	---
HVAC2b	-13.3%	-13.1%	-12.6%

Electric Heating System Test Specifications

Test #	System Type	Capacity	Location	Efficiency
HVAC2c	Air Source	56.1 kBtu/h	Colorado	HSPF = 6.8

Transactions, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., Atlanta, GA, June 2004. (Also available online at http://www.fsec.ucf.edu/bldg/pubs/hspf/)

	Heat Pump		Springs, CO	
HVAC2d	Air Source Heat Pump	56.1 kBtu/h	Colorado Springs, CO	HSPF = 9.85
HVAC2e	Electric Furnace	56.1 kBtu/h	Colorado Springs, CO	COP =1.0

Electric Heating System Acceptance Criteria

Test #	Mfg. Equip Performance Rating (MEPR) Change	Low Acceptance Criteria	High Acceptance Criteria
HVAC2c	Base case	---	---
HVAC2d	-31.0%	-26.0%	-19.1%
HVAC2e	99.2%	47.8%	63.4%

Annex F – RESNET Distribution System Efficiency (DSE) Tests

(Normative)

Distribution System Efficiency (DSE) tests are designed to ensure that the impact of duct insulation, duct air leakage and duct location are properly accounted for in software. Tables 1 and 2 below describe the test specifications and the bounds criteria for these important tests.

1. Test Case Specification

For all tests, assume that the air-handling unit is in conditioned space. If the software tool being tested has the ability to modify inputs for duct area, assume that the supply duct area is equal to 20% of the conditioned floor area and the return duct area is equal to 5% of the conditioned floor area. The duct leakage shall be 250 cfm_{25} for cases 3d and 3h with the return and supply leakage fractions each set at 50%. All tests assume a natural gas forced air furnace and forced air cooling system with efficiencies of 78% AFUE = 78% for the heating system and SEER = 10 for the cooling system.

Furnace and air conditioner heating and cooling capacities should be modified for each of the duct system efficiency test cases according to the values provided in Tables 1a and 2a. Similarly, the specified heating and cooling coil airflow (cfm) should be altered by case using a value of 360 cfm/ton (30 cfm/kBtu) of capacity. Also, the exterior air film resistance of the duct system should be added to the specified duct R-values given in Tables 1a and 2a to obtain agreement for duct conductance. For non-insulated sheet metal ducts (R-0) the air film has a resistance of approximately R=1.5 ft^2-^oF-hr/Btu and for insulated ducts (R=6) the air film has a resistance of R=1.0 as shown by test results obtained by Lauvray (1978) at a typical residential duct airflow rate of 530 fpm.[34] These values are currently established for the purposes of duct design calculations by ASHRAE within the Handbook of Fundamentals (2001, p. 34.15). Thus, unless the software undergoing test accounts for these film resistances, the uninsulated sheet metal duct (R=0 in Tables 1a and 2a) should be entered as R=1.5 while the insulated ducts (R=6 in tables) should be entered as R=7.

For the heating comparison test cases (Table 1a), which assume a basement, use the HERS BESTEST Case L322 home. The basement is to be unconditioned, have a floor area equal to the main floor area (1539 ft^2) and have R11 insulation in the floor joists of the main floor with a framing fraction of 13%. The basement case has no basement wall insulation. For the cooling comparison test cases (Table 2a), use the HERS BESTEST case L100 home.

2. Bounds Criteria

The bounds criteria for these tests were established using ASHRAE Standard 152-04, using the spreadsheet tool constructed for the U.S. DOE *Building America* program by Lawrence

[34] T.L. Lauvray, 1978. "Experimental heat transmission coefficients for operating air duct systems," ASHRAE Journal, June, 1978.

Berkeley National Laboratory (LBNL).[35] In all cases, the input values for the Standard 152 calculations assumed the following:

- Single story building
- Single speed air conditioner/heating system
- System capacities as specified in Tables 1a and 2a
- Coil air flow = 360 cfm per 12,000 Btu/h
- Ducts located as specified in Tables 1a and 2a
- Supply duct area = 308 ft^2
- Return duct area = 77 ft^2
- Supply and return duct insulation of R=1.5 and R=7 for uninsulated (R=0) and insulated (R=6) ducts, respectively
- Supply and return duct leakage = 125 cfm each, where so specified in Tables 1a and 2a.

Following the ASHRAE Standard 152 analysis, the resulting DSE values were converted to a percentage change in heating and cooling energy use ("Target Delta" in Tables 1b and 2b) using the following calculation:

$$\% \text{ Change} = 1.0 - (1.0 / \text{DSE})$$

Bounds criteria were then established as this target delta plus and minus 5% to yield the values given in Tables 1b and 2b for heating and cooling test minimum and maximum delta bounds criteria, respectively.

2.1. Heating Energy Tests

Table F-1a. Heating Energy DSE Comparison Test Specifications

Test #	Location	System Type	System Capacity (kBtu/h)	Duct Location	Duct Leakage	Duct R-val*
HVAC3a (base case)	Colorado Springs, CO	Gas Furnace	46.6	100% conditioned	None	R=0
HVAC3b	Colorado Springs, CO	Gas Furnace	56.0	100% in basement	None	R=0
HVAC3c	Colorado Springs, CO	Gas Furnace	49.0	100% in basement	None	R=6
HVAC3d	Colorado Springs, CO	Gas Furnace	61.0	100% in basement	250 cfm_{25}	R=6
* Duct R-value does not include air film resistances. For uninsulated ducts, this film resistance is approximately R=1.5 and for insulated ducts it is approximately R=1.0. If software does not consider this air film resistance in detail, then these air film resistances should be added.						

[35] See http://www.eere.energy.gov/buildings/building_america/benchmark_def.html

Table F-1b. Heating Energy DSE Comparison Test Bounds Criteria

Test #	Target Delta* Heating Energy Relative to HVAC3a	Minimum Delta* Heating Energy	Maximum Delta* Heating Energy
HVAC3a	Base case	---	---
HVAC3b	26.4%	21.4%	31.4%
HVAC3c	7.5%	2.5%	12.5%
HVAC3d	20%	15%	25%
* Delta = % Change in energy use = ((alternative – base case) / (base case)) * 100			

2.2. Cooling Energy Tests

Table F-2a. Cooling Energy DSE Comparison Test Specifications

Test #	Location	System Type	System Capacity (kBtu/h)	Duct Location	Duct Leakage	Duct R-val*
HVAC3e (base case)	Las Vegas, NV	Air Conditioner	-38.4	100% conditioned	None	R=0
HVAC3f	Las Vegas, NV	Air Conditioner	-49.9	100% in attic	None	R=0
HVAC3g	Las Vegas, NV	Air Conditioner	-42.2	100% in attic	None	R=6
HVAC3h	Las Vegas, NV	Air Conditioner	-55.0	100% in attic	250 cfm_{25}	R=6
* Duct R-value does not include air film resistance. For uninsulated ducts, this film resistance is approximately R=1.5 and for insulated ducts it is approximately R=1.0. If software does not consider this air film resistance in detail, then these air film resistances should be added.						

Table F-2b. Cooling Energy DSE Comparison Test Bounds Criteria

Test #	Target Delta* Cooling Energy Relative to HVAC3e	Minimum Delta* Cooling Energy	Maximum Delta* Cooling Energy
HVAC3e	Base case	---	---
HVAC3f	31.2%	26.2%	36.2%
HVAC3g	11.5%	6.5%	16.5%
HVAC3h	26.1%	21.1%	31.1%
* Delta = % Change in energy use = ((alternative – base case) / (base case)) * 100			

Annex G – RESNET Domestic Hot Water (DHW) Tests
(Normative)

Domestic hot water system tests are designed to determine if software tools accurately account for both the hot water use rate (gallons per day) and the climate impacts (inlet water temperatures) of hot water systems. The tests are limited to standard gas-fired hot water systems and cannot be used to evaluate solar hot water systems, heat pump hot water systems, hot water systems that recover heat from air conditioner compressors (heat recovery or de-super heater systems), or other types of hot water systems. In addition, distribution losses associated with hot water distribution systems are not covered by this test.

1. Test Description. The following table provides summary specifications for the six required hot water tests. The tests are segregated into two sets of three tests – one set of cold climate tests (Duluth, MN) and one set of hot climate tests (Miami, FL).

Table G-1. Summary Specifications for Standard Hot Water Tests

Test Number	System Type	Climate Location	System Efficiency	Number of Bedrooms
DHW-MN-56-2	40 gal, gas	Duluth, MN	EF = 0.56	2
DHW-MN-56-4	40 gal, gas	Duluth, MN	EF = 0.56	4
DHW-MN-62-2	40 gal, gas	Duluth, MN	EF = 0.62	2
DHW-FL-56-2	40 gal, gas	Miami, FL	EF = 0.56	2
DHW-FL-56-4	40 gal, gas	Miami, FL	EF = 0.56	4
DHW-FL-62-2	40 gal, gas	Miami, FL	EF = 0.62	2

Additional specifications used in the creation of the reference results that establish the hot water system test acceptance criteria are as follows:

1.1. Hot Water Draw Profile

The hot water draw profile is as specified by ASHRAE Standard 90.2, as given in Table G-2 below:

Table G-2. Hourly Hot Water Draw Fraction for Hot Water Tests

Hour of Day	Daily Fraction	Hour of Day	Daily Fraction	Hour of Day	Daily Fraction
1	0.0085	9	0.0650	17	0.0370
2	0.0085	10	0.0650	18	0.0630
3	0.0085	11	0.0650	19	0.0630
4	0.0085	12	0.0460	20	0.0630
5	0.0085	13	0.0460	21	0.0630
6	0.0100	14	0.0370	22	0.0510
7	0.0750	15	0.0370	23	0.0510
8	0.0750	16	0.0370	24	0.0085

1.2. Inlet Mains Temperature

The cold-water inlet mains temperatures to the hot water system are calculated in accordance with the following formula:[36]

$$\mathbf{T_{mains} = (T_{amb,avg} + \mathit{offset}) + \mathit{ratio} * (\Delta T_{amb,max} / 2) * \sin (0.986 * (day\# - 15 - \mathit{lag}) - 90)}$$

where:

T_{mains}	= mains (supply) temperature to domestic hot water tank (ºF)
$T_{amb,avg}$	= annual average ambient air temperature (ºF)
$\Delta T_{amb,max}$	= maximum difference between monthly average ambient temperatures (e.g., $T_{amb,avg,july} - T_{amb,avg,january}$) (ºF)
0.986	= degrees/day (360/365)
day#	= Julian day of the year (1-365)
offset	= 6°F
ratio	= 0.4 + 0.01 ($T_{amb,avg} - 44$)
lag	= 35 – 1.0 ($T_{amb,avg} - 44$)

1.3. Additional TRNSYS Simulation Parameters

Additional inputs for TRNSYS reference result simulations are as follows:

- Rated Power 40,000 Btu/hr
- Recovery efficiency: 0.78
- Tank UA for EF=0.56 system: 10.79 Btu/hr-F
- Tank UA for EF=0.62 system: 7.031 Btu/hr-F
- Tank set point temperature: 120 F
- Tank space temperature ("loss temp"): 75 F
- Tank stratification: 15 equal nodes
- Simulation time step: 1/16th hour

2. Acceptance Criteria

In each of the two sets of three test cases, the first test listed (DHW-xx-56-2) is the base case and the other two cases are the alternative cases. There are two metrics used for acceptance criteria a difference metric (delta) and an absolute metric (MBtu). The delta metric is the % change in energy use for the alternative cases with respect to the base case, which is determined as follows:

$$\% \text{ Change} = (\text{alternative} - \text{base}) / (\text{base}) * 100$$

The absolute metric is the projected hot water energy use given in millions of Btu (site MBtu). The acceptance criteria given in Table G-3 below are determined from reference results from three different software tools – TRNSYS version15, DOE-2.1E (v.120) as used by EnergyGauge USA version 2.5, and RemRate version 12. Minimum and maximum

[36] NREL, "Building America Research Benchmark Definition." National Renewable Energy Laboratory, Golden, CO, December 29, 2004. May be found online at: http://www.eere.energy.gov/buildings/building_america/pa_resources.html

acceptance criteria are determined as the 99% confidence interval for these reference results using the student t-test.

Table G-3. Acceptance Criteria for Hot Water Systems Tests

Case	Mean	St Dev	99%CI	Minimum	Maximum
MN,0.56,4 (delta)	29.3%	0.58%	2.85%	26.5%	32.2%
MN,0.62,2 (delta)	-9.3%	0.51%	2.49%	-11.8%	-6.8%
FL,0.56,4 (delta)	24.1%	1.02%	5.01%	19.1%	29.1%
FL,0.62,2 (delta)	-13.6%	1.19%	5.87%	-19.5%	-7.7%
MN,0.56,2 (MBtu)	20.13	0.38	1.89	18.24	22.02
FL,0.56,2 (MBtu)	12.69	0.36	1.76	10.92	14.45
MN-FL (MBtu)	7.44	0.40	1.95	5.49	9.39

Annex H – HERS Method Tests
(Normative)

The HERS Method tests are intended to determine the ability of HERS tools to accurately calculate the HERS Index given a set of Reference Home End Use Loads (REUL), Reference Home End Use Energy Consumptions (EC_r), Rated Home End Use Energy Consumptions (EC_x) and the applicable manufacturers equipment performance ratings (MEPR).

1. Minimum Reporting Requirements. At a minimum, all software tools must report the following values:

1.1. Reference Home End Use Loads (REUL) to the nearest 0.1 MBtu
- i. Heating (MBtu)
- ii. Cooling (MBtu)
- iii. Hot water (MBtu)

1.2. Reference Home End Use Energy Consumption (EC_r) to the nearest 0.1 MBtu
- i. Heating (MBtu)
- ii. Cooling (MBtu)
- iii. Hot Water (MBtu)

1.3. Rated Home End Use Energy Consumption (EC_x) to the nearest 0.1 MBtu
- i. Heating (MBtu)
- ii. Cooling (MBtu)
- iii. Hot Water (MBtu)

1.4. Manufacturer's Equipment Performance Ratings (MEPR)
- i. Heating system (HSPF, COP, AFUE, or CAFUE)
- ii. Cooling system (SEER, EER or COP)
- iii. Hot Water system (EF or CEF)

2. Test Description

Home Energy Ratings for the following cases, located in Colorado Springs, CO, shall be computed, reporting the values listed above.

2.1. Case L100A-01: Using the HERS BESTEST L100 case, create a 3-bedroom Rated Home containing the following equipment:
- i. Heating system – electric HP with HSPF = 6.8
- ii. Cooling system – electric A/C with SEER = 10.0
- iii. Hot Water – 40 gal electric with EF = 0.88
- iv. All the equipment are to be located inside the conditioned space and heating and air conditioning ductwork are to be located in the conditioned space and have zero (0) air leakage.

2.2. Case L100A-02: Identical to Case L100A-01 except that the hot water heater is changed to a 40 gal natural gas with EF = 0.54.

2.3. Case L100A-03: Identical to Case L100A-01 except that the space heating system is changed to a natural gas furnace with AFUE = 78%.

2.4. Case L100A-04: Identical to Case L100A-01 except that the space heating system is changed to a high efficiency HP with HSPF = 9.85.

2.5. Case L100A-05: Identical to Case L100A-01 except that the space heating system is changed to a natural gas furnace with AFUE = 96%.

3. Acceptance Criteria

Using the calculation spreadsheet provided by RESNET (method_check-2006_form.xls), software tools shall demonstrate the following:

3.1. That reported Reference Home End Use Loads (REULs) vary by less than 0.2% across all cases.

3.2. That the difference between the HERS Indices calculated by the software tool and those calculated by the calculation spreadsheet provided with this Test Standard is less than 0.5% of the index reported by the software tool for all cases.

Annex I – New Home Tax Credit Method Test
(Normative)

The New Home Tax Credit Method tests are intended to determine the ability of HERS tools to accurately calculate the energy use ratios given a set of Reference Home End Use Loads (REUL) excluding hot water, lighting and appliance loads, Reference Home End Use Energy Consumptions (EC_r) excluding hot water, lighting and appliance consumptions, Qualifying Home End Use Energy Consumptions (EC_x) excluding hot water, lighting and appliance consumptions and the applicable manufacturers equipment performance ratings (MEPR).

1. **Minimum Reporting Requirements.** At a minimum, all software tools must report the following values:

1.1 Reference Home End Use Loads (REUL) to the nearest 0.1 MBtu
- i. Heating (MBtu)
- ii. Cooling (MBtu)

1.2 Reference Home End Use Energy Consumption (EC_r) to the nearest 0.1 MBtu
- i. Heating (MBtu)
- ii. Cooling (MBtu)

1.3 Qualifying Home End Use Energy Consumption (EC_x) to the nearest 0.1 MBtu
- i. Heating (MBtu)
- ii. Cooling (MBtu)

1.4 Manufacturer's Equipment Performance Ratings (MEPR)
- i. Heating system (HSPF, COP, AFUE, or CAFUE)
- ii. Cooling system (SEER, EER or COP)

2. Test Description

Tax Credit Qualification for the following cases, located in Colorado Springs, CO, shall be computed, reporting the values listed above.

2.1 Case L100A-01: Using the HERS BESTEST L100 case, create a 3-bedroom Rated Home containing the following equipment:
- i. Heating system – electric HP with HSPF = 6.8
- ii. Cooling system – electric A/C with SEER = 10.0
- iii. All the equipment are to be located inside the conditioned space and heating and air conditioning ductwork are to be located in the conditioned space and have zero (0) air leakage.

2.2 Case L100A-02: Identical to Case L100A-01 except that the space heating system is changed to a natural gas furnace with AFUE = 78%.

2.3 Case L100A-03: Identical to Case L100A-01 except that the space heating system is changed to a high efficiency HP with HSPF = 9.85.

2.4 Case L100A-04: Identical to Case L100A-01 except that the space heating system is changed to a natural gas furnace with AFUE = 96%.

3. Acceptance Criteria

Using the calculation spreadsheet provided by RESNET (method_check-2006_form.xls), software tools shall demonstrate the following:

3.1 That reported Reference Home End Use Loads (REULs) for heating and cooling vary by less than 0.2% across all cases.

3.2 That the difference between the energy ratios calculated by the software tool and those calculated by the calculation spreadsheet provided with this Test Standard is less than 0.5% of the index reported by the software tool for all cases.

Annex X – ECM Guidelines (Informative)

General Guidelines for Determining Energy Conservation Measure (ECM)
Service Lifetimes and Maintenance Fractions

	RESNET HERS Standard (March 2012)[1]	Database for Energy Efficient Resources[2]	California Measurement Advisory Council[3]	American Council for an Energy-Efficient Economy[4]	Navigant[5]	National Association of Home Builders[6]	RESNET Standards Committee Estimate[7]	Range (years)
Duct Sealing	20	18						18-20
Air Sealing	30		10					10-30
Attic, Ventilation	30					"lifetime"		30
Attic, Radiant Barrier	30							30
Color, Roof Shingles	15	15						15
Color, Wall Paint	10	6				15		6-15
HVAC, Replacement	15	15	18	10-20	14	10-16		10-20
Furnace, Replacement	20	20	18		15-20	15-20		15-20
Hot Water, Heat Pump Water Heater	15	10	13	13	14			10-15
Hot Water, Heat Recovery	15							15
Hot Water, Pipe Insulation	15	12						12-15
Hot Water, Tank Wrap	12		10					10-12
Hot Water, Solar, Direct	40	15		13	20			13-40
Hot Water, Solar, ISC	40	15		13	20			13-40
Hot Water, Solar, Indirect	40	15		13	20			13-40
Hot Water, Standard System	12	15	13-15	13	9-15	10		9-15
Hot Water, Tankless Gas Water Heater	12	20		13	20	20		12-20
Insulation, Block Wall	40		25			"lifetime"		25-40
Insulation, Ceiling Insulation	40	20	25			"lifetime"		20-40
Insulation, Frame Wall Insulation	40	20	25			"lifetime"		20-40
High Efficiency Fluorescent Lamps	5	3.9-10.6						3.9-10.6
High Efficiency LED							15	15
Pool Pump, High Efficiency	15	10						10-15
Refrigerator Replacement	15	14	18		14-18	13		13-18

Low Flow Showerhead	15	10	6-8.9			"lifetime"		6-15
Window Replacement	40	20	25			15-30		15-40
Window Film or Tint	15	10				10		10-15
Window Solar Screens	15	10						10-15

1. Residential Energy Service Network (RESNET). "Mortgage Industry National Home Energy Rating Systems Standards, March 2, 2012
2. Database for Energy Efficient Resources (DEER). "DEER 2008 for 09-11 Planning/Reporting ." 2008. http://www.deeresources.com May, 10, 2012
3. California Measurement Advisory Council (CALMAC): CALMAC Protocols. "Appendix F: Effective Useful Life Values for Major Energy Efficiency Measures." 1994-2007. http://www.calmac.org/events/APX _F.pdf May 10, 2012
4. American Council for an Energy-Efficient Economy (ACEE): "Consumer Resources by Measure Type" January 2011. www.acee.org May 10, 2012
5. Navigant Consulting. "EIA – Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case Second Edition (Revised)." Sept 2007.
6. National Association of Home Builders (NAHB): "National Association of Home Builders/Bank of America Home Equity Study of Life Expectancy of Home Components." February 2007. http://www.nahb.org/fileUpload_details.aspx?contentID=99359 May 10, 2012.
7. Residential Energy Service Network (RESNET). Standard Development Committee estimate for Standard 301. June 2012.